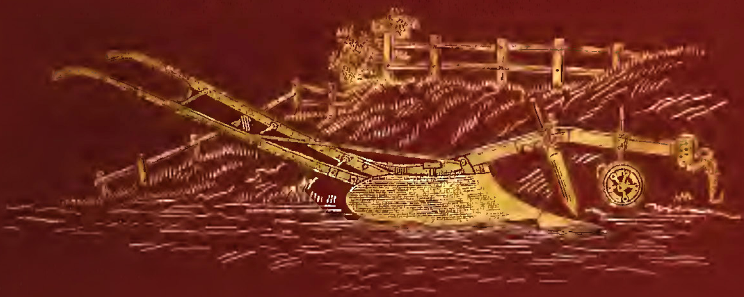
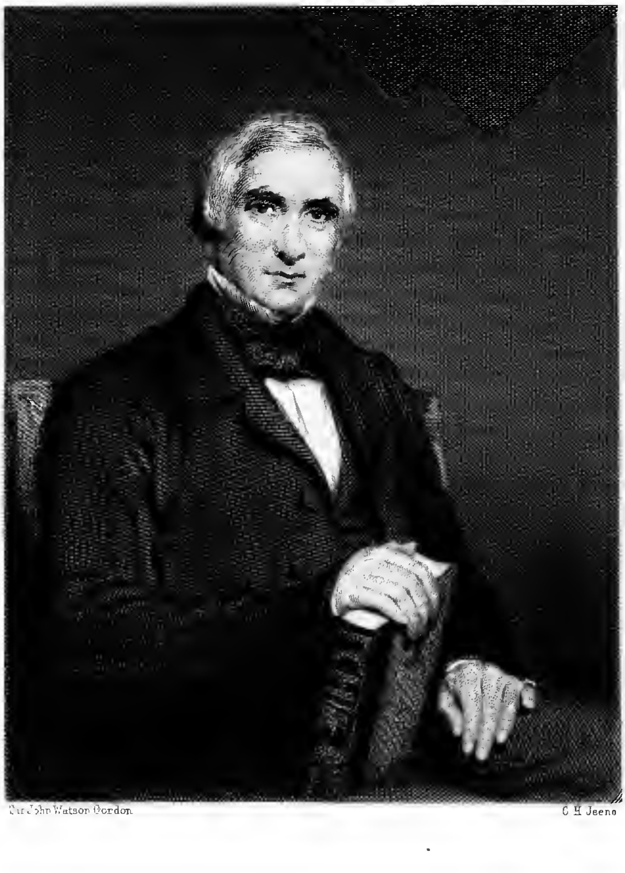


THE

BOOK OF THE FARM

Wherefore come on, O young husbandman!
Learn the culture proper to each kind.

VIRGIL.



Sir John Watson Gordon — C H Jeens

Henry Stephens

W. Blackwood & Sons, Edinburgh & London.

THE

BOOK OF THE FARM

DETAILING THE LABOURS OF THE

FARMER, FARM-STEWARD, PLOUGHMAN, SHEPHERD, HEDGER, FARM-LABOURER, FIELD-WORKER, AND CATTLE-MAN

BY

HENRY STEPHENS, F.R.S.E.

CORRESPONDING MEMBER OF THE NATIONAL AND CENTRAL SOCIETY OF AGRICULTURE OF FRANCE; OF THE AGRICULTURAL SOCIETY OF GALICIA; OF THE AGRICULTURAL INSTITUTE OF GOREGORETZK IN RUSSIA; OF THE ROYAL AGRICULTURAL SOCIETY OF SWEDEN; OF THE ROYAL IMPROVEMENT SOCIETY OF NORWAY

FOURTH EDITION

REVISED, AND IN GREAT PART REWRITTEN, BY

JAMES MACDONALD

OF THE 'FARMING WORLD';

AUTHOR OF 'FOOD FROM THE FAR WEST'; JOINT AUTHOR OF 'POLLED CATTLE,' 'HEREFORD CATTLE,' ETC., ETC.

IN THREE VOLUMES

VOLUME I.

WILLIAM BLACKWOOD AND SONS

EDINBURGH AND LONDON

MDCCCXCI

PREFACE.

More than twenty years have elapsed since the third edition of *The Book of the Farm* was prepared. In that comparatively short period of time British agriculture has undergone a striking change. It has seen its highest point in prosperity and almost its lowest in depression. Since the disastrously wet and sunless year of 1879, bad seasons have in themselves swept away a vast amount of farming capital. Foreign countries, with virgin soil and cheap labour, have flooded our open ports with meat and bread-stuffs; and, in spite of a largely increased population and much greater purchasing power on the part of the consuming public, the prices of nearly all varieties of farm produce have greatly declined.

How serious is the influence which these great movements have exercised upon our beloved country cannot readily be conceived. What they have signified to the farming community itself has, alas! been only too clearly visible. How fundamentally the fabric of British agriculture has been affected will be best understood by a consideration of the figures which represent the movements in imports and prices of agricultural produce, as well as the variations in the cropping and stocking of British farms.

The value of the imports of agricultural produce had grown in 1887 to the formidable figure of £117,019,064, rather more than 48½ millions sterling in excess of the sum sent abroad for these commodities twenty-one years previously. Reckoned per head of population, the imports in 1887 amounted to £3, 3s. 9d. for every man, woman, and child in the United Kingdom, or nearly 18s. 6d. per head more than in 1866. And the growth in quantities has been greater than in the value of the imports by from 25 to 30 per cent.

With such a vastly increased volume of foreign competition as these figures exhibit, the prices of farm produce in British markets could not fail to have suffered decline. The falling off in prices has indeed been very great, and it has extended in less or greater extent to almost every article produced on British farms.

It has been greatest in grain, greatest of all in wheat. From about 50s. per quarter in 1866 wheat fell to 31s. in 1887. In the same period barley lost 11s. and oats 8s. per quarter. Wool has fallen from 1s. 9d. to from 10d. to 1s. per lb.

The prices of beef and mutton have had many "ups" and "downs" since 1866. They are now (May 1891) not much below the level they presented then, but are from 15 to 25 per cent below the high range of prices attained between 1870 and 1883.

In sympathy with these alterations in prices, the systems of cropping and general farm management pursued throughout the United Kingdom have naturally undergone, and are still undergoing, considerable modification.

In the extent of cultivated land—arable land and permanent pasture—there has been a substantial increase in the past twenty years,—no less than 2,870,714 acres in Great Britain. But, as the result of the depression, as many as 833,393 acres have in twenty years gone from regular tillage into permanent pasture.

Looking more narrowly into the division of the arable land amongst the various crops, we find that the twenty years from

1868 to 1887 introduced changes which are even more significant. The corn crops have lost ground considerably, falling from about 52 per cent of the arable land in 1867 to about 48 per cent in 1887. Green crops and grasses have both grown in proportionate extent—the former by about 7 and the latter by 58 acres in every 1000 acres of arable land. But the most notable change occurs in the area of bare fallow, which has fallen off by nearly 50 per cent. In Ireland similar movements have taken place.

In the relative positions of the individual crops in regard to acreage, the past twenty years have effected some significant changes. Amongst cereals, wheat has had to yield the premier position to oats. Barley has been nearly stationary. Beans have declined by nearly 30 per cent. Turnips are losing ground, potatoes gaining a little. The former is still, of course, by far the most extensively grown of the green crops. Mangels have increased by about 50 per cent.

It is thus obvious that corn-growing has lost its supremacy in the agricultural interests of this country. Increased reliance is placed upon live stock; and although this industry has not escaped the vicissitudes of the recent depression, it has nevertheless made substantial progress during the past twenty years. The progress in that period has not been continuous, and it has not extended to all varieties of farm live stock; yet the national wealth in the live stock of the farm is very much greater now than it was prior to 1870.

Between 1867 and 1887 the stock of cattle in Great Britain increased by nearly 1½ million head, and in Ireland by about half a million head. Curiously enough, in the same period the stock of sheep fell off by nearly 3 million head in Great Britain and 1½ million head in Ireland. Somehow pig-rearing, although when well conducted it is notoriously profitable, does not find favour with the majority of British farmers, and their stock of pigs has decreased by more than half a million head in the past twenty years. Irish farmers are more kindly disposed towards the pig, and their stock has increased substantially since 1867.

Despite the prediction that the steam-engine would tend to supplant horse-labour, the demand for draught-horses is now greater than ever. The stock of horses is larger than it was twenty years ago; yet it is undoubted that the breeding of horses might be extended with profitable results.

The important circumstances thus briefly indicated have produced something like a revolution in the position and prospects of the British farmer. He can no longer be the easy independent waiter upon Providence that he used to be when wheat was at 50s. per quarter. His life must be a struggle for existence, and he must prepare himself with a scientific and technical knowledge of his work in all its details and departments; must acquaint himself with the latest ideas of the practical and scientific agriculturist, and test them by his own experience and possibilities; and must cast around him in search of information as to how he can make the most of the altered condition of things. It is by knowledge combined with experience that the farmer of the future must make his way. The State has begun to appreciate this fact by establishing means of providing agricultural instruction. But the practical farmer requires more full and special sources of information,—a work which he can with profit make the subject of general study, and which he can with confidence refer to at any moment when he is in want of advice. Such a work, it is hoped, *The Book of the Farm* in its new and enlarged form will prove to be.

In the preparation of this the Fourth Edition of *The Book of the Farm*, the important changes of the past twenty years have been carefully and anxiously considered. To a large extent the work has been rewritten; what remains of the original text has been carefully revised.

Alike in providing the new matter and in revising the old, the great object aimed at has been to adapt the work to the altered and still shifting circumstances and surroundings of the

British farmer. Without neglecting, or turning our back upon, any of the branches of farming which may perhaps be of comparatively less importance than in former times, we have devoted more attention than was given in previous editions to some other interests which have risen in the scale of importance. Prominent amongst these latter is the great subject of stock-rearing, notably the breeding and feeding of cattle. The portions in the new edition relating to this branch of farming consist almost entirely of fresh matter; and so important is it considered, that it has been dealt with more fully and more exhaustively than has ever before been attempted.

Scientific and practical research have thrown fresh light upon the fundamental processes of maintaining the fertility of the soil. An entirely new chapter places the reader in possession of this extended and corrected experience. The system of ensilage, the latest agricultural innovation, and the extension of dairy farming, have received due attention. Every modification and development of great or minor importance, every new or extended influence affecting agriculture, has had careful consideration. Brief sketches of all the varieties of British horses, cattle, sheep, and swine are enhanced in usefulness by a full series of high-class animal portraits, which embraces typical animals of all the leading breeds, and which has been specially prepared at great expense for this edition by eminent artists. It is interesting to contrast with these the few portraits retained of animals representing the period from 1840 to 1850.

The original plan of the work has been in the main preserved. With the view of facilitating reference, some minor changes, such as headings instead of numbers to paragraphs, have been introduced. Much care has been bestowed upon the introduction of these paragraph headings, and they are set forth clearly, so that the reader may learn at a glance the subjects dealt with in any part of the work.

As in the third edition, the work is divided into heads: 1. Initiation, in which the young man desirous of becoming a farmer is advised to acquaint himself beforehand with certain branches of science which have a close relation to Agriculture, and is also instructed as to how this knowledge is to be obtained and as to where he can best learn the practice of his art; 2. PRACTICE, which details the entire operations, through the four seasons, of raising crops, and rearing the domesticated animals; 3. REALISATION, wherein the young farmer is advised how to bargain for and stock a farm—how to execute many operations he may have to undertake—how to judge and to conduct the breeding of live stock—and, lastly, how to keep accurate accounts of all his transactions.

It is hoped that the new edition, in its greatly extended and thoroughly revised form, may efficiently help farmers to pursue their occupation with pleasure and profit. Farming, if it is to maintain its importance as an industry, must, like any other business, be conducted at a profit. With reduced prices and other magnified obstacles, it is more difficult than ever to accomplish this. More than ever, therefore, is it important that the farmer should fortify himself with all the guidance, stimulus, and encouragement which *The Book of the Farm* is capable of affording to him. The work is designed as a guide to him in every piece of practical work and every item of farming business he is called upon to engage in. It presents itself as a faithful compendium of the experience of a whole army of agricultural "specialists,"—men who have shown themselves to be proficient in some special branch of practical farming or province of allied science. The work thus aims at forming in itself a compendious professional library for every well-equipped farmer.

In taking up the life-work of the able and respected author of *The Book of the Farm*, I have felt the responsibility all the greater because of the exceptional conditions which at the present moment surround the British farmer. Happily, in the preparation of the new edition, I have had the privilege of the cordial co-operation of a great many of the leading agricultural and scientific authorities of the day. I have, in particular, had valuable aid from the following, to whom, and to many other helpers, I heartily acknowledge my indebtedness—viz., Mr Gilbert Murray, Elvaston Castle, Derby; Mr George Brown, Watten Mains, Caithness; Miss E. A. Ormerod; Mr John Speir, Newton Farm, Glasgow; Professor Primrose M'Connell; Professor M'Cracken; Dr A. P. Aitken; Mr Bernard Dyer, F.C.S.; Mr C. M. Aikman, M.A., F.C.S.; Mr R. Warington, F.C.S.; Dr Fream; Professor Thomas Jamieson; Professor R. Wright; Professor Long; Mr John Milne, Inverurie, Aberdeenshire; Ex-Provost Black of Sherifston, Elgin; Mr Charles Whitehead; Mr Martin John Sutton; Mr Robert Bruce; Mr Alexander Macdonald; Mr Thomas Bell; Mr William Morton; Mr John M'Laren; Mr H. Evershed; Mr Edward Brown; Mr Sanders Spencer; Mr R. H. Rew; Mr W. Scarth Dixon; Mr H. F. Euren, &c. &c. I feel that, by the assistance thus accorded to me, I have been enabled to impart to the work a comprehensiveness and efficiency which could not otherwise have been attained. It will be sincerely gratifying to me if the work in its new form should be considered worthy the memory of the late Henry Stephens, whose services to the interests of British farmers have earned for his name a lasting place in the annals of agriculture.

JAMES MACDONALD.

EDINBURGH, 1891.

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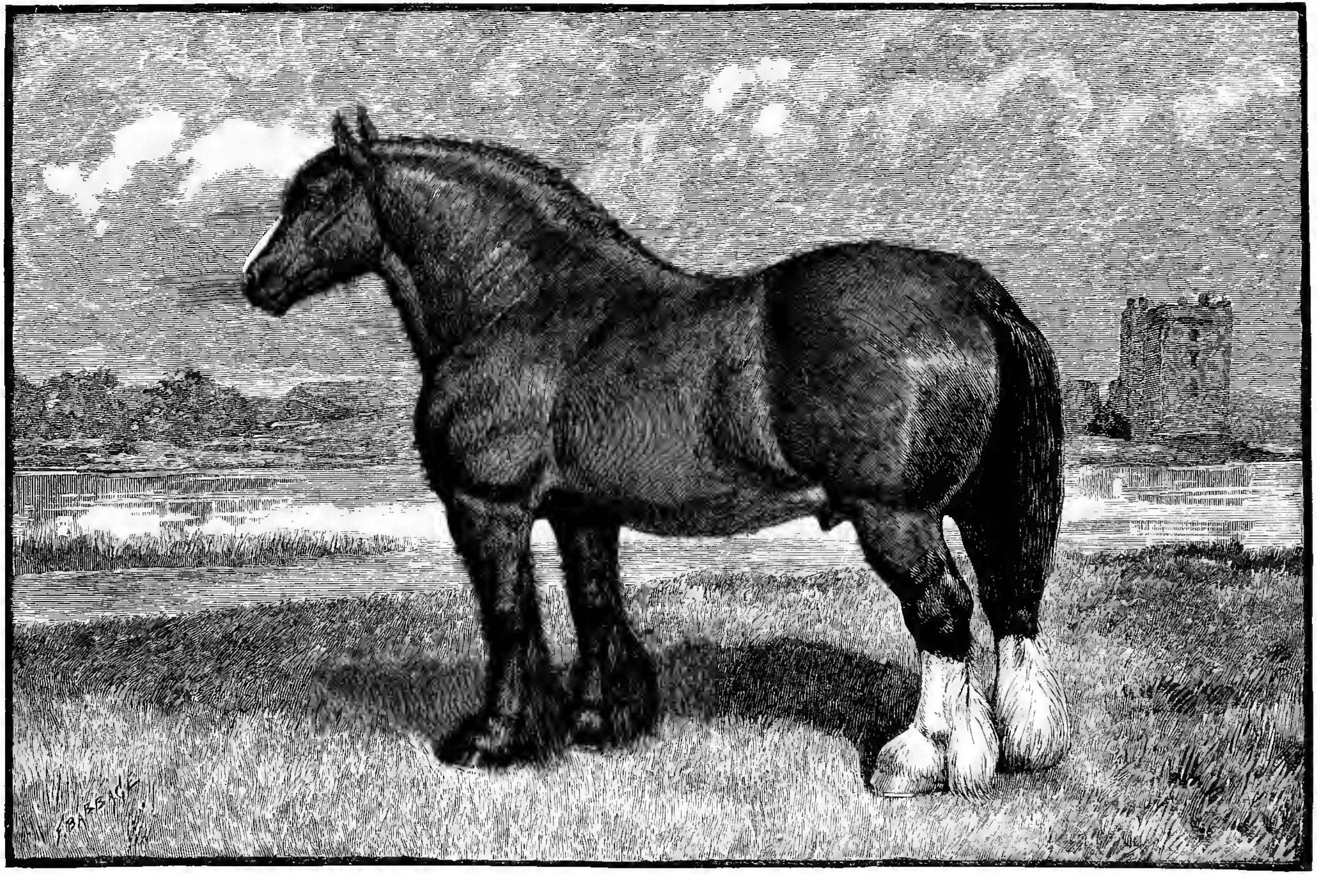

CLYDESDALE STALLION, "MACGREGOR," 1487.

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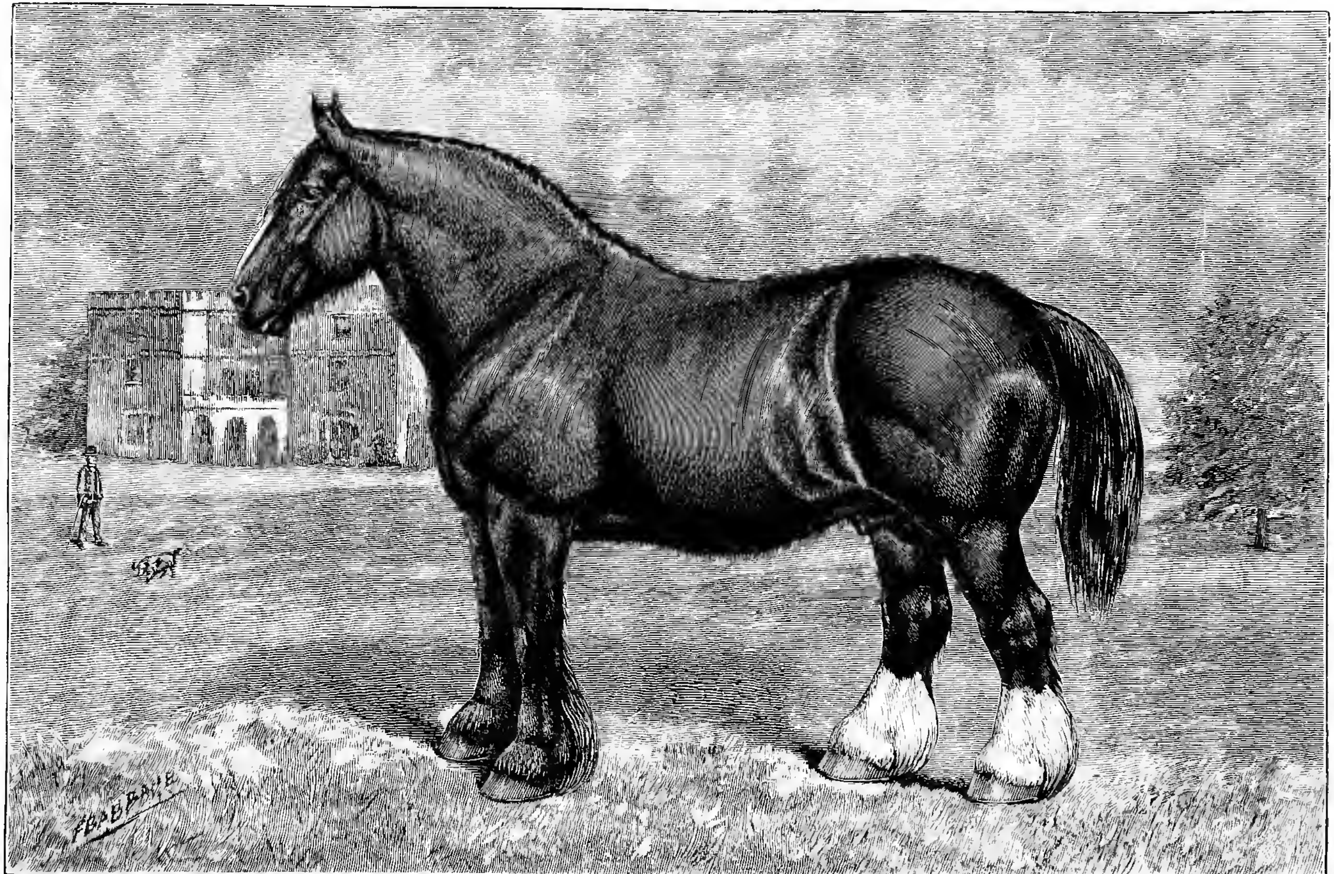
PLATE 4



SHIRE STALLION. "SPARK." 2497.

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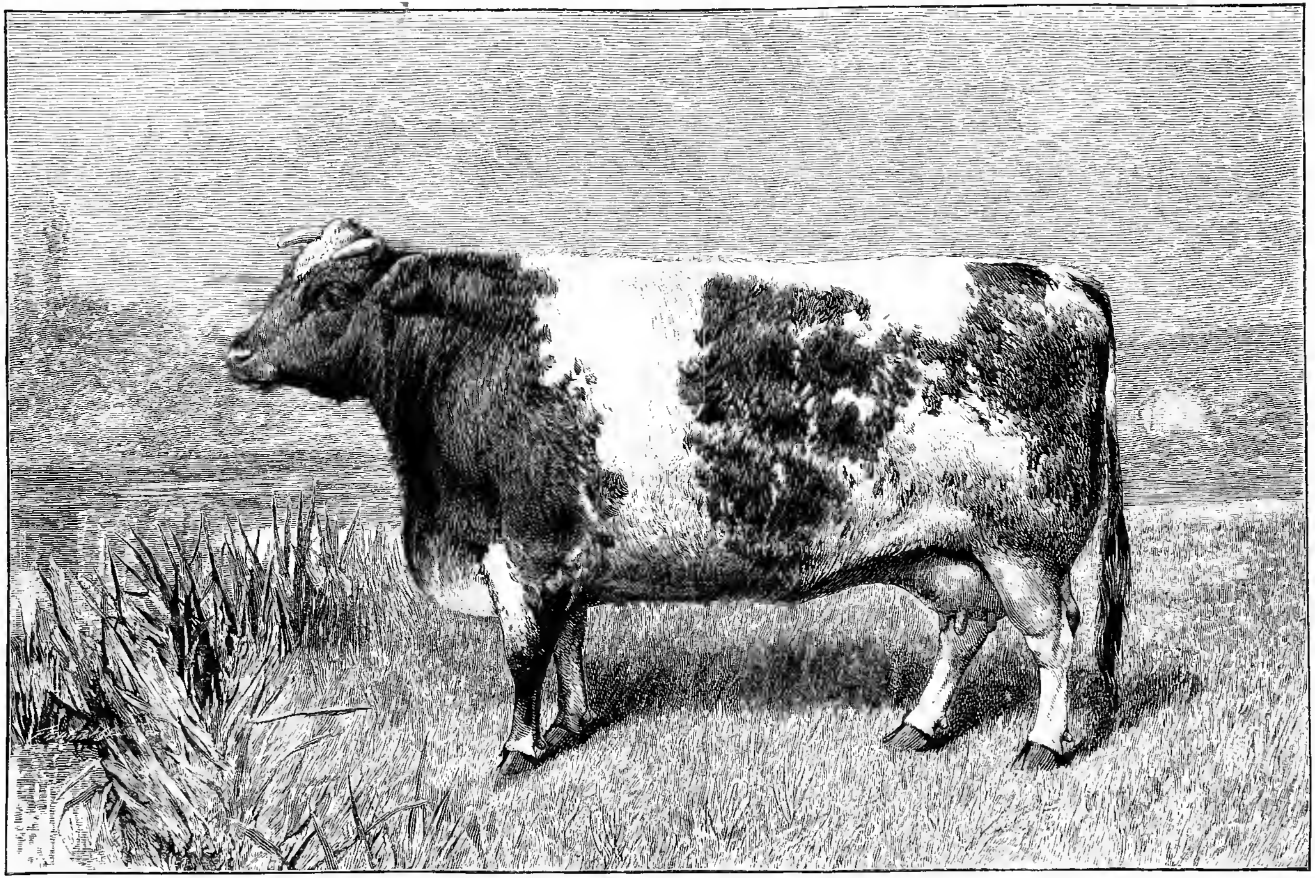

SHORT-HORN COW, "LADY PAMELA."

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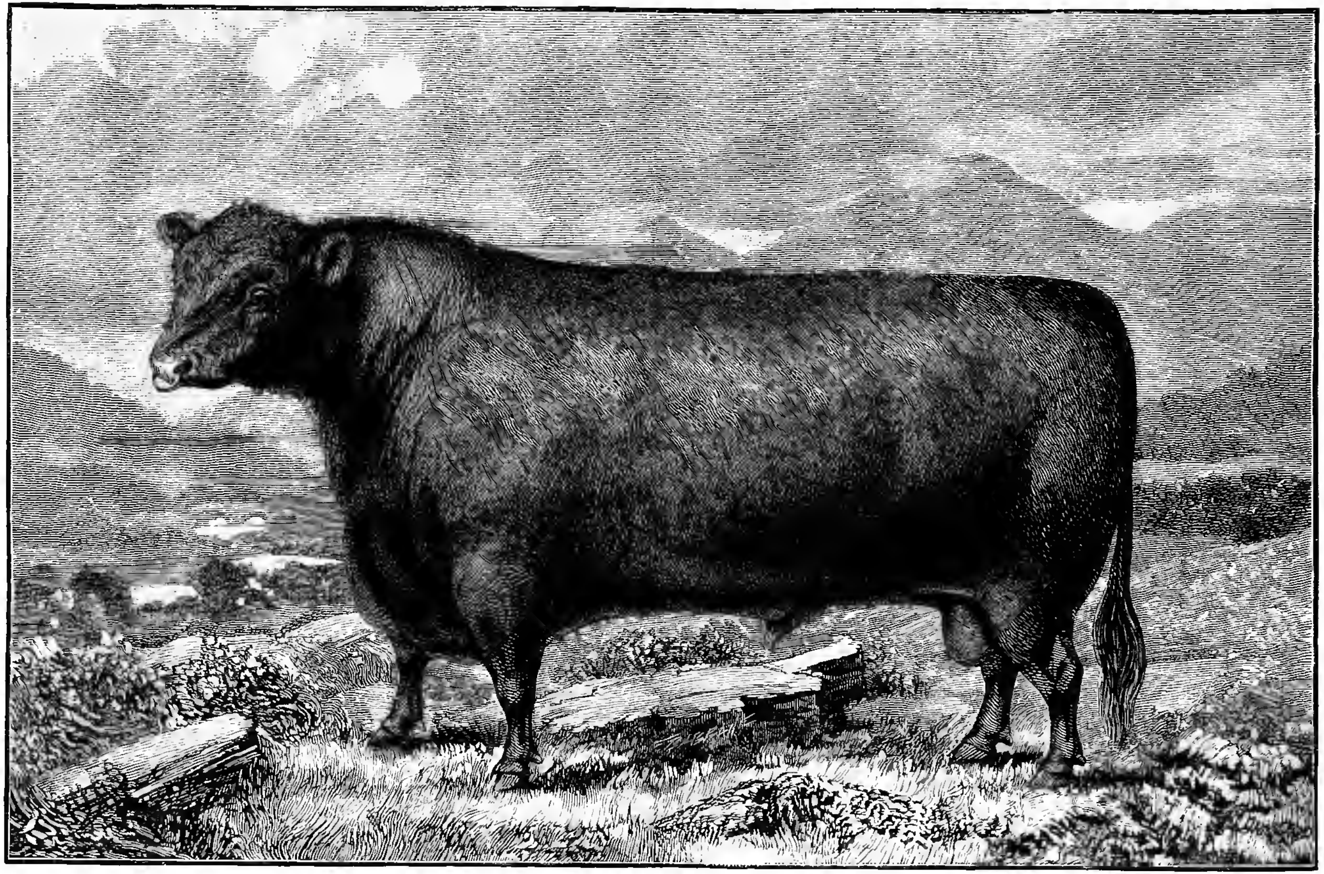

POLLED ABERDEEN-ANGUS BULL, "JUSTICE," 1462.

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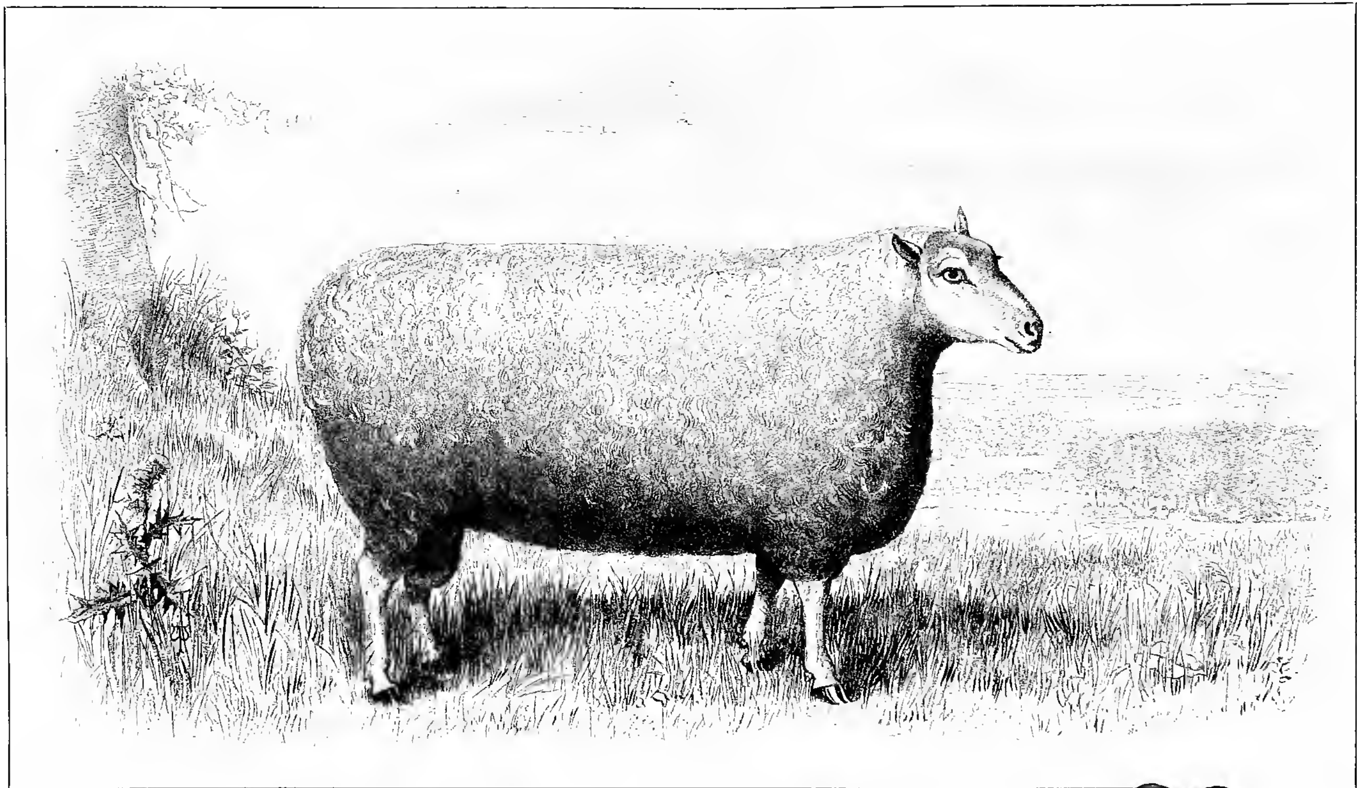

LEICESTER RAM.

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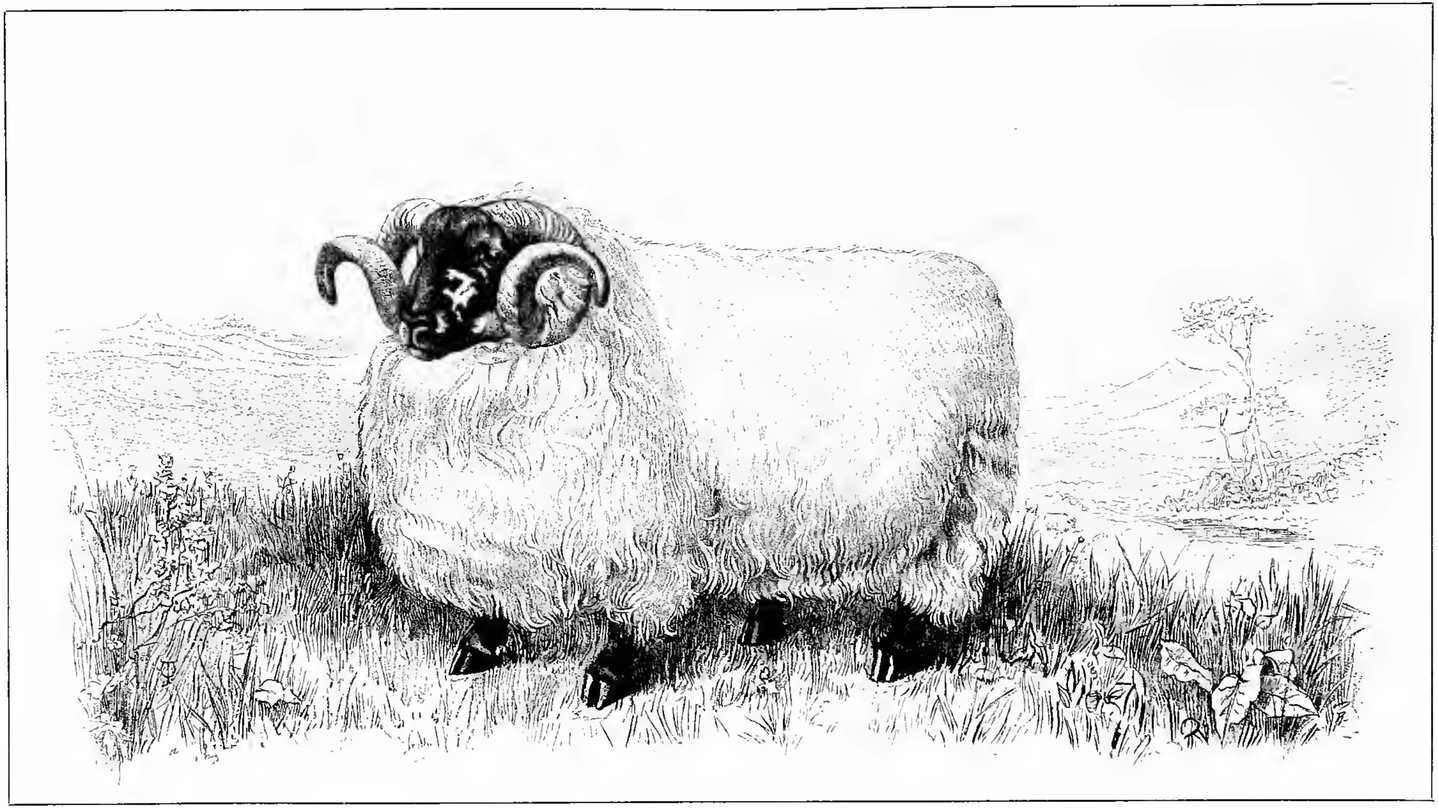

BLACKFACED RAM, "SEVENTY-TWO."

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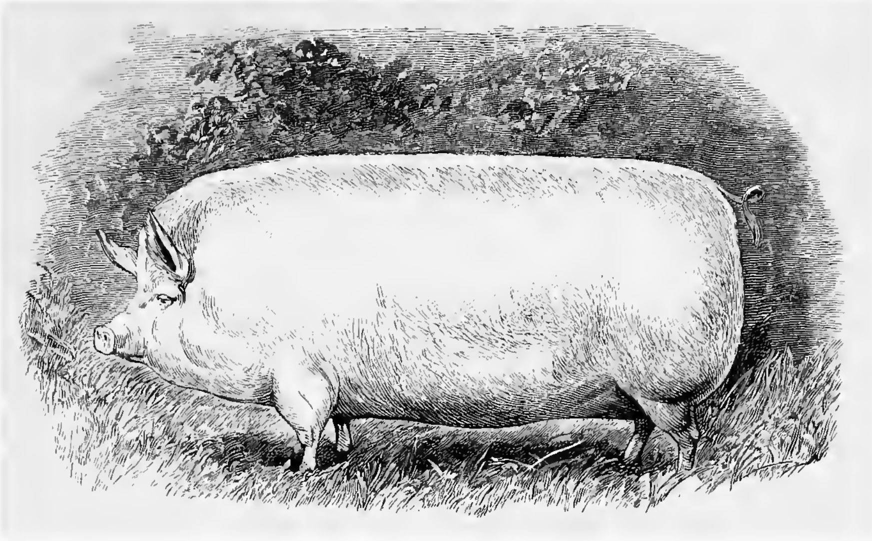
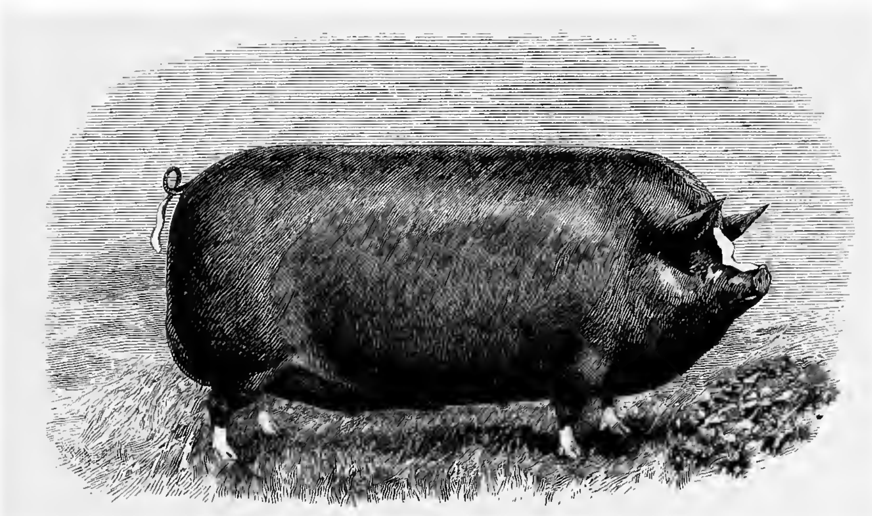
PLATE 36



LARGE WHITE PIG.

THE PROPERTY OF SANDERS SPENCER, ESQ., HOLYWELL MANOR, ST IVES, HUNTS.



BERKSHIRE BOAR.

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THE

BOOK OF THE FARM.

INITIATION.

METHODS OF ACQUIRING A KNOWLEDGE OF PRACTICAL FARMING.

It must not be taken for granted that any book, however constantly perused, will enable any man to become a practical farmer. It can only be a guide to direct him into the way where he can best acquire practice; be always at his side to indicate what he should look for, and to explain the meaning of what he is witnessing. These items of information he would be a long time of finding out for himself.

The only place a young man can acquire practice is upon a farm, and there he will find the 'Book of the Farm' an instructive companion. And this function which the 'Book of the Farm' essays to fulfil is a very important one, demanding a work of a varied and comprehensive character—one which would not be complete if it did not exhibit itself as a compendium of the writings and doings of those who, in their various spheres, have been prominent in the good work of advancing agricultural knowledge.

Tutor-Farmers.—A tutor-farmer should have the reputation of being a skilful cultivator of land, an able breeder, and an excellent judge of stock. He should possess the faculty of communicating his ideas with ease and distinctness. He should occupy a farm, consisting of a variety of soils, and situate in a fair climate.

Hints to Farm-Pupils.—A residence of one year must pass ere the pupil can witness a course of operations on a farm. As all operations are preparatory for certain results, the second year will be employed in studying the progress of works in preparation. In the third year, when his mind is stored with the modes of doing work, and the purposes for which they are performed, the pupil may request to put his knowledge into practice, under the correcting guidance of his tutor; or he may feel confident of being able to manage a farm for himself or for another.

The pupil should come to his tutor at the *opening of the agricultural year—in the beginning of winter*, when all the great operations are *begun;* and, to their being understood, he should *see them begin.*

The first thing the pupil should become well acquainted with is the *physical geography* of the farm—its position, exposure, extent; its fences, whether of wall or hedge; its shelter, in relation to rising-grounds or plantations; its roads, public or private, whether conveniently directed to the different fields or otherwise; its fields, their number, names, sizes, relative positions, and supply of water; the position of the farmhouse and farm-offices. Familiar acquaintance with these particulars will enable him to understand more readily the orders given by the farmer for the work to be performed in any field. A plan of the farm would much facilitate its familiar acquaintance. A *tutor*-farmer should be provided with such a plan; but if not, the pupil can construct a rough one for himself.

Fees for Farm-Pupils.—The fees for pupils vary from £50 to £120 per annum or more, for bed, board, and washing, with the use of a conveyance to occasional markets and shows. If the pupil desire a horse of his own, about £30 a-year more is demanded.

A Word to Guardians of Farm-Pupils.—It is considered impolitic to give a pupil a horse of his own at first. Constant attention to field-labour may be irksome, while exercise on horseback is tempting to young minds. The desire to possess a horse of one's own is so very natural in a young person living in the country, that, were the pupil's inclinations alone consulted, the horse would soon be in his possession; and if he be an indifferent pupil, he will certainly prefer pleasure to duty—such as following the hounds, forming acquaintances at a distance from home, and loitering about towns on market-days in indulgence and extravagance. This consideration should have its weight with parents and guardians, when they are importuned by the pupil for the luxury of a horse. The diligent pupil will daily discover new sources of enjoyment at home, far more satisfactory, both to body and mind, than in jogging along the dirty or dusty highways, until the jaded brute he bestrides is ready to sink under its unworthy burden.

The pupil should provide himself with an ample stock of strong clothing and shoes.

THE DIFFICULTIES IN LEARNING FARMING AND THE MEANS OF OVERCOMING THEM.

The pupil, if left to his own guidance when beginning to learn farming, would encounter many perplexities. The first difficulty that obtrudes itself is the *distribution* of the labour of the farm—the teams are employed one day in one field at one kind of work, and the next day in another field at another kind of work; the field-workers assist the teams one day, and in the next they work by themselves elsewhere.

Variety of Farm-Labour.—Another difficulty is in the *variety* of the labours performed. One day the horses in the plough move in a direction opposite, in regard to the ridges, to what they were in another field. On another day the horses are with a different implement from the plough. The field-workers have laid aside the implement with which they were working, and are performing their labour with the hand. All field-work being *preparatory* to some other work, is the circumstance which renders its object so perplexing to the learner. He cannot foresee what is aimed at. It is not easy for the tutor to make him appreciate the importance of foresight. The pupil only sees the value of an event after it has happened. But in reality, let experience in farming be ever so extensive—or the knowledge of minutiæ ever so intimate—unless the farmer guide his experience by *foresight*, he will never be enabled to conduct a farm aright. Both foresight and experience can only be acquired by observation, and though observation is open to all farmers, all do not profit by it. Every farmer may acquire, in time, sufficient *experience* to conduct a farm in a passable manner; but many farmers never acquire *foresight*, because they never reflect, and therefore never derive the greatest advantage from their experience. Conducting a farm by foresight is a higher acquirement than the most intimate knowledge of the minutiæ of labour. Nevertheless, a knowledge of the minutiæ of labour should be first acquired by the pupil; and by carefully tracing the connection between combined operations and their ultimate ends, he will acquire *foresight.*

Necessity of Foresight.—The necessity of possessing foresight in arranging the minutiæ of labour renders *farming* more difficult of acquirement, and a longer time of being acquired, than most other arts. This statement may seem incredible to those who are accustomed to hear of farming being easily and soon learned by the meanest capacity. In most other arts, no great time usually elapses between the commencement and completion of a piece of work, and every piece of work is continued in hand until finished. The apprentice can thus soon perceive the connection between the minutest portion of the work in which he is engaged and the object for which the work is prosecuted.

The pupil-farmer has no such advantage in his apprenticeship. Many minutiæ connected with very different operations in progress claim his attention at one and the same time; and if he neglects one for another, he will suffer a loss. It is a serious misfortune to a pupil to be retarded in his progress by an apparently trifling neglect of any field operation, for he cannot make up his leeway until after the revolution of a year; and though ever so attentive, he cannot possibly learn to anticipate operations in a shorter time than a year, and therefore cannot understand the object of a single operation in the first year of his pupilage. The first year is thus spent almost unprofitably, and certainly unsatisfactorily to an inquisitive mind. One year's residence will therefore not suffice.

Personal Attention by Farm-Pupils.—Formidable as these difficulties may seem, it is in his power to overcome them all. The most satisfactory way of overcoming them is to resolve to learn his business in a truly practical manner—by attending to *every* operation *personally.* Merely being domiciled on a farm is not, of itself, a sufficient means of acquiring farming; for the advantages of residence may be squandered away by idleness, by frequent absence from home, by spending the busy hours of work in the house, or by only casual attendance on field operations. Such habits must be avoided by the pupil if he desire to become a *practical* farmer.

Training Farm-Pupils.—*Much* assistance in acquiring knowledge should not be *expected* from the farmer. No doubt it is his *duty* to communicate all he knows to his pupils, and he is willing to do so; but as efficient tuition implies constant attendance on work, the farmer himself cannot be constantly present at every operation, or even explain any, unless his attention is directed to it; and much less will he deliver extempore lectures at appointed times. Reservedness in him does not necessarily imply *unwillingness* to communicate his skill; because, being himself familiar with every operation that arrests the attention of his pupil, an explanation of minutiæ at any other time than when the work is in hand, and when only it can be *understood,* would only serve to render the subject more perplexing to the pupil. Should the farmer be absent, the steward, or ploughmen, or shepherd, as the nature of the work may be, will afford information until he associates with the farmer at the fireside.

Farm-Pupils must work.—To be enabled to discover that particular point in every operation which, when explained, renders the whole intelligible, the pupil should put his hand to every kind of work, be it easy or difficult, irksome or pleasant. Experience acquired by himself will solve difficulties much more *satisfactorily* than the most elaborate explanations given by others; and the larger the stock of personal experience he thus accumulates, the sooner will he understand the purport of everything that occurs in his sight. Daily opportunities occur for joining in work: for example, when the ploughs are employed, or when at the farmstead, where the thrashing-machine and winnowing-machine are at work, attendance will be amply repaid by the acquisition of a knowledge of the plough and of the quality of grains. There is no better method of acquiring knowledge of *all* the minor operations of the farm than to superintend the labours of the field-workers, their work being methodical, almost always in requisition, and consisting of minutiæ; and its general utility is shown, not only in its own intrinsic worth, but in relation to the work performed by the teams.

Study Stock-Feeding.—The feeding of cattle in the farmstead, or of sheep in the fields, does not admit of much participation of labour with the cattle-man or shepherd; but either practice forms an interesting subject of study to the pupil, and without strict attention to both he will never acquire a knowledge of feeding, and of computing the value of live stock.

Learn young.—Other considerations in regard to the acquisition of practical knowledge deserve attention from the pupil. It is most conducive to his interest to learn his profession in youth, before the meridian of life has arrived, when labour of every kind becomes irksome.

Advantages of a thorough Training to Farmers.—It is also much better to have a *thorough* knowledge of farming *before* engaging in it, than to acquire it in the course of a lease, when losses may be incurred by the commission of comparatively trivial errors at the early period of its tenure, when farms in all cases are most difficult to conduct. It is an undeniable fact that the work of a farm never proceeds *so* smoothly and satisfactorily to all parties engaged in it, as when the farmer is thoroughly conversant with his business. His orders are then implicitly obeyed, because a skilful master's directions inspire undisputed confidence in the labourers.

Loss from want of Training.—Let the converse of this state of things be imagined—let the losses to which the ignorant farmer is a daily prey be calculated—and it will soon be evident that it is much safer for a farmer to trust to his own skill than to depend on that of his servants. A trustworthy steward may be found to manage for him; but, in such a position, a steward is placed in a state of temptation; and as servants never regard him as a master, where the master himself is resident, his orders have not the same authority.

A faithful Guide.—Surrounded thus by difficulties, the 'Book of the Farm' should prove a faithful guide to the pupil. On acquiring the contents of the work from the Index, he has only to consult it as his daily monitor, and receive the desired information on the extent and kind of work being executed at the season of the year, and which will be sufficient information for the time being. The book being divided into the Four Seasons, every operation under each of these may easily be found.

Search for Information.—By thus searching for information, the pupil will acquire as much in the course of the first year as he would in the second by his own observation alone, and thereby saving a year of probationary trial, he will learn in two years what would require three.

THE DIFFERENT KINDS OF FARMING, AND SELECTING THE BEST.

Perhaps the pupil will be surprised to hear of the many kinds of farming there are possessing distinctive characteristics. There are at least six outstanding kinds practised in this country. Soil, situation, and locality determine the respective kinds.

Pastoral Farming.—The simplest kind, the *pastoral*, is determined by situation. It is found in the Highlands and Islands of Scotland; in the Cheviot and Cumberland hills of England; and in Ireland and Wales. In all these districts, farming is principally directed to the breeding of cattle and sheep; and as natural pasture and hay form the principal food of live stock there, very little arable culture is practised. Cattle and sheep are not always reared on the same farm. Cattle are reared in large numbers in the *pastoral valleys* among the mountain-ranges of England, Wales, and Scotland. Sheep are reared in still greater numbers in the *upper parts* of the mountain-ranges of Wales and Scotland, and on the green round-backed hills of the north of England.

One kind of sheep, or one kind of cattle, is usually reared on pastoral farms, though both classes of stock may be found where valleys and mountains are on the same farm. The arable culture practised on them is confined to the raising of provisions for the families who live upon them, and of turnips for stock during severe weather in winter; the principal winter food being hay, obtained from natural grass on spots of good land on the banks of a rivulet. Pastoral farms are all large, some containing many thousands of acres—nay, miles in extent; but from 1500 to 3000 acres is perhaps an ordinary size.

Stocking a Pastoral Farm.—The *stocking* of a pastoral farm consists of a breeding or flying stock of sheep, or a breeding stock of cattle. A proportion of barren stock is sold and fattened in the low country. A large capital is required to stock at first, and afterwards to maintain such a farm; for although the quality of the land may support a few heads of stock per acre, yet, as the farms are large, the number required to stock them is very considerable. The rent, when consisting of a fixed sum of money, would be of small amount per acre, but often its amount is fixed by the number of stock the land will maintain, and it is calculated at so much money per head.

Pastoral Farmers.—A *pastoral farmer* should be well acquainted with the rearing and management of cattle or sheep, whichever his farm is best suited for. A knowledge of field culture is of little use to him, though he should know how to raise a large crop of turnips and make good hay.

Carse-Land Farming.—Another kind of farming is practised on *carse* land, which consists of deep horizontal depositions of alluvial or diluvial *clay*, on one or both sides of a considerable river, and comprehending a large tract of low country. In all respects, a carse is quite the opposite to a pastoral farm. Soil entirely decides carse farming.

Stocking a Carse Farm.—Being entirely arable, a *carse farm* is stocked with many animals and implements of labour; and these, with seed-corn, require a considerable outlay of capital. Carse land always maintains a high rent, whether solely of money or of money and corn valued by the market price of corn. A carse farm, requiring a large capital and much labour, is never of great extent, seldom exceeding 200 acres.

Carse Farmers.—A *carse farmer* should be well acquainted with the cultivation of grain, and all the stock he requires are a few cows, to supply milk to his own household and farm-servants, and a number of cattle in the straw-yard, purchased for the winter, to trample down the large quantity of straw into manure, with the assistance of a few turnips.

Suburban Farming.—A third sort of farming is *in the neighbourhood of large towns.* In the immediate vicinity of London and other large cities, farms are appropriated to the growth of garden vegetables for Covent Garden market, and, of course, such culture can have nothing in common with either pastoral or carse farms. In the neighbourhood of most towns, garden vegetables, with the exception of potatoes, are not so much cultivated as green crops, such as turnips, potatoes, and grass; and dry fodder, such as straw and hay, for the use of cowfeeders and stable-keepers. In this kind of farming all the produce is disposed of, and manure purchased in return, constituting a sort of retail trade. The sale of fresh milk is frequently conjoined with the raising of green crops, in the neighbourhood of large towns. When the town is not large enough to consume all the disposable produce in its neighbourhood, the farmer purchases cattle and sheep to eat the turnips and trample the straw into manure, in winter. Pasture grass is kept in paddocks for the accommodation of stock in the weekly market. Locality entirely decides this kind of farming.

The chief qualification of an *occupant of this kind of farm*, is a thorough acquaintance with the raising of prolific green crops, of potatoes, clover, and turnips.

Capital for a Suburban Farm.—The *capital required for a farm of this kind*, which is all arable, is as large as that for a carse one. Being close to a town, the rent is always high, and the extent of land not large.

Dairy-Farming.—A fourth kind of farming is the *dairy*. In it, butter and cheese are made, and fresh milk is sold from it. A dairy-farm is much the better of having a considerable extent of *old pasture*. Stock are *reared* on dairy-farms only to a small extent of quey (heifer) calves, yearly to replenish the cow stock; the bull calves being fed for veal, or sold to be reared by others. In many cases, indeed, no cattle are reared. Pigs are reared and fattened on dairy refuse. Sometimes young horses are also reared. Horse-labour being comparatively small, mares rear their young and work at the same time; while old pasture, spare milk, and whey, afford great facilities for nourishing young horses to a large size in bone. Locality establishes this kind of farming.

Stocking a Dairy-Farm.—The purchase of *cows* is the principal expense of *stocking* a *dairy-farm*, and requires a considerable capital. Such a farm seldom exceeds 150 acres.

What a Dairy-Farmer should know.—A *dairy-farmer* should be well acquainted with the properties and management of milk-cows, the making of butter and cheese, the feeding of veal and pork, and the rearing of horses; and he should also possess as much knowledge of arable culture as to raise large green crops and make good hay.

"Common" Farming.—A fifth mode of farming is that practised in most arable districts, consisting of every kind of soil not strictly carse land, and may be named *common farming*. This method consists of a regular system of cultivating grains and sown grasses, with very partial rearing or wholly purchasing of cattle. No sheep are reared in this system, being purchased in autumn, to be fed on turnips in winter, and sold fat in spring; and hence sheep on it are called a *flying stock*. This system may be said to *combine the professions of the farmer, the cattle-dealer, the sheep-dealer, and the pig-dealer*. Besides the plenishing of the farm, which may be of considerable extent, this system requires a large floating capital, for the purchase of cattle or sheep, or of both.

Mixed Farming.—A decided improvement on this system long ago originated, and is now practised extensively throughout the United Kingdom. The farmer of this improved system combines all the qualifications of the various kinds of farming enumerated. Rearing cattle and sheep, and having wool to dispose of, he is a stock-farmer. Cultivating grains and the sown grasses, he possesses the knowledge of the carse farmer. Converting milk into butter and cheese after the calves are weaned, he passes the autumnal months as a dairy-farmer. Feeding cattle and sheep in winter on turnips, he attends the markets of fat stock as well as the common farmer; and in many cases he breeds and rears the greater portion of his live stock. Thus raising and retaining all his produce until they arrive at maturity, he derives whatever profit they are capable of yielding.

This system of *mixed husbandry* ensures a mutual dependence and harmony of parts between crops and stock. Such a variety of products demands more than ordinary attention and skill; and accordingly, it has made its farmers the most skilful and intelligent in the kingdom.

This system cannot very advantageously be conducted within narrow bounds, and therefore *mixed farms* are generally large in extent—from 150 to 500 acres or more. The capital required to furnish live stock and the means of arable culture is considerable. The rents are large in amount, although not per acre. Mixed husbandry is determined by no peculiarity of soil and locality, but has a happy constitution in adapting itself to most circumstances in an arable district.

Selecting a System.—One of the above systems the pupil must adopt for his profession. If he succeed to a family inheritance, his farming will most probably depend on that pursued by his predecessor, which he will learn accordingly; but when free to choose for themselves, most pupils adopt the mixed husbandry, as it contains within itself all the requisites for a farmer to know, and is the safest farming under most circumstances.

Mixed husbandry is in ordinary circumstances the safest, because, should his stock be much lowered in value, the farmer has the grain to depend upon; and should the grain give a small return, the stock may yield a profit.

THE PERSONS WHO CONDUCT AND EXECUTE THE LABOUR OF THE FARM.

The persons who give their labour to a farm constitute the most important part of the staff. They are the farmer, the steward or grieve, the ploughman, the hedger or labourer, the shepherd, the cattle-man, the field-worker, and the dairymaid.

The Farmer.—And first, the *farmer*. It is his province to determine the period for commencing and pursuing every operation,—to give orders to the steward, when there is one, and when none, to the ploughmen, for the performance of every field operation,—to have a superintending eye over the field-workers, to see the cattle cared for,—to watch the state of the crops,—to guide the shepherd,—to direct the hedger or labourer,—to sell the surplus produce,—to purchase the materials for the progressive improvement of the farm,—to disburse expenses,—to pay the rent to the landlord,—and to fulfil the obligations incumbent on him as a residenter of the parish. He is his own master,—makes bargains to suit his own interests,—stands on an equal footing with the landlord on the lease or agreement,—has entire control over the servants. Such a man occupies both an independent and responsible position.

Farm Steward.—The *steward*, or *grieve*, as he is called in some parts of Scotland, and *bailiff* in England, receives instructions from the farmer, and sees them executed by the people under his charge. He exercises a direct control over the ploughmen and field-workers, but in most cases he has no control over the shepherd or hedger. The farmer reveals to the steward alone his plans of management; intrusts him with the keys of the corn-barn, granaries, and provision stores; delegates power to act in his absence, and has confidence in his integrity and skill. In return for such confidence, the steward studies the interest of his master as if it were his own. A faithful steward is a very valuable servant.

On most large farms, the steward has no staid labour with his own hands. He should, however, never be idle. He should deliver the daily allowance of corn to the horses, keep accounts of the workpeople's time, and of the quantity of grain thrashed, consumed on the farm, and delivered to purchasers. He overlooks the reapers at harvest, and directs the filling of the stackyard. On small farms he works a pair of horses like a common ploughman; and when he has no horses, he sows the corn, superintends the workers, builds the stacks, and prepares the corn. It is objectionable to employ a steward to work horses, as these nicer operations must then be intrusted to an inferior person.

Duties of Ploughmen.—The duties of *ploughmen* are to take charge of a pair of horses, and work them at every kind of labour for which horses are employed on a farm. Horse-labour on a farm is various. It is connected with the plough, the cart, the sowing-machines, the roller, and the thrashing-mill, when horse-power is employed. In the fulfilment of his duties, the ploughman has a long day's work to perform; for, besides expending the appointed hours in the fields with the horses, he must groom them before he goes to the field in the morning, and after he returns from it in the evening, as well as attend to them at mid-day—that is, except, as in parts of England, where the care of the horses when not at work is intrusted to a servant specially employed for the purpose. When, from any cause, his horses are not working, the ploughman must himself work at any farm-work he is desired. There is seldom any exaction of labour from the ploughman beyond the usual daily hours of work, these occupying at least 10 hours a-day for 7 months of the year, which is sufficient work for any man's strength to endure. But occasions do arise which justify a greater sacrifice of his time, such as seed-time, hay-time, and harvest. For such demands upon his time at one season, many opportunities occur of repaying him with indulgence at another, such as a cessation from labour in bad weather. Ploughmen are seldom placed in situations of trust; and having no responsibility beyond the care of their horses, there is no class of servants more independent. There should be no partiality shown by the master or steward to one ploughman over another. When one displays more skill than the rest, he is sufficiently honoured by being intrusted to execute the most difficult kinds of work, such as drilling; and such a preference gives no umbrage to the others, because they are as conscious of his superiority in work as the farmer himself. The services of ploughmen are required on all sorts of arable farms, from the carse farm to the pastoral, on which the greatest and the least extent of arable land is cultivated.

Hedgers.—The *hedger*, the *spade-hind*, the *spadesman*, as he is differently called, is a useful servant on a farm. He is strictly a labourer, but of a high grade. His principal duty is to take charge of the hedge-fences and ditches of the farm, and cut and clean them as they require in the course of the season. He also renews old fences and makes new ones. He cuts channels across ridges with the spade, for the surface-water to find its way to the ditches. He is the drainer of the farm. He is dexterous in the use of the spade, the shovel, and the pick, and he handles the small cutting-axe and switching-knife with a force and neatness which a swordsman might envy. As the principal business of a hedger is performed in winter, he has leisure in the other seasons to assist at any work. He can sow corn and grass-seeds in spring; shear sheep and mow the hay in summer; and build and thatch stacks in autumn. He can also superintend the field-workers in summer, and specially in the weeding of the hedges. The hedger is a very proper person to superintend the making of drains, which, when done on a large scale, is often executed by hired labourers on piece-work. The hedger is thus an accomplished farm-servant.

Hedgers are not required on all sorts of farms. They would be of little use on pastoral farms, where fences are few, and most of them at an elevation beyond the growth of thorns; nor on farms whose fences are stone walls; nor on carse farms, which are seldom fenced at all. On carse farms they might be usefully employed as ditchers and makers of channels for surface-water. In the combination of arable with stock culture, the services of the hedger are indispensable. Still, the farm that would give him full employment must necessarily be of large extent. A *small* farm cannot maintain him.

Shepherds.—The services of *shepherd*, properly so called, are only required where a flock of sheep is constantly kept. On carse farms, and those in the neighbourhood of large towns, he is of no use; and on those farms where sheep are bought in to be fed off turnips in winter, he is of course required only at that season of the year. On pastoral farms, on the other hand, as also those of the mixed husbandry, his services are so indispensable that they could not be conducted without him. His duty is to undertake the entire management of sheep; and when he bestows the requisite pains on the flock, he has little leisure for any other work. His time is occupied from early dawn, when he should see the flock before they rise from their lair, during the whole day, to the evening, when they again lie down for the night. To inspect a large flock three times a-day over extensive bounds, implies the exercise of walking to fatigue. Together with this daily exercise, he has to attend to the feeding of the young sheep on turnips in winter, the lambing of the ewes in spring, the washing and shearing of the fleece in summer, and the bathing or smearing of the flock in autumn. And besides these major operations, he has the minor ones of weaning lambs, attending the milking of ewes, drafting aged sheep; not to omit keeping the flock clean from scour and scab, and repelling the attacks of insects. The shepherd takes charge of the pastures, to see that they adequately maintain the stock upon them.

As no one but a shepherd, thoroughly trained, can attend to sheep in a proper manner, there must be one where a breeding flock is kept, whatever be the extent of the farm. On *large* pastoral or mixed husbandry farms more than one shepherd may be required. The establishment then consists of a *head* shepherd, and one or more young men training to be shepherds, who are placed under his control. The office of head shepherd is one of great trust. Sheep being individually valuable, and in most instances reared in large flocks, a misfortune happening to a number, from whatever cause, must incur great loss to the farmer. On the other hand, a careful and skilful shepherd maintains his flock in good health and full number throughout the year. The shepherd acts the part of butcher in slaughtering the animals used on the farm; and he also performs the part of the drover when any portion of the flock is taken to a market for sale. The only assistance he depends upon in personally managing his flock is from his faithful collie dog, whose sagacity in many respects is little inferior to his own.

The Cattle-man.—The services of *cattle-man* are most wanted at the steading in winter, when the cattle are housed in it. He has the sole charge of them. It is his duty to clean out the cattle-houses, and supply the cattle with food, fodder, and litter, at appointed hours every day, and to make the food ready, when prepared food is given them. In summer and autumn, when the cows are at grass, it is his duty to bring them into the byre or to the gate of the field, as the custom may be, to be milked at appointed times; and it is also his duty to ascertain that the cattle in the fields are plentifully supplied with water. The cattle-man also sees the cows served by the bull in due time, and keeps an account of the reckonings of the time of the cows' calving. As his time is thus only occasionally employed in summer, he is a suitable person then to undertake the superintendence of the field-workers. In harvest, he is usefully employed in assisting to make and carry the food to the reapers, and to lend a hand at the taking in of the corn. An elderly person makes a good cattle-man, the labour being neither constant nor heavy, though regularly timed and methodical. He ought to exercise much patience and forbearance towards even the most capricious of the cattle under his charge.

Field-Workers.—These are indispensable servants on every arable farm. They consist chiefly of young women in Scotland, and of men and boys in England; but the manual operations of the field, such as cutting and planting sets of potatoes, gathering weeds, picking stones, collecting the potato crop, and filling carts with turnips, are better performed by women than men. The operations with the smaller implements are, pulling turnips and preparing them for storing, performing barn-work, carrying seed-corn, spreading manure upon the land, hoeing potatoes, singling turnips, and weeding. They work in a band, and work most steadily under superintendence. The steward, the hedger, or cattle-man superintends them when the band is large; but when small, one of themselves, capable of taking the lead in work, may superintend them, having a watch to mark the time of work and rest. Field-workers at times work along with the horses. Some farmers set aside the horses, in order to employ the ploughmen rather than field-workers. This may avoid a small outlay of money, but it is not true economy.

Dairymaids.—The duties of *dairymaid* in Scotland are to milk the cows, to manage the milk in all its stages, bring up the calves, and make into butter and cheese the milk obtained from the cows after the weaning of the calves. Others assist her in milking the cows and feeding the calves, when there is a large number of both. In England, the dairymaid's duties are usually confined to those operations which are conducted within the dairy, especially where the making of butter and cheese is pursued extensively. Should any lambs lose their mothers, the dairymaid brings them up with cow's milk until the time of weaning, when they are restored to the flock. Should any of the ewes be scant of milk at the lambing season, the shepherd has his bottles replenished by the dairymaid with new cow's milk. In many cases she attends to the poultry, feeds them, sets the brooders, gathers the eggs daily, takes charge of the broods until able to provide for themselves, and sees them safely lodged in their respective apartments every evening, and puts them abroad every morning. In some cases, too, it is the dairymaid who gives out the food for the reapers, and takes charge of their articles of bedding. On large dairy farms, however, the dairymaid has enough occupation in attending to the particular duties of the dairy, without extraneous work.

These are the respective classes of servants found on farms. They are not all required on the same farm. A pastoral farm has no need of a steward, but a shepherd; a carse farm no need of a shepherd, but a steward; a farm in the neighbourhood of a town no need of a hedger, but a cattle-man; and a dairy farm no need of a shepherd, but a dairy-maid; but on a large farm of mixed husbandry there may be need for them all.

SCIENCES APPLICABLE TO AGRICULTURE.

Agriculture has often been defined as an art founded on scientific principles, a definition which is perfectly correct so far as it goes. There is no such thing as *a* science of agriculture in the sense that we speak of the science of geology, botany, or chemistry. But all farming operations are capable of being explained on scientific principles, and no one can thoroughly understand farm work, or know all its bearings, or the capabilities of its development, who is not acquainted with certain teachings of modern scientific research.

It is, of course, not to be supposed that a merely scientific man will certainly make a good farmer. There have been now and then notable failures of theoretical men, though this is not the fault of science, but of those who professed a knowledge of it.

Science with Practice.—What is really required is a knowledge of *both* the practice and theory of the ancient art of agriculture, to enable a man to cope with the many difficult questions and circumstances which are incident to landholding in the present day, even during prosperous times, and which are aggravated during seasons of depression in trade and industry.

Practical men have hitherto looked askance at what they have designated "book-farming," and no doubt, in many cases, with good reason. But the opinion is now gradually gaining ground that the man who, in addition to the practical knowledge common to most tenant-farmers, has a knowledge of the scientific principles of his operations, is in a better position to achieve success than the man who, without knowing the reason why, merely does things because it is the custom of his district, or because his father did it before him. Practical work alone is pretty much of an empirical matter—that is, it is without rule, or system, or reason. Experience has shown the farmers of a particular locality, in the course of years, what style of work is the best to pursue, and thus they "get along somehow," without knowing the why and wherefore of a single operation.

But immediately they shift to a new locality, or a state of markets and trade arises which necessitates a change of practice, they are quite at a loss how to proceed, and often commit ruinous blunders. Experience has taught them what to do under a given set of circumstances, but immediately those circumstances are changed they are thrown "out of harmony with their environment," and it is a chance whether they fail or succeed.

In many cases a knowledge of the anatomy and physiology of the plants and animals they cultivate, of the composition of foods and manures, of the geological structure of the country and its surface formations (soil), and of the laws of the health and disease of living beings, would have enabled them to steer clear of dangers, and use their practical knowledge to much better effect. Even those who are successful practical men would be still more successful if on to their practice there were grafted a knowledge of science.

Science growing in favour.—But in recent years there has been a great awakening throughout the agricultural world in these matters, and it would be perhaps rare to find now any intelligent farmer, whose opinion is worth anything, who is an opponent of scientific teaching for farmers, though he may not be much acquainted with it himself. This could certainly not have been said at one time, and not so very long ago, and it is a pleasing fact that there has been this change of feeling with regard to the matter. It is certainly a hopeful sign for the future.

Sciences applied to Agriculture.—It is not intended in this work to give a complete treatise on the various sciences which have a bearing on agriculture. Its object is rather to explain and describe minutely the practical details of the working of a farm, leaving the scientific aspects to be treated of in books devoted to their own special departments. At the outset, however, it is desirable to give an outline of the principal subjects with which it is essential nowadays that a farmer should acquaint himself, and to point out their bearing on farm management, and also to give some guidance to the farm-pupil as to acquiring a knowledge of these at the least expense of time and money.

Prominence given to Chemistry.—To those who have only a superficial knowledge of the matter, the one subject which will most readily occur to their minds as the representative of scientific farming is Chemistry. This is not the least to be wondered at when we recollect that this is not only the first subject to be studied as an introduction to all the others, but that it was also the first to be applied to the unravelling of the mysteries of nature met with on a farm every day; and also from the fact that many of the best-known names, both of the present and a preceding generation, in the scientific world, have been associated with this subject, or with its special department, Agricultural Chemistry.

It has been reserved for our day, however, to demonstrate that if chemistry has not been overrated, it is certainly only one of half-a-dozen branches of science which are of almost equal importance to a farmer in helping him to fill his pockets, or—what is perhaps as great a matter—in preventing them from being emptied.

Scientific Education widening.—This fact is gradually being recognised, and we may hope soon to see as much attention paid to the study and development of other departments of research as there has been in the past to chemistry.

Our various agricultural societies have from time to time given practical shape to this growing feeling by the appointment of experts in other subjects besides chemistry, and it is gratifying to find that those so appointed do not lack employment. The Royal Agricultural Society of England, besides their well-known chemist, Dr John Voelcker, have their consulting botanist, engineer, and veterinary surgeons, in addition to Miss Eleanor Ormerod as entomologist. The Highland and Agricultural Society has its chemist, botanist, engineer, and veterinary professors. The British Dairy Farmers' Association has both a chemist and a botanist.

It is worthy of note, however, that whenever any farmers' society becomes important enough to employ a scientific man, it is always chemistry which is first patronised. This is no doubt right and proper, because one of the matters in which farmers need most help and advice is in the purchase and use of artificial manures and feeding-stuffs; and it is the business of a chemist to know all about these. Another reason is, that although a man might have the knowledge necessary to enable him to analyse these materials, yet he cannot do so without the necessary apparatus and conveniences, so that it is usually better for him to employ a professional man to do it for him. On the other hand, a farmer can carry all the information in his head necessary to be able to identify a plant, or a disease among his cattle, so that he has less often to call in the aid of an "expert" for these purposes.

Nevertheless, as time goes on there will be more and more need for the others, and we may even expect to see the appointment of men skilled in additional departments of knowledge, and their advice freely asked for.

The sciences which have a bearing on agricultural matters are almost innumerable—in fact, there are none of those which are known as the "natural sciences" which are not more or less necessary for the full explanation of everything about a farm, so far as our present knowledge enables us to go; while a large number of those which are designated mathematical, physical, and experimental, are all more or less valuable.

A feature of modern scientific research is specialism. One investigator takes up only one branch of his subject, and devotes himself to the study and development of it, so that many which at one time were studied as a whole have now become split up into a large number of minor sciences, each of which has its votaries.

Sciences to be studied by Farmers.—We may say, however, that there are six or eight principal subjects, some knowledge of which is essential to every farmer who aims at being well posted up in matters relating to his business; and we may further state that these are the ones prescribed for the various diplomas and degrees granted by those bodies which are empowered to examine candidates for honours in agricultural science, of which more will be said further on. Those sciences are Chemistry, Biology, Geology, Engineering, Natural Philosophy, and Veterinary Hygiene. It must not be supposed that these exhaust the list of subjects which are useful and necessary to a farmer, but they are the principal ones, and all others might almost be included under these headings.

An effort will now be made to show the farm-pupil in what manner a knowledge of each one will be useful to him, and how they explain the *minutiæ* of intelligent practical work.

CHEMISTRY.

This subject has often been called the "handmaiden of the sciences." It has been described thus from the fact that whatever other science is taken up, it is almost always necessary to refer back to the composition of all material substances when we come to study them. This is true of all except those mental or mathematical branches of knowledge which are more or less mere conceptions of the mind. Chemistry, therefore, ought to be studied first by all those who wish to become acquainted with science, whether for farming or any other purpose. So much so is this held to be the case, that many public schools teach it as a part of their ordinary curriculum, in common with classics or mathematics, while it is very often prescribed as a subject in the entrance examination in "general education" in many of our colleges and universities.

Chemistry investigates and compares the properties of all the various kinds of matter, and endeavours to account for the difference in these properties. Very early in the history of man's inquiry into the phenomena of the material world around him it became necessary to know what things were made of; and as one man here discovered a little, and another one there evolved some new fact, gradually a system of analysis was built up. It was found that the vast majority of things which we meet with on the surface of the globe are *compounds*—that is, made up by the union or chemical combination of two or more separate bodies. As investigation and experiment went on, it was found that compound bodies were always capable of being split up into two or more certain well-defined constituents, which resisted any further attempts to reduce them. These constituents are called the "elements," and every form of matter of which the human senses can take cognisance is made up of one or more of these, united or combined in different proportions. The number of elementary bodies known to chemists has varied from time to time. As chemical research has gone on new ones have been brought to light, while some that were considered elementary have been reduced to component parts. At present sixty-four are recognised, but it is quite within the bounds of probability that some of these may turn out to be compounds some day, when subjected to improving means of investigation. It is of course manifest that a large proportion of these are of no practical interest, at least to farmers, and some of them are indeed little more than scientific curiosities. But with others, again, we are coming into daily and hourly contact, and no inquiring mind can abstain from seeking information regarding them.

Chemical Elements important to Farmers.—The elementary bodies which particularly concern us as farmers are some eighteen in number, and of these there are only about twelve of importance. They are as follows:—

Metals.

Potassium.	Aluminium.
Sodium.	Iron.
Calcium.	Manganese.

Magnesium.

Non-metals.

Oxygen.	Bromine.
Hydrodgen.	Fluorine.
Nitrogen.	Sulphur.
Carbon.	Phosphorus.
Chlorine.	Silicon.
Iodine.	

The young farmer must make himself particularly well acquainted with the chemistry of these, from an agricultural point of view. But before doing so, he must have some knowledge of the theoretical part, which is usually classed as *General Chemistry.* This he must acquire before he takes up the special department of *Agricultural Chemistry.* In colleges and institutions where these subjects are taught, they usually form the subject of separate courses of lectures, the student taking the former first in order. It may be objected that a farmer ought to confine himself to his own special department, and not waste time in studying a whole subject in its general aspects. To this the answer is, that "before we can apply a science successfully to any special art, whatever that art may be, we must thoroughly master the elementary and essential principles of the science, thus securing a solid basis. Before a man can apply chemistry to any practical end, such as farming, he must know the simplest facts about the various kinds of matter with which he meets on all sides; something about the changes which they suffer and the forms they assume; something about what they are and what they seem to be. He must know not only how to separate one kind of matter from others, but how to recognise it when separated. And besides all this knowledge, necessary before the conclusions of chemistry can be appreciated, he must, in order successfully to adapt and apply these conclusions in his own department and for his special ends, have become in some measure practically acquainted with the modes of chemical manipulation. In order to show how intimately and how invariably chemical processes are involved in agricultural operations, it would be necessary to trace the successive steps in, say, plant culture, in all of which this connection is more or less clearly displayed. To talk of carbonic acid, of nitric acid, of ammonia, of lime and potash, of silica and phosphates, and of their sources natural and artificial, their uses and their changes in the marvellously complex operations of vegetable growth, without knowing whether these chemical substances are simple or compound, solid, liquid, or gaseous, soluble or insoluble, liable to be lost by evaporation, washed away by water, or locked up in some unavailable form, is like looking for fruit on a tree which has not flowered—like pointing out the variations of a species before that species has been itself described." [1]

General Chemistry.—General Chemistry is usually divided into the two departments of Inorganic and Organic,—divisions which, although not absolutely correct, are very handy for the purposes of study. The former treats of the composition of matter as we meet with it in the mineral world—simple, or compounded from the action of the laws of chemical affinity or of crystallisation, and apart from all life. The latter studies it as it occurs in organic bodies, plant or animal, and as the result of living force. It is a curious fact that the one element carbon is found in every organic compound, and in by far the largest proportion, so that "organic chemistry" and the "chemistry of the carbon compounds" are synonymous terms.

Agricultural Chemistry.— Having mastered the elements of the general subject, the farm student is then in a position to attack his own particular branch of Agricultural Chemistry, and from the preliminary training of the former, he should be able to grasp freely the facts of the latter.

Soils, manures, plants, animals, and foods all involve so many chemical changes — actions, reactions, combinations, &c.—that many eminent men have found it profitable to spend their lives in the study of these, and in experimenting for the elucidation of problems, many of which still remain unsolved. The vast subjects of manuring our soils to raise maximum crops at the least expense, and of feeding our cattle economically and efficiently, fall largely under the subject of the chemistry of

[1] Prof. Church.

the farm. But it is hardly necessary to say any more on a subject about which all are agreed as to its importance to practical men.

It is not necessary or desirable that a young man should go to all the trouble and expense of becoming an analyst for the purpose of being able to inquire into the composition of his soil, manure, or feeding-stuffs. When he has a farm of his own, it will generally pay him better to "play the overseer" rather than raise bad smells and waste both time and chemicals in a rough-and-ready laboratory. Some practical work in the laboratory while a learner is of immense benefit, but by private reading and attending lectures he can gain information which will be of the greatest service to him in the everyday work of the farm.

BIOLOGY.

This is the name given to the study of *Life*—whether that is manifested in plants or animals—and it includes the two definite sciences of Botany and Zoology. Sometimes it is looked upon as a special subject in itself, and taught as such, as a general introduction to these two branches. But for our purpose it will be sufficient to show the value of these latter to a farmer, leaving the classification and the mode of acquiring a knowledge of them to be settled by individual circumstances.

The discoveries of modern science have shown that it is a very difficult matter to separate the animal from the vegetable kingdom; that, in fact, we can scarcely define an animal in such terms as shall not equally well apply to a plant. This, of course, seems strange to those who have never gone any deeper than the surface of things, and there may seem no difficulty in knowing the difference between a horse and the hay which he eats; but when we go down to the lowest organisms and study the beginnings of life we find a great deal of difficulty in saying to which kingdom they belong, although many of them are of vast importance in the economy of nature or of a farm.

For this reason, therefore, the life-history of these lowly organisms is sometimes studied as the science of Biology, with the study of plants and animals proper as a continuation of the same.

BOTANY.

Botany, shortly defined, is the study of plants, their structure, functions, and habits. There has been an opinion current among the uninitiated that botany was merely the naming and classification of plants. As a matter of fact, this is only a very small and unimportant part of the subject, for "a man might be a profound botanist and not know the *names* of half-a-dozen plants." As a proof of this, we may take the case of many gardeners. Their business leads them to make themselves acquainted with all the Latinised names and divisions of the long list of varieties and sub-varieties of florists' flowers; and though all gardeners know these, it is only now and again we meet with one who is really a botanist, and has studied their anatomy and physiology.

There is, no doubt, a vast deal of drudgery to be encountered in commencing the study of this science. The structural parts — especially if microscopic—have no common English names, and therefore it was necessary to invent names derived from Latin or Greek. Many of these names must be mastered before any progress can be made in the subject, or before we can tackle the plants themselves. Once they are mastered, however, botany becomes one of the most pleasant studies, apart altogether from its usefulness. It is a subject that particularly lends itself to the life of a farmer, who is always in the fields, and who has the opportunities above every one else for the prosecution of it. It does not require any expensive apparatus or fittings, like practical chemistry, for a pocket-lens is sufficient to enable one to go a great length into it.

Of course, it is the botany of the cultivated crops which especially concerns farmers; but as the working of a farm is directed quite as much to the keeping down or counteracting the evil influence of weeds or wild plants, it behoves him to know almost as much about the latter as the former. In fact, a knowledge of the habits and peculiarities of native plants will often give hints as to the capabilities of soil or climate or pasturage which could otherwise be learned only by expensive experience.

Classification of Plants.—For ease of reference and study, plants have been classified into what are called "Natural Orders." All the plants which have the general arrangement of their parts similar to one another, the structure of the flowers especially being on the same plan, are classed together. All the known plants on the face of the earth have thus been grouped into between 200 and 300 "Natural Orders."

Plants of the Farm.—The farm plants of this country, however, occur in about twelve only of these. They may be tabulated as follows:—

Graminaceæ	Wheat, barley, oats, rye, grasses, &c.
Leguminosæ	Beans, peas, vetches, clover, sainfoin, lucerne, &c.
Cruciferæ (*Brassicaceæ*)	Turnips, swedes, rape, cabbage, kohl-rabi, mustard, &c.
Solanaceæ	Potato, tobacco.
Umbelliferæ	Carrot, parsnip, caraway.
Chenopodiaceæ	Mangel, beet.
Linaceæ	Flax.
Urticaceæ	Hops, hemp.
Boraginaceæ	Comfrey.
Dipsacaceæ	Teazle.
Polygonaceæ	Buckwheat.
Compositæ	Artichokes, chicory.

The first half-dozen of these contain the most of the plants cultivated in the ordinary farming of this country, the others being grown only under special circumstances. As, however, almost every plant native to a locality will be found on or about a farm, and may have some possible influence on the management thereof—either as one likely to be eaten by the domestic animals, or as a weed infesting the land,—the young farmer who wants to dip into the heart of things will not rest content with knowing these outstanding ones, but will try his best to know something about all that come under his notice.

Germs.—Further, many of the diseases which attack our crops are fungoid growths — such as the potato disease, smut, mildew, &c.; and many of the diseases of animals are also due to the presence of these low vegetable organisms, to which is given the general name of "germs"—such as anthrax, tubercle, fowl cholera, &c. — so that there is scarcely any department which does not concern him.

Scope and Necessity for Botanical research.—A good book on Agricultural Botany has yet to be written, and in the absence of that the student must be content to work up the subject from some one of the many general text-books in existence. A list of the particular plants native to his district is usually to be found in some of the "Floras" issued for different localities.

There is quite as much scope for investigation and the finding out of fresh facts in the field of Agricultural Botany as there is in any, and much more than in some other branches. It is not that one who is constantly in the fields has an opportunity of finding out merely a new "habitat" for some species, but we are only as yet partially acquainted with the peculiarities and special food or other value of the hundreds of plants which go to make up our meadows and pastures, not to mention other crops. Out of some thirty species of grasses which are cultivated in this country, we do not yet thoroughly know which are relished most by horses, or cattle, or sheep, or which will yield the most beef or the best milk. Again, a difference of soil or climate has often such an effect, that one species which may be acknowledged good at one place, may be almost worthless at another. The famous blue grass of Kentucky (*Poa pratensis*), for instance, is only reckoned second or third rate quality in Britain. A farmer, therefore, who has the necessary botanical knowledge, and who will take the trouble to investigate these matters, might not only gain information of importance to himself, but also of value to all.

ZOOLOGY OR NATURAL HISTORY.

This other great department of Biology is limited to the study of the comparative anatomy and life-histories of animals. A farmer is, of course, interested mainly in knowing all he can about the six or eight animal species which are "domesticated," and which form the live stock of the farm. But it is well worth his while to extend his study a good deal beyond these, for many of the lower forms, which are not very conspicuous to the eye in themselves, can yet make or mar the fortunes of the cultivator, from the losses produced by them among stock or crop.

The special study of the domestic animals — their comparative anatomy, physiology, diseases, and treatment—forms the subject of *Veterinary Science*, which is thus in this sense a branch of Zoology, or of Biology, and will be touched upon later on.

Animal Parasites.—There is a great deal, however, concerning certain of the lower organisms which is of interest to the farmer quite as much as to the veterinarian. A great many of the diseases which afflict our domestic animals are due to the presence of parasites, the life-history of which, and position in the scale of animal life, it is the province of Zoology to inquire into. Such, for instance, are the parasites which cause "measly pork," "sturdy" and "liver rot" in sheep, "hoose" in calves, &c., &c.

ENTOMOLOGY.

There is, again, the wide and important subject of *Entomology*—the study of insects—which is usually raised to the dignity of a special science by itself, but which falls to be classed as a department of Natural History. When we consider the vast amount of damage that is done to both stock and crops by the ravages of insects, it is hardly necessary to use arguments to convince farmers of the necessity of giving some attention to this matter. Some few of the most prominent ones alone—such as the turnip-flea beetle, the wheat-midge, green-flies, warble-flies, maggot-flies, &c.—are sufficient of themselves to cause a loss of millions of pounds annually to the British farmer. Many years ago the Royal Agricultural Society of England appointed the late Mr Curtis to systematically investigate the subject of farm insects. The result was a portly volume, which long remained the standard authority on the matter. Lately, the accomplished lady scientist, Miss E. A. Ormerod, has been appointed as entomologist to the above Society; and our knowledge of the life-history of many insects, and the ways and means of preventing or mitigating their attacks, has through her exertions been greatly increased.

There is thus great benefit to be obtained by the general study of Natural History, giving, of course, the most attention to those animals, or classes of animals, which are connected with the farm.

VETERINARY SCIENCE.

This is a very general name given to the study of those subjects which relate to the anatomy, physiology, and diseases of live stock. Long ago it was raised to the dignity of a profession. A regularly qualified Veterinary Surgeon has to go through a course of training and attendance at classes occupying from two to three years, having separate courses of lectures and practical work on such subjects as Chemistry, Botany, Anatomy, Physiology, Materia Medica, &c.; while, after those preliminary subjects have been mastered, special attention is given to the diseases and treatment of live stock under the names of Horse and Cattle Pathology, Veterinary Surgery, &c.

There is no doubt that a veterinary surgeon has got a sufficient knowledge of, at least, one half of the scientific subjects which relate to farming, and has had a specially good chance of gaining a knowledge of live stock. But it is not necessary that a farmer should go through the whole course of this training, unless he also wishes to become a professional "vet." A great deal less than this will be sufficient for a young farmer to give his attention to, for it must be remembered that the department which specially concerns him is more the prevention of disease than its treatment. Once trouble has crept into his stock, it is generally desirable to call in the services of a qualified man, whose experience and ability in this line must necessarily be greater than his own. The few shillings charged for advice by most country practitioners is a small matter compared to the loss or deterioration of an animal.

Prevention better than Cure.—It is, however, to the prevention of disease that a farmer ought to give his attention. To be able to do this thoroughly, he must know something about the structure and vital processes of the bodies of the animals he owns. Respiration, digestion, and reproduction are the three general functions performed by all living beings; and if we can keep these always going on naturally and properly, it would enable us to escape the greater number of the diseases which infest our live stock. In order to do so, a farmer ought to lay himself out to understand not only how these functions are carried on, but also to study such matters as ventilation, sanitation, and dieting, as these fall properly within the bounds of "preventive medicine." It reflects credit on the veterinary profession that the researches by its members have been quite as much directed to the prevention as to the cure of diseases, and advice has been freely given to this end.

Studying Minor Ailments.—Notwithstanding the utmost vigilance and care, however, animals will turn unwell now and again, and there are a large number of what might be called minor diseases affecting our live stock, some of which are of almost daily occurrence. Such ailments as colds of all kinds, sprains, purging, affections at parturition, foot-rot, hoven, and colic, are sure to arise now and again, so that a farmer is compelled to gain some knowledge of these, whether he desires it or not. It is out of the question to think of seeking professional advice on each and every little occasion, any more than a human being would think of calling in the doctor every time he had a headache or a cut finger.

It is, therefore, of the first importance that a farmer study these minor ailments, and thus be able to check what might otherwise develop into something serious.

Veterinary Guide-Books.—There is this difference between Veterinary science and the last two touched upon—Botany and Zoology—that whereas these latter have no books extant on them specially intended for farmers, the former has no end of works devoted to its different subjects, and written in a popular style which can be "understanded of the people," in contradistinction to the technical works intended for professional readers.

Without, therefore, attempting to become any more than an amateur at the subject, every one who has anything to do with live stock should endeavour to make himself acquainted with their rational treatment and common ailments.

ANATOMY AND PHYSIOLOGY.

Apart altogether, however, from the treatment of diseases, there are the two branch sciences of Anatomy and Physiology, a knowledge of which would be of the greatest service to every one who is buying and selling or judging stock. It is manifest, for instance, that one who thoroughly understands the arrangement of the bones and ligaments which comprise the hock of a horse, will be better able to give an opinion as regards this point on the merits of any animal placed before him than one not so well informed; or if he understands the structure and working of a cow's udder, he will have a better idea of her capabilities in the absence of actual trial. Instances might be multiplied of the usefulness of such knowledge—knowledge, too, which a farmer has ample opportunities of acquiring.

GEOLOGY.

The study of the rocks which form the surface of the earth, their various modifications and arrangements, and the ways and means by which the surface of the country has been sculptured out into hill and dale, stream and lake, is known as the science of Geology. It is not much more than a generation ago since it first became reduced to a systematic science, and the men who first brought it into prominence, and made the great initial discoveries in it, are not long dead. Very early, of course, in the history of mankind, when people began to move about from one country to another, they must have noticed the different features of the land in different places,—a hard dark-coloured rock prevalent in one place, and a white soft one in another; poor moory ground here, and deep fertile soil there; while the exposure of beds or strata on the faces of cliffs, &c., would show the regular superposition of several varieties one on the top of the other.

It was reserved for our times, however, to explore these matters, and eliminate a system which would explain all the phenomena met with in the "crust of the earth." In fact, Geology is one of the youngest of the sciences, although it has made gigantic strides forward in the comparatively short time it has been studied.

At first sight it might appear that, as it is only the surface soil of the country which a farmer cultivates, he need not therefore trouble himself about going any deeper, but may confine himself to the "surface geology" of his district. But as the outside appearance and conformation of an animal depend on the internal structure of the same, so does the varied features of a district depend on the geological formations which constitute its anatomy; and we all know that these general features have as much to do with farming as the soil actually cultivated.

For convenience, the different strata have been grouped into what are called "systems," divided from one another by some natural gap or "unconformity"; and the rocks which make up each system are known as "formations." It is a curious and interesting fact that nearly all the formations are represented in Great Britain, so that the farming which is conducted on the top of these must be very varied, and must take notice of them all.

It is of course in the study of the soil that geology can materially aid a farmer—its formation and mineral composition; and every one who has mastered the principles of the science has got a key to the soils of not only this country, but also to all those which have had their rocks mapped out.

Formation of Soils.—The portion which we cultivate is composed of two parts—the mineral or inorganic, and the vegetable or organic. The latter is the product of the decayed roots, &c., of plants which have previously grown on the surface, while the former is simply equivalent to so much powdered and weathered rock. Whenever a part of a formation becomes exposed, the natural forces of rain, frost, and atmospheric action immediately attack it, with the result that large quantities become detached and weathered down, and this *débris* forms the greater part of a fresh piece of soil, either at the place where it was separated from the parent rock, or it is washed away, mixed up with others, and redeposited somewhere else. This is how most of our soils have been formed; and though in this country the greater part have been due to the washing away and mixing-up process—and are thus seldom derived from the rock lying immediately below—yet the subjacent material usually gives the "character" to a soil, and at any rate can explain all the other features of a locality.

The most of the accumulations of material above the solid strata are usually designated "drift," and the different varieties and arrangements of these go under such names as "boulder-clay," "glacial drift," &c., and the occurrence of these gives rise to the existence of stiff clay in one place, loamy soil in another, and gravel in a third. The drifted material is really a formation itself, and forms the surface part of a large proportion of Great Britain, especially the northern parts. Still it is always influenced by the strata below. In red sandstone regions the soil is of a red sandy nature, while shaly or clayey rocks give a stiff character to the accumulations above.

Each particular formation or group of formations has got its own special kind of soil, and it therefore follows that the varieties of soil and of farming are almost as many and as varied as the former. All of them are crowded into the narrow limits of the British Islands. In many districts abroad the same formations and the style of farming extend for many hundreds of miles. In the old province of Perm in Russia—which gives its name to the Permian rocks—these formations cover an area almost as large as France, so that there cannot be any great variety in the farming for hundreds of miles. But here, where things are on a smaller scale and there are changes every few miles, several different formations with as many different soils may exist within the limits of one farm, or even one field.

It is, of course, when a farmer is moving into a strange locality that a knowledge of its geology would help him to understand its farming. One who has resided on and worked a particular farm for several years, has generally found out from experience far more about that farm than any map or general geological knowledge could tell him; but if he removes to a strange part, a sketch of the geology of that district—read aright—would give him a vast amount of useful knowledge relating to the soil, and the most suitable style of farming to pursue. But even in a familiar place, when it becomes necessary to do such work as draining or sinking wells for water, it is seldom that a knowledge of geology will not be helpful.

Geological Survey. — Happily in this country there is ample opportunity of acquiring this knowledge at little trouble or expense. The Government Geological Survey is almost completed, and coloured sheets representing the "solid" strata of each district can be had for a few shillings. Like most Government undertakings relating to farming, the agricultural part—the "surface" or "drift"—has been left to the last, so that it has not progressed very far as yet. Every farmer, however, ought to procure the sheets issued for his locality, and learn to read them.

Relation of Geology to Animals.—But it is not only in the soils or cultivation of a farm that geology can give useful information. There is not the least doubt that the many distinct breeds of our domestic animals, which have been brought to such perfection in these days of pedigrees and shows, owe their typical or primitive and more natural characteristics to the geological features of their native districts. Thus the Southdown sheep has been developed on the chalky hills of south-eastern England, the Welsh and Highland cattle on the rugged Silurian and granitoid formations of Wales and Scotland—and so on. True, man's interference has had much to do with these in later times, but the soil had, and still has, much influence. We are only on the threshold of a great deal of information which awaits us in this direction, and therefore there is great need as well as many inducements for a young man to give his attention to it.

In short, a farmer who has some knowledge of the subject sees many reasons for the differences of farm practices which never occur to one not so well informed.

NATURAL PHILOSOPHY.

We now come to a consideration of those subjects which are of a mathematical or experimental nature, differing from the matters already touched upon, in that they do not treat of life or living bodies, but rather of the forces which affect matter, and the manifestations of which can be reduced to calculation.

Natural Philosophy or *Physics* is the general name given to a very wide subject—or group of subjects—the object of which is to discover the laws of Nature,—the properties of matter and the forces which act upon it. It has been separated into over a dozen different sciences, each of which treats of one particular department, but all of which are related to one another as they treat either of different aspects of the same force or the same matter. Every one is familiar with at least the names of those separate departments, the principal ones being, Heat, Light (Optics), Sound (Acoustics), Electricity, Magnetism, Hydrostatics, Mechanics, Meteorology, Chemical Affinity, Astronomy, &c. &c. This list might be almost indefinitely increased, as the whole of the phenomena of inanimate Nature—from the laws which regulate the motions of stars and planets to those which govern the molecular building up of crystals—are included in the general term "*Natural Philosophy.*" Each department is capable of being studied as a definite and extensive science by itself, though related more or less to all the others. It is of course apparent that the majority of those mentioned above are not of any particular interest or use to the farmer. Nowadays, however, every one who pretends to have a good general education is expected to have some knowledge of these subjects; and the perusal of such text-books as Professor Balfour Stewart's *Elementary Physics* will give one almost as much information about them as is necessary for those who do not require to study them deeply.

Two or three of these branches the farmer must study thoroughly, as they are of the utmost use in the everyday work of the farm, and these we may consider a little more fully.

METEOROLOGY.

This is the "science" of the weather. In an open-air business like farming, where so large a part of the work is done in the fields, and where the state of the soil and the successful growing of crops and management of stock depend so largely on atmospheric conditions as regards rain, frost, wind, &c., it does not require much argument to prove that anything relating to these ought to be of the first importance. Meteorology is not a science in the usual sense of the term, because as yet its facts have been little more than collected together, and no "laws" have been enunciated which will explain and connect all, and enable us to foretell to a certainty what is going to happen with regard to aerial phenomena. At the same time, there is perfect certainty as regards some points—such, for instance, as why the wind blows, why the clouds form and rain falls, why dew is deposited, and so on,—the uncertainty being in not knowing *when* these things are to happen, or what originates the changes which result in the particular weather of each day. The Meteorological Office has for many years had observers all over the country who have kept an exact record of the rainfall, direction of wind, height of barometer, &c. &c., and these have been collected and tabulated, and results worked out, so that the average kind of weather and climate of any particular place is now pretty well known. What the weather is to be for any particular day, however, is quite another matter, though this also is a subject which, as time goes on and experience increases, is being brought to greater accuracy.

Weather Forecasts.—Most readers of newspapers will have noticed the column which gives the daily "forecasts" of the weather issued by the above office. These have been in the past so often right, or partly right, that they are most valuable to those who have to pay attention to the state of the atmosphere, and it is likely that they will become more and more correct as observations extend and improved means are devised. As the whole of the British Islands, however, are parcelled out into only eleven "districts," it is manifest that the forecast issued for any one of these must be very general, and might not apply to a particular spot within a district. There is such a thing as local weather—as there might be heavy rain in one place, and a bright sunshiny day in the next valley a few miles distant.

There is not the least doubt that if a man could find out the kind of weather that would be experienced on his farm twenty-four hours—or even twelve—beforehand, it would be of immense use to him, and save him many a pound, especially in haymaking and harvest time. We have not arrived at such perfection of detail as yet, and therefore there is all the more need of farmers making themselves acquainted with the facts and laws of weather and climate, so far as these have been worked out.

Most people keep a barometer hanging up somewhere about their house, and call it a "weather-glass," and believe that its use is to foretell when to expect rain and when fine weather. Few, however, know that its object is simply to show variations in the weight of the atmosphere, whether these are due to the presence of moisture, or height above sea-level, or the effects of the wind. A great deal, no doubt, is to be learned from a proper use of the barometer, hygrometer, thermometer, &c., and it is part of the object of meteorology to show how they are to be used, and the reasons why, while more extended and general observation would be likely to increase our knowledge of this important subject.

There is an abundance of handy text-books devoted to the subject, while it is usually treated of in works on general physics, and no farmer will regret making himself acquainted with it. It is by no means a narrow or contracted science, as it may be said that it not merely affects us here in Britain, but the weather and climate within several thousands of miles of us has its influence on our atmosphere, so that the study of it is world-wide. More than this, there is great reason to believe that the sun has much influence on our atmosphere, and that from it issue the initial changes which rule our weather. The spots which occur on the face of the sun have a maxima every ten or eleven years, and it is asserted by those who have studied what is jocularly called the science of "sun-spottery," that the weather runs in corresponding cycles. It has been further found that when a "magnetic storm" occurs on the photosphere of our luminary, there are corresponding perturbations of the needle of the compass, with atmospheric changes producing changes of weather. The subject thus embraces some knowledge of astronomy and magnetism, and there is reason to believe that we are on the threshold of important discoveries, which will give the key to the whole, and make the matter an exact science like the others.

MECHANICS.

Generally stated, the principles of machinery is the subject embraced by the science of mechanics. It is usually divided into the two branches of *statics* and *dynamics*, the former of which treats of the forces which act on bodies at rest, and the latter relates to forces causing motion in bodies — dynamics, indeed, being sometimes all that is included in "mechanics" proper.

One of the principal features of modern farming is the extensive use of machinery in everyday work, which still continues to extend, so that it is quite as necessary for a farmer to know something about the "iron horse" and machinery in general, as about the horse of flesh and blood which has done his work so long.

The object of these notes has been to point out the benefit to be derived from the study of the scientific *principles* which underlie and explain all our practical work, and Mechanics is emphatically one of those subjects which are thus of the greatest value. An implement or machine which is constructed on wrong principles can never work with any degree of satisfaction, if, indeed, it work at all; and every one who has made himself acquainted with the mechanical laws can see again and again how often the machinery exhibited in an agricultural show-yard infringes them. It is to be presumed that those who invent and make our implements are acquainted with those principles, but some do not appear to know anything about them; therefore when a farmer requires to invest in machinery, there is great need for him to know which to take and which to avoid.

Mechanics usually has for an introduction information about "force," "energy," &c., and then it is shown how these are practically applied in what we call the "mechanical powers." If a young farmer masters the principles of these powers, he will find them of the utmost benefit to him whenever he has anything to do with a machine. They are six in number, and well-known, as the Lever, Pulley, Wheel and Axle, Inclined Plane, Wedge, and Screw. The lever and the inclined plane are the principal ones, as the others are, in a sense, only modifications of these. Every implement, machine, or tool used on a farm, or anywhere else, is simply a variety or combination of these, so that an acquaintance with them enables a man to understand better what he is doing, to select the best at the beginning, to work it properly, to see faults and suggest improvements. How often, for instance, we see ploughs far too short in the stilts to give a man sufficient leverage power to hold steadily, drills with two steerage wheels where there should only be one, and cultivators and other implements with low wheels where they ought to be high! and so on—mistakes which this science points out.

Unfortunately our patent laws are rather against the production of perfect machines, though, no doubt, they protect the inventor and manufacturer. It often happens that there are both good and bad points in a particular implement made by different firms: if all the good parts were combined into one article, the product would be better than any at present in the market, but the interests of different patentees are opposed to this. However, a farmer who understands the principles of the matter is in a position to suggest improvements to makers of implements which he can verify for himself, and is thus not solely dependent on others.

The above two subjects are those of most importance to farmers in Physics; but where steam is so largely used as a motive power at present, with the possibility of electricity in the future, it is more than likely that the subjects of heat and electrical science will, as time goes on, become quite as necessary as the others. All of them are interesting and useful, whether they have a direct bearing on farming or not, as they relate to the ordinary phenomena of nature occurring every day around us.

ENGINEERING.

Engineering might almost be called the practical application of the principles of the various branches of Natural Philosophy to the arts of construction and to the performing of work. All that has been said regarding Mechanics is applicable to this branch of science, with the addition of a great deal more.

It has hitherto been popularly divided into two departments, Civil and Mechanical—the former of which treats of such matters as levelling, surveying, and designing structures and works; while the latter is confined to machinery, or "applied mechanics." In the full sense of the term, Engineering takes in a vast deal more than is comprised within the limits of a farm; and the knowledge necessary to lay off a railway or design a bridge is, of course, far beyond what is required by a farmer.

In this again, however, it is principles which are to be attended to in the first place, and much of the work done about a farm lies quite as much within the province of Engineering as is the making of a railway.

The laying out of a farm, or equipment of an estate, falls within this subject, and these are matters which farmers have often to undertake, and which cannot be exactly called part of farm work. The draining of a field, the making of a mill-dam for water-power, the procuring of a water-supply or the laying out of a water-meadow, the building of a steading, &c., all fall within the province of the engineer, and no farmer can undertake these with thoroughly satisfactory results who has not given some attention to such matters as mensuration, levelling, surveying, building construction, drawing, &c. It is seldom that a professional engineer is called in to superintend these operations, unless they are on a larger scale than is to be found within the confines of a farm, and therefore there is all the more reason for a farmer to be able to do something at them himself, more especially since the passing of the Agricultural Holdings Act. Even the ability to measure a field, or part of one, to find out the acreage, implies some "engineering" knowledge.

In the department of "Applied Mechanics," as has been already pointed out above, we learn all about the construction and working of machinery—knowledge which will enable us to improve our present farm implements, and work them to greater advantage. Farmers do not generally make, and only sometimes repair, such, but they might often be able to prevent breakages, and make tear and wear less, if they understood the principles of such things as "strains," "strength of material," "millwork," &c., &c.—matters which belong to the province of mechanical engineering. It might almost, in short, be said, that all the improvements included in Sections I. and II. of the Agricultural Holdings Act belong more to the domain of the civil engineer than the farmer, and in order to carry these out satisfactorily and make good a claim for compensation, the farmer must make himself more or less acquainted with engineering matters.

The various branches of science, a knowledge of which is essential to the well-educated farmer, have thus been indicated. It may perhaps be useful to append the following general notes which appeared in the previous edition, and which convey interesting information upon points embraced in the important sections of science enumerated.

The Atmosphere.—The atmospheric air surrounds the entire surface of our globe to a height, it was said, of 50 miles, now said of over 200 miles, although at the greater height it is much rarer. It presses with considerable force upon the surface of the earth, and upon every object thereon. The weight of 100 cubic inches of air, at 60° Fahrenheit, and the barometer at 30 inches, has been computed at 30,679 grains. With this weight, and a height of 50 miles, the air exerts a pressure on every square inch of surface of 15 lb. At this rate its entire weight has been computed at 5,367,214,285,714,285 tons, or equal to that of a globe of lead 60 miles in diameter. The surface of an ordinary-sized man contains 2000 square inches, so that such a person sustains a pressure of 30,000 lb., which would be sufficient to crush him to death in an instant, were it not that, in obedience to the laws of equal and contrary pressure of the air without and within the body, the catastrophe is prevented.

The air consists in 100 parts of—

	By Measure.	By Weight.
Nitrogen .	77.5	75.55
Oxygen . .	21.0	23.32
Carbonic acid . .	0.08	0.10
Watery vapour .	1.42	1.03
	100.00	100.00

These constituents are not chemically combined, but only mechanically mixed, and yet their proportions never vary—although both animals and vegetables use the air, and change these proportions: the powerful agency of the sun's heat and light evolves an abundant supply of oxygen from the luxuriant vegetation in the tropics, whilst the predominant existence of animals in the colder regions affords a large supply of carbonic acid.

The Barometer.—The gravity of the atmosphere is measured by the well-known instrument, the *barometer*. Its short column of mercury of 30 inches is as heavy as a column of air of the same diameter of 50 miles of height, and of water 33 feet in height.

The wheel barometer is very popular with farmers, because it shows the deviations of pressure very obviously, by the index traversing the circumference of a large circle. Containing a somewhat clumsy machinery, it is liable to go wrong, and the circle, large as it is, is not large enough to indicate extreme elevations and depressions of the mercury.

A much better instrument is the common upright barometer, fig. 1, in which the deviations in the height of the mercury in the scale are marked by means of a screw at top. When desired to move the barometer to another place, the mercury is pushed up to the top of the tube by means of the screw at the bottom.

This barometer should be suspended quite perpendicularly. It should not be exposed to the direct rays of the sun or to the heat of a fire. In making an observation, the frame should be gently tapped by the fingers, and in bringing the eye on a level with the mercury in the tube, the index is brought to that by the screw.[1]

The barometer was invented in Italy by Torricelli, a pupil of Galileo, in 1643.

Fig. 1. *Barometer.*

The Aneroid.—The *aneroid* barometer, which means "without moisture," fig. 2, is the most portable of all barometers, and is therefore most suitable for tourists, especially since it is now made as small as a large watch. The principle on which it depends is the varying pressure of the atmosphere upon an elastic metallic chamber partially exhausted of its air, and so constructed that by a system of levers a motion is given to a pointer which travels over a graduated dial. The usual form is

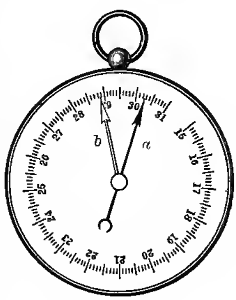


Fig. 2.—*Aneroid.*

[1] It is unnecessary to give a description of the common upright barometer so well known to every one, but those desirous of having a knowledge of the varieties of this instrument may be referred to Buchan's *Handy Book of Meteorology.*

about 4 inches in diameter. It is read exactly like the wheel barometer. The chief objection to it is its liability to change from the hand shifting by a shake, or in some other way. If it chances to go wrong, it can easily be reset by a turn of the screw at the back of the instrument. With proper care it may go correctly for years, but opportunity should be taken from time to time to compare it with some barometer whose accordance with the standard may be relied on, since, owing to the principle of its construction, it cannot be depended on like the mercurial barometer, fig 1. The indicator is *a*, fig. 2, the marker by the hand is *b*. Mr Belville, of the Royal Observatory, Greenwich, has made many experiments with the aneroid, and he found its movements always consistent. It is a delightful companion, may be carried in the pocket, in a steamboat, a carriage, in the hand in mounting elevations, without the chance of being injuriously affected. It is therefore highly useful, its indications preventing many an excursion which would have ended in disappointment. The tourist should never travel without it; and the seaman will find it a safe guide when the motion of the mercurial column renders the marine barometer almost useless.

Common Sucking - Pump. — The pressure of the atmosphere explains the action of the *common sucking-pump*. The plunger, by its upward movement, withdraws the air from the chamber of the pump, and the air, pressing on the water in the well, causes it to rise and fill the chamber vacated by the air. The air cannot force the water higher than 33.87 feet theoretically, but practically not more than 30 feet.

Force-Pump.—The *force-pump* acts both by the elasticity and pressure of the air. The pressure causes the water to be lifted to a height not exceeding 30 feet, but the elastic force of the air in the condenser causes it to rise to a very considerable height. It is on this principal that the fire-engine causes the water to rise to the roofs of houses.

The Siphon.—The *siphon* operates by the pressure of the air, and is useful in withdrawing liquids in a quiescent state from one vessel into another, or the water from a lake to a river or to a lower ground. Water from a quarry may sometimes be removed better by the siphon than by any other means. The efficiency of this instrument depends on the greater difference of length between its two limbs.

Wind. — *Wind* is occasioned by a change in the density of the atmosphere, the denser portion moving to occupy the space left by the rarefied. The density of the atmosphere is chiefly affected by the sun's heat raising the temperature of the earth in the tropics to a great degree, and the heated earth, in its turn, rarefies the air above it by radiation. The air, on being rarefied, rises, and is replaced by cold currents from either pole, and these currents, being constant, constitute the well-known and useful *trade-winds.* The great continent of Asia is heated in summer, and the cool air of the Indian seas moves north to occupy the displaced air above the continent. In winter, on the other hand, the water of this ocean, together with the land in the same latitude, are heated in like manner, and the cool currents from the great continent move south to replace the air rarefied by them, and these two currents constitute the half-yearly *monsoons.*

Land and Sea Breezes.—The air over the entire coasts and islands of the ocean is rarefied during the day and condensed in the night, and these two different states of the air give rise to the daily *land* and *sea breezes.*

Weathercock.—The direction of the wind is best indicated by the *wind-vane* or *weathercock*, a very useful instrument to the farmer. It should be erected on a conspicuous part of the steading, that it may be readily observed from one of the windows of the farmhouse. The cardinal points of the compass should be marked with the letters N. E. S. W. The vane should be provided with a ball or box containing oil, which may be renewed when required. There is no neater or more appropriate form for a vane than an arrow, whose dart is always ready to pierce the wind, and whose butt serves as a governor to direct the dart into the wind's eye. The whole apparatus should be gilt, to prevent rusting.

Force of the Wind.—The *force* of the wind is measured by an instrument called the *anemometer*, or measurer of the wind's intensity. Such an instrument is of little value to the farmer, who is more interested in knowing the direction than the intensity of the wind, as that has great effect on the weather. The intensity of the wind has, however, a material effect in modifying the climate of any locality, such as that of a farm elevated upon the gorge of a mountain-pass. Still, even there its direction has more to do in fixing the character of the climate than its intensity.

The *velocity* of the wind is measured by Robinson's hemispherical cupped anemometer, but its indications are not to be depended on in the higher velocities. The measurement is effected by a series of discs, as in a gas-meter.

Principles of Ventilation. — The principle of *ventilation*, whether natural or artificial, lies in a change of the density of the air. "We may be filled with admiration," says Dr Arnott, "on discovering how perfectly the simple fact of a lighter fluid rising in a heavier, provides a constantly renewed supply of fresh air to our fires, which supply we should else have to furnish by the unremitted action of some expensive blowing apparatus. But the operation of the law is still more admirable as respects the supply of the same vital fluid to breathing creatures. The air which a man has once respired becomes poison to him; but because the temperature of his body is generally higher than that of the atmosphere around him, as soon as he has discharged any air from the lungs, it ascends away from him into the great purifying laboratory of the atmosphere, and new takes its place. No act or labour of his, as by using fans and punkas, could have done half so well what this simple law unceasingly and invisibly accomplishes, without effort or attention on his part, and in his sleeping as well as in his waking hours." [1]

This process of natural ventilation necessarily goes on in every stable and byre; and were the simple law allowed to take its course, by giving the heated and vitiated air an opportunity of escape by the roof, and the fresh air to enter by a lower point, the animals inhabiting those dwellings would be much more comfortably situated than they usually are.

[1] Arnott's *Elem. Phys.*, i. 412—*Pneumatics.*

Weight of Fluids. — *Hydrostatics* treat of the laws which govern the *weight* of fluids. The application of the physical pressure of fluids to the purposes of domestic economy and the wants of civilised life are extremely important, and afford some valuable objects of study to the mechanic and engineer, and with many of these it would be the interest of farmers to become acquainted.

Fluids are subject to the operation of gravity. A cubic foot of pure water weighs 1000 ounces, or 62½ lb., and an English pint 1 lb.

Water in a vessel exerts a twofold pressure, on the base and on the sides of the vessel. The pressure on the *base* is in the direction of gravity. Suppose that the height of water is measured by 100 drops arranged one above the other, the lowest drop will exert on the base a pressure equal to the weight of the 100 drops. Every drop touching the *side* of a vessel presses laterally on the point of contact with a force equal to the weight of all the drops above it to the surface of the fluid. The lateral pressure of water thus varies as its depth. Bodies immersed in water are pressed by it in all directions with a force increasing as the depth.

Specific Gravity.—The *specific gravity* of bodies having equal bulks is the proportion subsisting between their absolute weights in air and in water. It is consequently found by dividing the body's absolute weight by the weight it loses in water. The specific gravities of a few common and useful things, distilled water being considered as 1.000, are these:—

Of Rain-water	1.0013
Sea-water	1.027
Beef-bones	1.656
Common earth	1.48
Rough sand	1.92
Earth and gravel	2.02
Moist sand	2.05
Gravelly sand	2.07
Clay	2.15
Clay and gravel	2.48
Siliceous sand	2.653
Sandy clay	2.601
Loamy clay	2.581
Brick clay	2.560
Pure grey clay	2.533
Pipe clay	2.540

Arable soil			2.401
Garden mould			2.332
Humus			1.370
Flint, dark			2.542
Do., white			2.741
Lime, unslaked			1.842
Basalt, whinstone	2.8	to	3.1
Granite	2.5	"	2.66
Limestone	2.64	"	2.72
Porphyry	2.4	"	2.6
Quartz	2.56	"	2.75
Sandstones (mean)	2.2	"	1.5
Stones for building	1.66	"	2.62
Brick	1.41	"	1.86
Iron, wrought	7.207	"	7.788
Lead, flattened			11.388
Zinc, rolled			7.191
Rock-salt			2.257

	Fresh-felled.	Dry.
Alder	0.8571	0.5001
Ash	0.9036	0.6440
Aspen	0.7654	0.4302
Birch	0.9012	0.6274
Elm	0.9476	0.5474
Horse-chestnut	0.8614	0.5749
Larch	0.9206	0.4735
Lime	0.8170	0.4390
Oak	1.0754	0.7075
"	1.0494	0.6777
Spruce	0.8699	0.4716
Scots fir	0.9121	0.5502
Poplar, Italian	7.9634	0.3931
Willow	0.7155	0.5289[1]

The Swede turnip in December	1.035
It is heaviest in April, about the shooting of the new leaves; and in June, after the development of the flower-stalk, it is	0.9940
White Swede turnip	1.022
Tweeddale purple-top yellow 980 to	1.000
Yellow bullock	0.940
White globe	0.840
Carrot	0.810[2]

Hydraulic Press.—Water being almost incompressible, any pressure exerted against its upper surface is immediately communicated throughout the entire mass. Bramah's *hydraulic press*, for compressing hay and other elastic substances, and for uprooting trees, is a practical application of this principle. If the cylinder of the force-pump is half an inch in diameter, and that of the press 20 inches, the water will exert a pressure on the piston of the ram 40 times that on the force-pump. If the arms of the lever are as 1 to 50, and that of the force-pump is worked by a man with a force of 50 lb., the piston of the pump will descend with a force of 2500 lb., and the ram will rise with one of 100,000 lb.

Motion of Fluids.—*Hydraulics* treat of the laws which govern the *motion* of fluids. If two vessels communicate with each other, and the height at which the water stands in the one exceeds the height of the other, then the water will flow into the second vessel until there remains as much water in the first as its height shall be equal to the height of the second. It is on this principle that water is supplied from reservoirs and cisterns to towns and villages and farmsteads, and that it rises from springs at a higher level into wells, whether of the common or Artesian form.

Velocity of Water.—The *velocity* of water issuing from an orifice is as the square root of its altitude. Thus, calling the velocity issuing 1 foot below the surface 1, that escaping from a similar orifice 4 feet below the level will be 2; at 9 feet, 3; at 16 feet, 4; and so on. From this we learn, that of water issuing from two similar vessels, it will issue, from similar orifices, from the one kept constantly full, twice as fast as from the other. A *short* tube will assist the issue of water from an orifice to the extent of half as much more.

Water-Ram.—It has been long observed that, when a cock at the end of a pipe is suddenly stopped when water is issuing out of it, a shock and noise are produced. A leaden pipe, even of great length, is often widened or burst in this way. The forward pressure of an arrested stream has been used as a force for raising water, and the apparatus has been called a *water-ram.* The ram may be described as a sloping pipe in which the stream runs, having a valve at its lower end, to be shut at intervals, and a small tube rising from near that end towards a reservoir above, to receive a portion of the water at each interruption of the stream. Water allowed to run for one second in a pipe 10 yards long, 2 inches wide, and sloping 6 feet, acquires momentum enough to drive about half a pint, on the shutting of the cock, into a tube leading to a reservoir 40 feet high. Such an apparatus, therefore, with the valve shutting every second, raises about 60 half-pints or 4 gallons in a minute. The

[1] Peschel's *Elem. Phys.*, i. 157-187.
[2] Keith's *Agric. Rep.*, 302.—*Aberdeen.*

valve is ingeniously contrived so that the stream works it as desired, and it is called a *sniffling valve.* This ram would supply water from a rivulet to cisterns in the farmhouse or steading standing at a height beyond the power of a force-pump.

Embankments against a Stream.—The effect produced by moving water depends on the quantity of water that strikes in one minute of time against the surface of the opposing body, and on the velocity with which the collision takes place. If the collision happens in a direction vertical to the surface of the body, its effect is equal to the pressure of a column of water, having for its base the surface impinged on, and an altitude equal to that of the column which generates the velocity of the stream. If the water impinges obliquely on the surface, the force may be resolved into two others — one parallel to the side of the body, and the other perpendicular to it. The latter alone is effective, and is proportional to the square of the sine of the angle of incidence. From this law we learn to calculate the amount of resistance required in an embankment against the force of a stream.

Water-Wheels.—The motive power of water is usefully applied to drive machinery by means of *water-wheels.* When water-power can be obtained to drive the thrashing-machine or other fixed machinery of a farm, an immense advantage is gained over the employment of horses. It is found that water-power, in the thrashing of grain alone, saves the work of one pair of horses out of every five pairs. Any form of water-wheel, therefore, is more economical than horses.

Undershot Water-Wheel.—When a wheel with float-boards merely dips its lower part into a stream of water, and is driven by its momentum—that is, by the bulk and velocity of the water—it is called an *undershot* wheel. This wheel is employed in low falls with large quantities of water. To have a maximum of effect from undershot wheels, they are generally made to turn with a velocity about one-third as great as that of the water.

Breast Water-Wheel.—When the water reaches the wheel near the middle of its height, and turns it by falling on the float-boards of one side as they sweep downwards in a curved trough fitting them, the modification is called a *breast*-wheel. This form is employed in moderate falls commanding a large supply of water.

Overshot Water-Wheel.—When the float-boards are shut in by flat sides, so as to become the bottoms of a circle of cavities or buckets surrounding the wheel, into which the water is allowed to fall at the top of the wheel, and to act by its weight instead of its momentum, the modification is called the *overshot* wheel. This form requires a high fall, but comparatively a small supply of water, and is most desired when circumstances will permit its adoption. Overshot wheels usually have their circumference turning with a velocity of about 3 feet per second.

Turbines. — The turbine is an ingenious and most useful modern invention for utilising water-power. The principles of its working will be explained in a later section.

Velocity of Streams.—*Friction* affects the motion of streams of water very sensibly. The velocity of a stream is greater at the surface than at the bottom, in the middle than at the sides; and the water is higher along the middle than at the sides. But for the retarding power of friction, the water in open channels and ditches would acquire so great a momentum as to destroy their sides, and to overflow them at every bending. Rivers issuing from a high source, but for friction and the effect of bending, would pour down their waters with irresistible velocity at the rate of many miles per hour. As it is, the ordinary flow of rivers is about 3 miles per hour, and their channels slope 3 or 4 feet per mile.

To measure the *velocity of a stream at the surface*, hollow floating bodies are used, and the space they pass over in a given time—one minute—is observed by the watch. It is very difficult to ascertain the true velocity of an irregular stream. To learn what quantity of water flows in a stream, its breadth and depth are first measured at various places to obtain a mean of both; and the sum of these constituting the section of the stream is then multiplied by the velocity, and the product gives the number of cubic feet per minute.

A more exact method usually employed is to dam up the stream with boards or planks and allow the water to flow over a rectangular or triangular "notch," where the speed and dimensions can be accurately measured.

Horse-Power.—It may be useful to know the rule for calculating the number of *horse-power* any stream may exert if employed as a motive power. It is this: multiply the specific gravity of a cubic foot of water, 62½ lb., by the number of cubic feet flowing in the stream per minute, as ascertained by the preceding process, and this product by the number of feet in the fall, and divide by 33,000 (the number of pounds raised 1 ft. high in 1 min. by a "horse-power"); the product is the answer.

Thus,—Multiply the number of cubic feet flowing per minute in the stream—suppose . . .	350
By the weight of a cubic foot of water 62½ lb. . .	62½
	175
	700
	2100
	21,875
And then multiply the product by the number of feet of fall available—suppose . .	12
Divide the remainder by	33,000)262,500(7.9 horse-power.

And the quotient, 7.9, gives the number of horse-power

This is, of course, the theoretical horse-power, of which only a proportion can really be utilised, varying from 35 per cent in undershot wheels to 75 per cent in turbines.

Electricity. — Electricity is universally present in nature. This is proved not only by its being set free by friction, but by almost every form of mechanical change to which any substance can be submitted, mere pressure being quite sufficient for the purpose. It is in a latent state — in a state of quiescence and equilibrium; but this equilibrium is very easily disturbed, and then a series of actions supervenes, which continues until the equilibrium is restored.

It has been found that certain bodies possess the property of conducting electricity, whilst others are incapable of conducting this form of matter, however subtle. On this account, bodies have been divided into two great groups—conductors and non-conductors of electricity; the conductors, such as metals, being termed *analectrics*, because they cannot produce sensible electricity; and the non-conductors, such as wax or glass, *idio-electric*, because they can.

The atmosphere is the part in which electricity, liberated by various processes, accumulates; it constitutes, in fact, the great reservoir of sensible electricity, our solid earth being rather the field in which this mighty power is again collected and neutralised. Sensibly, electricity is found in the atmosphere at all times and in every state, but varies both in kind and intensity.

Wheatstone announced his important discovery of the velocity of the electric force to the Royal Institution of London in 1835, and that it is 288,000 miles per second.

Electro-Culture.—The very general distribution of electricity through every substance, the ease with which it can be excited into activity, and the state of activity it displays around plants in a state of healthy vegetation, have led to the belief that were means devised to direct a more than usual quantity of electricity through plants when growing, their growth might be much promoted. It was conceived that metallic wires might be so placed as to convey this increased quantity; and accordingly experiments were made so as to direct it through given spaces of ground into the plants growing upon them; and this process has been named *electro-culture.* The results having been contradictory and discouraging, the process has been relinquished.

Humus is valuable by its union with oxygen in supplying carbonic acid and electricity to vegetables in all their stages. During the time it is in the soil, it is a greater attracter and retainer of moisture.

All the *inorganic* substances of plants are non-conductors, and therefore valuable as retaining electricity for the use of vegetation.

Heat.—Heat may be regarded as the antagonistic force to gravity. Were gravity to act alone, every object would become a confirmed solid, and there would be no such existence as life. It is the property of heat to part asunder the atoms of all bodies, and these remain or change into solids, liquids, and gases, as their atoms are more nearly or remotely placed from each other—the farther they are separated, the weaker the attraction being between them.

Thermometers.—Whenever heat becomes sensible or free, it alters the form of bodies by dilation; and the measure of this increase has given rise to a class of useful instruments called *thermometers.*

The common *mercurial thermometer* is nearly a perfect instrument, and has been the means of establishing important facts to science; but being a mere measurer of temperature, it is incapable of indicating changes of the atmosphere, as the barometer, and is therefore a less useful instrument to the farmer. Regarding the ordinary temperature of the atmosphere, the feelings can judge fairly well; and as the state of the productions of the farm indicates nearly whether the climate of the particular locality can bring them to perfection, the farmer almost seems independent of the thermometer. Still, it is useful for him to know the lowest degree of temperature in winter to put him on his guard, as certain kinds of farm produce are injured by the effects of extreme cold, which the feelings are incapable, from want of habit, of estimating. For this purpose, a thermometer self-registering the lowest degree of cold will be found a useful instrument on a farm; and as great heat seldom occurs in our climate, a self-registering thermometer of the greatest heat is not so useful an instrument as that which registers the greatest cold.

Reaumur Scale.—Reaumur was the first to propose the use of mercury as the expansive medium for the thermometer. This liquid metal has many advantages over every other medium; it has the power of indicating an extensive range of temperature, and expands very equally. On its adoption, the melting-point of ice was taken as a fixed point, and the divisions of the scale were made to correspond to $\frac{10}{1000}$th parts of the parts of the capacity of the bulb.

Fahrenheit Scale.—It was left for the ingenious Fahrenheit[1] to fix another standard point—that of boiling-water under the mean pressure of the atmosphere, which is given on his scale at 212°; the melting-point of ice at 32°. This scale of division has universally been adopted in Britain, but not on the Continent. The zero of this scale, adopted by Fahrenheit, from the erroneous idea that the greatest possible cold was produced by a mixture of common salt and snow, has favourable advantages for a climate like ours. The other divisions of the thermometer, between the two fixed points of freezing and boiling water in general use, are those of Reaumur[2] and Celsius.[3] Reaumur divides the space into 80 equal parts; the division of Celsius is into 100 parts. In both these scales the zero is placed at the melting-point of ice, or 32° Fahrenheit.[4]

The rule for converting the Reaumur scale into that of Fahrenheit is—multiply the degrees of Reaumur by $2\frac{1}{4}$, and add 32°. For example, take 12° Reaumur, which multiply by $2\frac{1}{4} = 27$; and add $32° = 59°$ Fahrenheit.

The rule for converting the Celsius or centesimal scale into that of Fahrenheit is—multiply the degrees of Celsius by $\frac{9}{5}$, and add 32°. For example, take 12° Celsius, which multiply by $\frac{9}{5} = 21.6°$; add $32° = 53.6°$ Fahrenheit. Also, $\frac{4}{5}$ multiplied by Celsius = Reaumur, and $\frac{5}{4}$ multiplied by Reaumur = Celsius.

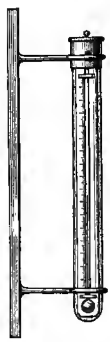


Fig. 3. *Fahrenheit Thermometer mounted.*

Fahrenheit Thermometer. — The common Fahrenheit thermometer, fig. 3, is too well known to need description. Its tube is filled with mercury. It may be purchased for 1s. and upwards, but so very low-priced

[1] A Danish philosopher who experimented in Iceland. Born 1686, died 1736.

[2] A French philosopher. Born 1683.

[3] A Swedish philosopher. Born 1670, died 1756.

[4] *Jour. Agric.*, iii. 5.

ones are worse than useless, errors of 1°, 2°, and even 8°, being of frequent occurrence. It is mounted with iron pins screwed into a window-sash.

Minimum Thermometer.—The *minimum* thermometer, fig. 4, registers the greatest cold during the night. The tube is filled with spirit of wine, in which a small index *a* floats, which, being drawn down by the fluid towards the bulb as the temperature falls, is left undisturbed as it rises, indicating the lowest point to which the temperature has fallen. The reading is taken from the head of the index farthest from the bulb. This instrument gets out of order by the column of spirit breaking up into parts, but fortunately they can be reunited by striking the bulb-end of the frame firmly and repeatedly against the palm of the hand, or by raising it over the head and rapidly and forcibly swinging it downwards, to force the spirit towards the bulb. After this it may be left a short time in a slanting position to drain more completely. To adjust this instrument, slope it so as to make the head of the float come to the end of the column of spirit of wine.[1]

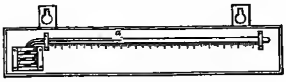


Fig. 4.—*Minimum Thermometer.*

Stack Thermometer.—The thermometer, fig. 5, is useful in ascertaining the temperature of the hearts of stacks, to determine whether heating has begun or not, and the temperature in the interior of dung-heaps. It consists of a long glass tube, cased in a strong metal tube of brass, tin, or zinc, pierced with small holes at the bottom.

Fig. 5.—*Stack or Dung Thermometer.*

[1] *See* Buchan's *Hand. of Meteo.*—"*Thermo.*"

Placing Thermometers.—Thermometers of all kinds, when fixed up for observation, should be placed out of the reach of the direct rays of the sun, or of any reflected heat. If at a window or against a wall, the thermometer should have a northern aspect, and be kept at a little distance from either. The common thermometer is fixed perpendicularly, the minimum horizontally, but loose, so as to allow the float index to be adjusted. The maxima of temperature are generally indicated too great, from the near contact in which the instrument is usually placed with large ill-conducting masses, such as walls—the temperature of the night thus being kept up, and the minima also.

As thermometers are usually placed, they cannot indicate the temperature received by growing crops. To attain that knowledge, the thermometer should be exposed day and night as the crops are—to sunshine, cloud, and night; and it is only in this way that the vicissitudes of temperature during the twenty-four hours can be correctly ascertained.

Air-Engine.—Bodies, on receiving heat, expand generally more rapidly than the temperature increases; and the expansion is greater as the cohesion in the particles becomes weaker from increased distance—being considerably greater in liquids than in solids, and in airs than in liquids. Thus solids gain in bulk 1 part in from 100 to 400; liquids, in from 9 to 55; and all gases and vapours gain 1 part in 3. It is this dilating property of air which prompted some persons to employ the force of expanding air as a motive power: the same quantity of heat that would produce one cubic foot of common steam would double the volume of 5 cubic feet of atmospheric air. The air-engine is now an accomplished fact; and it has been proved that this power may be much more economically employed than steam.

Steam-Engine.—In expanding on the reception of heat, bodies receive it in different quantities ere they exhibit a given increase of temperature; and this difference marks their different capacities for heat. It is this property which renders steam so powerful and economical a force to be employed in moving machinery; and as a motive power the *steam-engine* at present stands unrivalled. As it came from the hands of Watt, the steam-engine may almost be said to be endowed with human intelligence, as may be seen on perusing at length Dr Arnott's well-expressed encomium on this wonderfully simple machine. "It regulates with perfect accuracy and uniformity," he observes, "the *number of its strokes* in a given time—*counting* or *recording* them, moreover, to tell how much work it has done, as a clock records the beats of its pendulum; it regulates the *quantity of steam* admitted to work—the *briskness of the fire*—the *supply of water* to the boiler—the *supply of coals* to the fire; it *opens and shuts its valves* with absolute precision as to time and manner; it *oils its joints;* it *takes out any air* which may accidentally enter into parts which should be vacuous; and when anything goes wrong which it cannot of itself rectify, it *warns its attendants* by ringing a bell:—yet with all these talents and qualities, and even when exerting the powers of six hundred horses, it is obedient to the hand of a child; its aliment is coal, wood, charcoal, or other combustible; it consumes none while idle; it never tires, and wants no sleep; it is not subject to malady, when originally well made, and only refuses to work when worn out with age; it is equally active in all climates, and will do work of any kind; it is a water-pumper, a miner, a sailor, a cotton-spinner, a weaver, a blacksmith, a miller, &c.; and a steam-engine in the character of a *steam-pony* may be seen dragging after it, on a railroad, a hundred tons of merchandise, or a regiment of soldiers, with greater speed than that of our fleetest coaches. It is the king of machines, and a permanent realisation of the *genii* of Eastern fable whose supernatural powers were occasionally at the command of man."[1]

Steam-Power on Farms.—The steam-engine is becoming daily more useful to the farmer in working his machines. Windmills, and water-wheels scantily supplied with surface-water are being laid aside when worn out, and the steam-engine substituted in their stead. This power, at command at all times, in all seasons, and to any extent, is also employed to cut straw and hay, and bruise corn and cake. The steam-engine is a befitting motive power for the plough; but in the form of a locomotive, it is yet too delicate a machine for all the varieties of ploughing in the different states of the ground incidental to farms. In the locomotive form, it becomes an attendant anywhere on the thrashing-machine.

Hygrometers.—Instruments intended to show the quantity and condition of vapour in the atmosphere are called *hygrometers;* when they merely indicate the presence of aqueous vapour, without measuring its amount, they are called *hygroscopes.*

The measurement of the humidity of the atmosphere by a hygrometer is no better, as a foreteller of humidity, than is the thermometer, which only tells the existing heat.

The *conservatory hygrometer*, fig. 6, is of some use to the farmer in deter-

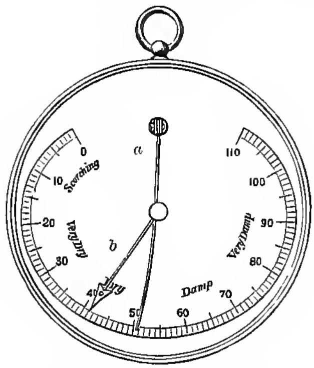


Fig. 6.—*Conservatory Hygrometer.*

mining roughly the wetness or dryness of the atmosphere. The pointer *a* is made of two pieces of wood so glued together that, as the humidity increases, it twists successively through 60°, 70°, 80°, to 100°; and as the dryness increases, it twists back through 40°, 30°, 20°, 10°, to zero. The movable index *b* marks the last observation. A little practice will soon enable the intelligent farmer to assign definite values to the indications of these thermometers and hygrometers, and draw practical conclusions from them. They are of par-

[1] Arnott's *Elem. Phys.*, i. 383—"*Pneu.*"

ticular value when taken in connection with the barometer in predicting the changes of the weather. For a rising barometer with increasing dryness and heat are a pretty good indication of dry weather, and a falling barometer and thermometer with increasing humidity are almost a certain indication of rain.

"Hygrometers were made of quills by Chiminello, which renders it probable that birds are enabled to judge of approaching rain or fair weather. For it is easy to conceive that an animal having a thousand hygrometers intimately connected with its body, must be liable to be powerfully affected, with regard to the tone of its organs, by very slight changes in the dryness or humidity of the air; particularly when it is considered that many of the feathers contain a large quantity of blood, which must be alternately propelled into the system, or withdrawn from it, according to their contraction or dilation by dryness or moisture."[1] May not this strong hygrometric feeling in birds be an exciting influence for their migration?

The vapour issuing from the funnel of a locomotive steam-engine may be regarded as a hygrometer. When the air is saturated with vapour, it cannot absorb the spare steam as it is ejected from the funnel, and hence a long stream of white steam, sometimes 400 yards in length, is seen attached to the train. When the air is very dry, the steam is absorbed as it issues from the funnel, and little of it is seen.

It is the influence of external pressure that keeps the particles of water from being evaporated rapidly into the atmosphere. Even at 32°, the freezing-point, if placed in a vacuum, water will assume the form of vapour, unless constrained by a pressure of 1 ounce on each square inch of surface, and at higher temperatures the restraining force must be greater: at 100° it must be 13 ounces; at 150°, 4 lb.; at 212°, 15 lb.; at 250°, 30 lb. Whenever the restraining force is much weaker than the expansive tendency, the formation of steam takes place so rapidly as to produce the bubbling and agitation called *boiling*.

Boiling-Point.—An atmosphere less heavy than our present one would have allowed water to burst into vapour at a lower temperature than 212°, and one more heavy would have had a contrary effect. Thus, the ebullition of water takes place at a lower temperature the higher we ascend mountains, and at a higher temperature the deeper we descend into mines. The boiling-point may thus be made the measure of altitude of any place above the sea, or of one place above another. Dr Lardner has given a table of the medium temperature at which water boils at different places at various heights above the sea.[2] It appears that, at such an elevation as to cause the barometer to indicate 15 inches of atmospheric pressure, or at half the ordinary pressure of the atmosphere, water will boil at 180°. As a general rule, every tenth of an inch which the barometric column varies between the limits of 26 and 31 inches, the boiling temperature changes by one-sixth of a degree.

Fuel.—The comparative value as *fuel* of different kinds of carbonaceous substances has been found by experiment to be thus:—

1 lb. of charcoal of wood melts	95	lb. of ice.
" good coal	90	"
" coke	84	"
" wood	32	"
" peat	19	"

It is thus seen how valuable good coal, and how very inferior peat is, as a generator of heat—the latter not being much above half the value of wood. Good coal is thus the cheapest kind of fuel where it is abundant.

"It is wasteful to wet fuel, because the moisture, in being evaporated, carries off with it as latent, and therefore useless heat, a considerable proportion of what the combustion produces. It is a very common prejudice, that the wetting of coal, by making it last longer, is effecting a great saving; but while, in truth, it restrains the combustion, and, for a time, makes a bad fire, it also wastes the heat."

"In close fireplaces—viz., those of great boilers, as of steam-engines, &c.

[1] *Edin. Ency.*, art. "*Hygro.*"

[2] Lardner *On Heat*, 413.

—all the air which enters after the furnace-door is shut must pass through the grate and the burning fuel lying on it, and there its oxygen is consumed by the red-hot coal before it ascends to where the smoke is."

"A smoke-consuming fire would be constructed on a perfect principle, in which the fuel was made to burn only at the upper surface of its mass, and so that the pitch and gas disengaged from it, as the heat spread downward, might have to pass through the burning coals where fresh air was mixing with them; thus the gas and smoke, being the most inflammable parts, would burn first and be all consumed."[1] Or the fresh fuel might be introduced at the bottom, and thus the gaseous matter would be consumed while passing through the hot fuel above. When smoke, which is vapour and coal-dust, has accumulated at the throat of the chimney, it cannot thereafter be consumed.

Weather Axioms. — The changes which the atmosphere daily undergoes being necessarily the changes which constitute the weather, renders *meteorology* one of the most important studies that can occupy the attention of the farmer. Who of us does not pride himself on the possession of a few weather axioms, by which we think to foresee the coming changes? Some of these axioms are sound; others are essentially true, but are often misapplied; while a large portion are false. That the latter should be a large class is obvious, because the casual observer is too apt to draw general rules from particular cases, without taking into account all the accidental circumstances that may be present. The only means we possess of eliminating these sources of error, and arriving at the general laws which govern atmospheric phenomena, is a course of faithful and unwearied observation, followed by sound and accurate deduction. The scientific world have been awakened to the importance of this course; and very efficient means are now in progress toward the attainment of the object in view.

Weather and Farm Work.—The weather has the power to modify, if not entirely to alter, the operations of the farm. It may oblige the farmer to pursue a different and much less efficient treatment of the land than he desires, and the amount and quality of its produce may be very seriously affected by such a change of treatment.

Now, when such a change is, and may in any season be, imposed upon the farmer, it is a matter of prudence to become as much acquainted with ordinary atmospherical phenomena as to be able to anticipate the nature of the ensuing weather. As particular changes of weather are forerunners of results, the farmer, by observation, might anticipate them, and arrange his operations accordingly. Shepherds and sailors have long been famed for possessing the faculty of forecasting the weather, and there is nothing to prevent farmers doing the same if they would but bestow their attention on atmospherical phenomena.

Judging Weather. — *Atmospherical phenomena being the great signs by which to judge of the weather,* the barometer and thermometer are instruments which might direct our judgment. If the mercury in the tube of the barometer (fig. 1) be convex, the mercury is on the rise, and indicates fair weather; if concave, the mercury is on the fall, and foul weather may be looked for; and if the rise or fall goes on steadily, the weather indicated may be relied upon. The cause of these forms of the mercury is the friction against the sides of the tube which retards the rise or fall, while the centre of the column is more free to move. A great and sudden fall indicates a storm somewhere in 24 hours. Alternate short elevations and depressions of the mercury indicate unsteady weather. An E. and N.E. wind elevates the mercury, while a W. or S.W. wind depresses it. The extent of range affected by these winds may be from $\frac{2}{10}$ to $\frac{7}{10}$ of an inch. The barometer at sea is a good indicator of wind, but not of rain. No attention should be paid to the words fair, rain, stormy, often marked on the face of the barometer or aneroid; for the condition of the mercury at any particular place is no indication of what it is at any other place situated higher or lower.

[1] Arnott's *Elem. Phys.*, ii. Part I., 149—"*Heat.*"

A rise of temperature indicated by the thermometer tells of a drier state of the air, and a fall is indicative of damp. Observation has established that the hour of the day of minimum temperature is 5 in the morning, and the maximum temperature at 40 minutes past 2 in the afternoon. Also, that there are hours of the day when the mean temperature for the whole year was equal to the mean of the whole 24 hours.

Dew.—Invisible evaporation sends a large quantity of vapour into the lower stratum of the atmosphere, which never ascends so high as to form clouds, but is deposited in *dew*, in drops, upon the points of objects having a rough surface, such as the blades of grass and other suchlike plants.

Dr Wells's theory of dew, therefore, is, "that the cold observed with dew is the previous occurrence, and consequently, that the formation of this fluid has precisely the same immediate cause as the presence of moisture upon the outside of a glass or metallic vessel, where a liquid considerably colder than the air has been poured into it shortly before." As an obvious application of this theory, the experiments of Dr Wells, which led to its establishment, evince, that of all natural substances, grass is peculiarly adapted to the exhibition of dew, inasmuch as it becomes, under ordinary circumstances, colder than the air above it, by the radiation of more heat towards the heavens than it receives in any way; and accordingly, whenever the air is calm and serene, dew may be seen on grass when it may not be observed on other substances.

Hoar-Frost.—*Hoar-frost* or *rime* is just frozen dew. What is a remarkable phenomenon in regard to rime is, that its congeries of crystals differs on different kinds of plants, but the congeries is the same on the same kinds of plants.

Vapour.—At all temperatures, at all seasons, water is converted into *vapour* and carried up into the atmosphere; and when the air has acquired as much as it can unite with at the temperature it then possesses, it is then said to be saturated with vapour. The quantity of vapour attains its *minimum* throughout the year, in the morning before sunrise. At the same time, on account of the low degree of temperature, the humidity is at its *maximum*. In proportion as the sun rises above the horizon, the evaporation increases, and the air receives every moment a greater quantity of vapour. But as the air increases in its capacity for vapour as the temperature rises, it becomes farther and farther removed from the point of saturation, and the relative humidity becomes more and more feeble. The rate continues without interruption until the moment when the temperature attains its *maximum*.

Vapour being thus the result of the action of heat on water, it is evident that its quantity must vary at different hours of the day, in different seasons, in different parts of the globe, and at different heights of the atmosphere. It is supposed that the medium quantity of vapour in the atmosphere is $\frac{1}{70}$ of its bulk.

Moist and Dry Winds.—Daily experience has long taught us that the air is not equally moist with every wind. When the farmer wishes to dry his corn or his hay, or the housewife spreads out her wet linen, their wishes are soon satisfied if the wind blows continuously, but a much longer time is required with a W. wind. Certain operations in dyeing do not succeed unless during E. winds.[1]

Weight of Vapour. — This table gives the weight in grains of a cubic foot of vapour, at different temperatures of 10°, from 0° to 90° Fahrenheit; and clearly shows that the higher the temperature of the air, the greater is the quantity of vapour held in solution in it.

Temperature in degrees.	Weight in grains.	Temperature in degrees.	Weight in grains.
0	0.856	50	4.535
10	1.208	60	6.222
20	1.688	70	8.392
30	2.361	80	11.333
40	3.239	90	15.005

Clouds. — When by any cause the temperature of the air is reduced, its

[1] Kaemtz's *Meteo.*, 88-97.

particles approach nearer each other, and so do those of the vapour held suspended in the air; and as steam becomes visible when mixed with atmospheric air, so vapour becomes visible when it suffers condensation by a reduction of temperature, and then becomes *clouds*. These differ much in altitude and size.

It would appear that their altitude extends from 1300 to 27,000 feet above the sea. That clouds exist at different heights is easily proved while ascending mountains, and when seen to move in opposite directions at the same time.

It is natural to suppose that the lighter clouds—those containing vapour in the most elastic state—should occupy a higher position in the air than the less elastic, and hence only fleecy clouds are seen over the tops of the highest Andes. Clouds, in heavy weather, are seldom more than half a mile above us, but in clear weather from 5 to 6 miles.

Clouds are often of enormous *size*, 10 miles each way, and 2 miles thick, containing 200 cubic miles of vapour; but sometimes they are even ten times that size. The size of small clouds may be easily estimated by observing their shadows on the ground in clear weather in summer. The shadows of larger clouds may be seen resting on the sides of mountain-ranges, or spread out upon the ocean.

Among the objects of nature, there are few more certain premonitors of change in the weather than the clouds, and as such they are worthy of attentive study by the farmer. In a casual glance at the clouds, exhibiting as they seemingly do so great a variety of form, it can scarcely be believed that they all originate from three forms. The three forms are *Cirrus* or curl-cloud, *Cumulus* or heap-cloud, and *Stratus* or lay-cloud. The combinations of these three forms are the *cirro-cumulus*, the heaped curl; the *cirro-stratus*, the lay curl; the *cumulo-stratus*, the heaped layer; and the *cumulo-cirro-stratus*, the heaped-curl-lay-cloud, or *nimbus*, or rain-cloud.

The suspension of clouds in the air is a phenomenon that has not yet been satisfactorily explained; and when we see a cloud pour out thousands of tons of water upon the ground in a small space, we cannot comprehend how it can float in the atmosphere. Condensed vapour — water — cannot float in air, while in the state of vapour it can, being then specifically lighter than air.

Study the Clouds.—It is desirable to impress upon pupils and even upon farmers to devote their attention, when in the open air, to every change in the aspect of the clouds, as they are sure prognosticators of change in the weather. It may be remarked as general prognostics, that when clouds attach themselves to others or to mountain-tops they indicate rain. When they form and soon disappear, fair weather ensues. Ragged edges of clouds indicate a moist state of air; when much ragged, wind may be expected. When the edges are well defined, the air is in a dry state; when they are much rolled up, a discharge of electricity may be looked for. It is unwholesome weather when clouds of all denominations have undefined edges. The *most wholesome weather* is when W. winds and day cumuli prevail — when a stratus evaporates as the sun rises—on the formation of well-defined cumuli throughout the day, most abundant in the afternoon, and disappearing in the evening, succeeded by strong dew. In these circumstances the barometer is always steady, and the thermometer high.

Fog or Mist.—The phenomenon of *fog* or *mist* occurs at all seasons, and it appears always under the peculiar circumstances explained by Sir Humphry Davy. His theory is, that radiation of heat from land and water sends up vapour until it meets with a cold stratum of air, which condenses it in the form of mist, that naturally gravitates towards the surface. When the radiation is weak, the mist seems to lie upon the ground; but when more powerful, the stratum of mist may be seen elevated a few feet above the ground. Mist, too, may be seen to continue longer over the water than the land, owing to the slower radiation of vapour from water; and it is generally seen in the hollowest portions of ground, on account of the cold air, as it descends from the surrounding rising-ground, mixing with the air in the hollow, and diminishing its capacity for moisture.

Mist also varies in its character according to its electric state: if negatively affected, it deposits its vapour more quickly, forming a heavy sort of dew, and wetting everything like rain; but if positively, it continues to exist as dry fog. Thin hazy fogs frequently occur in winter evenings after clear cold weather, and they often become so permanently electric as to resist for days the action of the sun to disperse them.

The prognostic regarding fog is, that if it creep towards the hills it will be rain, but if it goes to the sea it will be fine weather.

Rain.—The life of plants and animals depending as much on moisture as on temperature, and their development being greatly modified by the dryness or humidity of the atmosphere, the cause and effects of *rain* become important objects of study to the agricultural student.

Although the actual quantity of rain that falls in a given part of a country is not an exact measure of the dryness or humidity of its climate, that being chiefly determined by the frequency and not the quantity of rain that falls; still it is interesting to know the quantity of rain that falls in any given locality. The rain that falls is measured by a *rain-gauge.*

Rain-Gauge.—A simple gauge has been proposed, whose measure, if lost or broken, may be easily reproduced. It consists of a simple funnel of metal, *a*, fig. 7, of 4.697 inches diameter, and a fluid ounce measure of metal, *b*. This funnel is fitted into the mouth of a bottle or jar placed in the ground, into which the rain-water falls. For every fluid ounce of the rain-water thus collected one tenth of an inch of rain has fallen. The fluid ounce measure may be graduated with as much niceness as may be desired. This simple rain-gauge will be found to be a convenient and useful one to farmers. Japanned tin remains long free of rust.

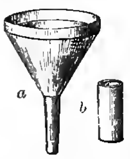


Fig. 7.—*Funnel Rain-Gauge.*

Position of the Rain-Gauge.—A most important point in connection with the rain-gauge is its position. It should never be placed on a slope, nor near the edge of a terrace, but on a level piece of ground at a distance from shrubs, trees, walls, and buildings, at the very least as many feet from their base as they are in height. The rim of the gauge should be perfectly level, even a quarter of an inch from the horizontal producing sensible errors. The rim should be from 3 inches to a foot above the surface of the ground. If it exceeds a foot, the quantity of rain collected will be proportionally diminished. It should be immediately surrounded by old grass kept constantly cropped.

Gauging Snowfalls.—"In cases of snowstorms the rain-gauge may not give a correct quantity, as a part may be blown out, or a greater quantity have fallen than the mouth will contain. In such cases, the method of knowing the quantity of water is, to take any cylindrical vessel and press it perpendicularly into the snow [on the ground], bringing out a cylinder of snow with it equal to the depth; and this, when melted, will give the quantity of water by measurement. The proportion of snow to water is about 17 : 1, and hail to water 8 : 1. These quantities, however, are not constant, but depend upon the circumstances under which the snow or hail has fallen, and the time they have been upon the ground."[1]

Theory of Rain.—The *theory* proposed by Dr Hutton, that rain occurs from the mingling together of great beds of air of unequal temperature differently stored with moisture, is that which was adopted by Dalton, Leslie, and others, and is the current one, having been illustrated and strengthened by the clearer views of the nature of deposition which we now possess, and which teach that as the S. to S.W. winds bring the vapour, so the upward current of the atmosphere carries it to a lower temperature, when an immediate precipitate takes place of the vapour in the form of rain, and especially great upon mountains.

Buchan remarks that whatever tends to lower the temperature of the air is a cause of rain. Various causes, he says, may conspire to effect this, but it is chiefly brought about by the ascent of air into the higher regions of the atmosphere.

[1] *Jour. Agric.*, iii. 13.

On the connection of rain with the *fall of the barometer*, Mr Meikle has shown that the change of pressure may be a cause as well as an effect; for the expansion of air accompanying diminished pressure, being productive of cold, diminishes the elasticity of the existing vapour, and causes a deposition.[1]

Distribution of Rainfall.—Taking a general view of the rain that falls over the globe, it is found that the tropical region is subject chiefly to *periodical rains*—that is, large quantities falling at one time of the year, while at other times none falls for months. In portions of the globe no rain falls at all, and they are, in consequence, called the "rainless districts," which comprehend part of the desert of Sahara and Egypt, part of Arabia, Persia, the desert of Gobi, Thibet, and Mongolia, and part of Mexico and Peru.

On each side of the tropical zone, towards the poles, is the zone of "constant precipitation,"—not that rain constantly falls, but that it may fall in any day of the year, and is always accompanied with electrical explosions. Captain Speke described this zone as containing the most luxuriant vegetation he had seen in Africa.

Amount of Rainfall.—The annual amount of rain that falls in the Old and the New World is as follows:—

The annual amount of rain	
Under the tropics of the New World	115 inches.
" " " Old World	76 "
Within the tropics generally .	95½ "
In the temperate zone of the New World (United States) . .	37 "
Of the Old World (Europe) .	31¾ "

There are general laws which affect the distribution of rain over the globe, and these are—"The amount of rain decreases as we recede from the equator to the poles; thus, while under the tropics the yearly average amount of rain is 95½ inches, in Italy it is less than a half, or 45 inches; in England about one-third, or 30 inches; in the north of Germany, about one-fourth, or 22½ inches; and at St Petersburg, only one-fifth, or 17 inches."

The number of rainy days increases from the equator to the poles; so that, where the most rain falls, there are the fewest rainy days. According to the observation of M. Cotte, the numbers stand thus:—

From N. Lat.		12° to 43°	there are	78	rainy days.
"	"	43° to 46°	"	103	"
"	"	46° to 50°	"	134	"
"	"	50° to 60°	"	161	"

Rainfall in Great Britain.—At places at some distance from hills, and in some inland situations, the annual fall is much diminished. For instance, in the west of Great Britain, away from hills the rainfall is from 30 to 45 inches; while in the east of the island it is only from 20 to 28 inches. In the immediate neighbourhood of high hills in the west of Great Britain and Ireland the fall is as great as from 80 to 150 inches, occasionally even higher. At Seathwaite, in Cumberland, in 1861, it was no less than 183½ inches.

"The amount of rain decreases in the direction from the coasts to the interior of continents, and this is exemplified by the difference between the coasts of the Atlantic Ocean and the countries of Eastern Russia. The western coasts of Great Britain, France, and Portugal have an annual average of from 30 to 35 inches. Bergen, in Norway, has 80, and Coimbra, in Portugal, 111 inches of rain; while in central and eastern Europe, in Bavaria, and through Poland and Russia, it falls to 15 inches. At Iekatrinburg, in the Ural Mountains, it is only 13 inches, and in the interior of Siberia it is still less.

"In both hemispheres, within the temperate zone, the west coasts are proportionally more moist than the east. In this quarter of the globe, it is explained by the prevalence of the W. winds, which, before arriving in Europe, become charged with vapour in passing over the Atlantic Ocean; whilst those which blow from the E. pass over the interior of the continents of Europe and Asia, where the dryness of the air increases rapidly. . . . The determining causes of the distribution of rain in Europe are thus seen to be the predominance of W. winds, with the existence of a vast ocean on one side and a great continent on the other."[2]

[1] *Roy. Inst. Jour.*

[2] Johnston's *Phys. Atlas*—"*Meteo.*"

Weight of Rainfall per Acre.—A statement by the English Registrar-General, written in February 1865, gives the following interesting information in respect to rainfall: "Rain fell in London to the amount of 43 inches, which is equivalent to 4300 tons of rain per acre. The rainfall during last week (Feb. 1865) varied from 30 tons per acre in Edinburgh to 215 tons per acre in Glasgow. An English acre consists of 6,272,640 square inches; and an inch deep of rain on an acre yields 6,272,640 cubic inches of water, which at 277.274 cubic inches to the gallon makes 22,622.5 gallons; and as a gallon of distilled water weighs 10 lb., the rainfall on an acre is 226,225 lb. avoirdupois; but 2240 lb. are a ton, and consequently an inch deep of rain weighs 100.993 tons, or nearly 101 tons per acre. For every 100th of an inch a ton of water falls per acre. If any agriculturist were to try the experiment of distributing artificially that which nature so bountifully supplies, he would soon feel inclined to 'rest and be thankful.'"

Ammonia in Rain.—Foreign matter is brought down from the air, gaseous as well as mineral. "The nitrogen of putrefied animals," says Liebig, "is contained in the atmosphere as ammonia, in the state of a gas, which is capable of entering into combination with carbonic acid, and of forming a volatile salt. Ammonia, in its gaseous form, as well as all its volatile compounds, is of extreme solubility in water. Ammonia, therefore, cannot remain long in the atmosphere, as every shower of rain must effect its condensation, and convey it to the surface of the earth. Hence, also, rain-water must at all times contain ammonia, though not always in equal quantity. It must contain more in summer than in spring or in winter, because the intervals of time between the showers are in summer greater; and when several wet days occur, the rain of the first must contain more of it than that of the second. The rain of a thunderstorm, after a long-protracted drought, ought for this reason to contain the greatest quantity conveyed to the earth at one time.

"As regards the quantity of ammonia thus brought down by the rain,—as 1132 cubic feet of air, saturated with aqueous vapour at 59° Fahrenheit, should yield 1 lb. of rain-water, if the pound contain only one-fourth of a grain of ammonia, a piece ground of 26,910 square feet—43,560 square feet being in an acre—must receive annually upwards of 80 lb. of ammonia, or 65 lb. of nitrogen, which is much more nitrogen than is contained in the form of vegetable albumen and gluten in 2650 lb. of wood, 2500 lb. of hay, or 200 cwt. of beetroot, which are the yearly produce of such a piece of ground; but it is less than the straw, roots, and grain of corn, which might grow on the same surface, would contain."[1]

Prognostics of Rain.—These are regarded as general prognostics of *rain:* When cattle snuff the air and gather together in a corner of the field with their heads to leeward, or take shelter in the sheds—when sheep leave their pastures with reluctance—when goats go to sheltered spots—when asses bray frequently and shake their ears—when dogs lie much about the fireside and appear drowsy—when cats turn their backs to the fire and rub their faces—when pigs cover themselves more than usual in litter—when cocks crow at unusual hours and flap their wings much—when hens chaunt—when ducks and geese are unusually clamorous—when pigeons wash themselves—when peacocks squall loudly from trees—when the guinea-fowl makes an incessant grating noise—when sparrows chirp loudly, and congregate on the ground or in a hedge—when swallows fly low, and skim their wings on water, on account of the flies upon which they feed having descended so low—when the carrion-crow croaks solitarily—when water wild-fowl dip and wash vigorously—when moles throw up hills industriously—when toads creep out in numbers—when frogs croak—when bats squeak and enter houses—when singing-birds take shelter—when the robin approaches near the dwellings of man—when tame swans fly against the wind—when bees leave their hives with caution, and fly only short distances—when ants carry their eggs busily—

[1] Liebig's *Chem. Agric. Physio.*, 3d edition, 43-47.

when flies bite severely, and become troublesome in numbers—when earthworms appear on the surface of the ground and crawl about—and when the larger sorts of snails appear.

A certain prognostic of rain may be obtained from the *aurora borealis.* When a bright aurora occurs in the autumn for the first time, a fall of rain two days after may be expected for three days in succession. The appearance of the aurora is at all times a strong indication of unsettled stormy cold weather for days.

Prevailing Winds.—The comparative prevalence of the E. and W. winds in Great Britain is shown in the following table:—

Years of Observation.	Places.	Wind.	
		Westerly.	Easterly.
10	London	233.0	132.0
7	Lancaster	216.0	149.0
51	Liverpool	190.0	175.0
9	Dumfries	272.5	137.5
10	Branxholm, near Hawick	232.0	133.0
7	Cambuslang	214.0	151.0
8	Hawkhill, near Edinburgh	229.5	135.5
	Mean	220.3	144.7

Variable Winds.—The variations in the intensity and direction of the *wind* are the nearest indices to the change of weather that the agricultural student can study. In the temperate zone, and particularly in this island, flanked as it is with one great ocean, and not far removed from an extensive continent, the variations of the wind are so great, and apparently so capricious, as to baffle minute and correct inquiry; whereas in the tropics, the periodic winds correspond exactly with the uniform course of the seasons, and the limited range of the barometer—phenomena characteristic of that portion of the globe. It is the *variable* winds which stamp the nature of every climate; for although most apparent in their effects in the temperate regions, they nevertheless also exist in the tropics, as may be experienced along every coast and large island in the Indian Ocean. Their course, therefore, depends on causes which act uniformly, notwithstanding their apparent irregularities. They may be all intimately connected with one another, and may probably succeed each other in a certain order, though that connection and that order have not hitherto been ascertained. When both have been discovered, then the course and intensity of the variable winds may be reduced to calculation as certainly as the regular winds are already.[1]

Tides and Winds.—There being an atmospherical wave as well as a tidal, and as any elevation of the atmosphere cannot fail to produce a change in parts immediately below the point of disturbance, there seems no reason to doubt that an *analogy exists betwixt the tides and the winds, and also with rain.*

Prognostications of Wind.—The approach of high *wind* may be anticipated from the general prognostics: When cattle appear frisky, and toss their heads and jump—when sheep leap and play, boxing each other—when pigs squeal, and carry straw in their mouths—when a cat scratches a tree or a post—when geese attempt to fly, or distend and flap their wings—when pigeons clap their wings smartly behind their backs in flying—when crows mount in the air and perform somersets, making at the time a garrulous noise—when swallows fly on one side of trees, because the flies take the leeward side for safety against the wind—when magpies collect in small companies, and set up a chattering noise.

Storm Signals.—These are general indications of a *storm:* When the missel-thrush (*Turdus viscivorus*) sings loud and long, on which account it has received the name of the storm-cock—when sea-gulls come in flocks on land, or make a noise about the coast—when the porpoise (*Phocæna communis*) comes near the shore in numbers—when a great noise comes from the sea.

Foretelling Weather.—Every one is aware of the uncertainty of foretelling the state of the weather, but every one who has attempted to foretell it, and has not succeeded, is not aware of the

[1] Polehampton's *Gall. Nature and Art,* iv. 185.

nature of the many particulars which render his success doubtful. Fortunately for farmers and seamen, Admiral Fitzroy proved that forecasts of the weather may be ventured on, and even depended upon, much beyond what could have been conjectured not many years ago.

SOILS.

The term *soil* does not convey the same meaning to all persons. The geologist does not recognise the term at all —except, perhaps, in common with the botanist and planter, as the mould which supports ordinary vegetation and trees; for "the term rock," as Sir Henry de la Beche said, "is applied by geologists not only to the hard substances to which the name is commonly given, but also to those various sands, gravels, shales, marls, or clays, which form beds, strata, or masses."[1] The common observer considers the ground he treads on as the soil. The farmer strictly confines his definition of a soil to the portion of the ground turned over by the plough.

The leading characters of all soils are derived from only two earths, *clay* and *sand*, the greater or less admixture of which stamps their peculiar character—for the properties of these earths are found to exist in calcareous and vegetable soils.

Clay Soil.—A pure *clay* soil has such distinctive external characters, that it may easily be recognised. When fully wetted, it feels greasy to the foot, which slips upon it. It has an unctuous feel in the hand, by which it can be kneaded into a smooth homogeneous mass, which retains the shape given to it. It glistens in the sunshine. It retains water upon its surface, and renders water very muddy when mixed with it, and the mud is long of settling to the bottom. It feels cold to the touch, and soils everything that touches it. It cuts like soft cheese with the spade. It parts with its moisture slowly. When dry, it cracks into numerous fissures, becomes hard to the foot, and collects into lumps, very difficult to be broken. It absorbs moisture readily, and adheres to the tongue. When neither wet nor dry it is tough, and soon becomes hard with drought or soft with rain. On these accounts it is the most obdurate of all soils to manage, being, even in its best state, heavy to turn over with the plough, and difficult to pulverise with the other implements; and when wet, is in an unfit state to be wrought with any of the implements. A large number of horses is thus required to work a clay farm; and its workable state continues only for a short time, even in the best weather. But it is a powerful soil in its capability, bearing luxuriant crops, and producing them of an excellent quality. It generally occurs in deep masses, on a considerable extent of flat surface, exhibiting few undulations, along the margin of a large river or its estuary, and evidently being a deposition from deep water. It is a naturally fertile soil, containing little vegetable matter, and of a yellowish-grey colour.

Sandy Soil.—A pure *sandy* soil is also easily recognised. When wet it feels firm under foot, and then admits of being turned over by the plough with a pretty entire furrow. It feels harsh and grating to the touch, and will not compress into a ball with the hand. When dry it feels soft, and is so yielding that every object of weight sinks into it, and it is very apt to be blown away with the wind. Sandy soil generally occurs in deep masses, near the termination of the estuaries of large rivers, or along the sea-shore; and in some countries in the interior of Europe, and over a large proportion of Africa, it covers immense tracts of flat land, and has evidently been brought into its place by water.

Soil of Clay and Sand.—When clay is mixed with sand, its texture as a soil

[1] De la Beche's *Man. Geol.*, 35.

is very materially altered, and its productive powers are deteriorated. It is then called *till*. When such a clay is in a wet state, it still slips under the foot, and feels harsh rather than greasy. It does not easily ball in the hand. It retains water on its surface for a time. It renders water very muddy, and soils everything touching it. It has no lustre. When dry it feels hard; and when betwixt the state of wet and dry, is easily reduced to a fine tilth or mould. This kind of soil does not occur in deep masses, is rather shallow, in many instances is not far from the hard rock, nor is it naturally prolific. It occupies by far the larger portion of the surface of Scotland, much of the wheat being grown upon it, and may be characterised as a naturally poor soil, with but little vegetable matter, and of a yellowish-brown colour.

Loamy Soil.—When clay or sand is mixed with a considerable proportion of decomposed vegetable matter, naturally or artificially, the soil becomes a *loam*, the distinguishing character of which is derived from the predominating earth—clay loams and sandy loams. Loam, in modern phraseology, consists of any kind of earth containing a *sensible admixture of decomposed vegetable matter*,—a *sensible* admixture is mentioned, as there is no soil under cultivation, whether composed chiefly of clay or of sand, but contains some decomposed vegetable matter. Unless, therefore, the decomposed vegetable matter of the soil so preponderates as to greatly modify the usual properties of the constituent earths, the soil cannot in truth be called by any other name than a clayey or sandy soil; but when it does so prevail, a *clay loam* or a *sandy loam* is formed—a distinction well known to the farmer. Hence it is possible for husbandry to convert any earthy soil into a loam, as is clearly exemplified in the soil in the vicinity of large towns.

Clayey Loams.—A *clay loam* constitutes a useful and valuable soil. It yields the largest proportion of the finest wheat raised in this country, occupying a larger surface of the country than the carse clay. It forms a lump by the squeeze of the hand, but soon crumbles down again. It is easily wetted on the surface with rain, and then feels soft and greasy; but the water is absorbed, and the surface soon becomes dry. It is easily wrought, and may be so any time after a day or two of dry weather. It becomes finely pulverised; is generally of some depth, forming an excellent soil for wheat, beans, swedes, and red clover; and is of a deep brown colour, often approaching to red.

All clay soils are better adapted to fibrous-rooted plants than to bulbs and tubers, such as wheat, the bean, red clover, and the oak, rather than turnips and potatoes. Its crops, bearing abundance of straw, require a deep hold of the soil. Clay soils are generally slow of bringing their crops to maturity, which in wet seasons they attain imperfectly; but in dry are usually strong, and of superior quantity and quality.

Gravelly Soil.—Sandy soils are divided into two varieties, which do not vary in kind but only in degree. Sand is a powder, consisting of small round particles of siliceous matter; but when these are of the size of a hazel-nut and larger—that is, gravel—they acquire the distinctive name of a *gravelly soil*, which, when mixed with a sensible proportion of vegetable matter, becomes gravelly loam. Gravelly deposits sometimes occupy a large extent of surface, and are of considerable depth. Such a soil never becomes wet, absorbing the rain as fast as it falls, and after rain feels somewhat firm under the foot. It can be easily wrought in any state of weather, and is not unpleasant to work, although the small stones with which it abounds render ploughing rather unsteady. This soil is admirably adapted to plants with bulbs and tubers; and no kind of soil affords so dry and comfortable a lair to sheep on turnips in winter, and on this account it is distinguished as "*turnip soil.*"

Sandy Loams.—*Sandy* and *gravelly loams*, if not the most valuable, are the most useful of all soils. They become neither too wet nor too dry in ordinary seasons, and are capable of growing every species of crop, in every variety of season, to considerable perfection. On this account they are esteemed "*kindly soils.*" They never occur in deep masses, nor do they extend over large tracts of land, being chiefly confined to the margins of small rivers, forming haughs or holms, through which these rivers direct their course from amongst the mountains towards the larger rivers, or even to the sea.

Chalky Soils.—Besides these, there are soils which have for their basis another kind of earth—*lime*, of which the *chalky* soils of the south of England are examples. These differ in agricultural character according to the particular formation in which the chalk is situated. If the chalky soil is derived from flinty chalk, then its character is similar to that of a sandy soil; but if from the hard chalk formation, its character corresponds more nearly to that of clay.

Peaty Soils.—Writers on agriculture also enumerate a *peat* soil, derived from peat; but peat, as crude peat, does not promote vegetation, and when decomposed assumes the properties of *mould*, and should be regarded as such.

Any of the loams which have been long under cultivation, and enriched by putrescent manures, is converted into *mould*, and forms a most valuable soil for every species of crop, as well in the field as in the garden.

Subsoil.—As the soil consists of that portion of the earth's surface which is turned over by the plough, so the ground immediately beneath the plough-furrow is the *subsoil;* and it may consist of the same earthy substance as the soil itself, or it may be of quite an opposite character, or it may consist of hard rock. The subsoil, whatever it may be composed of, exercising a sensible influence on the agriculture of the soil, is a subject of great interest to the farmer, and should be carefully studied by the agricultural student. An endeavour is made to illustrate the varieties by a figure of soils and subsoils. Let *a*, fig. 8, be the surface of the ground, the earthy mould derived from the growth and decay of natural plants; *b*, a dotted line, the depth of the plough-furrow. Now, the plough-sole may either just pass through the mould, *a*, when the mould will be the soil, and the earth below it, *b*, the subsoil; or it may not pass entirely through it, as at *c*, when the soil and subsoil will be both of mould; or it may pass through the earth below the mould, as at *d*, when the soil and subsoil will again be similar, while neither will be mould, but earth; or it may move along the surface of *e*, when the soil will be of one kind of earth, not entirely of mould, and the subsoil of another—of sand, gravel, or clay; or it may penetrate to *f*, when the soil will be of earth, a mixture of clay, sand, and mould, and the subsoil of hard rock. These different cases of soils and subsoils, each forming a distinct sectional division, may so occur in nature, though probably not all in the same locality.

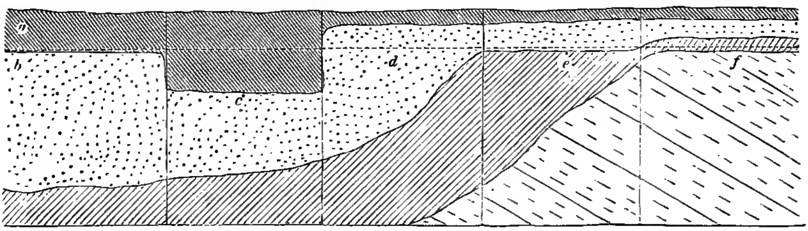


Fig. 8.—*Sections of Soils and Subsoils.*

Influence of Subsoil.—The subsoil undoubtedly *produces a sensible effect on the condition of the soil above it.* If the soil is clay, it is impervious to water, and if the subsoil is clay also, it also is impervious to water. The immediate effect of this juxtaposition of retentiveness is to render both soil and subsoil continually wet, until evaporation dries first the soil and then the subsoil. A retentive subsoil, in like manner, renders even a porous soil above it wet. On the other hand, a gravelly subsoil, which is always porous, greatly assists to keep a retentive clay soil dry. When a porous soil rests upon a porous subsoil, scarcely any degree of humidity can injure either. Rock may be either a retentive or a porous subsoil, according to its structure—a massive structure keeping the soil above it always wet; while a stratified one, with the stratification dipping downwards from the soil (as at *f*, fig. 8), will preserve even a retentive soil above it in a comparatively dry state.

Conditions of Soils.—These are the different *conditions* of *soils* and *subsoils*, considered practically. They have terms expressive of their state, which when spoken of the pupil should keep in remembrance.

Heavy Soil.—A soil is said to be *stiff* or *heavy* when it is difficult to be wrought with the ordinary implements of the farm; and all clay soils are so, and clay loams more or less so.

Light Soil.—On the other hand, soil is *light* or free when it is easy to work; and all sandy and gravelly soils and loams are so.

Dry and Wet Soils.—A soil is said to be *wet* when it is constantly wet; and to be *dry* when as constantly dry. All soils, especially clays, on retentive subsoils, are wet; and on porous subsoils, especially gravel and gravelly loams, dry.

Rich and Poor Soils.—Any soil that cannot bring to maturity a fair crop, without an inordinate quantity of manure, is considered *poor;* and any one that does so naturally, or yields a large return with a moderate quantity of manure, is said to be *rich.* As examples,—thin hard clays and ordinary sands are poor soils; and soft clays and deep loams are rich.

Deep and Thin Soils.—A soil is *deep* when it descends to a depth below the reach of the plough; and a soil is *thin* when the plough easily reaches beyond it; but good husbandry can, by deep digging, render a thin soil deep, and bad husbandry in shallow tillage may cause a deep soil to assume the character of a thin one. A deep soil conveys the idea of a good one, and a thin that of bad. Carse clays and sandy loams are instances of deep soils, and poor clays and poor gravel those of thin.

Hungry Soil.—A soil is said to be *hungry* when it requires frequent applications of manure to bear ordinary crops. A thin poor gravel is an instance of a hungry soil.

Grateful Soil.—A soil is *grateful* when it returns a larger produce than might be expected from what was done for it. All loams, whether clayey, gravelly, or sandy—especially the last two—are grateful soils.

Kindly Soil.—A soil is *kindly* when every operation upon it can be done without doubt, and in the way and at the time desired. A sandy loam and a clay loam, when on porous subsoil, are examples of kindly soils.

Soil becoming Sick.—A soil becomes *sick* when the same crop is made to grow too frequently upon it; thus, soils become sick of growing red clover and turnips.

Sharp Soils.—A *sharp* soil is that which contains such a number of small gritty stones as to clear up the plough-irons quickly. Such a soil never fails to be porous, and is admirably adapted for turnips. A fine gravelly loam is an instance of a sharp soil. Some say that a sharp soil means a *ready* one—that is, quick or prepared to do anything required of it; but this opinion is not quite correct, because a sandy loam is a ready enough soil for any crop, and it cannot be called a sharp soil in any sense.

Deaf or Dead Soil.—A *deaf* soil is contrary to a sharp one—that is, it contains too much inert vegetable matter, in a soft spongy state, apt to be carried forward on the bosom of the plough. A deep black mould, whether derived from peat or plants, is often an example of a deaf soil.

Porous and Retentive Soil.—A *porous* or *open* soil and subsoil are those which allow water to pass through them freely and quickly, of which a gravelly loam and gravelly subsoil are eminent examples. A *retentive* or *close* soil and subsoil retain water on them; and a clay soil upon a clay subsoil is a double instance of retentiveness.

Hard and Soft Soils.—Some soils are always *hard* when dry, let them be ever so well wrought, as in the case of thin retentive clays. Other soils are *soft*, as fine sandy loams, which are very apt to become too soft when too often ploughed or too much shell-marled.

Fine and Coarse Soils.—Some soils are always *fine*, as is the case with deep easy sandy loams. Other soils are always *coarse* and *harsh*, as thin poor clays and gravels. A fine clay becomes *smooth* when in a wet state. A thin clayey gravel is *rough* when dry.

Soil with Fine Skin.—A soil has a *fine skin* when it can be finished off with a beautifully granulated surface. Good culture will bring a fine skin on many soils, and rich sandy and clay loams are naturally so; but no art can give a fine skin to some soils, such as thin hard clay and rough gravel.

Black Soils.—The *colours* of soils and subsoils, though various, are limited in their range. *Black* soils are found on crude peat, and in deep deaf vegetable mould, the carbon of vegetable matter evidently giving origin to the colour. Soils of other colours may be made blacker by the addition of soot, charcoal, and of composts of peat. Oxide of manganese naturally gives a black colour to soils. Very black soils are deaf and inert.

White Soils.—*White* soil is met with in the chalky districts of the south of England. Many sandy soils forming tracts of country, as well as near the sea-shore, are of a yellow-white colour; and so are calcareous sands formed in a great measure of the comminuted shells of crustaceous animals. White soils assume a tinge of brown by the addition of vegetable matter in cultivation. Greyish-white stones and sand indicate the moory origin of the soil in which they occur. Some strong clays are light brownish yellow.

Blue Clay.—Fine clay, originating in the bottom of basins of still water, has frequently a *blue* colour, which changes to dark brown or brownish-black on cultivation and exposure to the air, and forms a useful soil for wheat, swedes, and mangel-wurzel.

Red Soils.—Soils are not unfrequently of a *red* colour, derived most probably from an oxide of iron; and this colour is a favourable indication of the good quality of the soil or subsoil, whether of a heavy or light texture. In East Lothian and the cider district of Herefordshire, examples of red soil may be found.

Brown Soils.—But the most common colour presented by soils is *brown*, and the tint most desired is the brown of the hazel-nut, and on that account is named a hazel soil. This colour is most probably derived from oxide of iron existing in the soil, and is rendered darker by the addition of vegetable manure, used in cultivation, to hair and dark chestnut brown. Sharp, grateful, and kindly soils are always of a brown colour. Sand and gravel loams are usually of this colour.

Colour of Subsoils.—The *colour* of *subsoils* is less uniform than that of soils, owing, no doubt, to their exclusion from direct culture and air. Some subsoils are very particoloured, and the more so, and the brighter the colours they sport, are the more injurious to the soils resting upon them—such as light blue, green, bright red, bright yellow, and white. Dull red and chestnut brown subsoils are good; but the nearer they approach to hazel brown the better. Dull browns, reds, and yellowish greys are permanent colours, and are little altered by cultivation; but blues, greens, bright reds, and yellows, become darker and duller by exposure to the air, and admixture with manures and the surface soil.

Influence of Colour in Soils.—The colours of soil have a considerable influence in regulating the quantities of heat absorbed by soils from the sun's rays. The darker-coloured, such as black, brown, and dark reds, absorb more heat than greys and yellows; and all dark-coloured soils reflect least, whilst light-coloured most rays of light. According to Schübler, while the thermometer was 77° in the shade in August, sand of a natural colour indicated a temperature of 112½°, black sand, 123½°, and white sand 110°, exhibiting a difference of 13° in favour of the black colour. The highest temperature attained by the soil was observed by Schübler on 16th June 1828, in a fine day, calm, with the air from the west, at 153½° in the sun, that in the shade being 78°.

Colour has also an influence in *retaining heat* acquired by soils from the sun, dark-coloured radiating their heat more quickly in the absence of the sun's rays than light-coloured; and colour, together with dryness, has a greater influence in warming the soil than that of the various materials composing it. Thus sand will cool more slowly than clay, and clay than a soil containing much humus. According to Schübler, a peat soil will cool as much in 1 hour 43 minutes as a pure clay in 2 hours 10 minutes, and as a sand in 3 hours 30 minutes. The practical effect of this difference is, that while the sand will retain its heat for three hours after the sun has gone down, and the clay two hours, the vegetable soil will only retain it for one hour; but then the vegetable soil will all the sooner begin to absorb the dew that falls, and in a dry season it may in consequence sustain its crops in a healthy state of vegetation, while those in the sandy soil may be languishing for want of moisture.

Temperature of Soils.—It is a fact well known to farmers, that the soil becomes much more heated when exposed to the rays of the sun in a perpendicular than in a sloping direction. "If the actual increase of temperature," says Schübler, "produced by the perpendicular rays of the sun beyond the temperature in the shade be between 45° and 63°, as is often the case in clear summer days, this increase would only be half as great if the same light spread itself in a more slanting direction, over a surface twice as large. Hence it is sufficiently explained why, even in our own climate, the heat so frequently increases on the slopes of mountains and rocks which have an inclination towards the south. When the sun is at an elevation of 60° above the horizon, as is more or less the case toward noon in the middle of summer, the sun's rays fall on the slopes of mountains, which are raised to an inclination of 30° to the horizon, at a right angle; but even in the latter months of summer the sun's rays frequently fall on them at a right angle, in cases where the slopes are yet sharper." Where the exposure and aspect of the soil are most favourably situated for absorbing the sun's rays, the light-coloured will derive more benefit than the dark in a less favourable position.

If we compare in the earths their power of retaining heat with their other physical properties, we shall find it to be nearly in proportion to their specific gravities. We may therefore conclude from this, with a tolerable degree of probability, as to the greater or less power of retaining heat.

Heat in Soils.—Heat renders all sorts of soil dry by evaporating the moisture out of them; and so great an effect has heat on peat and strong clay in a course of dry weather, that they *shrink* one-fifth of their bulk. Thus, according to Schübler, in 100 parts the following soils shrank in these proportions:—

Siliceous sand	no change.
Sandy clay	6.0 parts.
Loamy clay	8.9 "
Brick clay	11.4 "
Grey pure clay	18.3 "
Garden mould	14.9 "
Arable soil	12.0 "
Humus	20.0 "

The consistency of a soil, and its tendency to shrink, exert a greater influence in deep than shallow soils.

Heat in Soils influenced by Moisture.—The influence of a damp or dry state of soils, on their acquisition of *warmth*, is also considerable. As long as they remain moist, the depression of temperature, arising from evaporation of water, amounts to 11¼° to 13½° Fahrenheit; and in this state they exhibit but little difference in the power of acquiring heat, as they give off to the air, in this state of saturation with water, nearly equal quantities of vapour in the same time. When they have become a little dried, it is found that light-coloured earths, with great powers of containing water, acquire heat most slowly; while dark-coloured, with less power of containing water, become warm quicker and hotter.

Absorbing Power of Soils.—Excepting siliceous sand, all kinds of soil have the property of *absorbing moisture* from the atmosphere; and the absorption is greatest in clay soils, especially when they contain humus. Humus shows the greatest power of absorption. The absorption by all soils is greatest at first, and they absorb less the more gradually they become saturated with moisture, and attain that point in a few days. If exposed to the sunlight, a portion of the absorbed moisture becomes again vaporised, and this is again absorbed during the night. These daily periodic changes in respect to moisture must have a beneficial effect on vegetation. Schübler has given the following table of the relative absorbing powers of soils:—

Kinds of earth.	1000 grains of earth on a surface of 50 square inches absorbed in			
	12 hours.	24 hours.	48 hours.	72 hours.
Siliceous sand	0	0	0	0
Sandy clay .	21	26	28	28
Loamy clay .	25	30	34	32
Brick clay .	30	36	40	41
Grey pure clay	37	42	48	49
Garden mould	35	45	50	52
Arable soil .	16	22	23	23
Humus . .	80	97	110	120

Soils' Capacity for containing Water.—Different soils have different capacities for containing *water* to *saturation.* Schübler gives this table of differences:—

	Per cubic foot. lb.
Siliceous sand . .	27.3
Sandy clay . .	38.8
Loamy clay . .	41.4
Brick clay . .	45.4
Pure grey clay .	48.3
Garden mould . .	48.4
Arable soil . .	40.8
Humus . . .	50.1

Sands have the smallest power of containing water, whether compared in weight or volume with other earths; and siliceous sand has the least power of all. These differ according to the different fineness of their grains; the power of the large-grained becomes diminished down to 20 per cent, while it amounts to 40 per cent when the particles are very fine. Humus has usually the greatest power of containing water to saturation of all ingredients of soil, and especially when the humic acid is still mixed with a large proportion of half-decomposed organic matters, as remains of wood, leaves, roots, &c. Where we meet with water-holding power exceeding 90, we may reckon on an abundant admixture of organic matter.

Retentive Power of Soils.—So, in like manner, different soils have different powers of *retaining* the *moisture* they have absorbed to saturation until they become dry, and this power increases with the depth of soils. Schübler has given this table on the subject:—

Kinds of earth.	Water evaporated in 4 days.	Containing power of water of the earths.
	Grains.	Per cent.
Calcareous sand . .	146	29
Light garden mould	143	89
Very light turf soil	132	366
Black turf soil not so light	128	179
Arable soil . .	131	60
White fine clay .	123	70
Grey fine clay . .	123	87

Hence the difference in degree of looseness or consistency of the ground has a considerable influence on drying deep soils. Garden mould, notwithstanding its great power of containing water, in which it stands near to pure clay (292), gave off to the air far more moisture, in the same time, than clay. Turf soils, though high in containing water, also became dry again at a quicker rate than clay. Fine grey clays, after 14 days, exhibited still a damp surface, while the surfaces of turf soils were perfectly dry many days earlier.

Soils absorbing Oxygen from the Air.—Another important physical property of soils is their power to *absorb oxygen* from the atmospheric air. Schübler's experiments on this subject afforded these results:—

Grains.				Cubic inches.	
1000	Siliceous sand, in a wet state, absorbed	.	.	0.24	From 15 cubic inches of atmospheric air containing 21 per cent of oxygen.
"	Sandy clay	"	"	1.39	
"	Loamy clay	"	"	1.65	
"	Brick clay	"	"	2.04	
"	Grey pure clay	"	"	2.29	
"	Garden mould	"	"	2.60	
"	Arable soil	"	"	2.43	
"	Humus	"	"	3.04	

All earths lose, in drying, the property of absorbing oxygen from the air, but regain it in the same proportion as before on being moistened. If covered with water, the absorption takes place in the same manner. Water alone, however, in the same quantity, absorbs only a small portion per cent—a clear proof that it is the earths themselves which induce this process in a greater proportion.

Humus, of all the earths, exhibits the greatest degree of absorption of oxygen; the clays approach nearly to it, the sands the least. The included air standing over it becomes at last so poor in oxygen that lights would become extinguished and animals die in it. In this mode of absorption there is an essential difference between humus and the inorganic earths. Humus combines partly with the oxygen, in a strictly chemical sense, and assumes a state of higher oxygenation, in consequence of which there is formed also more carbonic acid.

The inorganic earths, on the other hand, absorb the oxygen without intimate combination.

In the case of earths which are frozen or covered with a surface of ice, no absorption of oxygen takes place, any more than in the case of dry earths.

In a moderately warm temperature, between 59° and 66° Fahrenheit, the earths absorb, in a given time, more oxygen than in a temperature only a few degrees above the freezing-point.

Physical Properties of Soils.—M. Schübler thus recapitulates the *physical properties* of soils: "The more an earth weighs, the greater also is its power of retaining heat; the darker its colour and the smaller its power of containing water, the more quickly and strongly will it be heated by the sun's rays; the greater its power of containing water, the more has it in general the power also of absorbing moisture when in a dry, and oxygen when in a damp state, from the atmosphere, and the slower it usually is to become dry, especially when endued with a high degree of consistency; lastly, the greater the power of containing water, and the greater the consistency of a soil, the colder and wetter, of course, will that soil be, as well as the stiffer to work, either in a wet or dry state."[1] The physical changes effected in soils by the atmosphere are:—

Pulverisation and expansion after frost.

Caking after rain.

Compression when filled with moisture.

Cracking in drought.

[1] *Jour. Roy. Agric. Soc. Eng.*, i. 177-212.

DISCRIMINATING SOILS BY THE PLANTS THEY PRODUCE.

There is another method by which the physical characters of soils and subsoils, such as have been explained, may be discriminated—namely, by the *plants which grow upon them.* This test, however, cannot be relied on so confidently as the chemical composition, or the external characters given above, for distinguishing soils.

Notwithstanding the difficulties attending the discrimination of soils by plants, it is an undoubted fact that plants do affect certain soils, as also certain conditions of the same soil. Such plants are limited in number, and may therefore be easily remembered. Only such as have come under our own observation need be enumerated—separating those which grow upon the soil, in a state of nature, from those which make their appearance after the land is in cultivation.

Weeds. — Every plant—other than that which it is intended to grow—found among cultivated corn, green crops, and sown grasses, is a *weed.*

On good *clay* soils, in a state of nature, in the low country, these herbaceous plants will be found—

Spiræa Ulmaria . .	Queen of the meadow.
Angelica sylvestris . .	Wild angelica.
Ranunculus Lingua .	Great spearwort.
Rumex Acetosa . .	Common sorrel.

After such soils are in cultivation, these *weeds* appear, which have been sown either with corn, grass seeds, or carried by the wind, or amongst the dung—

Rumex obtusifolius .	Common broad-leaved dock.
Senecio vulgaris .	Groundsel.
Lapsana communis .	Nipple-wort.
Agrostemma Githago .	Corn-cockle or popple.
Matricaria Chamomilla .	Wild chamomile.
Sonchus oleraceus . .	Common sow-thistle.

Thin clays, in their natural state in the low country, yield the following plants—

Ranunculus acris .	Bitter crowfoot, butter-cup.
Aira cæspitosa .	Tufted hair-grass.
Equisetum arvense .	Corn horse-tail.
Stachys palustris . .	Marsh woundwort.

Thin clays become clay loams under cultivation, and then yield these *weeds*—

Tussilago Farfara . .	Common colt's-foot.
Sinapis arvensis .	Wild mustard, charlock.
Polygonum Aviculare .	Knot-grass.

On deep strong clayey loam, on a porous subsoil, in a state of nature, in the low country, these plants are found—

Silene inflata . . .	Bladder campion.
Linaria vulgaris . .	Toad-flax.
Scabiosa arvensis . .	Field scabious.
Centaurea Scabiosa . .	Great knapweed.
Polygonum amphibium .	Redshank.
Dactylis glomerata . .	Rough cock's-foot grass.

On thin strong clayey loam, on a porous subsoil, in a state of nature, in the low country, these plants are found—

Ononis arvensis . .	Common rest-harrow.
Trifolium arvense . .	Hare's-foot trefoil.
——— *procumbens* . .	Hop trefoil.

After cultivation, both deep and thin clay loams, on a porous subsoil, in the low country, yield these *weeds*—

Anagallis arvensis . .	Scarlet pimpernel.
Veronica hederifolia .	Ivy-leaved speedwell.
Sinapis nigra . . .	Black mustard.
Vicia hirsuta . . .	Hairy tare, or fetter.

Plants peculiar to *sandy* soils, in a state of nature, in the low country are—

Lotus corniculatus . .	Bird's-foot trefoil.
Campanula rotundifolia .	Common bluebell.
Euphrasia officinalis .	Eyebright.
Anthoxanthum odoratum	Sweet-scented vernal grass.

After cultivation, these *weeds* appear—

Spergula arvensis . .	Common spurry.
Lamium purpureum .	Purple dead-nettle.
Fumaria officinalis .	Common fumitory.
Capsella bursa-pastoris .	Shepherd's-purse.
Scleranthus annuus .	Common knawel.
Gnaphalium germanicum	Common cudweed.
Triticum repens . .	Common couch-grass.

Upon sandy loam on clay subsoil, in a state of nature, in the low country, are these plants—

Juncus effusus . . .	Common or soft rush.
Achillea Ptarmica . .	Sneezewort.
Potentilla anserina .	Goose-tongue or silver-weed.
Artemisia vulgaris . .	Mugwort.

After cultivation, these *weeds* appear—

Raphanus raphanistrum	Wild radish or "runch."
Rumex Acetosella . .	Sheep's sorrel.
Chrysanthemum segetum .	Corn marigold.
Juncus bufonius . .	Toad-rush.

Sandy loam, upon a porous subsoil, in a state of nature, in the low country, yields these plants—

Cytisus scoparius . .	Common broom.
Centaurea nigra . .	Black knapweed.
Galium verum . . .	Yellow bed-straw.
Senecio Jacobæa . .	Common ragweed.

When cultivated, the soil yields these *weeds*—

Mentha arvensis . .	Common corn-mint.
Centaurea Cyanus . .	Corn blue-bottle.
Sherardia arvensis . .	Field madder.
Lithospermum arvense .	Corn gromwell.
Alchemilla arvensis . .	Parsley-pier.
Avena elatior . . .	Tall oat-grass.
Cnicus arvensis . .	Corn-thistle.

Alluvial deposits, in a state of nature, in the low country, yield a vegetation indicative of wet clay soil and subsoil—

Arundo Phragmites .	Common reed.
Juncus conglomeratus .	Round-headed rush.
Agrostis alba . . .	Marsh bent-grass.
Glyceria aquatica . .	Reed meadow-grass.
——— *fluitans* .	Floating meadow-grass.

These plants disappear on cultivation, except the common reed, which keeps possession of the soil for an indefinite time amidst the best cultivation. Where such soil is indifferently cultivated, the corn-thistle, *Cnicus arvensis*, is a very troublesome *weed*.

Besides these soils, there are others in the low country which cannot be rendered arable, but form the sites of numerous plants, which find their way into the adjoining arable soils. From the sea-beach, gravel-pits, and sandy downs, plants stray by the assistance of the wind upon any kind of arable soil in their respective neighbourhoods.

On *gravel*, as found in the *débris* of mountains, occasioned by the disintegration of indurated rocks, the vegetation is different from that of the beaches, and is the same as the alpine plants of the district. In gravel in the low country these plants are found—

Polygonum Aviculare .	Knot-grass.
Rumex Acetosella . .	Sheep's sorrel.
Agrostis vulgaris . .	Common bent-grass.
Aira caryophyllea . .	Silver hair-grass.
Festuca duriuscula . .	Hard fescue-grass.
Arenaria serpyllifolia .	Thyme-leaved sandwort.
Hieracium murorum .	Wall hawkweed.
Papaver dubium . .	Long smooth-headed poppy.
——— *Rhœas* . . .	Common scarlet poppy.
Polygonum Convolvulus	Climbing buckwheat.
Chenopodium urbicum .	Upright goose-foot.
Lolium perenne . .	Perennial ryegrass.
Bromus mollis . .	Soft brome-grass.

Gravel on the sides of rivers producing these plants, indicates a wet subsoil—

Juncus bufonius . .	Toad-rush.
——— *acutiflorus* . .	Sharp-flowered rush.
Littorella lacustris . .	Plantain shore-weed.

Drifting sands, links, or *downs,* have this peculiar vegetation—

Elymus arenarius	Sea lyme-grass.
Triticum junceum	Sand wheat-grass.
Festuca duriuscula	Hard fescue-grass.
Carex arenaria	Sand carex.
Galium verum	Yellow bed-straw.

The vegetation of *moory* ground only a little elevated, varies according to the wetness or dryness of the subsoil. Wet moors are characterised by these plants—

Salix repens	Dwarf silky willow.
Pinguicula vulgaris	Butterwort.
Carex pitulifera	Round-fruited carex.
Juncus squarrosus	Moss-rush.
Parnassia palustris	Grass of Parnassus.

On dry moors, containing a proportion of peat-earth, and resting on a porous subsoil, these plants are found—

Genista anglica	Needls green-weed.
Nardus stricta	Mat-grass.
Viola lutea	Yellow mountain-violet.
Potentilla tormentilla	Common tormentil.
Gnaphalium dioicum	Mountain cudweed.

Marshes in the interior of the country produce these plants—

Lychnis Flos-cuculi	Ragged robbin.
Menyanthes trifoliata	Fringed buck-bean.
Caltha palustris	Marsh marigold.
Veronica Beccabunga	Brook-lime.
Comarum palustre	Marsh cinquefoil.
Galium uliginosum	Marsh bed-straw.

After marshy ground has been cultivated, these *weeds* retain a strong hold—

Tussilago Farfara	Common colt's-foot.
Petasites vulgaris	Common butter-bur.
Galium Aparine	Goose-grass.

On *peat* or *moss* the vegetation differs as it is wet or dry. On dry spots these plants are found—

Erica tetralix	Cross-leaved heath.
Calluna vulgaris	Common ling.
Agrostis canina	Dog bent-grass.

In wet hollows in peat these plants establish themselves—

Eriophorum polystachion	Cotton-grass or sedge.
Vaccinium Oxycoccos	Cranberry.

Cultivated peat is infested with these *weeds*—

Bromus mollis	Soft brome-grass.
Myosotis arvensis	Field scorpion-grass.
Avena fatua	Wild oats.
Galium Aparine	Goose-grass.

On *mountain pastures* plants are numerous. At moderate heights these prevail—

Calluna vulgaris	Common ling.
Dryas octopetala	Mountain avens.
Salix reticulata	Reticulated willow.
Gnaphalium alpinum	Mountain cudweed.
Rubus Chamæmorus	Cloud-berry.
Arbutus Uva-ursi	Common bear-berry.[1]

In very elevated mountain pastures these plants are found on peaty soil—

Calluna vulgaris	Common ling.
Empetrum nigrum	Crowberry.
Erica tetralix	Cross-leaved heath.
Lycopodium clavatum / ——— *alpinum*	Club-moss.
Juncus squarrosus	Moss-rush.
Equisetum palustre	Paddock-pipe.
Scirpus cæspitosus	Deer-hair.
Narthecium ossifragum	Bog asphodel.
Melica cærulea / *Sesleria cærulea*	Fly-bent, rot-grass, or blue moor-grass.
Nardus stricta	Wire-bent or mat-grass.

In wet mossy places these thrive—

Juncus effusus	Soft rush.
Holcus lanatus	Yorkshire fog.
Carex cæspitosa	Risp.
Juncus acutiflorus	Sprat.
Carex panicea	Pry.
Scabiosa succisa	Devil's-bit scabious.
Hypnum palustre	Marsh-fog.[2]

Professor Macgillivray truly remarked, that "no soil that we have examined has been found to produce plants peculiar to itself, excepting *sand* and *peat;* and these two soils, so different from each other in their mechanical and chemical nature, also form a striking contrast in respect to the plants growing upon them, each being characterised by a vegetation differing in aspect and qualities from each other, and scarcely agreeing in any one circumstance." The existence of peat is invariably indicated by *Calluna vulgaris*, common ling,—*Erica cinerea*, fine-leaved heath,—and *Erica tetralix*, cross-leaved heath; and loose sand is as invariably covered with *Psamma arenaria*, sand-reed, most frequently accompanied by *Triticum junceum*, sand wheat-grass, and *Galium verum*, yellow bed-straw.

In as far, then, as the arable soils are concerned, the information imparted by their *weeds* possesses greater interest to the farmer than their natural vegetation; and they give a truer account of the state of the soils at the time than of their nature, although this even is not overlooked. For example, *clayey* soils are indicated by the existence of the *grasses*, and of these the genera of *Poa*, *Agrostis*, and *Festuca* prevail.

Gravelly soils are indicated by *Aira caryophyllea*, silvery hair-grass; *Aira præcox*, early hair-grass; and *Rumex Acetosella*, sheep's sorrel. When intermixed with a little clay, the grasses also appear.

[1] *Trans. High. Agric. Soc.*, vii. 123.

[2] *Ibid.*, vii. 281.

Good *vegetable* soil is indicated by *Trifolia*, *Viciæ*, and *Lathyrus pratensis*. *Thymus Serpyllum*, wild thyme, indicates a thin vegetable mould; and ragweed, *Senecio Jacobæa*, one of depth. Where ragweed prevails, sheep are absent, as they fondly eat down its young leaves.

Purge-flax, *Linum catharticum;* autumn hawkbit, *Leontodon autumnalis;* and mouse-eared hawk-weed, *Hieracium pilosella*, indicate a dry soil;—the *Galium verum*, yellow bed-straw, one very dry.

Yellow iris, *Iris pseud-acorus;* the sharp-flowered rush, *Juncus acutiflorus;* lady's smock or cuckoo-flower, *Cardamine pratensis;* and ragged robin, *Lychnis Flos-cuculi;* the purple dead-nettle, *Lamium purpureum;* and smooth naked horse-tail, *Equisetum limosum*, assure us of a supply of moisture below.

The broom, *Cytisus scoparius*, indicates a pernicious, and the whin, furze, or gorse, *Ulex europæus*, a favourable subsoil.

The common nettle, *Urtica dioica;* common dock, *Rumex obtusifolius;* mugwort, *Artemisia vulgaris;* annual poa, *Poa annua;* field poa, *Poa pratensis;* and common tansy, *Tanacetum vulgare*, grow near the dwellings of man; while white clover, *Trifolium repens;* red clover, *Trifolium pratense;* annual poa, *Poa annua;* hoary plantain, *Plantago media;* ribwort or ribgrass, *Plantago lanceolata;* purple meadow-vetch, *Vicia Cracca;* and common daisy, *Bellis perennis*, are found in the pasture around his house.

Common chickweed, *Stellaria media;* and common fumitory, *Fumaria officinalis*, indicate a rich condition of soil.

The great ox-eye, *Chrysanthemum Leucanthemum*, points out a soil in a state of poverty; and its poverty from want of manure is indicated by the parsley-pest, *Alchemilla arvensis*.

Wild mustard or charlock, *Sinapis arvensis*, tells of manure having been derived from towns.

The common corn-thistle, *Cnicus arvensis*, is a tell-tale that the land is not well farmed.

Wherever there is the least admixture of peat, the *Erica* or *Calluna* and spotted-bearded orchis, *Orchis maculata*, are sure to be there.

General View of the Relation of Plants to Soils.—Taking a more extended view of the indications of the condition of soils by plants, the observations of Dr Singer are graphic: "*Green* mountains, like those of Cheviot and Ettric Forest, abounding in grass without heath, indicate a strong soil, which is rendered productive, though frequently steep and elevated, by a retentive subsoil. This quality, and the frequent mists and showers that visit rather elevated sheep-walks, render them productive in strong grasses (*Agrostis*). . . . *Dark* mountains, clothed with a mixture of heath and grass, indicate a drier soil on a less retentive bottom. Such are many of the Highland mountains, and such also are some of those which appear occasionally among the green mountains of the southern pastoral district, in which the light soil is incumbent commonly on gravel or porous rock. On these dark-coloured mountains, a green and *grassy* part often appears where there is no heath, and the subsoil is retentive; and if the upper edge of such a spot appears well defined, this is occasioned by the regular approach of a stratum of clay or other substance impervious to water towards the surface, and the green hue disappears below, when the subsoil again becomes open. . . . On any of the mountains, whether dark or green, when the fern or bracken, *Pteris aquilina*, appears in quantities, it indicates a deep soil and a dry subsoil."[1]

A stunted growth of heath indicates a part having been bared by the paring-spade; and when vegetation becomes of a brown colour in summer, the subjacent rock is only a little way under the surface.

Viewing the connection of plants to the soil on the great scale, one cannot but be forcibly impressed with the conviction that "the grand principle of vegetation is simple in its design; but view it in detail, and its complication astonishes and bewilders." And yet, as Professor Macgillivray justly observed, "it is the same sun that calls forth, and, thus elicited, gives vigour to the vegetation, the same earth that supports it, the

[1] *Trans. High. Agric. Soc.*, vii. 264.

same moisture that swells its vessels, the same air that furnishes the medium in which it lives; but amid all these systems of general, how multiple the variations of particular constituent causes, and how infinitely diversified the results!"

Agricultural Botany.—The relation of the study of plants to agriculture is this: "It is a fact familiarly known to all, in addition to those circumstances by which we can perceive the special functions of any one organ to be modified, there are many by which the entire economy of the plant is materially and simultaneously affected. On this fact the practice of agriculture is founded, and the various processes adopted by the practical farmer are only so many modes by which he hopes to influence and promote the growth of the whole plant, and the discharge of the functions of all its parts. Though the manures in the soil act immediately through the roots, they stimulate the growth of the entire plant; and though the application of a top-dressing to a crop of young corn or grass may be supposed first to affect the leaf, yet the beneficial result of the experiment depends upon the influence which the application may exercise on any part of the vegetable tissue." [1]

Distribution of Plants. — A knowledge of the geographical distribution of plants is a subject of interest to the farmer, as it may be useful by affording him the means of judging whether new plants, recommended for cultivation in this country, will be suitable to the soil of his own farm situate in a certain latitude and elevation above the sea.

"It is the influence of temperature which is the chief cause of the distribution of plants, and on this account the face of the globe has been divided into eight zones, called the isothermal zones, each of which is distinguished by a peculiar vegetation."

"As the physiognomy of the vegetable kingdom is characterised by certain plants in the different latitudinal zones from the equator to the poles, so also, in a perpendicular direction, in the mountain regions which correspond with the zones. Proceeding with the vegetation of the equatorial zone, we follow the series of vegetable regions in ascending lines, one after the other, and may compare them with the different zones as follows:—

1.	The region of palms and bananas—equatorial zone	—equator to lat. 15°—from max. temp. to 78°.
2.	" " trees, ferns, and figs—tropical zone .	lat. 15° to lat. 25°—mean temp. from 78° to 73°.
3.	" " myrtles and laurels—sub-tropical zone	" 25° " 34° " " 73° " 62°.
4.	" " evergreens—warm temperate zone .	" 34° " 45° " " 62° " 53°.
5.	" " European trees—cold temperate zone	" 45° " 58° " " 53° " 42°.
6.	" " pines—sub-arctic zone	" 58° " 67° " " 42° " 39°.
7.	" " rhododendrons—arctic zone . .	" 67° " 72° " " 32° " 28°.
8.	" " alpine plants—polar zone .	" 72° " 90° " " 16° " 1°."[2]

STRUCTURE AND COMPOSITION OF SOILS.

It is time to take a closer view of soils, their structure and composition. The structure is mechanical, the composition chemical. Their *mechanical structure* is thus described by Dr Henry Madden: "Soil, considered scientifically, may be described to be essentially a mixture of an impalpable powder with a greater or smaller quantity of visible particles of all sizes and shapes. Careful examination will prove to us, that although the visible particles have several *indirect* effects, of so great importance that they are absolutely necessary to soil, still the impalpable powder is the only portion which *directly* exerts any influence upon vegetation.

Inorganic and Organic Matter in Soils.—This impalpable powder consists of two distinct classes of substances—viz., *inorganic* or *mineral* matters, and *organic*, *animal*, and *vegetable* substances, in all the various stages of decomposition. The greater the proportion of the impalpable matter, the greater, *cæteris paribus*, will be the fertility of the soil.

Stones afford renewed Supplies of Mineral Matter. — "The *stones* which we meet with in soil have in general the same composition as the soil itself, and hence, by gradually crumbling down under the action of air and moisture,

[1] Johnston's *Lec. Agric. Chem.*, 2d ed., 159.
[2] Johnston's *Phys. Atl.*—"*Bot. Geog.*"

they are continually adding new impalpable matter to the soil, and as a large quantity of this impalpable mineral matter is annually removed by the crops, it will at once be perceived that this constant addition must be of great value to the soil. This, therefore, is one important function performed by the stones of the soil—viz., their affording a continually renewed supply of impalpable mineral matter."

Capillary Action of Soils.—On one important character of the mechanical property of soil—its capillary power and mode of action—Professor Johnston observed: "When warm weather comes, and the surface soil dries rapidly, then by capillary action the water rises from beneath, bringing with it the soluble substances that exist in the subsoil through which it ascends, for water is never pure. Successive portions of the water evaporate from the surface, leaving their saline matter behind them. And as the ascent and evaporation go on as long as the dry weather continues, the saline matter accumulates about the roots of plants, so as to put within their reach an ample supply of any soluble substance which is really not defective in the soil. I believe that in sandy soils, and generally in all light soils, of which the particles are very fine, this capillary action is of great importance, and is intimately connected with their power of producing remunerating crops. They absorb the falling rains with great rapidity, and these carry down the soluble matters as they descend, so that when the soil becomes soaked, and the water begins to flow over its surface, the saline matter, being already deep, is in little danger of being washed away. On the return of dry weather, the water reascends from beneath, and again diffuses the soluble ingredients through the upper soil." [1]

Chemical Composition of Soils.—"Hitherto," Dr Madden continues, "I have pointed out merely the mechanical relations of the various constituents of soil, with but little reference to their *chemical* constitution: this branch of the subject, although by far the most important and interesting, is nevertheless so difficult and complex that I cannot hope for the practical farmer doing much more than making himself familiar with the *names* of the various chemical ingredients, learning their relative value as respects the fertility of the soil, and acquiring a knowledge of the quantities of each requisite to be applied to particular crops; for as to his attempting to prove their existence in his own soil by analysis, I fear that it is far too difficult a subject for him to grapple with, unless regularly educated as an analytical chemist.

Twelve Substances in Soils. — "Soil, to be useful to the British agriculturist, must contain no less than 12 different chemical substances—viz., silica, alumina, oxide of iron, oxide of manganese, lime, magnesia, potash, soda, phosphoric acid, sulphuric acid, chlorine, and organic matter. I shall confine my observations solely to their relative importance to plants, and their amount in the soil.

Silica in Soils.—"*Silica* is the pure matter of sand, and also constitutes on an average about 69 per cent of the various clays, so that in soil it generally amounts to from 75 to 95 per cent. In its uncombined state, it has no *direct* influence upon plants, beyond its mechanical action, in supporting the roots, &c.; but as it possesses the properties of an acid, it unites with various alkaline matters in the soil, and produces compounds which are required in greater or less quantity by every plant. The chief of these are the *silicates of potash and soda*, by which expression is meant the compounds of silica, or, more properly, silicic acid with the alkalies potash and soda.

Alumina in Soils.—"*Alumina* exists pure in soil. It is the characteristic ingredient of clay, although it exists in that compound to the extent of only 30 or 40 per cent. It exerts no *direct chemical* influence on vegetation, and is scarcely ever found in the ashes of plants. Its chief value in soil, therefore, is owing to its effects in rendering soil more retentive of moisture. Its amount varies from ½ per cent to 13 per cent.

Oxides of Iron in Soils.—"There are two *oxides of iron* found in soils—

[1] Johnston's *Lec. Agric. Chem.*, 2d ed., 535.

namely, the protoxide and peroxide. The protoxide is frequently very injurious to vegetation—so much so, that ½ per cent of a soluble salt of this oxide is sufficient to render soil almost barren. The peroxide, however, is often found in small quantities in the ashes of plants. The two oxides together constitute from ½ to 10 per cent of soil. The blue, yellow, red, and brown colours of soil, are more or less dependent upon the presence of iron.

Oxide of Manganese in Soils.—"The *oxide of manganese* exists in nearly all soils, and is occasionally found in plants. It does not, however, appear to exert any important influence, either mechanically or chemically. Its amount varies from a mere trace to about 1½ per cent. It assists in giving the black colour to soil.

"These four substances constitute by far the greatest bulk of every soil, except the chalky and peaty varieties, but, nevertheless, *chemically speaking*, are of trifling importance to plants; whereas the remaining eight are so absolutely essential that no soil can be cultivated with any success unless provided with them, either naturally or artifically. And yet, when it is considered that scarcely any of them constitute 1 per cent of the soil, their value will no doubt excite surprise. The sole cause of their utility lies in the fact, that they constitute the

Ashes of the Plants ;

and as no plant can, by possibility, thrive without its inorganic constituents (*its ashes*), hence no soil can be fertile which does not contain the ingredients of which these are made up. The very small percentage of these ingredients in any soil necessitates a minute analysis of every soil before it can be ascertained whether or not it contains any, or what proportion, of these ingredients. But the reason for such minuteness in analysis becomes obvious when we consider the immense weights which have to be dealt with in practical agriculture; for example, every imperial acre of soil, considered as only 8 inches deep, will weigh 1884 tons, so that 0.002 per cent—that is, only a two-thousandth per cent — the amount of *sulphuric acid* in a barren soil amounts to 80.64 lb. in the imperial acre!

Potash and Soda in Soils.—"*Potash* and *soda* exist in variable quantities in many of the more abundant minerals, and hence it follows that their proportion in soil will vary according to the mineral which produced it. For the sake of reference, I have subjoined the following table, which shows the amount per cent of alkalies in some of these minerals, and likewise a rough calculation of the whole amount per imperial acre, *on the supposition of a soil composed solely of these rocks, and of a depth of 10 inches;* and the amount is abundant beyond conjecture:—

Name of Mineral.	Amount per cent of Alkali.	Name of Alkali.	Amount per Imperial Acre in a soil 10 inches deep.								
			Tons	cwt.	qr.	lb.		Tons	cwt.	qr.	lb.
Felspar . . .	17.75	Potash . . .	422	18	2	8					
Clinkstone . .	3.31 to 6.62	Potash and soda	71	17	2	0	to	143	15	0	0
Clay-slate . .	2.75 " 3.31	Potash . . .	35	18	3	0	"	71	17	2	0
Basalt . . .	5.75 " 10.	Potash and soda	17	0	0	7	"	25	7	3	7

"One acquainted with chemistry will naturally ask the question, How is it that these alkalies have not been long ago washed away by the rain, since they are both so very soluble in water? The reason of their not having been dissolved is the following—and it may in justice be taken as an example of those wise provisions of nature whereby what is useful is never wasted, and yet is at all times ready to be abundantly supplied. These alkalies exist in combination with the various other ingredients of the rock in which they occur, and in this way have such a powerful attraction for these ingredients, that they are capable of completely resisting the solvent action of water as long as the integrity of the mass is retained. When, however, it is reduced to a perfectly impalpable powder, this attraction is diminished to a considerable extent, and then the alkali is much more easily dissolved. Now this is the case in soil, and consequently, while the stony portions of soil contain a vast supply of these valuable ingredients in a condition in which water can do them no injury, the impalpable powder is supplied with them in a soluble state, and hence in a condition available to the wants of vegetation.

"In the rocks which we have mentioned, the alkalies are always associated with clay, and it is to this substance that they have the greatest attraction; it follows, therefore, that the more clay a soil contains, the more alkalies will it have, but at the same time it will yield them less easily to water, and through its medium to plants."

Analysis of Soil.—It may be useful to give the following *minute analysis of a soil*, by Dr Anderson, of a good arable light sandy loam, well fitted for the growth of turnips in Dumbartonshire.

Soluble in water.	Organic matter	5.53
	Peroxide of iron	0.37
	Lime	0.36
	Magnesia	0.49
	Potash	1.25
	Chloride of sodium	2.91
	Phosphoric acid	0.72
	Sulphuric acid	4.43
	Silicic acid	8.02
		24.08
Peroxide of iron		427.02
Alumina		260.15
Lime		33.77
Magnesia		27.71
Potash		221.05
Soda		3.48
Chloride of sodium		20.66
Phosphoric acid		37.77
Sulphuric acid		5.94
Silicic acid		52.68
Organic matter		576.61
Insoluble silicate		7,988.62
Moisture		323.46
		10,000.00

In a chemical point of view, this arable soil, analysed previous to liming and manuring, was a good one, and contained a suitable proportion of all the necessary elements of plants, and was particularly rich in potash.

What Plants withdraw from the Soil.—"On comparing the constituents of such a soil as the above with the mineral ingredients obtained by incineration from the ashes of plants, it is found that plants withdraw from the soil chiefly its alkaline, mineral acid, and earthy ingredients; and if all these were not essential to the very existence of the plants, they would not, of course, be taken up by them; and as the plants constituting our cultivated crops withdraw those ingredients in a varied amount, it follows that, unless the soils we cultivate contain them in ample amount and variety, it will be impossible for the plants placed upon them to arrive at a perfect state of development of all their parts; for, chemically speaking, and rationally speaking too, soils cannot be expected to produce crops abundantly unless they contain a sufficient supply of every ingredient which all the crops we wish to raise require from them." [1]

As examples of the *quantities of mineral ingredients taken from the soil under culture* by some of the cultivated plants, the following amounts of percentage are given:—

By grain crops—

100 lb. of	Grain.	Husk.	Straw.
Wheat	1.2 to 2.0	—	3.5 to 18.5
Barley	2.3 to 3.8	—	5.2 to 8.5
Oats	2.6 to 3.9	5 to 8	4.1 to 9.2
Rye	1.0 to 2.4	5 to 8	2.4 to 5.6
Rice	0.9 to 0.7	14 to 25	—
Indian corn	1.3	—	2.3 to 6.5
Buckwheat	2.13	—	—
Field-beans	2.1 to 4.0?	—	3.1 to 7.0
Field-pease	2.5 to 3.0	Pod 7.1	4.3 to 6.2
Vetches	2.4	—	—
Linseed	3.8 to 4.63	—	—
Flax-seed	4.5	—	1.28
Hemp-seed	5.6	—	1.78
Mustard-seed	4.2 to 4.3	—	—

By root and leaf crops—

	Root or tuber.		Leaves.	
100 lb. of	Undried.	Dried.	Undried.	Dried.
Potato	0.8 to 1.1	3.2 to 4.6	1.8 to 2.5	18 to 25
Turnip	0.6 to 0.8	6.0 to 8.0	1.5 to 2.9	14 to 20
Beet	—	6.3	—	—
Carrot	0.7	5.1	—	16.42
Parsnip	0.8	4.3	—	15.76
Mangel-wurzel	1.1	7.0	0.53	7.55
Cabbage	—	—	—	18 to 26

By grasses—

100 lb. of	Green.	Dry.
Lucerne	2.6	9.5
Red clover	1.6	7.5
White clover	1.7	9.1
Rye-grass	1.7	6.0
Knot-grass	—	2.3
Holcus lanatus	—	5.6 to 6.8
Poa pratensis	—	6.2
Scirpus	—	2.3

[1] Johnston's *Lec. Agric. Chem.*, 2d ed., 528.

By trees—

100 lb. of	Wood.	Seed.	Leaves, dried.
Larch . .	0.33	5.0	6.0
Scotch fir .	0.14 to 0.19	4.98	2.0 to 3.0
Pitch pine .	0.25	4.47	3.15
Beech .	0.14 to 0.60	—	4.2 to 6.7
Willow .	0.45	—	8.2
Birch . .	0.34	—	5.0
Elm . .	1.88	—	11.8
Ash . .	0.4 to 0.6	—	—
Oak . .	0.21	—	4.5
Poplar . .	1.97	—	9.2
Common furze	0.82	flower.	3.1
Hop . .	5.0	10.90	16.3

Inorganic Matter in Plants.—The discovery of the constant existence of *inorganic matter* in plants, which could have been discovered by chemistry alone, has a very important influence in regulating the practice of cultivating our plants. "It establishes a clear relation between the kind and quality of the crop, and the nature and chemical composition of the soil in which it grows; it demonstrates what soils ought to contain, and therefore how they are to be improved; it explains the effect of some manures in permanently fertilising and of some crops in permanently impoverishing the soil; it illustrates the action of mineral substances upon the plant, and shows how it may be, and really is, in a certain measure, *fed* by the dead earth;—over nearly all the operations of agriculture, indeed, it throws a new and unexpected light."[1]

Origin of Soils.—It is argued by many practical men that the *origin of soil* is not so easily explained as is attempted by geological writers; and the difficulty of explanation may be assumed from the fact of geologists having paid little attention to the loose materials composing the *surface* of the globe. The deposits of clay, sand, and gravel, bear a variable relation to one another, as well as to the indurated rocks upon which they rest, like that by the indurated rocks to themselves, and therefore have not been deposited by the operation of any law of superposition, but simply that of gravity; and it is the want of order in the position which baffles the ability of the geologist to ascribe their origin correctly.

Diluvium or Subaqueous Deposits.—The incoherent rocks, when complete in all their members, consist of three parts. The oldest or lowest part is not unfrequently termed *diluvium;* but this is an objectionable term, inasmuch as it conveys the idea of its having been formed by the Noachian deluge. Diluvium, therefore, should be termed *subaqueous deposits*, and may consist of clay, or gravel, or sand, in deep masses and of large extent. It may, in fact, be transported materials, which, if they had been allowed to remain in their original site, might have formed indurated aluminous and siliceous rocks. When such subaqueous deposits are exposed to atmospherical influences, an arable soil is easily formed upon them.

Alluvial Deposits.—True *alluvial* deposits may raise themselves by accumulation above their depositing waters, and art can assist the natural process by the erection of embankments against the waters of rivers and lakes, and by forming large ditches for carrying the waters away, as has been done in several places in the rivers and lakes of our country. Atmospherical influences soon raise an arable soil on alluvium.

Upper Mould.—The third member of soils is the upper *mould*, which is directly derived from vegetation, and can only come into existence after either of the other deposits has been placed in a situation favourable for the support of plants—that is, in the atmosphere. Mould, being the production of vegetation, always exists on the surface; but when either the subaqueous deposit or the alluvium is awanting, it is formed upon the indurated rock itself, but still by the atmosphere.

Notwithstanding the possibility of the formation of mould upon the surface of hard rocks by means of atmospheric influences, by far the largest proportion of agricultural soil is based upon incoherent and not indurated rocks.

Chemical Analysis of Soils Essential.—On viewing, then, the chemical composition of soils of known *natural fertility*, a standard will be afforded us by which we may, perhaps, be enabled to render other soils equally fertile by artificial means; but all our exertions may soon find a limit in this direction, inasmuch as without a certain amount of impalpable matter soils cannot possibly be fertile—and how can we produce

[1] Johnston's *Lec. Agric. Chem.*, 2d ed., 307.

this impalpable matter? Yet, while the existence of this material proves the soil to be *mechanically* well suited for cultivation, *chemical* analysis alone can *prove* its absolute value to the farmer. The subject of soils is thus full of interest in every respect—mechanically and chemically—to the agricultural student.

THE FERTILITY OF SOIL.

The fertility of the soil is the basis of all agricultural operations. Recent scientific and practical research has substantially increased our knowledge regarding this important subject, and the substance of what is known concerning it is embraced in the following treatise written specially for this edition by Mr R. Warington, F.C.S., who has had the benefit of being associated with Sir John Bennet Lawes and Dr Gilbert in the experimental work at Rothamsted:—

By the fertility of soil we understand its capability of producing crops. A soil producing small crops we speak of as deficient in fertility, while another yielding a large average produce we speak of as decidedly fertile. It is evident, however, to every one acquainted with agriculture, that the production of large or small crops depends greatly on circumstances quite unconnected with the nature of the soil. It depends, for instance, greatly on the climate of the district, or on the character of the season. The same soil in Sweden and in the south of France would yield very different amounts of produce. The same soil on the north and south sides of a Scotch hill will have a very different value. Or, to give one more familiar illustration, a change from the east to the west coast of Great Britain will entirely alter the productiveness of a soil for many crops.

The fertility of land is thus a very complex idea, and may depend on circumstances quite unconnected with the character of the soil. This fact must always be borne in mind. In the present short article we shall speak only of those elements of fertility which belong to the soil itself; these require the co-operation of a suitable climate and season before they can determine actual fertility—that is to say, the production of crops.

The limited influence of the character of the soil on the fertility of land is easily understood if we have any acquaintance with the facts of agricultural chemistry. A wheat crop, weighing at harvest 5000 lb., contains in the corn and straw only 172 lb. of incombustible constituents and 48 lb. of nitrogen, both of them derived from the soil; the whole of the rest of the crop has been derived from the air and rain. For the wheat plant to assimilate to itself the carbon of the atmosphere, and to form starch, fibre, and albuminoids, it is necessary that the energy of sunlight should be received by the plant; the vigour of the plant, in fact, mainly depends on the supply of light and heat during the months of active growth. The amount of produce, thus, in most cases, depends more on the character of the season than on the composition or condition of the soil.

Physical Condition of the Soil.

Fertility is dependent, to a considerable extent, on the physical condition of the soil. The particles of a soil must be neither too coarse nor too fine. A gravel can never be fertile, although the stones composing it may possibly contain an abundance of plant-food. A pure clay would be equally unsuitable as a soil. For a soil to be really fertile it must be porous, and freely allow the movement of water and air within it; but the particles of the soil must be fine, and exposing therefore a large surface; they must also be sufficiently close together for the soil to retain, as in a sponge, a considerable amount of water. A favourable mechanical condition is frequently confined to the surface soil, but in very fertile soils a deep tilth will always be found. The physical condition of a soil is fortunately a point on which the farmer's practical skill can have great influence; he can, to a considerable extent, consolidate it or pulverise it at pleasure. Who does not know the amazing difference in the growth of a crop of barley, or turnips, according to the kind of tilth which the farmer obtained at the time of sowing! Any lumps in a soil are clearly useless to the plant. Roots do not penetrate them; they neither furnish plant-food nor moisture. In a finely pulverised soil delicate roots spread with freedom, and every particle of soil is in a condition to yield to the roots the plant-food which it may contain.

There are a few points relating to the physical condition of soils which should be thoroughly understood by every farmer. The cementing ingredients in a soil are clay and humus. A sandy soil is made firmer, and its power of retaining water increased either by claying, or by applications of farmyard manure, or by the cultivation of grass or clovers, or by any treatment in which the vegetable matter in the soil is increased. Clays, on the other hand, are made more open and pulverulent by applications of chalk or lime, the effect of which is often quite surprising. An increase in the amount of humus will act in the same direction; and frost is also a most powerful disintegrating agent.

Relation of Soils to Water.

Some facts concerning the relation of soils to water should also be remembered. The ingredient of soils which has the greatest power of retaining water is humus; next to this stands clay. In a time of drought the soil loses least water when the surface is in a rough open condition, as under these circumstances the subsoil water cannot reach the surface by capillary attraction. Sometimes, however, as when sowing turnips in very dry weather, it is necessary to make use of any water remaining beneath the surface. To effect this the farmer must obtain a fine tilth, and finally consolidate the land by rolling: capillary attraction will thus be established, and probably enough moisture brought to the surface to germinate the seed.

In spring time, and generally in cold seasons, the warmth of the soil will have a great influence on its fertility. The warmth of a soil will be less in proportion to the amount of water which it contains. One of the great benefits of draining is to increase the temperature of cold soils, and thus determine an earlier growth in spring.

Plant-Food.

The fertility of soil depends in great measure on the amount and condition of the plant-food which it contains. The soil furnishes the plant with all its incombustible constituents, and also with nitrogen. The ash of plants always contains six substances, which, described by their most familiar names, are—potash, lime, magnesia, iron, phosphoric acid, and sulphuric acid. These six ash constituents, and nitrogen, are all absolutely essential for plant-growth, and the absence of any one of them would deprive a soil of fertility. Besides the six substances just mentioned, the ash of plants contains soda, silica, and chlorine; these are often present in the plant in large quantity, but they are far less important to plant-life than the six first mentioned.

Of the seven essential elements of plant-food which are derived from the soil, four — lime, magnesia, iron, and sulphuric acid — are usually present in the soil in sufficient quantity. The attention of the agriculturist has, therefore, chiefly to be directed to the remaining three — nitrogen, phosphoric acid, and potash. The various degrees of fertility possessed by different soils depend, to a large extent, on the amounts of these three substances present in the soil, and on their state or condition, as suitable or otherwise, for assimilation by crops.

Sources of Fertility in Soil.

The phosphoric acid, potash, and other ash constituents of plants which are found in soils, are derived from the rocks from which the soil has been formed. The nitrogen of the soil has, on the contrary, been originally derived from the atmosphere. The origin of soil is to be traced to the gradual disintegration of rocks—the work of frost, of simple chemical agents, as water and carbonic acid, and the action of vegetation. The first vegetation would be of the scantiest description, and consist of extremely simple organisms; these would derive the small amount of nitrogen they would require from the ammonia and nitric acid of the rain, and the ammonia of the air. The decay of these organisms would furnish the beginning of a vegetable soil, containing nitrogen and carbon. Gradually the disintegration of the rock, and the formation of a soil containing nitrogen, would reach the stage at which the herbage of a pasture or forest-trees would find a suitable feeding-ground. The soil might then remain in a condition of natural vegetation till broken up by man, and devoted by him to arable culture.

Many soils have not been formed in the places where we now find them, but have been brought to their present position by the washing of higher rocks by rain, or by the transporting power of rivers and floods. In this manner soils may be produced which contain carbon and nitrogen (the remains of vegetable matter) throughout a great depth. The most fertile soils have usually been formed by the transportation and accumulation of soil which had already attained great fertility; the deep rich soils of river-valleys have clearly such a history.

Distribution of Plant-Food in Soils.

As the nitrogenous matter of soils is derived from the remains of previous vegetation, it naturally follows that it is chiefly found at the surface. Frequently the subsoil is sand or clay, containing very little nitrogen, while the top 6 or 9 inches are of an altogether different texture, dark in colour, and containing a considerable amount of nitrogen and carbon. In an arable soil, and in an old pasture soil, at Rothamsted, there were found at different depths—

	Arable Soil.		Old Pasture Soil.			
	Nitrogen.		Nitrogen.		Carbon.	
	In 10,000 lb.	Per acre.	In 10,000 lb.	Per acre.	In 10,000 lb.	Per acre.
	lb.	lb.	lb.	lb.	lb.	lb.
First 9 inches . .	13.8	3507	24.7	5,336	337.7	73,079
9 to 18 " . . .	7.2	1679	7.2	1,916	76.4	20,223
18 to 27 " . . .	5.6	1272	4.4	1,329	37.3	11,346
27 to 36 " . .	4.0	886	4.3	1,290	28.9	8,772
36 to 45 " . .	3.3	772	3.8	1,231	23.1	7,464
45 to 54 " . . .	3.1	773	3.6	1,208	21.3	7,110
Total, 54 inches		8889		12,310		127,994

The concentration of both nitrogen and carbon in the first 9 inches is here very apparent.

The distribution of the important ash constituents in a soil is somewhat different. When a soil has been unmanured the phosphoric acid generally shows accumulation at the surface, but to a less extent than the nitrogen. Potash shows still less accumulation at the surface, and is sometimes more abundant in the subsoil. In a soil which has been well manured, the tendency to accumulation at the surface is naturally increased. Lime and magnesia are generally more abundant in the subsoil than at the surface.

Nitrogen, Phosphoric Acid, and Potash in Soils.

The proportion of nitrogen, phosphoric acid, or potash in a soil is generally very small. Thus the arable soil above mentioned, though of fair fertility, contained in the first 9 inches barely 14 lb. of nitrogen per 10,000 lb. of soil; and soils may be of very fair fertility which contain only 15 lb. of potash and 10 lb. of phosphoric acid per 10,000 lb. of soil. These quantities, however, become really considerable when we remember what they amount to *per acre.* Nine inches of soil when dry will weigh somewhere about 3,000,000 lb.[1] A soil, therefore, of the description just assumed, would contain in 9 inches, 4200 lb. of nitrogen, 4500 lb. of potash, and 3000 lb. of phosphoric acid on an acre. In soils of renowned fertility, the quantities of plant-food will be much more considerable. Thus C. Schmidt found in 10,000 lb. of the black earth of South Russia—

	Nitrogen.	Phosphoric Acid.	Potash.	Lime.
	lb.	lb.	lb.	lb.
First 7 inches	31	15	220	162
At 28 "	17	14	220	413
At 105 "	5	11	214	557

The proportion of nitrogen and potash is here very exceptionally high; the richness of the soil in these constituents, also, extends to a considerable depth. Deep soils with such a composition have an almost inexhaustible store of fertility.

The quantities of nitrogen, phosphoric acid, and other elements of plant-food contained in a soil, indicate, however, very imperfectly, its degree of fertility. Not only the quantity but also the *condition* of these elements has to be taken into account. An acre of soil may contain near the surface several thousand pounds of nitrogen and several thousand pounds of phosphoric acid; and yet the application of 50 lb. of nitrogen or nitrate of soda might double the wheat crop, and 50 lb. of phosphoric acid as superphosphate might double the turnip crop. Such facts would plainly show that, however large might be the quantity of nitrogen or phosphoric acid in the soil, the crops did not actually find enough *available for their use* without the aid of manure.

Humus.

We have seen that the nitrogenous matter found in the surface-soil is a residue from the decay of a previous vegetation. The nitrogen in this vegetable matter is in combination with a large amount of carbon; and in its original condition it is unfit to serve as food for crops. This nitrogenous vegetable matter is attacked in the soil by a number of agents—insects, worms, fungi, and bacteria—which, in various ways, effect the oxidation of the carbon, which is given off as carbonic acid gas, while the nitrogen remains in the soil in simpler combinations.

The black, nitrogenous, humic matter of soils is a substance admirably fitted to serve as a store of nitrogen within the soil. Only slowly acted on by water, it is not liable to be removed by excessive drainage; while by the natural processes of oxidation and hydration within the soil, a portion of the nitrogen is yearly converted into substances fitted to serve as plant-food. The most important result of the oxidation of humus is the production of nitrates. This work is accomplished by a minute vegetable organism, a bacterium.

Production of Nitrates in Soils.

As upon the production of nitrates the fertility of a soil greatly depends, we must for a moment glance at the conditions which are requisite for this operation to occur. The production of nitrates is favoured by aerating the soil, by ploughing, stirring, and cultivation of all kinds. It is increased when the soil becomes wet, provided that there is free drainage. It is greatly increased by a rise of temperature, and is far more active in summer than in winter. Nitrification will not take place in a sour soil, as a peat-bog. To such a soil chalk or a moderate dose of lime must be added before nitrification can occur.

A bare fallow affords the greatest opportunity for the accumulation of nitrates in the soil. The results of analyses of soil and of drainage-water have shown that not less than 80 lb. of nitrogen, per acre, are ordinarily converted into nitrates during a season of fallow (about fifteen months) on the farm-land at Rothamsted.

Solubility of Phosphates and Potash in Soils.

We have seen that only a very small part of the nitrogen in a soil is immediately available to a crop. The same may be said both of the phosphoric acid and potash which soils contain. Neither of the last-named substances occur in soils in a readily soluble form. If soluble phosphates or potash salts are ap-

[1] The true soil of the fields referred to in the preceding table weighed less than this, owing to the great bulk of stones present.

plied to a fertile soil, the potash and phosphoric acid are removed from solution by the soil. This fact is of great importance, as these valuable substances are thus scarcely at all removed from the soil by subsequent drainage. Potash and phosphates enter the plants chiefly through the solvent action of the feebly acid root-sap. The quantity of phosphoric acid and potash in a soil which is soluble in a weak acid may be very small. Thus Schmidt found in the Russian soil already referred to, that out of 220 lb. of potash in the surface-soil, less than 5 lb. were soluble in a cold one per cent acid, while 35 lb. were dissolved by hot acid of ten times the strength. In the same way, out of 15 lb. of phosphoric acid, 5 lb. were soluble in cold one per cent acid, and 13 lb. in hot ten per cent acid. The smallest of the quantities extracted by the chemist's acid would be much larger than a crop would be able to take up. We have then always to bear in mind that only a small proportion of the phosphoric acid and potash present in a soil is immediately available as plant-food.

It follows from what has been said that chemical analysis is not a certain guide in discriminating the value of soils; for while the chemist can state with certainty the total amount of nitrogen, phosphoric acid, potash, lime, &c., present, he can give very little information as to the amount annually available to a crop.

Accumulation and Exhaustion of Fertility.

Having now some elementary notions respecting the capital of fertility or store of plant-food which soils contain, we must next consider the manner in which practical agriculture influences this capital.

In the natural life of a prairie or a forest, there is no exhaustion of the fertility of the soil; all the incombustible constituents of the plants and animals dwelling on the land are returned again to the soil after their death; the greater part of their nitrogen is also returned to the soil. The early history of a prairie or forest soil is one of accumulation of nitrogen, the annual gain from the atmosphere somewhat exceeding the annual loss from the soil. By-and-by a stage will be reached at which the amount of nitrogen in the surface-soil, and in the vegetable and animal life upon it, has become so considerable that the annual loss of nitrogen is on an average equal to the annual supply from the atmosphere. An equilibrium will then be established, which will continue till man steps in and disturbs it. There will be also under the conditions of natural vegetation an accumulation in the surface-soil of some of the ash constituents of plants, since these are taken from the subsoil by the deeper roots, and returned to the surface on the decay of the plants, or in the manure or dead bodies of the animals pasturing there.

With human agriculture two distinct sources of soil-exhaustion commence. There is, first, the destruction of the accumulated nitrogenous matter of the soil by oxidation, which commences as soon as the soil is broken up by the plough; secondly, the general exhaustion, affecting all the elements of plant-food, which is brought about by the removal from the land of the crops and animals reared on it.

The effect which the ploughing up of pasture and the continuous growth in its place of arable crops has on the nitrogenous matter of the soil is well seen in the following analyses of soil, quoted by Sir J. B. Lawes in 1883, showing the amount of nitrogen in various arable soils, and in pastures of different age, at Rothamsted:—

Nitrogen per 10,000 lb. in first nine inches of soil.

	lb.
Very old pasture	24·7
Pasture laid down in 1838	19·5
Pasture laid down in 1863 . .	17·4
Pasture laid down in 1872 . . .	15·1
Ordinary arable land	12·4
Arable soil, wheat grown continuously 38 years without nitrogenous manure	10·0
Arable soil, roots grown continuously 27 years without nitrogenous manure	9·3

When we recollect that much of the arable land at Rothamsted was probably originally pasture, the destruction of nitrogenous matter by the arable culture of centuries becomes very evident. The slow accumulation of nitrogen which takes place during the making of a modern pasture is naturally the converse of the destruction of nitrogenous matter which takes place when ancient pasture is devoted to arable culture.

It is most important, if we are to have an intelligent acquaintance with the laws which determine the fertility of soil, that we should clearly understand the circumstances which determine the exhaustion or accumulation of nitrogen in the soil. In a bare fallow we have the conditions most favourable to the destruction of the nitrogenous vegetable matter which the soil contains; the nitrogen and carbon of this vegetable matter are oxidised in the manner already described, carbonic acid and nitrates being produced, and these nitrates are readily *washed out of the soil by rain.* The season in which the chief loss of nitrates in the drainage-water occurs is during the autumn and winter. In climates in which the soil is frozen during the winter months, the loss of nitrates from the soil will be considerably diminished.

When a crop is grown on arable land, the nitrates formed in the soil are taken up by the crop during its period of active growth. A wheat crop may take up all the nitrates in an arable soil between April and July, but fails to protect the soil from loss during the remainder of the year. If, on the other hand, the land is laid down with grass-seeds, the loss of nitrogen as nitrates is reduced to a minimum; the production of nitrates in the soil is diminished as the land is left unploughed, and the grass is always ready to take up and convert into vegetable matter any nitrates that may be present.

But a growing crop does something more than prevent the loss of nitrates in the drainage-water. Every crop leaves a residue of nitrogenous vegetable matter in the soil, consisting of roots, leaves, stubble, &c., and this residue is a fresh addition to the nitrogenous capital of the soil. If the quantity of nitrogen in a soil is stationary, neither increasing nor diminishing, the average annual additions to the soil, in crop residues and manure, equal the average losses which the soil sustains. In nature everything tends to come to an equilibrium. If the system of cropping is bad and manuring scanty, the nitrogen in the soil will gradually fall till the annual oxidation of nitrogenous matter is equal to the annual receipt. If the treatment is changed to one of high farming, the amount of nitrogen in the soil will rise, and with this the amount of nitrogenous matter annually oxidised, till at length again oxidation equals the annual receipt.

Leguminous Crops enrich the Soil with Nitrogen.

Different crops are of very different value as restorers of soil nitrogen. Foremost in this respect stand leguminous crops. Leguminous crops, as peas, beans, clovers, vetches, sainfoin, and lucerne, contain far more nitrogen than any other kind of crop grown by the farmer. To grow a crop of peas, and plough the whole into the land as manure, is a plan much used for renovating the soil in parts of the United States. The leguminous fodder crops, and especially those with deep roots, as red clover and lucerne, leave, however, so large a residue of root and leaf on the land, that the crop may be cut for hay and removed, and the surface-soil still left greatly enriched with nitrogen. On land which will grow leguminous crops, the farmer should have no difficulty in maintaining the nitrogenous richness of the surface-soil.

Nitrogenous Manures which enrich the Soil.

The manures which tend to increase the nitrogenous capital of the soil are those which contain nitrogen united with carbon, as farmyard manure, seaweed, oilcakes, &c. Salts like nitrate of soda or sulphate of ammonia benefit the crop and not the land; or rather, they benefit the land only through the crop, as the larger crops grown by their use leave of course a larger residue of roots, &c., in the soil. The experiments at Rothamsted afford several examples of the great enrichment in nitrogen of the surface-soil from long-repeated applications of farmyard manure or oilcake; they also show that the nitrogen of such manuring stored in the soil is but slowly transformed into a state suitable for plant-food, and that its effect is consequently spread over many years.

Oxidation in different Soils.

Before leaving the subject of the conservation of the nitrogen of the soil, we must remark that different soils will differ greatly in their rate of oxidation, and will demand, therefore, a different treatment. In a light soil, admitting a free access of air, and rapid drainage, the effect of manure will be far less enduring than on a heavier soil, and great skill will be needed to maintain such land in a fertile condition. On the other hand, upon heavy soils the effect of farmyard manure will be felt over many years; on such land oxidation may be so slow that bones may almost be without effect.

Farmers have long ago recognised the distinctive treatment proper to light and heavy soils. On light, free-draining soil, the farmer will rely on green-crop sheep feeding, and organic manures, and he will use artificial manures sparingly. He should endeavour to prevent loss of nitrates by keeping his land always occupied by some growing crop. Catch-crops of rye or mustard which can be fed off, or ploughed in immediately before sowing the main cereal crops, are very advisable. On heavy land organic manures are of less immediate value, and soluble artificial manures become of more importance. The farmer endeavours to keep the land from becoming too solid, and avoids sheep treading in winter. He will act wisely, however, by following the advice already given, and keeping the land as far as possible always under a crop. It should be borne in mind that although autumn ploughing is excellent for improving the physical condition of clay soils, it is at the same time frequently the cause of much loss of nitrogen to the soil. The aeration caused by ploughing, and the absence of crop through the winter months, are indeed the special conditions favourable to a loss of nitrates by drainage. When ploughing can be delayed till spring there is less loss of nitrogen in winter, and the aeration of the soil by the spring ploughing comes at the time when nitrate is needed by a young crop.

Exhaustion by removal of Crops and Stock.

We must next consider very briefly the exhaustion of fertility which is due to the removal of crops or animal produce from the land. The principal constituents of farm crops of average bulk are shown in the table on next page.

It is frequently supposed that cereal crops are among those most exhausting to the soil. A study of the table shows that this is not really the case. The grain from fairly good crops of wheat, barley, or oats, removes from an acre of land only about 35 lb. of nitrogen, 9 lb. of potash, and 14 lb. of phosphoric acid—quantities smaller (with one exception) than those contained by any other crop mentioned in the table. The apparently exhausting character of cereal crops is doubtless due to the small residues which they leave in the soil, and to the loss of nitrogen as nitrates which the soil frequently suffers from autumn and winter rains after the crop has been removed from the land. The straw of cereal crops usually contains a rather considerable amount of potash; the sale of straw from land naturally poor in potash is therefore unadvisable, unless manure containing potash is also purchased for the farm. Poverty in potash is, however, not a common fault of soils.

A crop of grass hay removes generally a greater quantity of valuable constituents from the soil than a cereal crop, and this is particularly the case in respect of potash. The exhaustion of potash is of greater importance, as the short roots of grass limit its power of taking potash from the subsoil. Potash manures are often of great service on meadows mown for hay.

Root crops, if removed from the land, are by far the most exhausting to the soil of any crops grown by the farmer. The amount of nitrogen they contain is very considerable, and the quantity of potash extremely large. As the growth of roots extends much later into the autumn than is the case with cereal crops, they are able to make use of nitrates formed in the soil long after the cereals have been removed. Root crops are thus economical so far as their demand for nitrogenous manure is concerned.

The leguminous crops remove very large quantities of nitrogen and potash from the soil; the nitrogenous residue of roots, leaves, and stubble left in the soil is, however, so considerable, that in practice they rank as agents for enriching the surface-soil with nitrogen.

The exhaustion of fertility by any crop depends of course on whether it is removed from the farm. The figures in the table given below plainly show that the sale of cereal grain removes a far smaller quantity of the elements of plant-food than the sale of hay or roots. The sale of straw will remove a considerable amount of potash, but will not else be productive of exhaustion to the soil.

THE WEIGHT AND AVERAGE COMPOSITION OF ORDINARY CROPS IN POUNDS PER ACRE.

	Weight of Crop.		Total pure Ash.	Nitrogen.	Sulphur.	Potash.	Soda.	Lime.	Magnesia.	Phosphoric Acid.	Chlorine.	Silica.
	At Harvest.	Dry.										
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Wheat, grain, 30 bushels	1,800	1,530	30	33	2.7	9.3	0.6	1.0	3.6	14.2	0.1	0.6
" straw . . .	3,158	2,653	142	15	5.1	19.5	2.0	8.2	3.5	6.9	2.4	96.3
Total crop .	4,958	4,183	172	48	7.8	28.8	2.6	9.2	7.1	21.1	2.5	96.9
Barley, grain, 40 bushels	2,080	1,747	46	35	2.9	9.8	1.1	1.2	4.0	16.0	0.5	11.8
" straw . . .	2,447	2,080	111	13	3.2	25.9	3.9	8.0	2.9	4.7	3.6	56.8
Total crop .	4,527	3,827	157	48	6.1	35.7	5.0	9.2	6.9	20.7	4.1	68.6
Oats, grain, 45 bushels .	1,890	1,625	51	38	3.2	9.1	0.8	1.8	3.6	13.0	0.5	19.9
" straw . .	2,835	2,353	140	17	4.8	37.0	4.6	9.8	5.1	6.4	6.1	65.4
Total crop .	4,725	3,978	191	55	8.0	46.1	5.4	11.6	8.7	19.4	6.6	85.3
Meadow-hay, 1½ ton .	3,360	2,822	203	49	5.7	50.9	9.2	32.1	14.4	12.3	14.6	56.9
Red clover hay, 2 tons .	4,480	3,763	258	102	9.4	83.4	5.1	90.1	28.2	24.9	9.8	7.0
Beans, grain, 30 bushels	1,920	1,613	58	77	4.4	24.3	0.6	2.9	4.2	22.8	1.1	0.4
" straw . .	2,240	1,848	99	22	4.9	42.8	1.7	26.3	5.7	6.3	4.3	6.9
Total crop .	4,160	3,461	157	99	9.3	67.1	2.3	29.2	9.9	29.1	5.4	7.3
Turnips, root, 17 tons .	38,080	3,126	218	63	15.2	108.6	17.0	25.5	5.7	22.4	10.9	2.6
" leaf . . .	11,424	1,531	146	49	5.7	40.2	7.5	48.5	3.8	10.7	11.2	5.1
Total crop	49,504	4,657	364	112	20.9	148.8	24.5	74.0	9.5	33.1	22.1	7.7
Swedes, root, 14 tons .	31,360	3,349	163	74	14.6	63.3	22.8	19.7	6.8	16.9	6.8	3.1
" leaf . . .	4,704	706	75	28	3.2	16.4	9.2	22.7	2.4	4.8	8.3	3.6
Total crop .	36,064	4,055	238	102	17.8	79.7	32.0	42.4	9.2	21.7	15.1	6.7
Mangels, root, 22 tons .	49,280	5,628	426	96	4.9	222.8	69.4	15.9	18.3	36.4	42.5	8.7
" leaf . . .	18,233	1,654	254	51	9.1	77.9	49.3	27.0	24.2	16.5	40.6	9.2
Total crop .	67,513	7,282	680	147	14.0	300.7	118.7	42.9	42.5	52.9	83.1	17.9
Potatoes, 6 tons	13,440	3,360	127	47	2.7	76.5	3.8	3.4	6.3	21.5	4.4	2.6

When the sales from the farm are confined to corn and meat, the annual loss of phosphoric acid from the farm is but small. In a four-course rotation with average crops this loss would be generally covered by the use of only 1½ cwt. of superphosphate per acre for the root crop. The loss of potash would, in the case assumed, be still less, and on a clay soil, containing considerable amounts of potash in the subsoil, might be safely neglected. Potash can be applied as potash salts, but is more usually restored to the land by the consumption of purchased food.

The annual loss of nitrogen by the sale of corn, and during the consumption of hay and root crops by stock, is much more considerable than the loss of phosphoric acid or potash. The amount of nitrogen retained by an animal from its food, and sold as meat, is but small, but the loss of nitrogen from the manure may be very great. The smallest loss of nitrogen will probably occur when the hay or root crop is consumed on the land during showery weather; on a dry soil there is sure to be loss of ammonia. In feeding roots to sheep, it is a good plan to let the plough follow the sheepfold as soon as possible.

When food is consumed at the homestead, and farmyard manure is made, there must be a good supply of litter. In Germany considerable use is made of powdered gypsum or kainit for preventing loss of ammonia in stables. One pound of either per horse per day, sprinkled on the litter, is said to be a sufficient quantity. Farmyard manure must be protected from heavy rain. But it should, on the other hand, not be allowed to become dry. A failure in these conditions will entail more or less loss of nitrogen.

As a set-off to the losses of nitrogen in farm practice, we must remember that the atmosphere supplies some quantity every year. The amount of ammonia, nitric acid, and organic nitrogen in the rain does not apparently exceed 4 lb. to 5 lb. per acre per annum, but there is, doubtless, a still larger amount directly absorbed from the atmosphere by soil and crop. What the total supply from the air may amount to we cannot say. It is clearly not enough to prevent the exhaustion of land suffered to lie fallow, or from which cereal or root crops are regularly removed without the employment of nitrogenous manure; but it is apparently sufficient to maintain the nitrogen of the soil undiminished in the case of permanent pasture, and in the case of certain rotations on poor heavy land, when the amount of nitrogen removed is limited by the consumption of straw and green crops on the farm.

We must not leave the subject of the exhaustion of land by crops without pointing out that the farmer has the power, by varying his rotation, to alter at will the amount of this exhaustion. Thus the conversion of a four-course rotation into a five-course, by keeping the land in grass and clover seeds for two years, would have a distinct effect in increasing the amount of nitrogen in the soil.

The amounts of nitrogen, phosphoric acid, potash, and some other elements of plant-food, which are removed from the farm by the sale of animal produce, are shown in the following table:—

ASH CONSTITUENTS AND NITROGEN IN 1000 LB. OF VARIOUS ANIMALS AND THEIR PRODUCE.

	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
	lb.	lb.	lb.	lb.	lb.
Fat calf . .	24.64	15.35	2.06	16.46	0.79
Half-fat ox . .	27.45	18.39	2.05	21.11	0.85
Fat ox . .	23.26	15.51	1.76	17.92	0.61
Fat lamb . .	19.71	11.26	1.66	12.81	0.52
Store sheep .	23.77	11.88	1.74	13.21	0.56
Fat sheep . .	19.76	10.40	1.48	11.84	0.48
Store pig .	22.08	10.66	1.96	10.79	0.53
Fat pig . .	17.65	6.54	1.38	6.36	0.32
Wool, unwashed	73.00	1.00	40.00	1.00	0.70
Milk . . .	5.92	2.00	1.70	1.70	0.20

It will be noticed that sheep, for the same weight, contain less phosphoric acid than oxen. A pig removes less of all the valuable constituents than an ox or sheep. A fat animal contains, for its weight, less nitrogen and phosphates than a lean one. The milk of one cow (600 gallons) will, if sold, remove in a year 36 lb. of nitrogen, 12 lb. of phosphoric acid, and 10 lb. of potash.

Restoration of Fertility by Manuring.

Having thus briefly considered the influences of cropping on the fertility of soil, and the losses of fertility arising from the sale of crops and of animal produce, we must, in the next place, speak still more briefly of the restoration of fertility by manuring.

The general manuring effected by the application to the land of the manure resulting from the consumption of crops by stock will, of course, only partially replace the loss of fertility by the soil; the sale of corn and animal produce, and the waste of nitrogen in the preparation of manure, and by winter drainage from the soil, will still remain as annual sources of loss. On heavy land in poor condition, the losses of nitrogen by sales, by drainage from the soil, and in the preparation of manure, may be so moderate, that the whole may be covered, or nearly covered, by the atmospheric supply; but on fertile soil, where good crops are produced, the quantity of nitrogen sold, the loss in dealing with a large bulk of manure, and the loss by drainage from a soil rich in nitrogen, will amount to a total far in excess of the supply from the air, and demanding, therefore, the use of additional manure if high fertility is to be maintained.

We need not now discuss the theories of manuring long ago propounded by Liebig. Facts have taught both the farmer and chemist that it is needless to attempt the restoration of *all* the elements removed by the crop from the soil, since with some of these the soil is abundantly provided. Neither must manuring be confined to the substances contained in the ash of crops. The supply of nitrogen to the soil is indeed frequently more necessary than the supply of ash constituents if we desire to restore a lost fertility.

Phosphatic Manure.

The secret of economical manuring is to apply the manure required on the farm to that crop which most stands in need of it, and in no greater quantity than will produce a profitable result. Thus the farmer will apply the phosphates which his land requires to the turnip crop, because this crop will show the largest return for phosphate. He will also, if he wishes to avoid waste, ascertain, *by trial on his own land*, what is the largest quantity of superphosphate that will give a paying result. It will frequently be found that any quantity exceeding 3 cwt. per imperial acre, drilled with the seed, produces no profitable result. In such a case, to use more than this is clearly waste.

Nitrate of Soda.

Nitrate of soda is a manure of the greatest value to a farmer, more especially for cereal crops and mangels. When the nitrates naturally formed in the soil have been in great part washed out by winter rains, a small spring dressing of nitrate of soda restores at once the lost fertility. If a considerable dressing of nitrate is to be employed, it should generally be accompanied by a dose of phosphate. Any amount of nitrate in the soil which is in *excess* of the other ingredients of plant-food is of no advantage to the crop. Sulphate of ammonia acts more slowly than nitrate of soda. The ammonia is converted into nitric acid in the soil. The relative permanency of the different nitrogenous manures, and their influence on the nitrogenous contents of the soil, have been already noticed (p. 62).

Potash.

Potash manures can now be purchased at a moderate price. On certain soils they produce a great effect on pasture, grass-seeds, potatoes, and roots. Potash salts are therefore worth a careful trial by every farmer.

Retention of Manures.

On soils containing clay, applications of potash have a permanent value, the manure unused by the crop remaining in the soil available for other crops. Phosphates are also firmly retained by a fertile soil. The phosphate of lime applied in the manure changes, however, in the soil to phosphate of iron, and becomes less valuable as plant-food. Fresh applications of phosphatic manure are thus continually demanded for the turnip crop.

The power of retaining phosphoric acid, potash, and ammonia, differs with different soils; a high retentive power is requisite for economic manuring and the accumulation of fertility. A soil having a high retentive power will, other things being equal, be naturally more fertile than one having less power of retention. The ingredients of the soil which retain potash and ammonia are clay, humus, and oxide of iron; oxide of iron and clay retain phosphoric acid. Phosphoric acid is more firmly held than potash or ammonia, and occurs only in minute quantity in drainage-waters.

Manurial Value of Foods.

A common mode of increasing the fertility of land is by the use of manure obtained by the consumption of purchased food. The value of such manure depends—1. On the composition of the food; 2. On the character of the animal consuming it; 3. On the treatment of the manure before it reaches the land.

A food rich in nitrogen, phosphates, and potash, will give a far more valuable manure than a food poor in these constituents. Indeed, as a rule, the richer is the diet in these constituents, the smaller will be the proportion of them retained by the animal. The following table shows the quantity of nitrogen, potash, and phosphoric acid contained in 1000 lb. of ordinary cattle-foods:—

MANURIAL CONSTITUENTS IN 1000 LB. OF ORDINARY FOODS.

	Dry matter.	Nitrogen.	Potash.	Phosphoric acid.
	lb.	lb.	lb.	lb.
Cotton-cake (decorticated)	918	70.4	16.3	31.5
Rape-cake	887	50.5	13.0	20.0
Linseed-cake	883	43.2	12.5	16.2
Cotton-cake (undecorticated)	878	33.3	20.0	22.7
Linseed	882	32.8	10.0	13.5
Palm-kernel meal (English)	930	25.0	5.5	12.2
Beans	855	40.8	12.9	12.1
Peas	857	35.8	10.1	8.4
Malt-dust	905	37.9	20.7	18.1
Bran	860	23.2	15.5	27.2
Oats	870	20.6	4.9	6.9
Wheat	877	18.7	5.3	8.1
Barley	860	17.0	4.7	7.8
Maize	890	16.6	3.8	5.9
Clover-hay	840	19.7	18.6	5.6
Meadow-hay	857	15.5	16.0	4.3
Bean-straw	840	10.1	19.4	2.9
Wheat-straw	857	4.8	6.3	2.2
Barley-straw	857	5.6	10.7	1.9
Oat-straw	857	6.4	16.3	2.8
Potatoes	250	3.4	5.8	1.6
Mangels	115	1.9	4.6	0.7
Swedes	107	2.4	2.0	0.6
Carrots	150	2.2	3.0	1.1
Turnips	80	1.6	2.9	0.8

These figures show that oilcakes, beans and peas, malt-dust and bran, are the most valuable foods for the production of rich manure. Hay and straw are characterised by containing a considerable amount of potash. The cereal grains and roots contain nearly the same quantity of nitrogen in their *dry substance*, the roots supplying the most potash. The poorest manure is that yielded by wheat-straw.

The proportion of nitrogen, &c., which passes into the manure depends, of course, on the amount retained by the animal. The same food supplied to different animals will yield manure of very different values. A ton of corn consumed by a milking cow or fattening pig will produce manure of much less value than if given to a working horse. When, as in the latter case, there is no increase of animal produce during feeding, the quantity of nitrogen, phosphates, and potash in the manure will be practically the same as in the food consumed.

Lastly, the value of the manure will much depend on the manner in which it is preserved. This part of the subject has been already noticed on p. 64.

Lime.

We have not spoken of lime as a manure, because it is not generally, like other manures, intended to serve as a plant-food. An application of chalk or lime often greatly increases the fertility of a soil; but it does this chiefly by improving its physical and chemical condition. Lime especially acts by attacking the nitrogenous organic matter of the soil, and rendering it more available as plant-food. Lime is invaluable in reclaiming peat.

Valuation of Unexhausted Manures.

Before concluding our brief summary of the chief points which determine the fertility of soil, some reference will probably be expected to the difficult question of the valuation of unexhausted improvements. Under certain circumstances an outgoing tenant can now claim compensation for past expenditure which has resulted in an increase of the fertility of the land. In considering any such claim, it should always be recollected that the only real proof of increased fertility is the fact that better crops can be grown than formerly. If this fact cannot be established, it is hard to see how any claim can be sustained. The amount of increase in the crops, and the length of time that the additional fertility of the land will probably endure, are thus points which would, if they could be fixed, determine the unexhausted value of past improvements. Such estimates are, however, attended with much uncertainty. In cases, therefore, in which the outgoer has a clear claim, either against the landlord or the incoming tenant, it is more usual to estimate what proportion of the value of each item of acknowledged improvement is unexhausted at the time of leaving. The value of such operations as draining or liming depends so greatly on the nature of the soil, that the experience already gained in carrying out these operations on similar land will be the chief, if not the only, guide in assessing a fair charge for these items of claim.

With regard to unexhausted manures something more may be said. We have already pointed out that while nitrate of soda and salts of ammonia give their effect entirely in the first year, applications of nitrogenous organic manures, as farmyard manure, sea-weed, fish, bones, or oilcakes, give only a portion of their effect in the first season of their application, and their employment may therefore become a subject of claim against the landlord or incoming tenant. The use of purchased phosphates or potash salts may also possibly become a subject of claim, as any surplus of phosphates or potash remaining in the soil is more or less available for future crops.

As nitrogenous manures are the most costly, and, on the whole, of most importance in increasing the fertility of the land, their valuation has naturally received the greatest attention. Nitrogenous organic manure is generally obtained by the consumption of food by stock. The consumption of purchased foods on the farm thus becomes a frequent subject of claim. The claim has frequently but erroneously been based on the price given for the cake or corn consumed; it is obvious, however, that the price of the food has no necessary connection with its manure value. A ton of wheat and of cotton-cake may be similar in price, but the latter contains nearly four times as much nitrogen as the former, and will yield a manure nearly four times as valuable.

Sir J. B. Lawes in 1860 published a table showing the estimated value of the manure obtained by the consumption of one ton of various articles of food. In 1885, Messrs Lawes and Gilbert returned to the subject, and published in the *Journal of the Royal Agricultural Society* (vol. xxi. p. 590) a table showing the estimated value of the manure from one ton of food, not only when freshly prepared, but during a series of eight years after the application of the manure to the soil. The amount of nitrogen, phosphoric acid, and potash in the manure is reckoned by subtracting from the amount in the food that which is stored up in the animal. The foods are assumed to be consumed by *fattening* animals; and it must be recollected that if the same foods were supplied to a growing animal, or to one producing milk, a larger proportion of the nitrogen, phosphoric acid, and potash would be retained by the animal, and therefore lost to the manure. The quantities of nitrogen, phosphoric acid, and potash estimated as present in the manure are first reckoned at the money value which these substances have in active artificial manures. This value is, however, clearly in excess of the true value of animal manure,—*firstly*, because the animal manure is sure to contain less than the estimated quantity of nitrogen, the manure being, in its preparation, exposed to several sources of loss; *secondly*, because the constituents of the manure, especially the nitrogen, are not in the immediately available condition which they possess in artificial manures, and have thus not an equal money value. Messrs Lawes and Gilbert, therefore, in the case of cake, corn, and roots, take one-half of the calculated full manure value, and in the case of hay and straw, one-third of the full value, as the highest figure to be used for the purpose of valuation.

This highest valuation would be awarded if the foods had been consumed in the last year, and the manure had not yet produced a crop. From this highest valuation ⅓ would be deducted if another year had elapsed, or $^1/_5$ in the case of hay and straw; and the valuation of each succeeding year would, always according to the character of the food, be ⅓ or $^1/_5$ less than that of the year preceding.

To give an example: The full calculated value of the manure from 1 ton of linseed-cake is £3, 18s. 6d. One-half of this, or £1, 19s. 3d., is taken as the fair value of the manure, if made last year, and has not yet grown a crop. The residual value of the same manure the second year is £1, 6s. 2d.; the third year, 17s. 6d.; the fourth year, 11s. 8d., and so on. In making this estimate of the gradual diminution in the value of the manure, it is assumed that the land to which it is applied is heavy land. On a sandy soil, and especially on a calcareous soil, the value of the manure will more rapidly disappear.

Causes of Infertility.

In conclusion, we must refer to some special conditions which render certain soils infertile. A soil may be "sour" from the presence of an excess of vegetable matter and water; the cure is lime and draining. A soil or subsoil sometimes contains ferrous salts, either natural to the formation, as in lias clays, or produced by the causes mentioned as yielding "sour" soils; the cure is lime and thorough ploughing. A soil reclaimed from the sea is charged with salts; these are best removed by throwing the land into ridges and draining. When the salts are alkaline, as is the case with large districts in California and India, repeated dressings of gypsum must accompany ridging and draining.

AGRICULTURAL EDUCATION.

In preceding pages reference has been made to the principal subjects of a scientific nature upon which a young farmer should endeavour to inform himself. The aim has been, rather to point out in what way these have a bearing on farm life, and to advise the farm-pupil to study them, than to enter into details regarding any particular one, leaving him to find these in books devoted to their special subjects. It must not, of course, be supposed that those mentioned are the only subjects which ought to be studied by those who desire to become successful farmers; but they are of greatest importance, and others not mentioned might almost be looked on as special departments of these general headings.

Besides these scientific matters, however, there are a large number of others —not exactly scientific in the proper sense of the term—which are equally important, such as book-keeping and commercial knowledge, agricultural law, forestry, &c.,—so that there is a wide range of subjects before the agricultural student.

But a beginner must not be disheartened by a too formidable array. The matter, indeed, will not be found so very difficult by any one who attacks it with the determination of doing earnest work.

Agricultural Curriculum.

Usually two winter sessions at a college, or at most two full years, are sufficient to enable a student to acquire sufficient information to pass the various agricultural examinations, and look on himself as "duly qualified" to "practise as a farmer," as we shall show immediately. For those who cannot afford the time or the money to attend college classes, there are a superabundance of books treating on each subject which might be studied in leisure hours, or during the long winter evenings, with the greatest benefit. There are not wanting men who have raised themselves to the highest position as authorities on agricultural science who have done it all by private study, without attending any classes, and scarcely even a lecture.

Nevertheless, attendance at classes where these subjects are taught is by far the best plan for the great majority of young men. The hard manual labour of the farm and the open-air life are not conducive to mental exertion, and one who has been at the plough-tail all day does not feel inclined to tackle chemistry or mechanics in the evening.

Practice and Science.

Farming is made up of two parts—practice and science. The practice can be learned only by actual continuous work on a farm, attending to all the minute details of labour and management. The science of agriculture is best learned away from the manual labour altogether. Both of them are necessary nowadays, the one being an essential complement of the other, to ensure agriculture being a successful whole; and both of them will be found equally useful by a young man when he comes to manage land for himself.

Importance of Agricultural Education.

It is perfectly certain that in the future—whatever it may have been in the past—the educated farmer will take the lead. The merely practical man, whose mind can hold only a few ideas, will give place to one who, while thoroughly well versed in every practical detail of work and management, is at the same time a man of education and scientific skill.

The period of "depression" which has befallen agriculture in common with other businesses, has had the effect of making the rank and file of tenant-farmers more willing to attend to anything which promises to help them to farm with better results, and thus of late there has been a greater inclination to hear what science has got to say on the matter, and to put it into practice. The various agricultural colleges and science-classes scattered up and down the country are becoming better attended as time goes on, and sooner or later the "leaven" will affect the whole mass, and we may then expect to see agriculture take the position it is entitled to hold.

TEACHING INSTITUTIONS.

Mention has been made of colleges and classes where the theory and practice of agriculture are taught. It will be useful if a short statement regarding the leading institutions is given, and the curriculum laid down for a farm-pupil. Before doing so, however, it may just be mentioned that some of them are more suited for the education of landowners and land-agents than for ordinary tenant-farmers. This is not because the information given is not of the proper kind—for all the classes are well chosen—but because it is necessary to charge fees which are prohibitory to ordinary occupiers, and also because the ordinary farmer's son will learn the practical work far better and cheaper at home on his father's farm than on any other.

It has already been pointed out that a young man ought to learn the practice first by regular manual labour on a farm, and *afterwards* study the sciences appertaining thereto, so that a college "with a farm attached" is quite an unnecessary institution for the great majority of farmers' sons.

But for those, however, who have not been bred on the farm, and whose means are ample enough, there is no doubt that two or three years at such an institution is the best possible arrangement—infinitely better than paying £100 to £150 per annum to learn farming from some "practical" man who, perhaps, has little or no teaching abilities.

For farmers' sons, attendance at lectures during the winter only, with a return home during the summer, is most to be recommended, both on the score of economy and suitability.

Royal Agricultural College, Cirencester.

The Royal Agricultural College, Cirencester, is the oldest and best known of the various institutions for teaching both the practice and science of agriculture. The complete course extends over two years, there being three terms in each, and students can graduate at the end of that time with the diploma of membership. Shorter periods of study can be undertaken, if desired, and students may be either boarders in the college or reside outside.

The subjects taught are Practical Agriculture and Dairy-Farming; Chemistry; Geology, Botany, and Zoology; Mensuration, Physics, and Mechanics; Land-Surveying and Estate Engineering; Veterinary Surgery; Book-keeping; Agricultural Law; Building and Construction; Estate Management and Forestry; and Drawing. There is a large farm of 500 acres attached to the college buildings, which is worked after the manner of the best-managed farms of the Cotswold district. To this the students have access, and they are expected to make themselves practically acquainted with all the work which is going on. Cotswold sheep and Berkshire pigs form the principal live stock—both being well known in the show-yard.

Instruction in dairy-work is one of the lately introduced features, and there is a veterinary hospital for the practical treatment of animals. There is also a botanic garden, and the building contains class-rooms, laboratories, museum, library, and all appliances for teaching.

The fees charged are £135 per annum or £45 per term for in-students, and £75 per annum, or £25 per term for out-students.

Edinburgh University.

Edinburgh University has had a Chair of Agriculture for well on to a century, and though the most of the sciences bearing on farming have been taught from other chairs, yet these have always had more of a medical or general than an agricultural bearing.

Degree in Agriculture.—In 1886 a degree of Bachelor of Science in Agriculture was instituted on the same standing as the B.Sc. degree in other departments, and open to all those who had attended certain qualifying classes. The subjects prescribed are eight in number, which can be taken in two periods of four each. These are Agriculture (Elementary Principles), Chemistry, Botany, and Engineering for the first part; with Zoology as an alternative for Botany; and Agriculture (the whole subject), Agricultural Chemistry, Geology, and Veterinary Science for the final.

As with all other medical and science degrees, however, there is a preliminary examination in general education, comprising some seven different subjects, and such as a youth coming up from a public school or academy is expected to be acquainted with. Students must have attended classes for three years, or for two years, with at least one year on a farm, one of the years being spent at Edinburgh University. Certain extra-mural classes are recognised as qualifying for graduation, especially those of Agricultural Chemistry and Veterinary Science, which are not as yet taught within the University.

It is notable that this is the only degree in Agricultural Science which is granted at a university in Britain—perhaps, we may say, in the world. And it is very appropriate that the university of the capital city of a country so long famous for good farming should be the first to recognise the importance of the subject in this way, and accept it as of equal standing with every other profession taught within its walls.

The cost of taking this degree will vary with the individual student, and may be kept down within a very moderate limit. In Scottish universities all the students reside in their own private lodgings, and consequently the outlay for each winter session of six months will depend on the style of living adopted. The class fees are usually about three or four guineas each, with extra fees for matriculation, examination, &c.; but altogether the cost of education and living need not exceed £40 per session, unless the student is personally extravagant. The whole course for the degree might be gone through by a farmer's son for less than £100.

College of Agriculture, Downton.

The College of Agriculture, Downton, Salisbury, Wilts was established in 1880 for the purpose of giving a practical and scientific course of instruction in agriculture. The farm — which extends to 600 acres—is in the occupation of the college, and its management is part of the work of the college authorities. It is farmed in a manner similar to the land in the neighbourhood, the soil being a good light loam, with the fields rising up to the Downs. The principal stock is the famous breed of Hampshire Down sheep; but the dairy, and a herd of Berkshire pigs, are notable features of the farm.

The subjects taught are,—Practical Agriculture; Dairy and Pastoral Farming; Estate Management, Land Agency, and Forestry; Mensuration, Trigonometry, Land-Surveying, Building, Construction, and Drawing; Book-keeping and Commercial Knowledge; Physics and Mechanics; Chemistry and Chemical Analysis; Geology and Mineralogy; Botany and Vegetable Physiology; Zoology and Entomology; Anatomy and Physiology; and Veterinary Surgery. The course occupies two full years, and is sufficient to qualify students for the examinations of the Royal Agricultural Society, the Highland and Agricultural Society of Scotland, the Royal Agricultural Society of Ireland, and the Surveyor's Institute.

There are three terms in the year, and the fees are £135 per annum for in-students and £72 for out-students.

Lectures at Oxford.

The University of Oxford has long had an endowment for a Chair of Rural Economy, but up till quite recently it was united with the Chair of Botany. Since 1884, however, the two have been separate, and now the students of that university have the privilege of attending a class on Agriculture. The lectures are given in Magdalen College, and twelve is the minimum number per annum—four in each term. The professor is appointed for three years only, and cannot hold the post for more than six years altogether. As the course is so short, the subjects of agriculture must be treated very generally, or else only a very small department taken up.

There is also a lectureship in "Agricultural Science" attached to Balliol College, Oxford, intended especially for the Indian Civil Service Probationers. Both are open to students who take an interest in farming, and as these are mostly of the landlord or land-agent class, they can gain a certain amount of information which will be of use to them later in life, though of course not a thorough or exhaustive knowledge of the subjects.

Aberdeen University.

In the University of Aberdeen there is the Fordyce lectureship on Agriculture, the chemical, botanical, and geological aspects of the matter being most largely dealt with. The lectures, not less than twelve in number, are given at intervals, and are free and open to any one, whether regular students of the University or not.

Glasgow Technical College.

In the Glasgow and West of Scotland Technical College there is a course of 100 lectures on Agriculture delivered during the winter six months, and arrangements have now been made for a special class of Agricultural Chemistry. Farming students can attend the ordinary classes on Botany, Geology, Engineering, Drawing, &c., in common with those of other professions. The full course occupies three winters, and is intended to cover the ground taken up by the diploma of the Highland and Agricultural Society, and qualifies students for the same, while the fees charged are very moderate, varying with the number of classes attended. Students have, of course, special advantages in seeing so much good practice going on, as the district of Clydesdale, which is at hand, is one of the best farmed localities in the United Kingdom.

Normal School, London.

The Normal School of Science and the Royal School of Mines (affiliated), London, some few years ago established a lectureship of Agriculture, which later on was made a professorship, where students could attend a course of about thirty to forty lectures. The other classes in the same institution, which were attended by young men intending to become mining engineers, geologists, &c., were utilised for making a complete course, as far as they had any connection with agriculture. Three years are required to complete attendance at all the prescribed classes, and at the end of that time a student can graduate with the degree of "Associate."

The subjects taught are—Chemistry; Physics and Astronomy; Mathematics and Drawing; Biology; Geology and Mineralogy; and during the third year Mechanics, Principles of Agriculture, and Agricultural Chemistry, in the special department of "Agriculture." The fees for the first two years amount to about £75, and for the remainder of the course for the associateship they vary from £30 to about £40.

Institute of Agriculture.

The Institute of Agriculture, South Kensington, has been established for the purposes of advancing technical instruction upon various sectious of agricultural practice, as a preparation for learning the business of farming, and especially for bringing these advantages within the reach of any and every person desiring to avoid much expense. Short courses of lectures on specific subjects are instituted from time to time, and gentlemen noted as authorities are asked to conduct a course on their own special department. The full series amounts to about 280 lectures at the rate of two daily, by about twenty of the most eminent authorities—the fees amounting to a total of £14.

The lectures are principally intended for teachers and students under the Science and Art Department, and they are varied to suit the demand for instruction.

The subject of the "Principles of Agriculture," which forms No. XXIV. of those under the superintendence of the Science and Art Department just mentioned, is perhaps the one which is best known and most widely taught in country districts. Wherever a sufficient number of students can be got together, a committee formed of men of local standing are at liberty to appoint a teacher to deliver one lecture per week—twenty-eight in all—during the winter six months. The students are expected to attend the examination in May, and the teacher is paid by Government grant according to the success of the students. The lecturer must possess certain qualifying certificates, or be otherwise approved by the Department. There are some 300 or 400 of these classes in the British Islands, and over 12,000 students—the number varying from year to year. There can be no doubt that for beginners, or for those who can attend local centres only, one of these classes would be very suitable and useful.

Agricultural College, Aspatria.

The Agricultural College, Aspatria, was established in 1874, for the purpose of affording pupils as much insight into agricultural science and practice as possible before they left school. The pupils first receive a good general education up to the age of fifteen, and then they proceed to the study of various sciences bearing on farming, such as Chemistry, Agricultural Chemistry, Physics, Botany, Animal Physiology, Geology, Entomology, Forestry, and Veterinary Science. The older youths work a portion of each day on one or other of nine distinct farms, under the personal supervision of the principal and practical farmers. The instruction qualifies the pupils for the Junior Examinations of the Royal Agricultural Society of England, the Bursary Examinations of the Highland and Agricultural Society, and for the Certificates of the Science and Art Department. The institution has been largely assisted by the landowners and farmers of Cumberland.

There are three terms in the year. In-pupils pay from 15 to 17 guineas per term, and out-pupils £3, 5s.

Dairy Schools.

Dairy schools recently established in Cheshire and Derbyshire are doing excellent work, and the British Dairy Farmers' Association have matured a scheme for founding a school or college near Aylesbury for teaching improved dairying.

AGRICULTURAL TEACHING IN IRELAND.

Ireland has long enjoyed exceptional advantages in respect to facilities for imparting agricultural education. Substantial Government grants have been given to Ireland for this purpose; and although the Irish National Agricultural Schools have not, as a whole, been so successful as could have been desired, there is no doubt that the country has derived great benefit from the movement for the promotion of technical and scientific training in agriculture. The Albert Institution at Glasnevin, near Dublin, with its admirably conducted model farm attached, is a well-equipped agricultural college, in the curriculum of which all the usual subjects, including a special course in dairying, are embraced.

Then the Munster Dairy School near Cork, supported by Government grant and local effort, is at present the most complete and most efficient institution of the kind in the United Kingdom.

GENERAL TEACHING FACILITIES.

It will thus be seen that there are considerable facilities for scientific teaching in relation to agriculture in the British Islands. Upon the whole, too, this teaching has been of a high character, and it has not been unreasonably expensive.

State Aid to Agricultural Education.—It is a noteworthy fact that

Continental countries and the United States do far more to encourage scientific education in farming, in the way of Government grants and equipping State-aided colleges, than is done here in Britain. On the other hand, it is generally recognised that British farmers are the best in the world. It has thus often been pertinently asked what good science does when, notwithstanding the existence of a college in every province abroad, British agriculture is so decidedly in advance of that in foreign countries? The answer to this is, that there the science has only just now reached down to the great mass of the farming community—often of the peasant-proprietor class—and is only of late being taken advantage of, so that in the immediate future there is likely to be greater results than ever before attained.

The fact, however, that Continental and other farm-produce of all kinds can be sold in our own markets at less than would be its cost of production in this country, while the quality is often superior, goes far to prove that there is something in their knowledge of the subject, and that it is not all the result of cheap labour or a better climate.

All that our Government has hitherto done to help in the matter in Great Britain has been to give an annual grant to the Chairs of Agriculture at Edinburgh and in the Normal School of Science, while, of course, the Science and Art Department work is carried on mostly by State aid.

At last, however, a step in advance has been taken. It was announced early this year (1888) that the Government had decided to establish an Agricultural Department, with a Minister of Agriculture at its head, and that a grant of £5000 would be given in aid of agricultural education in England and Scotland. Various schemes are on foot for the utilisation of this grant; the one which has received most favour being that of aiding institutions already in working order. To this end the money has been divided in various proportions among those institutions which have satisfied the Government authorities. It is to be hoped that the beginning thus made, tardy though it be, may develop into an extensive and useful organisation.

THE PLAN OF THE WORK.

Two modes of describing *farm business* may be adduced. One, to arrange the particulars of business under different heads, and describe similar operations under the same head, as is done in systematic works on agriculture. The other, to describe the operations as they *actually occur, singly, and in succession,* on the farm, as is to be done in this book; and this is the natural method. Both methods describe the general farm operations, and may be consulted for any particular operation. But the relative position any work stands in regard to, and influences any other, can be shown only by the natural method, and it does so at a glance. As one piece of farm work terminates, another commences, and at different periods of the year, the natural method only can clearly indicate the period in which any work commences, is continued, or terminates, and can give the details of it minutely.

The Agricultural Year.—The agricultural year, like the common, is conveniently divided under the four seasons, and the entire farm business is also conveniently divided into *four parts,* each bearing the name of the season that influences the operations performed in it. It is by such an arrangement only that every operation, whether requiring longer or shorter time for completion, can be intelligibly described, as it takes its turn in the field. The work that occupies only a short time to finish, in any of the seasons, may be described in a single narrative. Very few of the operations, however, are completed in one of the seasons, some extending over the whole four, and most into two or three. Any work that extends over most of the seasons can nevertheless be described with accuracy; for although it may occupy a long time to reach its completion, every season imposes its part on the work, and terminates it so far; so that cessations of labour are thus not mere conveniences, but necessary and temporary finishings of work which would be wrongly prosecuted but in its own proper season. In this way the extended works are advanced, in progressive steps, from season to season, until their completion; while the shorter ones are concurrently brought onwards and completed in *their* proper season.

These preliminary remarks, it is to be hoped, may enable the agricultural student and farmer to follow the details of farming as they usually occur. The mixed husbandry system is that which is most fully dealt with, but an endeavour is made to acquaint the reader with the corresponding operations in the other modes of farming adopted in localities peculiar to themselves.

Narrating the operations in the order they are performed, the work begins with WINTER—the beginning, also, of the agricultural year—and proceeds in the natural order through the seasons of SPRING, SUMMER, and AUTUMN, until the winter season and another year are again reached.

PRACTICE.

WINTER.

THE WEATHER, AND FIELD OPERATIONS IN WINTER.

Work in the Steading.—The subjects which court attention in winter are of the most interesting description to the farmer. He directs his attention mainly to work conducted in the steading, where the cattle and horses are collected, and this with the preparation of the grain for market affords pleasant employment within doors. The progress of live stock towards maturity is always a prominent object of the farmer's solicitude, and especially so in winter, when they are comfortably housed in the farm-steading, plentifully supplied with wholesome food, and so arranged in various classes, according to age and sex, as to be easily inspected at any time.

Field Work.—The labours of the field in winter are confined to a few great operations. These are chiefly ploughing the soil in preparation for future crops, and supplying food to live stock. The commencement of the ploughing for the year consists in turning over the ground which had borne a part of the grain crops, and which now bears their *stubble*—which is just the portion of the straw of the previous crops left uncut.

Water-channels in Ploughed Land.—The stubble land ploughed in the early part of winter, in each field in succession, is protected from injury from stagnant rain-water, by cutting channels with the spade through hollow places, permitting the rain to run quickly off into the ditches, and leaving the soil in a dry state until spring.

Ploughing Lea.—Towards the latter part of winter, the grass land, or *lea*, intended to bear a crop in spring, is ploughed; the oldest grass land being earliest ploughed, that its toughness may have time to be softened before spring, by exposure to the atmosphere. The latest ploughed is the youngest grass.

Best Season for Draining.—When the soil is naturally damp underneath, winter is selected for removing the water by draining. It is questioned by some farmers whether winter is the best season for draining, as the usually rainy and otherwise unsettled state of the weather renders the carriage of the requisite materials on the land too laborious. By others it is maintained that, as the quantity of water to be drained from the soil determines both the number and size of the drains, these are best ascertained in winter; and as the fields are then entirely free of crop, that season is the most convenient for draining. Truth may not absolutely acquiesce in either of these reasons, but, as a rule, draining may be successfully pursued at all seasons.

Planting Hedges.—Where fields are unenclosed, and are to be fenced with a quick thorn-hedge, winter is the season for performing the work. Hard frost, a fall of snow, or heavy rain, may put a stop to the work for a time, but in all other states of the weather it may be proceeded with in safety.

Water-meadows.—When water-meadows exist on a farm, winter is the season for carrying on the irrigation with water, that the fostered grass may be ready to be mown in the early part of the ensuing summer. It is a fact worth bearing in mind that *winter* irrigation produces more wholesome herbage for stock than summer irrigation. On the other hand, summer is the most proper season for forming water-meadows.

Stock in Houses.—Almost the entire live stock of an arable farm are dependent on man for food in winter. The stock, thus concentred before their owner, excite greater interest than at any other season. He classifies them in the farmstead by their age and sex, their nature and condition, and marks the progress of all towards the destination of each. He provides them with a comfortable bed and sufficient clean food at appointed hours.

Feeding Stock.—The feeding of stock is so large and important a branch of farm business in winter, that *it* regulates the time for prosecuting several other operations. It determines the quantity of turnips that should be carried from the field in a given time, and causes the prudent farmer to take advantage of dry fresh days to store up a reserve for use in any storm that may ensue. All the cattle in the farmstead in winter are placed under the care of the *cattle-man.*

Threshing Grain.—The necessities of stock-feeding also determine the quantity of straw that should be provided from time to time; and upon this, again, depends largely the supply of grain that may be sent to market at any time. For although it is in the farmer's power to thresh as many stacks as he pleases at one time, and he may be tempted to do so when prices are high; yet, as new threshed straw is better than old, both as litter and fodder, its threshing depends mainly on the wants of the stock; and as its use as litter is greater in winter, when wet weather prevails, the quantity then used is most considerable, and so must be the grain sent to market.

Sheep on Turnips.—The feeding of sheep on turnips, in the field, is practised in winter. When put on turnips early in winter, sheep consuming only a proportion of the crop, a favourable opportunity occurs for storing the remaining portion for cattle in case of bad weather. The proportion of turnips used by cattle and sheep determines the quantity that should be taken from the field.

Attention to Ewes.—Ewes roaming at large over pastures require attention in winter in frost and snow, when they should be supplied with clover-hay, or with turnips when hay is scarce. The *shepherd* has the charge of the sheep flock.

Marketing Grain.—The preparation of grain for sale is an important branch of winter farm business, and should be strictly superintended. A considerable proportion of the labour of horses and men is occupied in carrying grain to the market town or railway station—a species of work which used to jade farm-horses very much in bad weather, but railways have materially shortened the journeys of horses in winter.

Carting Manure.—In hard frost, when the plough is laid to rest, or the ground covered with snow, and as soon as

> "By frequent hoof and wheel, the roads
> A beaten path afford,"

farmyard manure is carried from the courts, and placed in large heaps on convenient spots near or on the fields which are to be manured in the ensuing spring. This work is continued as long as there is manure to carry away, or the weather proves severe.

Implements used in Winter.—Of the implements of husbandry, only a few are used in winter;—the plough is constantly so when the weather will permit; the threshing-machine enjoys no sinecure; and the cart finds frequent and periodic employment. The others are laid by for the winter.

Winter Marketing.—The winter is the season for visiting the market town regularly, where the surplus produce of the farm is disposed of—where articles are purchased or bespoken for the use of the farm, when the busy season shall arrive—where intermixture with the world affords the farmer an insight into the conduct of men.

Winter Recreation.—*Field-sports* have their full sway in winter, when the fields, bared of crop and stock, sustain little injury by being traversed. Although farmers bestow but a small portion of their time on field-sports—and many have no inclination for them at all—they might harmlessly enjoy these recreations at times. When duly qualified, why should not farmers join in a run with fox-hounds?—or take a cast over the fields with a pointer?—or shout a see-ho to greyhounds? Either sport forms a pleasing contrast to the week's business, gives a fillip to the mind and a stimulus to the circulation. These sports are pursued only in fresh weather, and when the ground is not heavy with wet. Should frost and snow prevent their pursuit, curling and skating afford healthful exercise both to body and mind.

Winter Hospitality.—Winter is the season for country people reciprocating the kindnesses of hospitality, and participating in the amusements of society. The farmer delights to send the best produce of his poultry-yard as Christmas presents to his friends in town, and in return to be invited into town to partake of its amusements. But there is no want of hospitality nearer home. Country people maintain intercourse with each other; while the annual county ball in the market-town, or an occasional one for charity, affords a seasonable treat; and the winter is often wound up by a meeting given by the Hunt to those who had shared in the sport during the hunting season.

Domestic Enjoyment. — Winter is the season of *domestic enjoyment.* The fatigues of the long summer day leave little leisure, and less inclination, to tax the mind with study; but the long winter evening, after a day of bracing exercise, affords a favourable opportunity for conversation, quiet reading, or music. In short, there is no class more capable of enjoying a winter's evening in a rational manner, than the family of the country gentleman or of the farmer.

Repose of Nature.—Viewing winter in a higher and more serious light—in the repose of nature, as emblematical of the mortality of man—in the exquisite pleasures which man in winter, as a being of sensibility, enjoys over the lower creation—and in the eminence in which man, in the temperate regions, stands, with respect to the development of his mental faculties, above his fellow-creatures in the tropics;—in all these respects, winter is hailed by the dweller in the country as the purifier of the mental as well as of the physical atmosphere.

Weather in Winter.—The *weather* in winter, being very precarious, is a subject of intense interest, and puts the farmer's skill to anticipate its changes severely to the test. Seeing that every operation of the farm is to some extent dependent on weather, a familiar acquaintance with local prognostics which indicate a change for better or worse becomes a duty. In actual rain, snow, or hard frost, few outdoor occupations can be executed; but if the farmer have wisely "discerned the face of the sky," he may arrange his operations to continue for a length of time, if the storm is to endure—or be left in safety, should the strife of the elements quickly cease. Certain atmospherical phenomena only occurring in winter should be noticed here—aurora borealis, halos, frost, ice, snow.

Aurora Borealis.—The only electrical excitation witnessed in winter is the *aurora borealis.* It consists of two varieties,—one a luminous quiet light in the northern horizon, gleaming most frequently behind a dense stratum of cloud; the other, vivid coruscations of white light, of sufficient transparency to allow a sight of the fixed stars. The coruscations are sometimes coloured yellow, green, red, and of a dusky hue: they are generally short, and confined to the proximity of the northern horizon; but occasionally they reach the zenith, and even extend to the opposite horizon, their direction being from N.W. to S.E.

The *prognostics* connected with the appearance of aurora in winter are these: When exhibiting itself in a gleam in the north, it is indicative of change; when it coruscates a little, the weather is decidedly changeable; and when the coruscations reach the zenith, and beyond, they augur cold stormy wind and rain. It has been long alleged that the aurora has the effect of producing a certain direction of wind. Mr Winn stated that in the south of England it was constantly followed by a S.W. wind and rain, and that the gale always began from 3 to 24 hours after the phenomenon; and that the intensity of the storm, and the time it appears, may perhaps depend on the intensity of the aurora.[1] Coloured aurora is usually indicative of a change from good to bad.

Thunderstorms in Winter.—*Thunderstorms* are of rare occurrence in winter, owing, probably, to the generally humid state of the atmosphere carrying off the superfluous electricity silently, and not allowing it to accumulate in any one place. Sometimes, however, they do occur, and are generally violent and dangerous; at times setting fire to dwellings, rending trees, and destroying elevated buildings. Such storms are almost always succeeded by intense frost and a heavy fall of snow in the line of their march. Flashes of white lightning near the horizon are sometimes seen in clear fresh nights, when stars are numerous and twinkling, and falling stars plentiful, and they all indicate a coming storm.

Halos.—A *halo* is an extensive luminous ring, including a circular area, in the centre of which the sun or moon appears, and is seen only in winter. It is formed by the intervention of a cloud between the spectator and the sun or moon. This cloud is generally the denser kind of *cirro-stratus*, the refraction and reflection of the rays of the sun or moon at definite angles through and upon which cause the luminous phenomenon. The breadth of the ring of a halo is caused by a number of rays being refracted at somewhat different angles, otherwise the breadth of the ring would equal only the breadth of one ray. Mr Forster has demonstrated mathematically the angle of refraction, which is equal to the angle subtended by the semidiameter of the halo. Halos may be double and triple; and there is one which Mr Forster denominates a *discoid* halo, which constitutes the boundary of a large corona, and is generally of less diameter than usual, and often coloured with the tints of the rainbow.[2] Halos are usually pretty correct circles, though they have been observed of an oval shape; and are generally colourless, and sometimes display faint colours of the rainbow. They are most frequently seen around the moon, and acquire the appellation of *lunar* or *solar* halos, as they happen to accompany the particular luminary.

The *corona* or *brough* occurs when the sun or moon is seen through a thin *cirro-stratus* cloud, the portion of the cloud more immediately around the sun or moon appearing much lighter than the rest. Coronæ are double, triple, and even quadruple, according to the state of the intervening vapours. They are caused by a similar refractive power in vapour as the halo, and are generally faintly coloured at their edges. Their diameter seldom exceeds 10°. A halo frequently encircles the moon, when a small corona is more immediately around the moon's disc.

Weather Prognostics in Winter.—*Prognostics* indicated by appearances in the sky in winter may be noticed: Sharp horns of a new *moon*, and a clear moon at any time, are characteristics of coming frost.

In frost, the *stars* appear small, clear, and twinkling, and not very numerous; when few in number in fresh weather, it is certain that much vapour exists in the upper portion of the atmosphere; but if very numerous, having a lively twinkle, rain is indicated—the transparent vapour, in the act of subsiding into clouds, causing the twinkling.

Falling stars occur pretty frequently in winter, appearing in greatest number when stars are numerous, and are indicative of deposition of vapour, accompanied with wind from the point towards which they fall.

Dull sun, moon, and stars—occasioned by thin cirro-stratus, almost invisible—are indicative of change to rain in fresh, and to snow in frosty, weather.

Coronæ always indicate fall of vapour, whether in rain, snow, or hail, according to the warmer or colder state of the air at the time. *Coloured* coronæ and halos are sure indications of approaching fall of rain in fresh, and snow in frosty, weather.

Clouds in Winter.—The most common *cloud* in winter is the *cirro-stratus*, whether in the state of a shrouding veil,

[1] *Field Natur.*, i. 108.
[2] Forster's *Atmos. Phen.*, 101-107.

more or less dense, across the whole sky for days, or in heavy banked clouds in the horizon before and after sunset. Whenever this cloud is present, there must be a large amount of vapour in the air, coming nearer to the ground as the power that suspends it is by any means weakened. Rain mostly falls direct from the cirro-stratus; but ere snow falls in any quantity, the cirro-stratus descends to the horizon into cumulo-stratus, from whence it stretches over the zenith in a dense bluish-black cloud. Cirri in winter are a sure indication of a change of wind in twenty-four or more hours from the quarter to which their turned-up ends point; but if their ends do not turn up, rain may be expected in twelve hours. Rain follows sooner than wind. It may be taken as an established fact, that if Noah's ark does not extend over the zenith, rain or wind will be experienced only at the place where it does span over the zenith.

Winter Rain.—The character of *winter rain* has more of cold and discomfort than of quantity. When frost suddenly gives way in the morning about sunrise, rain may be looked for during the day. If it do not fall, a heavy cloudiness will continue all day, unless the wind change, when the sky may clear up. If a few drops of rain fall before mid-day after the frost has gone, and then ceases, a fair and most likely a fine day will ensue, with a pleasant breeze from the N. or W., or even E. When the moon shines brightly on very wet ground, the shadows of objects become very black; which is a sign of continuance of rain, and unsettled state of the wind. Rain often falls with a rising barometer, which is usually followed by fine healthy weather, attended with feelings that indicate a strong positive state of electricity. "We have," says Mr Forster, "usually a warm and agreeable sensation of the atmosphere with such rain, which is strikingly contrasted to the cold and raw sensation occasioned by the fall of thick wet mists or rain, which happens when, even with a N. or E. wind, the barometer and thermometer sink together, and when the air has previously been found to be either negatively or non-electrified; and the cause of this is most probably occasioned by a supervening current of colder or supersaturated air; and the rise of the thermometer, which accompanies the fall of the barometer in this case, may be owing to the increase of temperature produced by the condensation of the vapour in the case of rain."

Winter Winds.—"Gusts of *wind*, in some high windy weather, seem to fluctuate in a manner somewhat analogous to the undulatory motion of waves. This fact may easily be seen by a pendulous anemometer. When the wind is accompanied by the rain, the periods of the gusts may be counted by the intervals of the more or less violent impulses of the water on the windows opposed to the wind, or the leaves of any tree twined across them."[1]

Utility of Rain.—Rain is useful in husbandry by consolidating light soils, and dissolving and carrying down solutions of manure *into* the soil—when sheep are feeding on turnips, for example—and placing them beyond the reach of evaporation; but its chief utility in winter is supplying threshing machinery, or irrigation, with abundance of water.

Cold and Frost.—*Frost* has been represented to exist only in the absence of heat; but, more than this, it also implies an absence of moisture. Sir Richard Phillips defines *cold* to be "the mere absence of the motion of the atoms called heat, or the abstraction of it by evaporation of atoms, so as to convey away the motion, or by the juxtaposition of bodies susceptible of motion. Cold and heat are mere relations of fixity and motion in the atoms of bodies."[2]

Frost, it is supposed, originates in the upper portions of the atmosphere, by expansion of the air carrying off existing heat, and making it susceptible of acquiring more. What the cause of the expansion may be, when no visible change has taken place in the meantime in the ordinary action of the solar rays, may not be obvious to a spectator on the ground; but it is known, from the experiments of Lenz, that electricity is as capable of producing cold as heat, to the

[1] Forster's *Atmos. Phen.*, 247 and 342.
[2] Phillips's *Facts*, 395.

degree of freezing water rapidly.[1] The poles of cold and the magnetic poles probably coincide.[2]

The most intense frosts in this country never penetrate more than one foot into the ground, on account of the excessive dryness occasioned by the frost itself withdrawing the moisture. Frost cannot penetrate through a thick covering of snow, or below a sheet of ice, or through a covering of grass on pasture, or the fine tilth on ploughed land, all which act as non-conductors against its descent.

Beneficial influence of Frost.—Frost is always present in winter, though seasons do occur in which very little exists. It is a useful assistant to the farmer in pulverising the ground, and rendering the upper portion of the ploughed soil congenial to the vegetation of seeds. It acts in a mechanical manner on the soil, by freezing the moisture in it into ice, which, on expanding at the moment of its formation, disintegrates the indurated clods into fine tilth. Frost always produces a powerful evaporation of the pulverised soil, and renders it very dry on the surface; by the affinity of the soil for moisture putting its capillary power into action, the moisture from the lower part of the arable soil, or even from the subsoil, is drawn up to the surface and evaporated, and the whole soil is thus rendered dry. Hence, after a frosty winter, it is possible to have the ground in so fine and dry a state as to permit the sowing of spring wheat and beans, in the finest order, early in spring. Frost, being favourable to the exhibition of electricity, may also prove useful to husbandry, by stimulating its influence, not only in the soil but on vegetation.

Snow.—Rain falls at all seasons, but *snow* only in winter, or late in autumn, and early in spring. Snow is just frozen rain, so that whenever symptoms of rain occur, snow may be expected if the temperature of the air is sufficiently low to freeze vapour. Vapour is supposed to be frozen into snow at the moment it is collapsing into drops to form rain, for clouds of snow cannot float about the atmosphere any more than clouds of rain.

"If flakes of snow," observes Kaemtz, "are received on objects of a dark colour, and at a temperature below the freezing-point, a great regularity is observed in their forms: this has for a long time struck attentive observers. The crystals of ice are never so regular as when snow falls without being driven by the wind; but temperature, moisture, the agitation of the air, and other circumstances, have a great influence over the forms of the crystals. Notwithstanding their variety, they may be all associated under a single law. We see that isolated crystals unite under angles of 30, 60, and 120 degrees. Flakes which fall at the same time have generally the same form; but if there is an interval between two consecutive falls of snow, the forms of the second are observed to differ from those of the first, although always alike among themselves."[3]

Forms of Snow.—The *forms of snow* have been arranged by Scoresby into 5 orders: 1. The *lamellar*, which is again divided into the *stelliform*, *regular hexagons*, *aggregation of hexagons*, and *combination of hexagons* with radii, or spines and projecting angles. 2. The *lamellar* or *spherical nucleus* with spinous ramifications in different places. 3. Fine *spiculæ* or 6-sided prisms. 4. *Pyramids* with six faces. 5. *Spiculæ*, having one or both *extremities* affixed to the *centre* of a *lamellar* crystal. There are numerous varieties of forms of each class.[4]

All the forms of crystals of snow afford most interesting objects for the microscope, and when perfect no objects in nature are more beautiful and delicately formed. The lamellated crystals fall in calm weather, and in heavy flakes, and are evidently precipitated from a low elevation. The spiculæ of 6-sided prisms occurring in heavy drifts of snow, accompanied with wind and intense cold, are formed at a considerable elevation, and are so fine as to pass through the minutest chinks in houses, and so hard and firm that they may be poured like sand from hand to hand, with a jingling

[1] Bird's *Nat. Phil.*, 232.
[2] Kaemtz's *Meteo.*, 462.
[3] Kaemtz's *Meteo.*, 127.
[4] Scoresby's *Pol. Reg.*

sound, and without the risk of being melted. In this country spiculæ are most frequently accompanied by one of the varieties of the lamellar crystals, which meet their fall at a lower elevation; but in mountainous countries, and especially above the line of perpetual snow, they constitute the greatest bulk of the snow, ready to be blown about with the wind, and lifted up in dense clouds, and precipitated suddenly upon the unwary traveller like sand-drift of the torrid zone. These spiculæ feel sharp when driven against the face, as is experienced on Mont Blanc.

Professor Leslie supposes that, all other things being equal, a flake of snow, taken at 9 times more expanded than rain, descends 3 times as slow.

From the moment snow alights on the ground it begins to undergo certain changes, which usually end in a more solid crystallisation than it originally possessed. The adhesive property of snow arises from its needly crystalline texture, aided by a degree of attendant moisture which afterwards freezes in the mass. Sometimes, when a strong wind sweeps over a surface of snow, portions of it are raised by its power, and, passing on with the breeze under a diminished temperature, become crystallised, and by attrition assume globular forms.

Snow keeps Land warm.—During the descent of snow the *thermometer sometimes rises*, and the *barometer usually falls*. Snow has the effect of retaining the temperature of the ground at what it was when snow fell. It is this property which maintains the warmer temperature of the ground, and sustains the life of plants during the severe rigours of winter in the arctic regions, where the snow falls suddenly after the warmth of summer; and it is the same property which supplies water to rivers in winter, from under the perpetual snows of the alpine mountains. "While air, above snow, may be 70° below the freezing-point, the ground below the snow is only at 32°."[1] Hence the fine healthy green colour of young wheat and grass after the snow has melted in spring.

Snow-water and Rain.—In melting, 27 inches of snow give 3 inches of water. Rain and snow-water are the *softest* natural waters for domestic purposes, and are also the purest that can be obtained from natural sources, provided they are caught before reaching the ground. Nevertheless, they are impregnated with oxygen, nitrogen, and carbonic acid, especially with oxygen; and rain-water and dew contain nearly as much air as they can absorb.[2] Liebig considers that ammonia is the probable cause of the great softness of rain and snow-water.

Falls of Snow.—A heavy fall of snow generally commences in the evening, continues throughout the next day, and at intervals in succeeding days. Snow-showers may fall heavily for the time; and when they fall, and the sky clears up quickly, another shower may follow. In such a case, the air always feels cold. In moonlight, masses of cumulo-strati may be seen to shower down snow at times, and then roll across the face of the moon with the most beautiful fleecy and rounded forms imaginable. The forms of flakes of snow are pretty correct indications of the amount of fall to be; as, when large and broad, and falling slowly, there will not be much, and the probability is that thaw will soon follow; but when they fall thick and fast, and of medium size, there may be some inches before it fairs, and may lie some time. When flakes are spicular and fall very thick and fast, a heavy fall may be expected, accompanied with a firm breeze of wind, varying from N.E. to S.E. Neither frost nor snow will last long if either come when the ground is in a wet state from rain.

Uses and Drawbacks of Snow.—Snow renders important services to husbandry. If it fall shortly after a confirmed frost, it acts as a protective covering against its further cooling effects on soil, and in this way protects the young wheat and clover from destruction by intense frosts. On the other hand, frost and rain and snow may all retard the operations of the fields in winter very materially, by rendering ploughing and the cartage of turnips impracticable. Heavy snow-

[1] Phillips's *Facts*, 440.

[2] Reid's *Chem. Nat.*, 192.

storms are also very detrimental to the interests of sheep farmers.

Hoar-frost. — *Hoar-frost* is not always frozen dew, for dew is sometimes frozen in spring into globules of ice which do not at all resemble hoar-frost, which is beautifully and as regularly crystallised as snow. The formation of hoar-frost is always attended with a considerable degree of cold, because it is preceded by great radiation of heat and vapour from the earth, and the phenomenon is the more perfect the warmer the day and clearer the night. In the country, hoar-frost is of most frequent occurrence in autumn and winter, in such places as have little snow or continued frost; and this arises chiefly from great radiation of heat and vapour at those seasons, occasioned by a suspension of vegetable action admitting of little absorption of moisture for vegetable purposes.

Dr Farquharson, Alford, Aberdeenshire, observed that the mean temperature of the day and night at which injurious hoar-frosts may occur may be, relatively to the freezing-point, very high. Thus, on the nights of the 29th and 31st August 1840, leaves of potatoes were injured, while the lowest temperatures of those nights, as indicated by self-registering thermometers, were as high as 41° and 39° respectively.

Hoar-frost takes place only during calm. A slight steady breeze will quickly melt away frosty rime.

The air is always unclouded at the time of hoar-frost. So incompatible is hoar-frost with a clouded state of the atmosphere, that on many occasions when white frosty rime has been formed in the earlier part of the night, the passage of a close cloud at a later part has melted it off before sunrise.

Hoar-frosts most frequently happen with the mercury in the barometer at a high point and rising, and with the hygrometer at comparative dryness for the temperature and season; but there are striking exceptions to these rules.

In general, low and flat lands in the bottoms of valleys, and grounds that are land-locked hollows, suffer most from hoar-frost, while all sloping lands and open uplands escape injury. But it is not their relative elevation above the sea, independently of the freedom of their exposure, that is the source of safety to the uplands; for if they are enclosed by higher lands, without any wide open descent from them on one side or another, they suffer more than similar lands of lesser altitude.

A very slight inclination of the surface of the ground is generally quite protective of the crops from injury by hoar-frost, while flat and hollow places suffer at the time great injury. But a similar slope downward in the bottom of a narrow descending hollow does not save the crop, although that on either side of the banks higher up may be safe.

An impediment of no great height on the surface of the slope, such as a stone-wall fence, causes damage immediately above it, extending upwards proportionally to the height of the impediment. A still loftier impediment, as a tall wood or belt of trees, across the descent, or at the bottom of sloping land, causes damage more severely.

Rivers have a bad repute as the cause of hoar-frosts in their neighbourhood; but the general opinion regarding their evil influence is erroneous: the protective effect of *running* water, such as rivulets or waterfalls from mill-sluices, on patches of potatoes, when others in like low situations are blackened by frost, is an illustration which can be referred to.

The severity of the injury by hoar-frost is much influenced by the wetness of the soil at the place; and this is exemplified in potatoes growing on haugh-lands by the sides of rivers. These lands are generally dry, but bars of clay sometimes intersect them, over which the land is comparatively damp. Hoar-frost will affect the crop growing upon these bars of clay, while that on the dry soil will escape injury; and the explanation of this is quite easy. The temperature of the damp land is lower than that of the dry, and on a diminution of the temperature during frost, it sooner gets down to the freezing-point, as it has less to diminish before reaching it.[1] Young potato-plants are exceedingly susceptible of being blackened by hoar-frost.

[1] *Trans. High. Soc.*, xiv. 250.

Frost-smoke.—Clear calm air, admitting much sunshine at the middle of the day, is very bracing, healthy, and agreeable; but in the evening of such a day the sun usually sets in red, and a heavy dew falls, which is frozen into *rime*, incrusting every twig of trees and shrubs into the semblance of white coral. When the cold is intense, the dew is frozen before it reaches the objects on which it is deposited, and it then appears like smoke or mist, and is called "*frost-smoke*," which, when deposited on the naked branches of trees and shrubs, converts them into a semblance of the most beautiful filigree-work of silver. This mist may last some days, during the day as well as night, and then new depositions of incrusted dew take place on the trees and walls every night, until they seem overloaded with it. The smallest puff of winter wind dispels the enchanting scene.

Winter-fog.—Winter-fog, as long as it hovers about the plains, is indicative of dry weather; but when it betakes itself to the hills, a thaw may be expected soon to follow; and nothing can be more true than "He that would have a bad day, may go out in a fog after frost;" for no state of the air can be more disagreeable to the feelings than a raw rotten fog after frost, with the wind from the S.E.

Hail.—*Hail*, consisting of soft, snowy, round, spongy masses, frequently falls in winter after snow, and may lie for some time unmelted.

Ice.—Though a solid, *ice* is not a compact substance, but contains large interstices filled with air, or substances that have floated on the surface of the water. Ice is a confused mass like the inside of the rolls of brimstone, but in the progress of crystallisation on the margin of water, needles are seen to shoot out in angles of 30°, 60°, and 120°. It is quickly formed in shallow, but takes a long time to form in deep water; and it cannot become very thick in the lower latitudes of the globe, from want of time and intensity in the frost. By 11 years' observations at the observatory at Paris, there were only 58 days of frost throughout the year, which is too short and too desultory a period to freeze *deep* water in that latitude.

Process of Freezing.—The process of the freezing of water into ice is like a freak of nature. The water *contracts in bulk* by the frost, until it reaches the temperature of 39°.39, when it is in its state of greatest density and least bulk, and then sinks in layer after layer. After this the water resists frost in calm air, until it reaches 28°, *without decreasing further in bulk*, and it remains floating on the *warmer* water below it, which continues at 39°.39. So placed, and at 28°, whenever agitated it freezes, and suddenly starts up to 32°, and then in the form of ice as suddenly *expands* one-ninth more in bulk than at its ordinary temperature, and of course more in bulk than in its most condensed state of 39°.39. After water has undergone all these mutations, it retains its expanded state as ice until that is melted.

So great is the force of water on being suddenly expanded into ice, that, according to the experiments of the Florentine Academy, every cubic inch of it exerts a power of 27,000 lb.

Sea-Water Freezing.—*Sea-water* freezes at once on the surface, and that below the ice retains the temperature it had when the ice was formed. Frost in the polar regions becomes suddenly intense, and the polar sea becomes as suddenly covered with ice, without regard to the temperature of the water below. The ice of the polar sea, like the snow upon the polar land, thus becomes a protective mantle against the intense cold of the atmosphere, which is sometimes as great as 70° below zero. In this way sea animals, as well as land plants, in those regions are protected at once, and securely, against the effects of the intensest cold.

Evaporation from Ice.—Ice *evaporates moisture as largely as water*, which property preserves it from being easily melted by any unusual occurrence of a high temperature of the air, because the rapid evaporation, occasioned by the small increase of heat, superinduces a great counteracting coldness on the surface of the ice.

Cooling Power of Ice.—The *great cooling powers of ice* may be witnessed by the simple experiment of mixing 1 lb. of water at 32° with 1 lb. at 172°—the mean temperature of the mixture will be as high as 120°; whereas 1 lb. of ice at 32°, on being put into 1 lb. of water at 172°, will reduce the mixture to the temperature of ice—namely, 32°. This perhaps unexpected result arises from more heat being required to break up the crystallisation of ice than to heat water.

Relation of Wind to Rain and Snow.—The true character of all the phenomena of rain and snow is much modified by the *direction of the wind.* In winter, it may be generally stated as a fact, that when the wind blows from the N.W. to S.E. by the N. and E., cold and frost may be looked for as certain, and if there are symptoms of a deposition from the air, snow will fall; but if the wind blows from the S.E. to N.W. by the S. and W., fresh weather and rain will ensue. Heavy falls of snow occur, however, with the wind direct from the S.; but they are always accompanied with cold. In this case, the wind veers suddenly from the N. or N.E. to the S., which causes the lower stratum of vapour to expand by the introduction of warm air, and the heavy cold vapour above then suddenly descends in quantity.

Any wind that blows for a considerable length of time, such as two or three days, lowers the temperature of the air considerably. When any wind blows a good way overhead, it will be fair weather for some time, or until a change of the wind take place; but when it blows very near the ground, and is raw, chilly, and thin to the feelings, rain will follow in fresh weather, and thaw in frost. Mostly all winds begin to blow in the upper portion of the atmosphere; and whether they will descend to the earth or not depends on the quantity, first, of the cirri, and then of the cirri-strati, in the air. Very frequently different currents of air, at different elevations, may be seen in winter at the same time by means of the motions of the clouds. These motions may be in the same or in contrary directions. When this is observed, it may be relied upon that the uppermost current will ultimately prevail. It is characteristic of winds in winter to shift much about—sometimes to all points of the compass in the course of 24 hours, and seldom remaining more than three days in one quarter. Winter winds are heavy, overpowering, stormy.

Sky-tints.—A difference in the blue tint of the *sky* in winter indicates a fall of different states of moisture: if of a deep blue, in fresh weather, rain will fall; of a yellowish or greenish colour near the horizon in frost, snow will certainly come; and on a clear watery blue opening in the clouds occurring in fresh weather near the horizon in the S., a heavy rain may be expected.

PREPARING AND COMMENCING WINTER OPERATIONS.

The Agricultural Year.—Attention will now be directed to the *practice* of farming. The agricultural year commences immediately after the completion of harvest, and of the sowing of autumn wheat; and as these operations may be finished sooner or later, according to the lateness or earliness of the season, so the agricultural year may commence sooner or later in different years. It seldom, however, commences before the middle of October, which it does when the harvest has been early. It may be postponed until towards the end of November when the harvest is very late.

Mixed Husbandry.—To preserve consistency in practice, it is necessary to adopt some regular method of good farming, and as *mixed* husbandry is the most comprehensive as well as the most general, it has been chosen. It is eminently adapted for the purpose of learning farming, since it embraces the raising of grain, as on heavy carse clays; of root and forage crops, as on farms in the neighbourhood of large towns; the rearing of stock, as in pastoral farming; the making of cheese and butter, as in dairy farming; and the feeding of cattle and sheep on grass in summer, and on turnips and other food in winter, as in common farming.

As large farms afford greater scope for managing the arrangements of labour than small, and as the mixed husbandry is suited to a large farm, we shall suppose we occupy a farm of 500 imperial acres.

The seasons usually permitting the finishing of harvest before the grass fails, the winter operations begin with ploughing. In an early winter, however, the ploughing is sometimes postponed, that turnips may be brought to the live stock housed in the steading.

PLOUGHS AND PLOUGHING.

THE PLOUGH, SWING-TREES, AND PLOUGH-HARNESS.

The *plough* serves the same purpose to the farmer as the spade to the gardener, both being used to *turn over* the soil. The object of both in doing so is to bring the soil into a state fit for the reception of the seed.

Digging and Ploughing.—The operation of the plough upon the soil is to imitate the effect of the *spade* upon it; but the plough being too large and heavy to be wielded by hand, it is not under man's control, as is the spade. The ploughman is obliged to call in the aid of horses to wield it, and through their means, in combination with harness, he can command its motions effectively. Turning over the soil with so very simple an implement as the spade seems an easy operation; but the act of digging is neither simple nor easy, requiring every muscle of the body to be put in action, so that any implement to imitate that action perfectly would be obliged to have a very complicated structure. This would be the case even were the machine fixed to a spot; but it is a difficult problem in practical mechanics to construct a light, strong, durable, and easily moved implement, which shall attain a complex result by a simple action. The modern plough is an implement possessing these properties to a certain extent, and is the most convenient implement as yet designed for the purpose.

Construction of the Common Plough.—The common plough used in this kingdom is made either wholly of iron, or partly of wood and partly of iron. Formerly it was universally made of wood and iron, but now almost as universally of iron alone. It is now made so, because iron withstands the changes of weather better than wood—a desirable property in any implement that must necessarily be much exposed to weather—and because, when old, iron is worth something, whereas ash timber is now scarce, dear, and worthless when decayed,—another advantage being, that iron implements are not so clumsy as those made of wood. An ordinary two-horse wooden plough with iron mountings weighs 14 stones imperial, and an iron one for the same work 15 to 20 stones.

Varieties of Ploughs.—Two varieties of ploughs, Small's and Wilkie's, were originally used in Scotland, and from these nearly all the forms now in use have been derived. The varieties to be found throughout the country are almost innumerable, most implement-makers having several patterns of their own.

Ordinary Scotch Plough.—Fig. 9 is the *furrow-side* elevation of the ordinary Scotch iron swing-plough. The ploughman holds and guides the implement by the *stilts*. The *bridle* or "muzzle" with the hook, is that part by which the horses are attached to the beam. The *coulter* is the cutting instrument that severs the slice of earth or furrow from the firm land. The *sock* or share severs the slice below from the subsoil. The *mould-board* receives the slice from the sock, turns it gradually over, and deposits it continuously at an angle. The coulter has a sharp cutting edge in front, and is slightly inclined that it may cut the cleaner.

Fig. 10 is the *land-side* elevation of the same plough. The *land-side plate* presents a straight broad surface to the firm land, and prevents the earth falling within the body of the plough. The sole-shoe supports the plough, and slides upon the firm subsoil below. The attachment of the sock is with the lower end of the head of the plough, which is concealed in the figure, and which is fixed to the beam by its upper end. The ear of the mould-board prevents the earth falling into the bosom of the plough on that side.

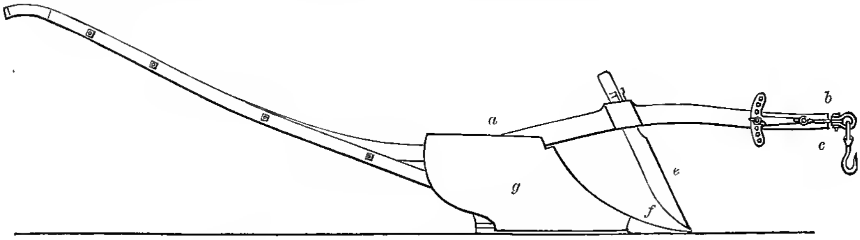


Fig. 9.—*Furrow-side elevation of a Scotch swing-plough.*

a b Beam.
c Bridle, with its hook.
a d Stilts or handles.
e Coulter.
f Sock or share.
g Mould-Board.

Fig. 11 is a plan of the same plough. The lines of the body of the plough on the land side are in one plane from the bridle to the end of the great stilt. The head of the coulter is fastened in a socket in the beam by means of iron

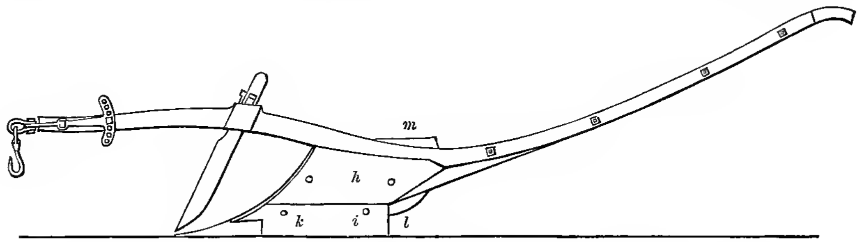


Fig. 10.—*Land-side elevation of a Scotch swing-plough.*

h Land-side plate.
i Sole-shoe.
k Onset of the sock.
l Heel.
m Ear of mould-board.

wedges. The rake of the coulter varies from 55° to 65°. In the mould-board the upper edge is straight, and the breast is formed on the lines of a screw, or a plate twisted about itself, the fore part of which is truncated. The sock is

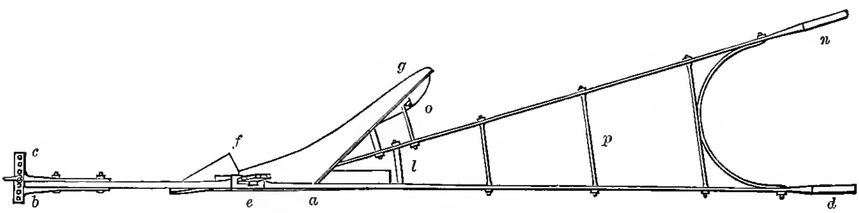


Fig. 11.—*Plan of a Scotch swing-plough.*

b d Straight line of body.
a b Beam.
c Bridle.
a d Great stilt.
a n Little stilt.
e Head of coulter.
f Feather of sock.
g Ear of mould-board.
l Heel.
o Bolts fastening the mould-board to the little stilt.
p Stays to support the stilts.

pointed, with a feather having a breadth of at least two-thirds the breadth of the furrow, and its cutting edge lying about as low as the plane of the sole. The neck of the sock is prolonged backward, joining and coinciding with the curve of the mould-board at its truncated end. This plough cuts a furrow-slice of 10 inches in breadth by 7 inches in depth, leaving the sole open level and clean. This width and depth are pretty near the standard size of furrow for two-horse ploughing on ordinary soils, and these proportions are the best adapted for the ends in view where a greater or lesser furrow-slice is desired.

Modern Scotch Plough. — The general differences between the modern Scotch and English ploughs are that an English plough has usually two wheels and chill-metal shares, while the Scotch has no wheel, or at most only one, and has wrought-iron shares. Less skill is required to hold a plough with two wheels; but in skilled hands the plough is, perhaps, more useful and more controllable without wheels. The main reason, no doubt, why Scotch farmers have adhered so largely to the use of the wrought-iron shares, is that their soil is of a very variable and stony nature, for which the chill-metal shares are not quite so suitable. They cannot be so easily adapted to stony and unequal soil as the wrought-iron shares, which can be altered by any country blacksmith

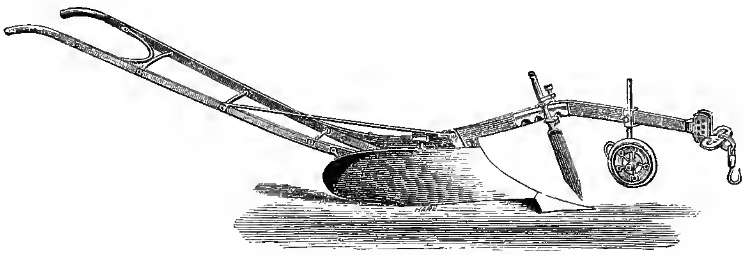


Fig. 12.—*Sellar's modern Scotch plough.* (Side view.)

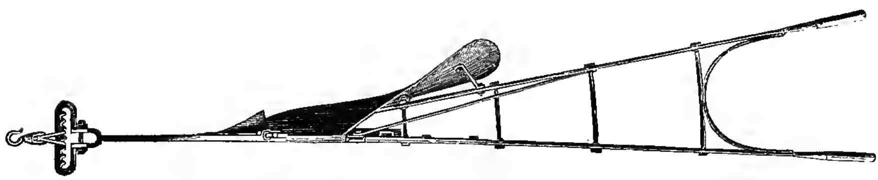


Fig. 13.—*Sellar's modern Scotch plough.* (Vertical view.)

to suit stony or clayey land, and to cut a rectangular or high-cut furrow of any shape as desired.

Figs. 12 and 13 represent the side and vertical views of Sellar's modern Scotch plough.

English Wheel-plough. — Fig. 14 gives a furrow-side view of Ransome's

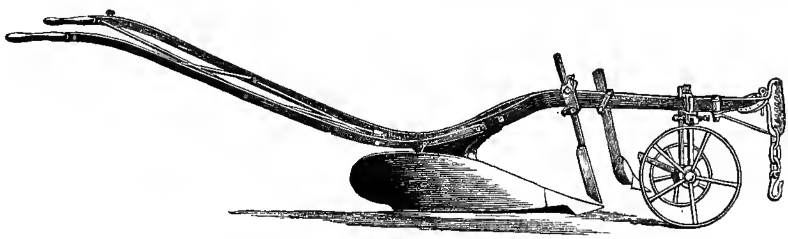


Fig. 14.—*Ransome's "Newcastle" plough.*

wheel-plough, one of the most improved of modern English forms. It is fitted with two wheels of unequal size on the front part of the beam, one of which is intended to run on the top of the ground, and the other at the bottom of the furrow.

By means of these the width and depth of the furrow-slice are regulated, so that the plough is kept steadily at the one place, and thus the draught is made easier for the horses, and less skill and exertion are needed on the part of the ploughman. It is also fitted with a skim coulter, the object of which is to pare off a little piece of the edge of the furrow-slice, so that the grass or surface-rubbish may be completely buried when the soil is turned over. The mould-board is removable, so that a long or short one can be used according to the kind of work desired. In wheel-ploughs the stilts are shorter and the beams longer than is the case with the swing-plough; and as the wheels really do the guiding part of the work, the handles could be dispensed with altogether, as is actually done in the case of the "gang-ploughs" of America.

Chilled Ploughs.—In recent years there has been introduced into this country a modification of these latter ploughs—viz., the American chilled-steel plough.

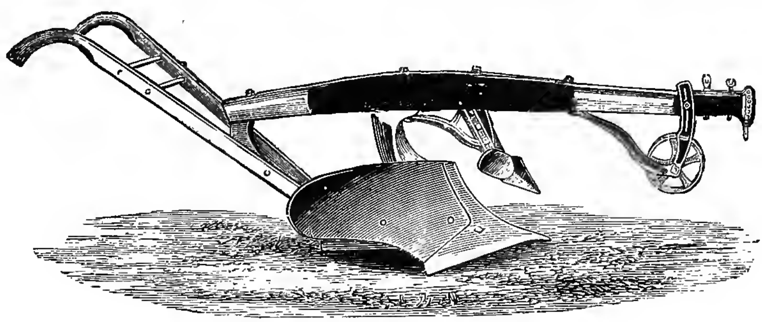


Fig. 15.—*Oliver's chilled plough.*

Fig. 15 represents Oliver's chilled plough, one of the best of the kind. This differs completely in appearance from those in common use in Britain in being very short and dumpy, though the beam is about the usual length. The principal point of difference lies, however, in the fact that the wearing parts are made of chilled steel, which takes on an exceedingly fine polish, thus reducing the friction of the draught some 25 to 30 per cent less than that of common ploughs, which have their breasts of ordinary steel or cast-iron only. The short wide-set mould-board has the effect of pulverising the furrow-slice as the plough goes along; and as it takes a great width in proportion to the depth, a large acreage can be quickly gone over. This sort of ploughing,

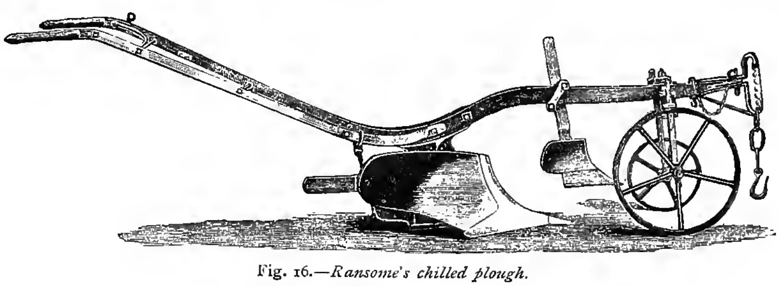


Fig. 16.—*Ransome's chilled plough.*

however, is suitable only for the moderate and lighter class of soils, and is not so well adapted for those of a heavy nature; the reason for which will be apparent when the principles of mechanics on which the plough works are explained.

Chilled ploughs are now made by several British firms, and the demand for them is very large and still increasing.

In figs. 16 and 17 are represented two of the best British chilled ploughs, made respectively by Ransome, Sims, & Jefferies, of Ipswich, and J. & F. Howard of Bedford.

MECHANICS OF THE PLOUGH.

The ordinary swing-plough, looked at as a machine, is a combination of some four of the "mechanical powers." The stilts with the body form a lever of the "first" or "second" kinds according to the way in which they are used. The share and front part of the wrest form an "inclined plane," up which slides the furrow-slice for a certain distance. The whole body of the implement forms a "wedge," as does also the coulter of itself; and the wrest or mould-board is to some extent a "screw."

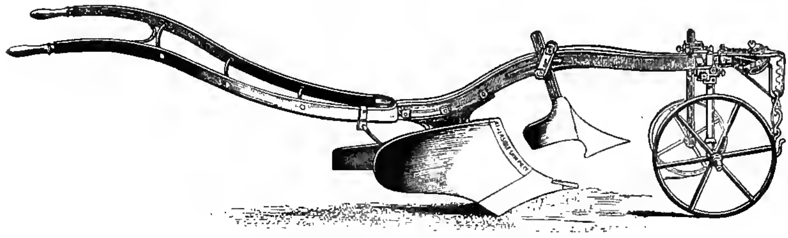


Fig. 17.—*Howard's chilled plough.*

Length of Stilts and Leverage.—In the case of the lever, every one knows from experience that the longer the "arm" or end at which the power or force is applied in proportion to the length of the other end, so much the more effective will be the "purchase" or ability to move a weight—as in the case of a labourer moving a stone with a crowbar. Applying this to the plough, we find that whether the heel of the sole-plate is used as a fulcrum (1st kind) in pressing down the handles, or the point of the share (2d kind) in lifting them up, the longer the stilts are the more power shall we have to do so—*i.e.*, to guide the implement easily. On the other hand, the length is limited by the necessity for easy manipulation of horses at the land ends, so that a medium of 6 or 7 feet is usually adopted between *a* and *d*, fig. 11. There are ploughs in practical use, however, with stilts 10 feet long.

Length of Beam.—On the other hand, the beam, *a b*, fig. 9, ought to be as short as possible. The horses are yoked to the end of it, and any unsteadiness on their part is communicated to the plough and must be counteracted by the ploughman, so that the less leverage power the animals have the more easily will the plough be held. The actual length is regulated by the "line of draught," which will be explained further on.

Body of Plough and Length of Wrest.—The body of the plough—including the coulter and share, as well as the wrest, cheek-plates, and sole-plate—is a combination of the inclined plane, wedge, and screw—the two latter of these being in their mechanical principles simply modifications of the first—so that we may study their various actions as parts of one whole. It may be necessary to explain that the power exerted and work done in connection with an inclined plane varies according to the perpendicular height of the plane and the horizontal length. In other words, if we have two inclined planes of equal height, but the one double the length of the other, then a body will be pushed up the longer one with one-half the exertion required for the shorter—neglecting friction,—but the time occupied will be double. The wedge is simply two inclined planes put base to base, and the same reasoning is true of it—that is, the thinner the wedge or more gradual the slope, the more easily it is driven. Applying this to the plough, we find that the coulter, share, wrest, cheek-plates, and sole-shoe, all form more or less continuous parts of a large wedge or moving inclined plane. The weight or body to be moved is represented by the furrow-slice, both as regards its actual weight and its tenacity or toughness; and from what has been already said it will be seen that the wrest should be as long as possible, as it will thus be equivalent to a gradual incline. It also follows that a short wrest stuck out at a greater angle will use up more of the power of the horses, just as a steep brae would do. On the other hand, if the wrest and body were too long it would make the implement unwieldy, and limit the leverage power of the handles, so that experience has taught that a medium of 30 to 36 inches is best, though ploughs with wrests about four feet long are in use.

Friction of the Earth.—The friction of the earth on the parts is a point of importance, and requires separate consideration. The law of friction is that it varies as the weight or pressure, and that it is independent of extent of surface, but roughness or smoothness of surface influence it very much. Applying this to our plough, it shows that the mere extent of surface sliding in contact with the soil has little effect; but, as already shown, a short wide wrest gives greater resistance to passage through the soil, and it follows that the friction on such will be greater than on a long-bodied tool. As regards the smoothness, the metal must take on as fine a polish as possible, and work clear or cleanly, as if earth lodges on the face of the breast, or the metal is rough, the friction will be immensely increased. Short mould-boards, of course, will break up and pulverise the furrow-slice more, and for this reason are often employed—independently of their greater difficulty of draught—especially on the lighter class of soils; but they are not so well suited for heavy lands, as none but the longer breasts will work satisfactorily there.

Wheels on Ploughs.—Wheels are put on ploughs for two reasons—viz., to keep the plough steadily at the one width and depth, and also to lessen the friction. In fig. 14 the front end of the beam is elongated a little, so as to allow of fitting on two wheels, whereby the former purpose is attained. There is nothing that tires out horses so quickly as jerky irregular work, a trouble that is obviated by these wheels, or even by the use of one alone running on the surface. More is necessary, however, for lessening the friction. The sole-plate and cheek have to bear about one-half of the total weight or friction on the whole plough body, and if we substitute wheels for these we can diminish it greatly. For this purpose the wheels must be placed either in a line with the body of the tool, or else behind it, as exemplified by the "gang" or wheel ploughs in common use in America—in which case the front wheels are sometimes dispensed with altogether. The friction at the axle of a wheel is, of course, very much less than that of the two large sliding surfaces.

Yoking Horses to a Plough.—In the yoking of the horses, again, certain mechanical principles come into play. The "centre of resistance" of the plough—that is, the point round which it would naturally balance itself when moving in work—is not a fixed point, but is about the heel of the share, and in the middle of the body. The horses really pull from this part; but as it is impossible to yoke them directly to it, the beam comes into use for this purpose, and the line of draught from the shoulder-hook of the haims to this point must pass through the bridle of the beam, else the plough will not move properly at the depth required. Again, the plough moves forward in a horizontal direction, while the horses are pulling obliquely upwards. Some portion of their power is therefore wasted from this indirectness, while to counteract the tendency to go upward, the point of the share is turned down a little, or the plough is set with a tendency to go deeper of itself. The draught-chains should therefore be as long as possible, consistent with convenience of handling, while a foot or so of chain between the whipple-trees and bridle is a great help. Practice has ruled that a total of about 10 feet from shoulder-hook to bridle-pin is the best mean.

Weight of Ploughs.—Ploughs, of course, must not be too heavy; but, on the other hand, they might be too light, not only on account of the liability of the parts to be too weak, but also because a heavy article has more "inertia" —that is, power of its own weight or mass to resist little jerks or shocks from stones, &c. Practice in this case, again, has found that 15 to 20 stones are the handiest limits.

Advantages and Disadvantages of American Ploughs.—From these statements of elementary facts in mechanics, it will be seen that the short, dumpy, and light American ploughs are made contrary to the ordinarily accepted rules of proportion of parts. But on the lighter and easier-worked soils this does not hinder them from being successfully used, more especially as their pulverising power is a desirable point in such cases. The stilts are so short that wheels are a necessity in guiding, as the ploughman has little control over them, while the large angle of the breast increases the draught more than a long sloping one would do. Their superiority lies in the material of which they are made—the fine polish of the wearing surfaces reducing the draught to a very great extent. Their defective principles, however, prevent them from being suitable for stiff land; clay soil will not pulverise, while the ploughman has not sufficient leverage power to be able, even with the aid of wheels, to hold them steadily with any degree of comfort. If the ordinary style of plough were made of the same material as these, it would be found a better all-round implement.

Draught of Ploughs.—There is a very great variation in the draught of different ploughs—that is, in the amount of power required by the horses to pull them through the soil. By means of a dynamometer this force can be measured in pounds or hundredweights, and of course, if everything else is right, the less exertion required by the horses the better. In the older forms of the plough —made mostly by country blacksmiths of malleable and cast iron, and still in very common use—the draught for a furrow 10 inches wide and 7 inches deep in medium soil is from 3 to 5 cwt. This is quite within the power of two good ordinary farm-horses, but it may be looked on as the limit, and no one who inquires into the matter will be satisfied nowadays with an implement requiring more power than this to work it.

From the introduction of improved forms of the wearing parts, and the use of chilled steel as a material, the resistance due to the tenacity of the soil and to friction has been so much reduced, that the same work can now be done with about half the expenditure of horse-power. We can therefore now plough much deeper with horses than it was possible to do at one time, and this is an additional reason in favour of deep work where the soil renders it desirable or beneficial.

Plough-staff.—A necessary accompaniment of every plough is the *plough-staff*, or plough-spade, fig. 18. It shovels off the mould that adheres to the breast of the mould-board, pushes away stubble or weeds which accumulate in the angle of the coulter and beam, and strikes out a stone when one fixes itself between the points of the coulter and sock. It lies upon the stilts, the spade being inserted into a staple in the bosom of the plough.

Fig. 18.—*Plough-staff.*

Swing-trees.—Horses are yoked to the plough by means of a set of levers named *swing-trees*, arranged so as to cause the united strength of the horses to be exerted at one point, by linking the ring of the swing-trees to the hook of the bridle of the plough. Swing-trees are used for attaching any number of horses to other implements besides the plough, such as harrows, small ploughs, &c.

In the plough-yoke a set of swing-trees consist of 3, as in fig. 19. The swing-trees are arranged in the position in which they are employed in working. The section of the main swing-trees is at the centre of attachment, with clasp and eye mounting, the scale of which is double the size of the principal figure in the cut.

Swing-trees are for the most part made of wood—oak or ash; sound Engglish oak is by much the most durable —though good Scotch ash is the strongest, so long as it remains sound, but it is liable, by long exposure, to a species of decay resembling dry-rot, and thereby becomes brittle. They are now also very often made of iron, and of various patterns, designed to give strength with lightness and durability.

Yoking 3 Horses to a Plough.—Ploughing is sometimes performed by three horses, as in cross-furrowing, or in breaking up stubble in autumn, when the land is clean, or in ploughing old rough lea ground. There are various ways of yoking *three* horses to the plough; the simplest is a pair working in the common swing-trees, fig. 19, with a light chain attached by a shackle to the middle of the main swing-tree. To this chain a third horse is yoked, taking his place in front of the other two, in unicorn fashion. This yoke is defective, inasmuch as there are no

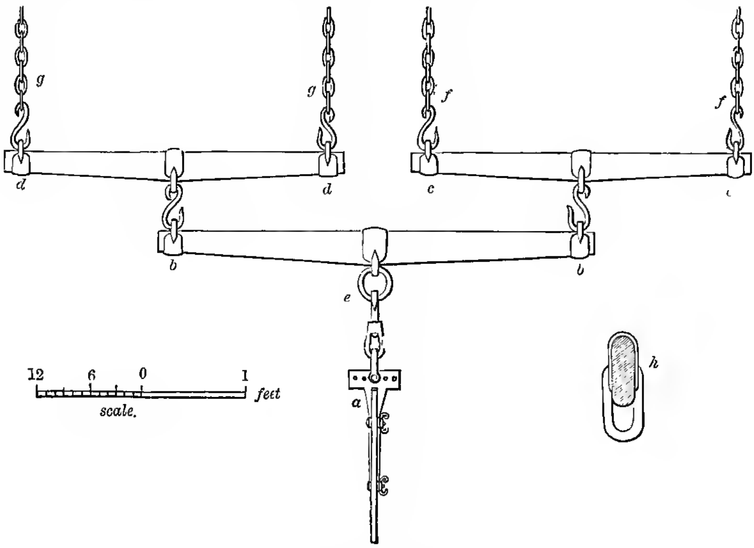


Fig. 19.—*Swing-trees for two horses.*

a Bridle of the plough.
b b Main swing-tree.
e Ring of main swing-tree.
c c Furrow or off side swing-tree.
d d Land or near side swing-tree.
f g Trace-chains from the harness.
h Section of main swing-tree.

means of equalising the draught of the third horse.

Perhaps the most perfect method of yoking a 3-horse team is abreast, with *compensation levers*, fig. 20—a statical combination, which is at once correct in its equalisation, scientific in principles, and elegant in arrangement. Between the main swing-tree and the three small ones the compensating apparatus is placed. Two of these are levers of the first order, but with unequal arms, the fulcrum being fixed at one-third of the entire length from the outward end of each; the arms of these levers are therefore in the proportion of 2 to 1, and the entire length of each between the points of attachment is 27 inches. The two levers are hooked by means of their shackles to the main swing-tree; and the three small swing-trees are hooked to the compensation lever.

Saving a Weak Horse.—The considerate farmer will frequently see the propriety of lightening the labour of some individual horse in this more than in the ordinary method of ploughing; and this is easily accomplished by the compensation apparatus. For this purpose, one or more holes are perforated in the levers *h i*, on each side of the true fulcrum *k*, to receive the bolt of the small shackle *k*. By shifting the shackle and bolt, the relation of the forces *h* and *i* are changed, and that in any proportion that may be desired; but it is necessary to observe that the *distance* of the additional holes, on either side of the central hole or fulcrum of equilibrium in the system, should be in the same proportion as the length of the arms in which the holes are perforated. Thus, if the distance between those in the short arm is half an inch, those in the

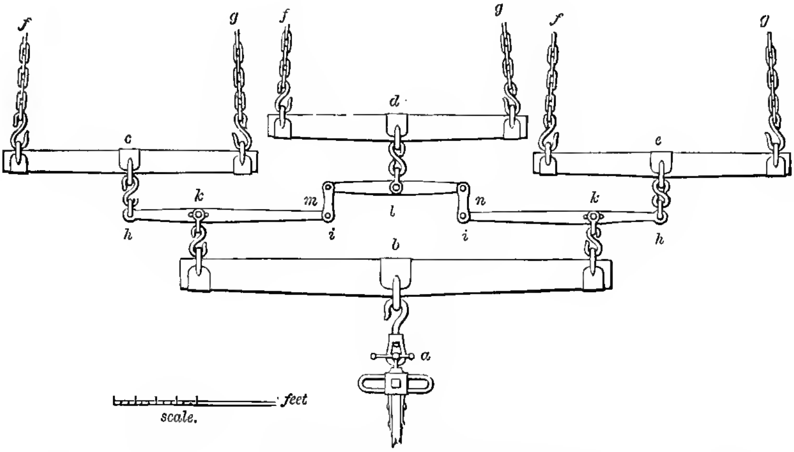


Fig. 20.—*Swing-trees for three horses.*

a Bridle of the plough
b Main swing-tree.
c d e Common swing-trees for a horse each.
f g Trace-chains from harness.
h i k l m n Compensating apparatus of three levers of iron.

longer arm should be an inch. By such arrangement, every increase to the exertion of the power, whether on the long or the short arm, would be equal.

Fig. 21 represents a set of trussed tubular iron whipple-trees made by Kells, Meats, & Co., Gloucester. They combine lightness, strength, and durability, and are adapted for two and four horses. By shifting the hook on the balance-bar, these whipple-trees can be used at the plough, with two horses in

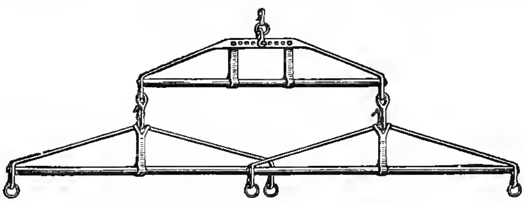


Fig. 21.—*Trussed iron whipple-trees.*

the furrow and one on the land, or with a colt or weak horse beside a strong one.

Yoking 4 Horses.—*In the yoking of 4 horses*, the best method is as in fig. 22. In this arrangement the balance of forces is perfectly preserved; for the hind horses and the leaders, as they pull at opposing ends of the chain, 11 feet in length, passing round a pulley, which must inevitably be always in equilibrium, each pair of horses has an equal share of the draught; and from the principles of the common swing-trees through which each pair acts, the individual horses must have an equally perfect division of the labour. In order to prevent either the hind horses or the leaders from slipping too much ahead, it is common to apply a light check-chain of about 15 inches long, connecting the two parts of the main chain, so as to allow only a short oscillation round the pulley, which is limited by the check-chain. When this is adopted, care should be taken never to allow the check-chain to remain upon the stretch; for if it do so, the advantage of equalisation in the yoke is lost, and it becomes no better than the simple foot-chain. In all cases of using a chain,

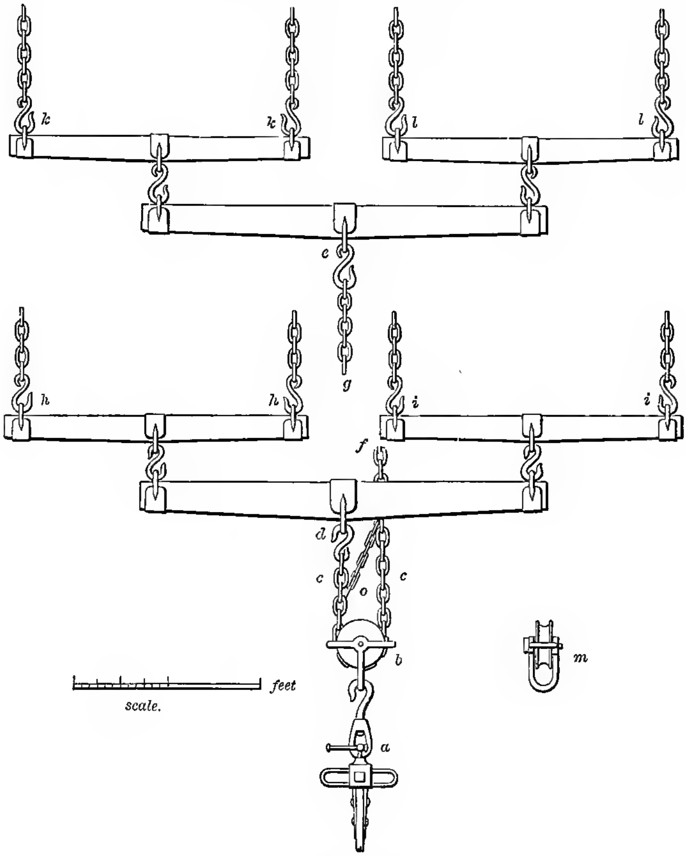


Fig. 22.—*Swing-trees for four horses.*

a Bridle of the plough.
b Pulley of cast-iron.
m Edge-section of pulley.
c Link-chain wove round the pulley.
d A set of common swing-trees.
e Another set of common swing-trees.
g f Chain connecting the two sets of swing-trees through the pulley.
h i k l Trace-chains from the harness.
o Check-chain.

that part of it which passes forward between the hind horses must be borne up by straps or cord attached to their back-bands, or suspended from their collars.

When more than four horses are yoked together, their strength is with difficulty simultaneously applied. It is therefore much better to work 2 sets of 4 horses than 1 set of 8.

Harness.—Besides swing-trees, horses require *harness* to enable them to apply their strength to the plough. The harness, as used in Scotland, is simple and efficient.

Collar.—A form of collar long used in Scotland is shown in fig. 23. The collar surrounds the neck of the horse, and serves as a padding to protect the skin of the neck and the points of the shoulder, while the horse exerts his strength in the draught. The covering of this collar consists of leather stiffened in its upper part with stripes of whalebone to form the cape. The body of the collar is stuffed with wheat-straw, or, what is better, rye-straw, and covered with strong twilled woollen cloth.

It will be observed that the under part of the collar is wider than the upper, because the under part of the neck of a horse is thicker than the upper or mane, upon which the collar rests; but as the crown of the head of the horse is broader than the muzzle, the collar is slipped over the head in the inverted position, and turned round upon the neck.

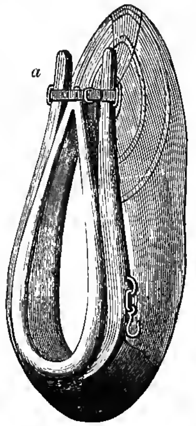


Fig. 23.—*Scotch draught-horse collar and haims.*

Fig. 24 shows a form of cape common in England. In modern English collars the cape is frequently made of a separate flap of leather, so that it can be folded down for the purpose of protecting the withers of the horse in wet weather. Similar capes are now often seen in Scotland, and are in both countries occasionally seen ornamented with flaring red worsted fringes round the edge, or with large tassels from the corner and middle, and even with bells.

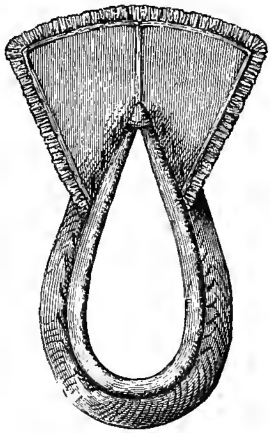


Fig. 24.—*English draught-horse collar.*

Haims.—The *haims* are placed immediately behind the outer rim of the collar at *a*, fig. 23. They consist of two pieces fixed below the throat of the horse with hooks and a link, and at the upper part at *a* with a leather strap. The pieces are formed entirely of iron, or of wood covered with thin sheet-iron, or of wood alone—now most frequently of iron. On each piece above the point of the shoulder of the horse is attached a staple with a hook, to which is fastened the trace-chains of the plough, or the draught-chains of the cart. In some parts of the country the haims are never removed from the collar; in most parts they are taken off every time the horse is unharnessed.

Bridle.—A part of the harness is the *bridle*, which serves to guide the horse's head. It is commonly of simple form, consisting of a head-stall, nose-band, blinders, bit, throat-lash, and bearing-reins. In some parts of the country the blinders are omitted. The plea for the use of blinders is, that they prevent the horse looking around and being frightened by distant objects he cannot distinctly see, and they keep his attention steady to his work. But it is found that horses accustomed to look around them are seldom frightened, whereas those used to blinders are easily scared when these are taken off, or when they hear any uncommon noise. The want of them keeps the head cooler in summer, and saves the eyes from injury by lateral pressure.

Bearing-reins.—In draught-horses, *bearing-reins* may be dispensed with, as unless the reins are allowed to hang loose, the animal has its head tied up, and cannot so easily lean forward to put its full power to the draught.

Back-band.—A piece of harness of the plough-gear is the *back-band*, which consists of a broad piece of leather passing over the horse's back, having small pads where it rests on the top of the back, both ends being fastened to the trace-chains of the plough by means of small iron hooks. Its office is to support the chains just *below* the line of draught; if above, the draught would become a strain upon the groins of the horse, through the medium of the back-band.

Plough-reins.—A necessary portion

of the equipment of a draught-horse in harness is the plough-*reins*, which are made of cord, on purpose light and strong, being fabricated of the best hemp. In some parts of the country, in the midland and northern districts, one rein is attached to the nigh horse in driving a pair in the plough, most of the horse's motions being performed by the command of the voice of the ploughman—the only use of the rein being to pull the horses to the nigh side. To give the ploughman a perfect command of his horses, double reins should be used—one passing from the left-hand stilt of the plough by the nigh side of the nigh horse, through one ring on the nigh side of the back-band, then through another ring on the nigh side of the haims, to the ring of the bridle-bit, to which it is fastened; the other rein goes from the right-hand stilt of the plough by the off side of the off horse, through rings in the back-band and haims to the bridle-bit on the off side. The other ends of the reins are usually held in the hands of the ploughman, or looped upon the handles of the stilts of the plough.

Weight and Cost of Harness.—The total weight of plough-harness may vary from 30 to 40 lb., and the cost from £2, 5s. to £3. Thus harnessed for the plough, each horse has not much weight to bear; nor is its harness costly, though made of the strongest harness-leather.

Some styles of English harness are much heavier, and also more costly. The harness required for a pair of horses for *carts* are 2 collars, 2 bridles, 2 haims, 2 saddles with breeching, and 2 belly-bands, costing in all from £9 to £12.

Ploughing with 2 Horses.—On examining the particulars of ploughing with two horses, fig. 25, the *collars* are

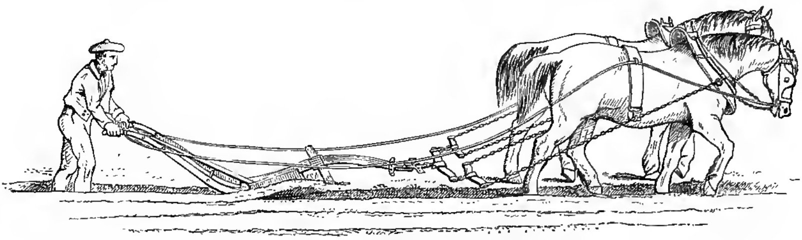


Fig. 25.—*Scotch plough at work with two horses.*

round the horses' necks; the top of the *haims* is seen at the upper part of the collar. The horses are yoked to the swing-trees by light *trace-chains*, linked on one end to the hooks of the haims, and hooked at the other into the eyes of the swing-trees. *Back-bands* of leather cross the back, near the groins of the horses, supporting the trace-chains by means of simple hooks. The *bridles* have blinders, and the *bearing-reins* are supported on the top of the haims. The *swing-trees* are hooked to the draught-swivel of the bridle of the plough; and being yoked abreast, the horses are enabled to exert their united strength much more effectually than if yoked one before the other. The two horses are kept together by a *leather strap*, buckled at each end to the bridle-ring, which prevents the horses separating beyond its length. The *reins* proceed from the ploughman's hands to the horses' heads. The off-side horse—that is, the one nearest to the spectator in the figure—is walking in the *last*-made open furrow—the nigh horse walking on the *firm land.* The plough is in the act of turning over a furrow-*slice* of land, and the ploughman is walking in the *new*-made open furrow, leaning forward slightly upon the stilts, to steady himself and the plough at the same time.

Ploughing with 3 Horses.—Fig. 26 shows the Scotch swing-plough at work with three horses. The yoking of the three horses through the instrumentality of the apparatus described in fig. 20 will at once be understood. The off horse—that is, next the spectator in the figure—is walking in the last-made furrow, the other two horses are on the firm land, while the ploughman is stepping in the new-made furrow. The depth of the furrow in this case is 10 to 12 inches, instead of 7 or 8 inches—the usual depth of ploughing. The three horses plough to this depth in ordinary soils with great ease. The advantages of this method of ploughing are, that it uproots every tap-rooted weed; that the furrows being open to the influences of the elements in winter, the soil becomes so completely pulverised by the spring that any further ploughing then is unnecessary; that a simple grubbing renders the soil fit to be done up for potatoes or turnips; that much labour is thus saved in the busy season of spring, and the additional depth of soil stirred gives more room for bulky manures to be effectually covered, and greater scope for

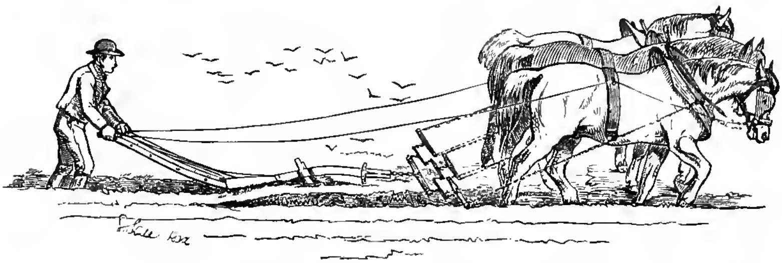


Fig. 26.—*Scotch plough at work with three horses.*

the roots of the cultivated plants to ramify in search of mineral food. These advantages from ploughing to this depth are, of course, derived only where the land is deep, and the subsoil of a suitable character. In all respects this mode of ploughing is similarly conducted to that with two horses, as plainly indicated in the two figures.

Language to Horses.—Besides the use of reins, it is customary to desire horses to go through their motions, when yoked to the draught, with the voice, using the *language to horses.* It would be quite possible to cause horses to perform all their motions by means of the double reins alone, but the voice keeps up an understanding between the men and horses. It is not practicable to make horses at the plough go through the requisite movements with a single rein, unassisted by the voice; but too much use of the voice makes horses become regardless of it.

The language addressed to horses varies in the different parts of the kingdom. The motions required of them at work are, to go forward—to step backward—to go to the right from you—to come to the left towards you—to turn round—and to stop. The word *Wo* is universally used to stop.

In all cases the speaker is supposed to be on the *near side* of the horse—its left side. The word *hup* is often used to go from, and *hie*, to come to, when describing any piece of work in which horses are employed.

ACTIONS OF VARIOUS PLOUGHS IN USE.

Small's Plough.—It would be well to make a comparison between the actions of the various ploughs in use before entering on the different methods of ploughing land; and first, of ploughs designed on the principles laid down by Small, fig. 27:—

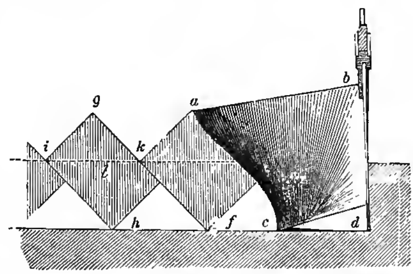


Fig. 27.—*Effects of a rectangular furrow-slice.*

a b c d Transverse section of mould-board.
f, g h Sections of furrow-slice.
g k a Right angle.
i g k Triangle equal to breadth of furrow-slice.
i g, g k Equal sides of triangle.
g l Half the breadth of furrow-slice.
h f c d Level sole of furrow.

In this example, the rectangular furrow-slice is 10 inches broad by 7 inches deep.

Wilkie's Plough.—Next of Wilkie's pattern, fig. 28:—

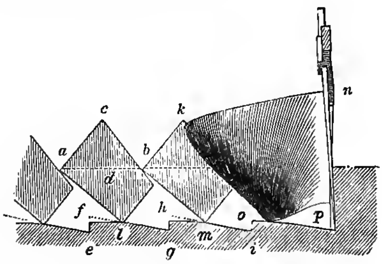


Fig. 28.—*Effects of a crested furrow-slice.*

k n p o Transverse section of mould-board.
k m, c l Sections of furrow-slice.
c Angle 84° or 75°.
a c b Isosceles triangle.
a c 6½ inches, upper end of furrow-slice.
l h 4½ inches, lower end of furrow-slice.
f h o p Crested furrow-sole.
e f g, g h i Triangular spaces 1½ inch left unploughed.

In comparing the furrow-soles in figs. 27 and 28, besides the loss of time and labour in ploughing a breadth of furrow 8½ inches, compared with a 10-inch furrow, the crested furrow-sole leaves part of the ground unploughed. Thus, in ploughing an imperial acre with a 10-inch furrow—leaving out of view the taking up of closings, turnings, &c.—the distance walked over by the man and horses will amount to 9.9 miles; with a 9-inch furrow the distance will be 11 miles; with an 8½-inch furrow, it will be 11½ miles; and with a 7½-inch furrow, 13¼ miles.

Steam-ploughs and Diggers.—There are several forms of steam-ploughs, and these will be noticed in a subsequent chapter dealing with the application of steam-power to farm-work. This also applies to steam-diggers.

PLOUGHING AND PLOUGHING-MATCHES.

Tempering the Plough.—The plough, as now made, consists of a number of parts; but how well soever those different parts may be put together, if not *tempered*, or adjusted—if any part has more to do than its own share of the work—the entire implement will move unsteadily. It is easy to ascertain whether or not a plough goes steadily, and is so by the following means:—

Less "Earth" required.—On holding a plough by the handles with both hands, while the horses are drawing it through the land, if it have a constant tendency to go deeper into the soil than the depth of the furrow-slice previously determined on, it is not going steadily. The remedy is twofold—either to press harder upon the stilts with the hands, and, by their power as levers, bring the share nearer the surface of the ground; or to put the draught-bolt of the bridle a little nearer the ground, and thus give the plough less "*earth.*" The pressure upon the stilts should first be tried, as being the most ready at command; but should it fail of effecting the purpose, and the pressure prove too severe upon the arms of the ploughman, the draught-bolt should be lowered; and should both these expedients fail, there must be some error in another part of the plough. On examining the share, its point may possibly be found to dip too much below the base-line (fig. 9), which will cause it to go deeper than it should. This error in the share can be rectified only at the smithy.

More "Earth" required.—Again, the plough may have a tendency to come out of the ground. This cannot be remedied by supporting the stilts upwards with the arms, because the body of the ploughman having no support, he could not walk steadily in the furrow. Hence, a very short man can scarcely hold a plough steady at any time, and does not make a desirable ploughman. The draught-bolt should, in the first instance, be placed farther from the ground, and give the plough more "*earth.*" Should this not effect the purpose, the point of the share will probably be above the base-line, and must therefore be brought down to its proper level by the smith.

More "Land."—It may be difficult to make the plough turn over a furrow-slice of the desired breadth. This tendency is obviated by moving the draught-bolt a little to the right, which gives the plough more "*land*"; but in case it arises from some casual obstruction underground, such as direct collision against a small stone or a piece of unusually hard earth, it may be overcome by leaning the plough a little over to the right or left for the time.

Less "Land."—The tendency, however, may incline to take a slice broader than is wanted; in which case, for permanent work, the draught-bolt should be put a little to the left, which gives the plough less "*land*"; and for a temporary purpose the plough may be leaned over a little to the left.

These are the ordinary causes of unsteadiness in the *going* of ploughs; and though narrated singly, any two of them may combine to produce the same result, as the going deeper, or shallower, with cutting a too narrow or too broad furrow-slice. The most obvious remedy should first be tried; but both may be tried at the same time if a compound error is apprehended.

Hold the Plough level.—Some ploughmen habitually make the plough lean a little over to the left, giving it less land than it would naturally have, and to counteract the consequent tendency to a narrow furrow-slice, move the draught-bolt a little to the right. The ploughing with a lean to the *left* is a bad custom, because it cuts the lowest end of the furrow-slice with a slope, which gives the horses a lighter draught than when turning over a square furrow-slice. Old ploughmen, feeling infirm, are apt to practise this deceptive mode of ploughing. The plough should always be level upon its sole, and turn over a rectangular furrow-slice.

Tall men, in having to stoop constantly, lean hard upon the stilts; and as this has the tendency to lift the plough up, they are obliged to put the draught-bolt higher to keep it in the ground.

A good ploughman will use none of these expedients, for he will *temper the irons*, so as there shall be no tendency in the plough to go too deep or too shallow into the ground, or make too wide or too narrow a furrow-slice, or cause less or more draught to the horses, or less or more trouble to himself, than the work requires to be performed in the best manner.

Tempering the "Irons."—In the attempt to temper irons, many ploughmen place the coulter in a position which increases the draught of the plough. When its point is brought down as far as that of the share, and projecting much to the left or land side, a stone in light land is very apt to be caught between the points of the coulter and share, which will have the effect of throwing the plough out of the ground. Such an accident is of little consequence in ploughing land to be ploughed again; but it disfigures the land in ploughing lea, and must be rectified instantly; but in doing this, time is lost in backing the horses to the spot where the plough was thrown out. To avoid such an accident on lea-ploughing, *in stony land*, the point of the coulter should be put immediately above, and almost close upon, that of the share, when they will both cut the soil clean. In smooth soils, free of small stones, the relative positions of the points of the coulter and share have not the same influence upon the steadiness of the plough.

Plough-"irons."—The *state of the irons* themselves has a material effect on the temper of the plough. If the cutting edge of the coulter, and the point and cutting edge of the share, are steeled, the irons will cut clean, and go long in smooth soil. This is an economical treatment of plough-irons for clay soils. But in gravelly and all sharp soils the irons wear down so very fast, that farmers prefer them made of ordinary iron, and have them laid anew frequently, rather than incur the expense of steeling, which perhaps would not endure work much longer in such soils. Irons are now seldom if ever steeled; but whether steeled or not, they are always in the best state when sharp and of the requisite dimensions. In English smooth soils, cast-iron shares are often used. In Scotland the soil is commonly too stony for cast-iron to stand the work, but could cast-iron shares be procured very cheap, they might be as economical as malleable-iron shares. The best material now used for the wearing parts of ploughs is chilled steel, which, on account of its extreme hardness, resists wear for a long time, while the fine surface it takes on lessens the friction to be overcome by the horses.

Keep the Plough in good Order.—An imperfect state of the mould-board is another interruption to the tempering of a plough. When new and rough, the soil adheres to it, and if pressing heavily against the turning furrow-slice, causes the plough to deviate from its right course. On the other hand, when the mould-board is worn away much below, it leaves too much of the crumbled soil on the bottom of the furrow, especially in loose soils. Broken side-plates easily admit the soil through them into the body of the plough, and cause a rough and unequal face on the firm land side; and when soil accumulates in the body, it affects the plough, both in temper and draught. These remarks on tempering are made on the supposition that ploughs are well made, and may therefore be tempered equally well; but ploughs are sometimes so ill constructed, that the best tempering the irons are capable of receiving will never make them do good work. It is more economical to have a good new plough than to work for a length of time with a worn-out one.

Good Ploughmanship.—When all the particulars which ploughmen should attend to in executing their work—in having their plough-irons in a proper state of repair, in tempering them according to the kind of ploughing to be executed, in guiding their horses, and in ploughing the land in a methodical way—are considered, it ceases to surprise one that so few ploughmen become first-rate workmen. Good *ploughmanship* requires greater faculty of observation than most people would readily imagine—greater than many young ploughmen possess,—greater judgment than most will take time to exercise,—more patience than most will bestow to become familiarised with every particular,—and greater skill than most can acquire. To be so accomplished, implies the possession of high talent for workmanship. "It is well known," says Sir John Sinclair, "that the horses of a good ploughman suffer less from the work than those intrusted to an awkward and unskilful hand; and that a material difference will be found in the crops of those ridges tilled by a bad ploughman, when compared to any part of the field where the operation has been judiciously performed."[1] Marshall contends that "one-fourth of the produce of the arable lands of the kingdom is *lost* through a *want of tillage.*"[2] It must be owned that by far the greatest part of ploughmanship is of a mediocre description; and reasons for its mediocrity are not difficult to adduce. Thus—

Learning Ploughing.—*Ploughmen* cannot learn their art at a very early age, and every business ought to be learned then to reach a high attainment in it. Ploughing requires a considerable degree of strength, even from grown-up men, and it bears much harder on the learner; but even after young men have acquired sufficient strength to hold the plough, they are left to learn ploughing more through sheer experience than by tuition from those better acquainted with the art. Experience cannot be transmitted from father to son more in this than in any other art; and in this, as in other arts, improvement is more frequently effected by imitation than by efforts of individual ingenuity and study. A learner of ploughing often cuts an awkward figure.

The best Ploughmen and Stewards.—The best ploughmen are generally those who have been taught directly by their fathers, and work constantly upon their fathers' farms; and they make, besides, the best stewards, because they have been accustomed to command servants, and have not associated freely with them. A steward promoted from the rank of a common ploughman is apt—unless he is a man of exceptional strength and firmness of character—to continue on too familiar a footing with them to sustain the authority due to his situation, and on being aroused to enforce authority perhaps becomes tyrannical.

Boy Ploughmen.—In England, boys are frequently employed to *tend* the plough, for they cannot be said to hold it, which is so constructed with wheels and apparatus as to turn over the soil without the aid of man, and his aid is required only for the turnings at the ends of the ridges.

Weight of Deep and Shallow Furrows.—It may be worth while to show the great difference in the weight of

[1] *Code of Agric.*, 298, 5th edition.

[2] Marshall's *Gloucester*, i. 72.

soil turned over in a deep and shallow furrow. If 10 inches are taken as a fair width for a furrow-slice, there will be 18 such slices across a ridge of 15 feet in breadth; and taking 7 inches as a common depth for such a furrow-slice, a cross section of the slice will have 70 square inches. A cubic foot of earth is thus turned over in every 24.7 inches of length of such a slice; and taking 1.48 as the specific gravity of common earth, the 24.7 inches of slice will weigh 6 stones 8 lb. imperial. If a furrow of only 4 inches in depth is taken, with its breadth only of 9 inches, the area of the slice will be 36 square inches, and its weight will be 3 stones 5 lb., a considerable difference of weight for horses to turn over in the same distance travelled. With the furrow of the 3 or 4 horse plough, say 14 inches by 10 inches, the weight of soil turned over would be 13 stones 2 lb.

Form and Placing Furrow-slice.—The proper form and position of the furrow-slice are requisites in good ploughing. The furrow-slice should be of such dimension, and laid in such position, that the two exposed faces in a series of slices shall be of equal breadth, and any departure from this rule is a positive fault. Laid up agreeably to this rule, furrow-slices will not only present the maximum of surface to the atmosphere, but also contain the maximum of cubical contents.

Fig. 29 represents the movement of

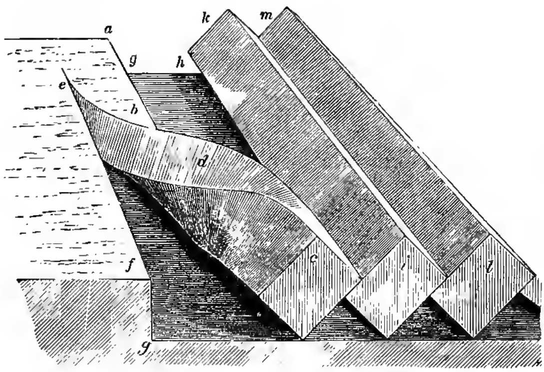


Fig. 29.—*View of the movement of the furrow-slice.*

a b Edge of land cut by preceding furrow.
c d Slice being turned over by the plough.
e f Edge of land being left by the ploughing furrow.
i k, *l m* Furrow-slices previously laid over.
g h Level sole of furrow.

the furrow-slice, as well as its position after it is laid by the plough. An examination of this figure also shows that the extension of the slice only takes place along the land-side edge, from *e* to where the backward flexure is given to it when rising on the mould-board at *d*; and where it is again compressed into its original length, in being laid down by the back part of the mould-board at *c*. The slices are laid over at an angle of 45 degrees; and in slices of 7 inches in depth and 10 inches in breadth, the altitude of the triangle is 5 inches, each side 7.071 inches, and the sum of the two exposed faces 14.142 inches.

These figures apply only to the rectangular furrow-slices by the common ploughs made after Small's type. Those of ploughs made on a different pattern will differ in the angle of the slice, and in the dimensions of the triangular crest.

Characteristics of correct Ploughing.—*Correct ploughing* possesses these characteristics: The furrow-slices should be quite straight; for a ploughman that cannot hold a straight furrow is unworthy of the name. They should be quite parallel as well as straight, which shows that they are of a uniform thickness; for thick and thin slices lying upon one another present irregularly parallel and horizontal lines. They should be of the same height, which shows that they have been cut of the same breadth; for slices of different breadths, laid together at whatever angle, present unequal vertical lines. They should present to the eye a similar form of crest and equal surface; because, where one furrow-slice exhibits a narrower surface than it should have, it has been covered with a broader slice than it should be; and where it displays a broader surface than it should have, it is so exposed by a narrower slice than should be. They should have their back and face parallel; and to discover this property after the land has been ploughed requires minute examination. They should lie easily upon each other, not pressed hard together. The ground, on being ploughed, should feel equally firm under the foot at all places, for slices in a more upright position than they should be, not only feel hard and unsteady, but will allow the seed-corn to fall between them and become buried. When too flat, they yield considerably to the pressure of the foot; and they cover each other too much, affording insufficient mould for the seed. They should lie over at the same angle, presenting crests in the best possible position for the action of the harrows. Crowns of ridges formed by the meeting of opposite furrow-slices should neither be elevated nor depressed with regard to the rest of the furrows in the ridge; although ploughmen often commit the error of raising the crowns too high into a crest, the fault being easily committed by not giving the first furrow-slices sufficient room to meet, and thereby pressing them against each other.

The last furrow-slice should be uniform with those of the rest of the ridge; but ploughmen are very apt to miscalculate the width of the slices near the edges of the ridges; for if the specific number of furrow-slices into which the whole ridge should be ploughed are too narrow, the last slices of the open furrow will be too broad, and will therefore lie over too flat; and should this too broad space be divided into two furrows, each slice will be too narrow, and stand too upright. When the last furrows are ill made, the open furrow cannot be proportionately ploughed out; because, if the space between the last furrows is too wide, the open furrow must be made too deep to fill up all the space; and if too narrow, there is not sufficient mould to make the open furrow of the proper size. If the last furrow-slices are laid too flat, the open furrow will throw too much mould upon the edges next the open furrow, and make them too high. When the last furrows of adjoining ridges are not ploughed alike, one side of the open furrow will have less mould than the other. From a consideration of these particulars, it is obvious that ploughing land correctly, which is best exhibited in lea-ploughing, is an art which requires a skilled hand and correct eye, both of which are much interfered with in the management of the horses. Hence a ploughman who has not his horses under strict command cannot be a good hand.

Speed of Horses Ploughing.—The usual *speed* of horses at the plough may be ascertained in this way: A ridge of 5 yards in breadth requires a length of 968 yards to contain an imperial acre; to plough which at 9 bouts (a *bout* being a walk along a ridge and back), with a 10-inch breadth of furrow-slice, counting no stoppages, will make the horses walk 9.9 miles, which in 10 hours gives a speed of 1742 yards per hour; at 10 bouts of 9-inch furrow-breadth, gives 11 miles of travel to the horses, or 1936 yards per hour; and at 7½ bouts of 12-inch furrow-breadth, gives 6⅓ miles of travel to the horses, or 1452 yards per hour. But as ridges of 968 yards in length are very rare, and as horses cannot draw a plough that distance without being affected in their wind, and as allowance must be made for time lost in turning at the ends of ridges, as well as affording rest to horses, those speeds will have to be considerably increased to do that quantity of work in the time.

In ploughing an acre on ridges of 270 yards in length, which is about the length of ridge considered best for horses in draught, the time lost by turnings, in ploughing 10 hours, with a 10-inch furrow-slice, is 1 hour 22 minutes. However easy the length of ridge may be for the draught, horses cannot go on walking in the plough for 5 hours together (a yoking) without taking breaths. Now 270 yards of length of ridge give 3.6 ridges to the acre, or 32 bouts of 10-inch furrows; and allowing a rest of 1 minute in every other bout, 16 minutes will have to be added to the 1 hour 22 minutes lost—that is, 1 hour 38 minutes lost out of every 10 hours, for turnings and rest. Thus 17,496 yards will be ploughed in 8⅓ hours, or at the rate of rather more than 1/5 mile per hour, or 11⅓ miles of walking in ploughing an acre in 8⅓ hours. These results are perhaps near the truth in ploughing lea in spring; they are too little in ploughing bare land in summer, and perhaps too much in ploughing heavy stubble-land in winter; but as lea-ploughing is the standard by which all others are estimated, the results arrived at may be taken as an approximation to the truth.

Hence this table:—

Length of ridge.	Breadth of furrow-slice.	Time lost in turning.	Time devoted to ploughing.	Hours of work.
Yards.	Inches.	H. M.	H. M.	H.
78	10	5 11	4 49	10
149	...	2 44	7 16	...
200	...	2 1	7 59	...
212	...	1 56½	8 3½	...
274	...	1 22	8 32	...
270	12	1 8	8 52	...

Long and Short Ridges.—Thus it appears that a ridge of no more than 78 yards in length requires 5 hours 11 minutes out of every 10 hours for turnings at the landings, with a 10-inch furrow-slice; whereas a ridge of 274 yards in length only requires 1 hour 22 minutes for turnings—making a difference of 3 hours 49 minutes in favour of the long ridge as regards the saving of time.

Very short *butts* in a field, therefore, involve much loss of time with the plough, the harrow, and the sowing-machine.

Extent of Land ploughed at different Speeds.—Further data from similar experiments are the quantities of land ploughed at different speeds at given breadths of furrow-slices, thus:—

Speed. Rate per Hour.	Breadths of furrows ploughed.	Distance walked in 8⅓ hours.		Quantity of land ploughed in 8⅓ hours at that speed.		
Yards.	Inches.	Miles.	Yards.	A.	R.	P.
1452	12	6	520	1	0	0
Miles.						
1	9	8	1284	0	3	1
	10	8	440	0	3	14
1½	9	12	642	1	0	21
	10	12	220	1	0	34
2	9	17	808	1	2	2
	10	16	880	1	2	28

A Regular Pace best.—*Horses driven in the plough beyond their ordinary step* cannot draw equally together, and the plough is consequently held unsteadily, having a tendency to take too much land; to obviate which, the ploughman leans the plough over to the left, when it raises a thin broad furrow-slice, and lays it over at too low an angle. On the other hand, when the horses move at too slow a pace, the ploughman is apt to forget what he is about, and the furrow-slices will then, most probably, be made too narrow and too shallow; and although they may be laid over at the proper angle, and the work seem well enough executed, there will be a deficiency of mould in the ploughed soil. A regular pace is therefore the best for man, horses, and work.

Ploughing Steep Land.—The *steepness of the ground* is a circumstance which greatly affects the speed of horses at work on hilly farms; and it is not unusual to find the ridges traversing such steeps straight up and down. Ridges in such a position are laborious to plough, to cart upon, to manure, and for every operation connected with farming. The water runs down the furrows when the land is under the plough, and carries to the bottom of the declivity the finest portion of the soil. In such a position, a ridge of 270 yards is much too long to plough without a breathing to the horses. Although the general rule for making ridges to run N. and S. is the correct one, in such a situation as a steep acclivity they should slope across the face of the hill; and the slope will not only be easier to labour, but the soil prevented being washed away in the furrows. But the direction of the slope should not be made at random,—it should so decline as that the plough shall lay the furrow-slice down the hill when in the act of climbing the incline; and on coming down, the horses will be better able to lay the furrow-slice up against the inclination of the ground. What the length of the ridges on such a slope ought to be, cannot be easily determined, but about 150 yards would be enough for the horses to draw at one breathing. It will be better for labouring an arable farm to have 2 fields each 150 yards long, one higher up the slope than the other, than have the whole ground in one field of 300 yards in length.

Ploughing-matches.—Although differences of opinion exist as to the usefulness of ploughing-matches, it can hardly be doubted that since their institution the skill of our ploughmen has risen considerably; not but that individual ploughmen could have been found before as dexterous as any of the present day. This improvement is not to be ascribed to the institution of ploughing-matches alone, for, no doubt, superior construction of implements, a better kept, better matched, superior race of horses, and superior judgment and taste in field labour in the farmer himself, have been potent elements in influencing the handicraft of ploughmen.

Highland and Agricultural Society Medals for Ploughing.—The *plough medals* of the Highland and Agricultural Society of Scotland being open in competition to all ploughmen in Scotland, numerous ploughing-matches take place every year in every district of the country. In 1886-87 the Society's silver medal was awarded at 150 ploughing-matches throughout Scotland. In 1864-65 the number was 145.

Besides stated competitions, a day's ploughing is frequently given to incoming tenants by neighbouring farmers as a welcome into the district.

How Ploughing-matches are Conducted.—Ploughing-matches are generally very fairly conducted in Scotland. They usually take place on lea ground, the ploughing of which is considered the best test of a ploughman's skill, though drilling is perhaps quite as difficult of correct execution. The best part of the field is selected for the purpose, and the same extent of ground is allotted to each competitor. A peg, bearing a number, is fixed in the ground at the end of each lot, which are as many as ploughs entered in competition. Numbers, on slips of paper corresponding to those on the pegs, are drawn by the competing ploughmen, who take the lots as drawn. Ample time is allowed to finish the ploughing of each lot. Although quickness of time in executing the same extent of work is not to be compared to excellency of execution, it should enter as an element in deciding the question of skill; but this it seldom does at ploughing-matches. Each competitor is obliged to "feer" his own lot, assort and guide his own horses, and trim his plough-irons, without assistance.

Judges at Ploughing-matches.—The judges are brought from a distance, so that they can have no personal interest in the exhibition, and in some cases they have been requested to inspect the ground after all the ploughs have been removed, having been kept away from the scene during the time the ploughs were engaged. This appears to be an objectionable part of the arrangements, which is made on the plea that, were the judges to see the ploughs at work, some particular ones might be recognised by them as belonging to friends, and their minds might thereby be biassed in their favour. Such a plea is a poor compliment to the integrity of a judge; and any farmer who accepts that responsible and honoured office, that would allow himself to be influenced by so pitiful a consideration, would deserve not only to be objected to on every such occasion, but banished out of society. One consequence of the exaction of this rule is, loss of patience by the spectators, while the judges are occupying no more than the necessary time for deciding the ploughing of, it may be, a large extent of ground.

The judges ought to be present all the time of the competition, when they could leisurely, calmly, and minutely ascertain the position and depth of the furrow-slices, and mature their thoughts on points which might modify first impressions. Inspection of the finished surface cannot furnish information whether the land has in all respects been correctly ploughed, which can only be obtained by comparing the soles of the furrows while the land is being ploughed. There is something also to be gained in observing the manner in which the ploughman guides his horses in making the best work in the shortest time.

Quantities of Earth turned over by different Ploughs.—Small's type of plough lays over a slice of a rectangular, and Wilkie's of a trapezoidal form, while making a high-crest slice and serrated furrow-sole, containing one-seventh less earth than the rectangular. Now when judges are prohibited seeing the work done in the course of execution, the serrated extent of the furrow-sole cannot so well be ascertained by removing portions of the ploughed ground here and there by the spade, as by constant inspection. As equal ploughing consists in turning over equal portions of soil in the same extent of ground, other things being equal, a comparison of the quantity of earth turned over by these two kinds of ploughs can only be made in this way: In a space of 1 square yard turned over by each, taking a furrow of 7 inches in depth, and the specific gravity of soil at 1.48, the weight of earth turned over by Small's type of plough would be 34 st. 9 lb., while Wilkie's would turn over only 29 st. 10 lb., making a difference of 4 st. 13 lb. in the small area of 1 square yard. With these results, is it fair to say that the horses yoked to Small's plough have done no more work than those yoked to Wilkie's? or that the crop for which the land has been ploughed will receive the same quantity of loosened mould to grow in in these cases, merely because the surface may please the eye more in the one case than in the other?

High-crested Furrows Objectionable.—The primary objects of ploughing-matches must have been to produce the best examples of ploughmanship—and by the best it must be understood that kind of ploughing which shall not only *seem* to be best done, but *has been* best done. The award should be given to the plough that produces not only a proper surface finish, but also turns over the greatest quantity of soil in the most approved manner. That this combination of qualities has ceased to be the criterion of merit, is now sufficiently apparent to any one who will examine for himself the ploughing which has been rewarded in ploughing-matches; and the cause of such awards is this:—

Wilkie's plough gave rise to the high-crested furrow-slice. It cannot be denied that the ploughs made on this principle produce work on lea land highly satisfactory to the eye of any person who appreciates regularity of form; and as there are many minds which dwell with pleasure on beauty of form, but combine not that idea with usefulness, it is no wonder that work which thus pleases the eye, and satisfies the judgment through the sense of sight only, should become a favourite one. While the crested system of ploughing kept within bounds it was well enough, but in course of time the taste for the practice became excessive; and at length, losing sight of the useful, a depraved taste sacrificed utility to beauty, in as far as ploughing is concerned. This taste gradually spread itself over certain districts, and plough-makers vied with each other in producing ploughs that should excel in that particular quality. A keen spirit of emulation amongst ploughmen kept up the taste amongst their own class, and frequently the sons of farmers became successful competitors in the matches, which assisted to give the taste a higher tone.

Thus, by degrees, the taste for this mode of ploughing spread wider and wider, until in certain districts it became the prevailing method. At ploughing-matches in those districts, the criterion of good ploughing was generally taken from the appearance of the surface; furrow-slices possessing the highest degree of parallelism, exposing faces of unequal breadth, and, above all, a high crest, carried off the palm of victory. More than once have a quorum of ploughing judges been seen "plodding their weary way" for two hours together over a field, measuring the breadth of faces, and scanning the parallelism of slices, but apparently never considering the underground work of any importance in enabling them to decide correctly. Under such regulations, it is not surprising that ploughmen devote their abilities to produce work to satisfy this vitiated taste, and that plough-makers find it their interest to encourage the desire, by exaggerating more and more the construction of those parts of the plough which produce such fine results. Thus have the valuable institutions of ploughing-matches, in the districts alluded to, been unwittingly made to engender an innovation which, though beautiful enough—and, when practised within due bounds, is also useful—has induced a deterioration in really useful and sound ploughing.

A useful Appendage of a Plough.—Ploughs should always be provided with the useful appendage of an *iron hammer*, fig. 30. The hammer and

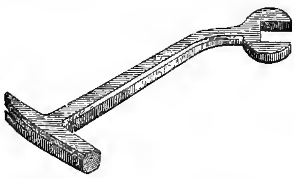


Fig. 30.—*Iron hammer nut-key.*

handle are forged in one piece of malleable iron, the handle being formed into a nut-key. With this simple but useful tool the ploughman has always at hand the means by which he can, without loss of time, alter and adjust the position of his plough-irons—the coulter and share—and perform other little operations which circumstances or accident may require, for the performance of which most ploughmen are under the necessity of taking advantage of the first *stone* they can find, merely from the want of this simple instrument. The hammer is slung in a staple fixed in the side of the beam in any convenient position. This little tool is now sent out by almost all makers as a regular appendage of the plough.

Plough-slide.—In removing ploughs from one field to another, or along a hard road to a field, instead of sliding them upon their sole-shoe, which is difficult to do when they have no hold of the ground, or upon the edge of the feather of the sock and the side of the mould-board—which is a more easy mode for the ploughman than the former, and is consequently more commonly taken—every ploughman should be provided with a plough-slide, a simple and not costly implement, as in fig. 31. It consists of a piece of hard-wood board 3 feet 4 inches long, 8 inches broad, and 2 inches thick, in which a long staple *a* is driven to take in the point of the sock; and at *b* are fastened two small bars of wood, longways, and at such distance from one another as to take between them the sole-shoe of the plough. On the under side of the board are nailed two pieces of flat bar-iron, to act as skeds to the slide. Upon this implement the plough may be conveyed with comparative ease along any road or headridge.

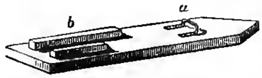


Fig. 31.—*Plough-slide.*

PLOUGHING DIFFERENT FORMS OF RIDGES.

One might imagine that, as the plough can do nothing else but lay over the furrow-slice, ploughing would not admit of any variety; but the student will soon see the *many forms in which land may be ploughed.*

Modes of Ploughing.—The several modes of ploughing have received characteristic appellations—such as gathering up; crown-and-furrow ploughing; casting or yoking or coupling ridges; casting ridges with gore-furrows; cleaving down ridges; cleaving down ridges with gore-furrows; ploughing two-out-and-two-in; ploughing in breaks; cross-furrowing; angle-ploughing, ribbing, and drilling.

Varying Methods to suit Soil and Season.—These various modes of ploughing have been contrived to suit the nature of the soil and the season of the year. Clay soil requires more caution in being ploughed than sandy or gravelly, because of its being more easily injured by rain; and, indeed, it is a bad thing to plough any land in a wet state. Greater caution is therefore required to plough all sorts of land in winter than in summer. The precautions consist in providing facilities for surface-water to flow away, and some sorts of ploughing afford greater facilities than others. Though the different seasons thus demand their respective kinds of ploughing, some modes are common to all seasons and soils. Attention to the various methods can alone enable the agricultural student to understand which kind is most suitable to the circumstances of the soil and the peculiar states of the season. To give the best idea of all the modes, from the simplest to the most complicated, let the ground be supposed to be perfectly flat on the surface.

The Parts of Ridges.—The supposed flat ground, after being subjected to the operation of the plough, is left in *ridges*, each of which occupies spaces of similar breadth. Ridges are composed of various parts—furrow-slices laid upon and parallel to one another, by the going and returning of the plough from one end of the ridge to the other: the middle line of the ridge receives the name of the *crown*,—the two sides, the *flanks*,—the openings between the ridges, the *open furrows*,—the edges of the furrow-slices, next the open furrows, the *furrow-brows*, and the last furrows, which are small, to narrow the open furrows, are the *mould* or *hint-end furrows*.

Direction of Ridges.—Ridges are usually made to lie in the direction of N. and S., that the crop growing upon both their sides may receive the light and heat of the solar rays in an equal degree throughout the day; but they, nevertheless, are made to traverse the slope of the ground, whatever its aspect may be, with the view of allowing rain-water to flow most easily away, without damaging the surface of the ground.

Width of Ridges.—Ridges are formed of different breadths, of 10, 12, 15, 16, and 18 feet, in different parts of Scotland, and in England they usually vary from 7 to 14 feet. These various breadths are occasioned partly by the nature of the soil, and partly by local custom. As regards the soil, clay soil is formed into narrow ridges, to allow the rain to flow off very quickly into the open furrows, and in many parts of England is ridged at only 14 feet in width, and in some localities are reduced to ridglets of 3½ or 7 feet. In Scotland, even on the strongest land, ridges are seldom less than 15 feet, in some localities 16, and on light soils 18 feet. In Berwickshire and Roxburghshire, the ridges have for a long period been 15 feet on all classes of soils—being considered the most convenient width for the ordinary manual and implemental operations. In other districts 18 feet are most common. In some parts of Ireland the land is not ploughed into ridges at all, being made with the spade into narrow strips called *lazy-beds*, separated by deep narrow trenches named *sheughs*. Where the plough is used, however, narrow ridges of 12 to 14 feet are mostly formed.

Ancient Form of Ridges.—More than half a century ago, ridges were made very broad—from 24 to 36 feet, and high on the crown—from an idea that an undulated surface affords a larger area for the crop to grow on, and that a crooked ridge like the letter S, from another mistaken notion, always presents some part of the crop in a right direction to the sun; which, although it did, removed other parts as far from it. Ridges were also made crooked to suit the lie of the land, so as to prevent the water in the furrows from gathering too great a force down-hill, and thus tend to wash away large quantities of useful soil. In parts many broad crooked ridges may still be seen; but the common practice is to have the ridges of moderate breadth, straight, and pointing to noonday. For distinctness of description, let it be understood that only a ridge of 15 feet in width is spoken of hereafter.

Fig. 32.—*Feering-pole.*

Feering.—The first process in the ridging of land upon the flat surface is *feering*, which is done by placing upright, in the direction of the ridges, not fewer than three poles, and as many more as are necessary (fig. 32), 8½ feet in length, graduated into feet and half-feet, and each painted at the top of a different colour, with bright blue, red, and white, to form decided contrasts with one another when set in line, and also with green trees and hedges, and brown ground.

Feering land is done in this manner: Suppose *a* and *b*, fig. 33, to represent the S. and E. fences of a field, of which *x* is the south *headridge* or *headland*, of the same width as the ridges — 15 feet. There are two headridges in every field. To mark off the width of the headridge distinctly, pass the plough in the direction of *r e*, with a small furrow-slice lying towards *x*. The same is done along the other headland, at the opposite side of the field. Then take a pole and measure off the width of a quarter of a ridge—viz., 3 feet 9 inches from the ditch-lip, *a e*—and plant a pole at *c*. With another pole set off the same distance from the ditch, *a e*, and plant it at *d*. Then measure the same distance from the ditch, at *e* to *f*, and at *f* look if *d* has been placed in the line of *f c*; if not, shift the pole at *d* until all the three poles are in a line. The plough-staff (fig. 18), set at *f*, will answer for a pole. Then plant a pole at *g* in the line

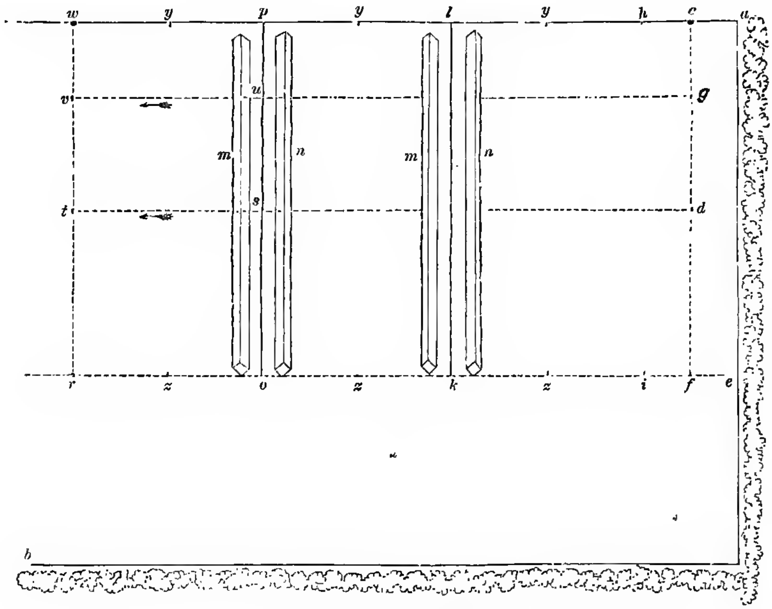


Fig. 33.—*Mode of feering ridges.*

a to *b* Fences of field.
x Headridge of field.
k l, *o p* Second and third feering of ridges; *f c* first feering of ridges.
m and *n* Furrow-slices of feerings.

f d c. Before starting to feer, measure off 1¼ ridge—namely, 18 feet 9 inches from *f* to *k*—and plant a pole at *k*.

To secure perfect accuracy in measuring breadths of ridges at right angles to the feerings, lines at right angles to *f c*, from *d* and *g*, should be set off in the direction of *t* and *v* by a cross-table and poles, and marked by a slight furrow drawn by the plough in each of these lines, previous to the breadth of the feerings being measured from *d* and *g* along them. Most people do not take the trouble of doing this, and a proficient ploughman renders it the less necessary; but every careful farmer will do it, even at a little sacrifice of time and trouble, to ensure perfect accuracy of work, and especially when he is feering for a seed-furrow, which fixes the rigidity of the ridge during the entire rotation of the cropping.

It is essential to the correct feering of the whole field to have the first two feerings *f c* and *k l* correctly drawn, as an error committed there will be transmitted to the other end of the field; and to attain this correctness, two persons, the ploughman and the farm-steward, or farmer himself, should set the poles.

Only an experienced ploughman, and a steady pair of horses, should be intrusted with the feering of land. Horses accustomed to feering will walk up of their own accord from pole to pole standing before them within sight.

Now, start with the plough from *f* to *d*, where stop at the pole standing between the horses' heads, or else pushed over by the tying of the horses. Then measure with it, at right angles to *f c*, a line equal to the breadth of 1¼ ridge, 18 feet 9 inches, in the direction of *t*, which will be in the line of *k l*, where plant a pole. In like manner proceed from *d* to *g*, where again stop, and measure off 1¼ ridge, 18 feet 9 inches, from *g* in the direction of *v*, which is still in the line of *k l*, and plant a pole there. Proceed to the other headridge to the last pole *c*, and measure off 1¼ ridge, 18 feet 9 inches, from *c* to *l*, and plant a pole at *l*.

From *l* look towards *k*, to see if the intermediate poles are in the line of those at *l* and *k*; if not, shift them till they are so. On returning by the furrow from *c* to *f*, obviate any deviation which the plough may have formerly made from the straight line. In the line of *f c*, the furrow-slices of the feering have been omitted, to show more distinctly the setting of the poles at *d* and *g*. The furrow-slices are shown at *m* and *n*.

Proceed in this manner to feer the line *k l*, and also the line *o p*; but in all feerings after the first, from *f* to *k*, the poles are set up at the exact breadth of the ridge, as from *k* to *o*, *l* to *p*, and again from *o* to *r*, *p* to *w*, in the direction of the arrows. And the reason for setting off *c l* at so much greater a distance than *l p* or *p w* is, that the half-ridge *a h*, *e i*, may be ploughed first, and the rest of the ridges ploughed by half-ridges instead of whole.

The first half-ridge *a h*, *e i*, is, however, ploughed in a different manner from the other half-ridges: it is ploughed by going round the feering *f c* by always *hupping* the horses until the open furrow comes to *a e* on the one side and *h i* on the other. This half-ridge is ploughed before any of the others are begun to.

The line *h i* then becomes the feering along with *k l* for ploughing the 2 half-ridges *z i* and *z k*, the open furrow being left in the line *z y*, corresponding to that in the line *e a*; and between these two open furrows is embraced and finished the full ridge of 15 feet *e z*, having its crown along *i h*. In ploughing these two half-ridges the horses are always *hied*.

As the plough completes each feering, the furrow-slices are laid over as at *m* and *n*. While one ploughman proceeds in this manner to feer each ridge along the field, the other ploughmen commence the ploughing of the land into ridges; and to afford a number of them space for beginning work at the same time, the feering ploughman should be set to work more than half a day in advance of the rest. On most farms now each ploughman does his own feering, although it may be doubted if it is usually performed so carefully as where the above method is pursued.

In commencing the ploughing of ridges, each ploughman takes two feerings, and begins by laying the furrow-slices *m* and *n* together of both the feerings, to form the crowns of two future ridges. One ploughman thus lays together the furrow-slices of *f c* and *k l*, whilst another is doing the same with those of *o p* and *r w*. These ridges are ploughed in half-ridges—that is, the half of one ridge is ploughed with the half of the adjoining ridge by always *hieing* the horses. The advantage of ploughing by half-ridges is, that the open furrows are made thereby exactly equidistant from the crowns; whereas, were the ridges ploughed by going round and round the crown of each ridge, one might be made narrower than the determinate breadth of 15 feet, and another broader, by a similar error of the ploughman.

Gathering up Ridges.—After laying the feering furrow-slices so as to make the crowns of the ridges at *f c*, *k l*, *o p*, and *r w*, the mode of ploughing the ridges from the flat ground is to *hie* the horses always towards you, on reaching the headridges, until all the furrow-slices between each feering are laid over as far as the lines *y z*, which become the open furrows.

This method of ploughing is called

gathering up, the disposition of the furrows in which is shown in fig. 34, where *a a a* embrace two whole ridges and three open furrows, on either side of which all the furrow-slices lie one way, from *a* to *b*, and also contrariwise from *b* to *a*, until both sets of furrow-slices meet in the crowns *b b*. The open furrows *a a a* are finished off with the mould or hint-end furrows.

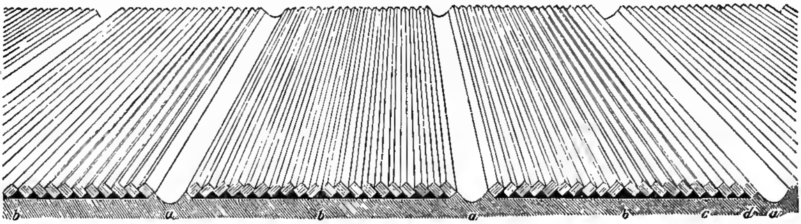


Fig. 34.—*Gathered-up ridges from the flat.*

a a a Three open furrows of two ridges.
a b Furrow-slices lying from left to right.
b a Furrow-slices lying from right to left.
b b Crown of two ridges.
c d Furrow-brow.
d Mould-furrow.

Number of Furrows in 15-feet Ridge.—The furrow-slices in fig. 34 are 20; whereas 10-inch furrow-slices across a 15-feet ridge would only be 18, which would be the number turned over in loose mould; but the figure represents gathered-up ridges in lea-ground, and the mould-furrows are shown as correctly formed as the others—which they ought to be; but in ploughing lea, the mould-furrow scarcely ever measures 10 inches in breadth, most ploughmen regarding it as not forming a part of the regular ridge, but only a finishing to it.

The Finish or Mould Furrows.—The *mould* or *hint-end* furrow is made in this way: When the last two furrow-slices of the ridges *a a*, fig. 35, are laid

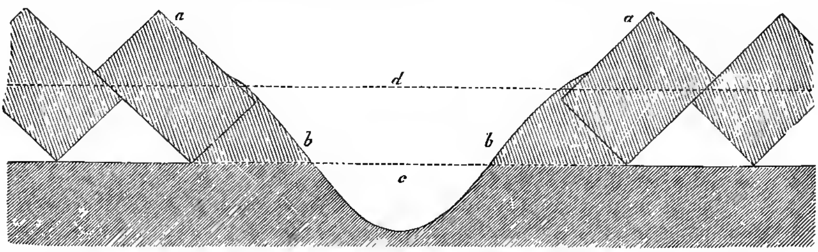


Fig. 35.—*Open furrows with mould or hint-end furrow-slices*

a a Two last-ploughed furrow-slices, and open furrow between them.
b b Two mould furrow-slices closing up the open furrow betweeu *a* & *a*.
c Finished open furrow.

over, the bottom of the open furrow is as wide as from *a* to *a*, and flat as the dotted line *c*. The plough goes along this wide space at *c*, and first lays over the triangular furrow-slice *b* on one side, and returning in the same furrow *c*, lays another slice of the same form *b* on the other side, up against and covering the lowest ends of the furrow-slices *a a*, by which action the ground is hollowed out in the shape represented below the dotted line at *c* by the sole of the plough. The dotted line *d* shows the place of the surface of the ground before it was ridged up, and the furrow-slices *a a* the elevation attained by the land above its former level *d*.

Crown-and-furrow Ploughing.—*Crown-and-furrow* ploughing can easily be performed on land which has been gathered up from the flat. No feering is required, the open furrows answering the purpose. Thus, in fig. 34, let the last furrow-brow slices *d* be laid over into the open furrows *a*, and it will be found that they will just meet, since they were formerly separated by the same means; and in ploughing the ridges in half-ridges, *a* will become the crowns of the ridges, and *b* the open furrows—hence the name of crown-and-furrow to this mode of ploughing. Its effect is to preserve the ploughed surface of the ridges in the same state as they were when gathered up from the flat.

When no surface-water is likely to remain on the land, as in the case of light soils, both these are simple modes of ploughing land; and they form an excellent foundation for drills for turnips on stronger soils, and are much practised in ploughing land for barley after turnips. But when the land for barley after turnips is to be *twice* ploughed, and it is inconvenient to cross-furrow the land, —which it will be when sheep on turnips occupy a field having long ridges, or the season is too wet to leave the land in a cross-furrow,—then the land should be so feered as, in gathering up from the flat, the crown-and-furrow ploughing may afterwards complete the ridges for the seed.

On looking at fig. 34, where the ridges are complete, it is obvious that, were they ploughed into crown-and-furrow, thereby making the open furrows *a a a* the future crowns, a half-ridge would be left at each side of the field,—a mode of finishing off a field displaying great carelessness and want of forethought. When the land is to be twice ploughed, the feering, therefore, of gathering up from the flat should leave a half-ridge on each side of the field, that the subsequent crown-and-furrow ploughing may convert them into whole ridges. Thus, the first feering for gathering up should be made at *e a*, fig. 33, instead of *f c*, and every other at the width of one ridge, 15 feet. On ploughing these feerings, the open furrows will be left at *i h*, *k l*, *o p*, and *r w*; and these will form the feerings of the subsequent crowns of the crown-and-furrow ploughing.

Casting Ridges.—Another mode of ploughing land from the flat surface is *casting* or *yoking* or *coupling* the ridges. The feering for this is done in a different manner from the two foregoing. The first feering is made in the line of *e a*, fig. 33, close to the ditch, and every other is made at 15 feet, the width of 1 ridge—as at *y z*, *y z*, *y z*. Two ridges are thus ploughed together, making a coupled ridge of 30 feet in width.

The true disposition of the furrow-slices is seen in perspective in fig. 36,

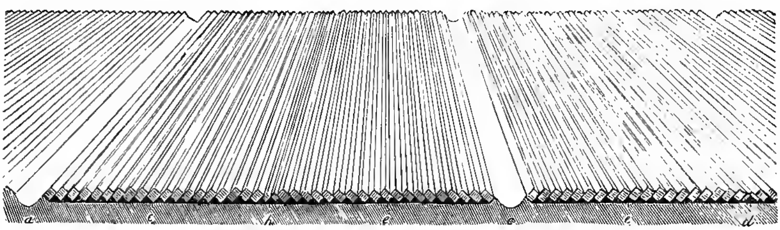


Fig. 36.—*Cast, yoked, or coupled ridges.*

a b One ridge with the furrow-slices lying to the right.
c b The other ridge with the furrow-slices lying to the left.
b Crown of the two coupled ridges.
c d Another ridge, with the furrow-slices lying to the right.
a and *c* Open furrows between the coupled ridges.

which exhibits a breadth of three entire ridges, *a b*, *b c*, and *c d*, two of which, *a b*, *b c*, are cast or yoked together, and meeting at *b*, the crown of the coupled ridge.

Ridges thus yoked can easily be re-cast, by reversing the furrow-slices of *b c* and *c d* into the open furrow *c*, and converting *c* into the crown of the yoked ridge *b d*, and making the crowns *b* and *d* open furrows.

Casting keeps the land in a level state, and can most conveniently be formed on dry soils. It forms a good foundation for drilling, and makes an excellent seed-furrow on dry land. Lea and seed-furrow for barley, on light land, are generally thus ploughed. It is an economical mode of ploughing land in regard to time, as it requires but few feerings; the furrow-slices are equal, and the horses are always turned towards you. It is best performed upon the flat surface, and should the land be ploughed again, it may be recast, and no half-ridges left at the sides of the field.

Gore-furrows.—Casting ridges is as suitable ploughing for strong as light land, provided the ridges are separated by a *gore-furrow*. A gore-furrow is a space formed to prevent the *meeting* of two ridges in a crown, and is a substitute for an open furrow between them; and can only be formed where a feering or an open furrow exists. It is made as shown in fig. 37. Let the dotted furrow-slices *a* and *e*, and the dotted line *i*, form an open furrow, of which *c* is a point in the middle, and let it be converted into a gore-furrow. Make the plough pass between the centre of the open-furrow *c* and the left-hand dotted furrow-slice *e*, as at *i*, and throw up to the right the triangular-shaped mould-furrow-slice *b*, with the mould seen below *c*. Then turn the horses sharp from you on the headridge, and lay the dotted furrow-slice *a* upon *b*, which will thus become the furrow-slice *d*. Again turning the horses sharp from you on the

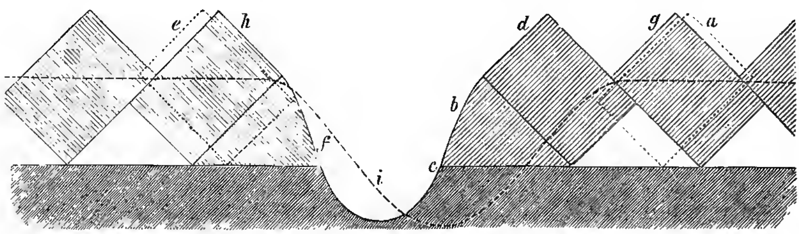


Fig. 37.—*Mode of making a gore-furrow.*

i The open furrow in a dotted line. *a* and *e* Brow-furrows, dotted, one on each side of
f c The gore-furrow. the dotted old open furrow *i*.

headridge, take the plough lightly through part of the dotted furrow-slice *e*, and lay it of a triangular shape for the mould-furrow-slice *f*, the upper angle of *e* being left untouched; but a portion of *f* will trickle down towards *i*, and so will also a portion of *d* when it was ploughed. Turn the horses on the off headridge still from you, and bring the plough down behind *d*, and lay upon it the ordinary furrow-slice *g*. Turning the horses again from you on the nigh headridge, lay the ordinary furrow-slice *h* upon the triangular-shaped mould-furrow *f*, by destroying the remainder of the dotted furrow-slice *e*, and some more earth; and then turn the horses *from* you again on the off headridge for the last time, and come down the open furrow *i*, pushing the soil up with the mould-board from *i* against *f*, and clearing the furrow of any loose soil in it, and the gore-furrow is completed.

A gore-furrow is best made and preserved in clay soil, for in tender soil it is apt to moulder down by the action of the air, and prevent itself being a channel for running water; and is therefore never made on light soils.

Casting with a gore-furrow upon a gathered ridge makes the open furrow barer of earth than the gore-furrow; but this is not an imperfection unavoidable in casting a ridge, as it is so only in casting after gathering up once or twice from the flat.

No Casting on Gathered Ridges.—Casting should never be practised on gathered ridges, to remain in a permanent state, though it may be used for a temporary purpose, as in fallowing, to stir the soil and overcome weeds; for observe its necessary consequences: Suppose two gathered ridges *a a a*, fig. 34, were cast together towards the middle open furrow *a*, the effect would be to reverse the position of the furrow-slices from *a* to *b*, on either side of *a*, and they would remain as flat as formerly; but what would be its effect on the furrow-slices on the other halves of the ridges from *b* to *d*? They would not be reversed, but heaped up in the same direction, so that the coupled ridge would have two high furrow-brows by two gatherings, and two low flanks by one gathering. They would be unevenly ploughed, and the open furrow on each side would be bared of soil, from being twice gathered up. The distortion might be partially obviated by making the furrow-slices between *a* and *b* on each side of the middle open furrow *a* deeper and larger than those between *b* and *d*, and a uniform shape to the coupled ridge might be preserved; but it would be done by the sacrifice of good ploughing; so it is but right to confine casting within its own sphere.

The "Two-out-and-two-in" Method.—Nearly allied to casting is ploughing *two-out-and-two-in*, which may also be executed on the flat ground, and requires a particular mode of feering. The first feering should be measured of the breadth of 2 ridges, or 30 feet, from the ditch *a e*, fig. 33; and every subsequent feering of 4 ridges breadth, or 60 feet. The feerings are thus but few.

The land is ploughed in this manner: After returning the feering furrow-slices, begin ploughing round the feering *c d*, fig. 38, keeping it on the right hand, and *hupping* the horses from you on both the headridges, until about the breadth of a ridge is ploughed on each side of *c d*, to *g g* and *h h*. While this is doing, 2 ridges to *i i* and *k k* are ploughed around *e f* by another ploughman. If there is not another ploughman, the same one ploughs round the feering *e f*, as he had done round *c d*. At this juncture open furrows occur at *h h* and *i i*, embracing between them 2 ridges, or 30 feet, from *h* to *i*. If

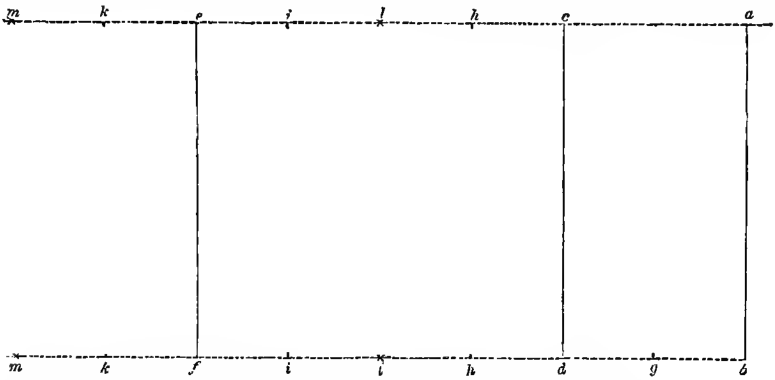


Fig. 38.—*Feerings for ploughing ridges two-out-and-two-in.*
c d and *e f* Feerings every 4 ridges or 60 feet. *l l*, *m m* Open furrows at every 4 ridges or 60 feet.

there is another ploughman, the ploughman who has ploughed round *c d* ploughs from *h* to *i*, laying the furrow-slices first to *h* and then to *i*, by *hieing* the horses towards him on both headridges, until the ground is all ploughed to *l l*, which becomes the permanent open furrow. If there is not another ploughman, the only one finishes the feering between *h i h i* as just described. The next permanent open furrow will be at *m m*, 60 feet or 4 ridges breadth from *l l*.

But as yet the ridge *g a* has not been ploughed, nor its corresponding ridge at the other end of the field. They are both ploughed along with the headridges *m a* and *b m* round the field, after all the ridges have been ploughed, laying their furrow-slices towards *g g*, in the same direction to the left as the furrow-slices from *g* to *c*, and making the open furrow at *a b*.

The appearance of the ground on being ploughed two-out-and-two-in is seen in fig. 39, where the space from *a* to *e* is 60 feet, comprehending 4 ridges, between the open furrows *a* and *e*.

This method of ploughing places the land in large flat spaces, and as it dispenses with many open furrows, is only suitable for light soils or well-drained land, in which it may be used for seed-furrowing, and for drilling turnips and potatoes upon.

Gore-furrows again.—Were the gore-furrow, in fig. 37, applied to ploughing strong classes of soils, its introduction would change the character of ridges, inasmuch as the crown c, fig. 39, would not only be converted into an open furrow, but the crown transferred from c to b and d, where furrow-slices *not meeting* from opposite directions, but lying across it, there would be no true crown.

In a similar manner, were the gore-furrow introduced into cast ridges, in fig. 36, the crowns at b and d would be converted into open furrows, and the crown e would not be a true crown, the furrow-slices lying across the ridges.

Ploughing in Breaks.—Nearly allied to ploughing two-out-and-two-in is *ploughing in breaks* or *divisions.* It consists of making feerings at indefinite distances, and ploughing large divisions of land without open furrows, comprehending 8 ridges or 40 yards; but so great a distance incurs considerable loss of time in travelling from furrow to furrow at the landings. Instead, therefore, of a given number of ridges, 30 yards are chosen; and this particular breadth has the advantage of causing the loosening of any hard land that may have been left untouched by the ordinary ploughing. Land is ploughed in breaks only for temporary purposes, such as pulverisation for seed-furrowing, or drilling up immediately thereafter.

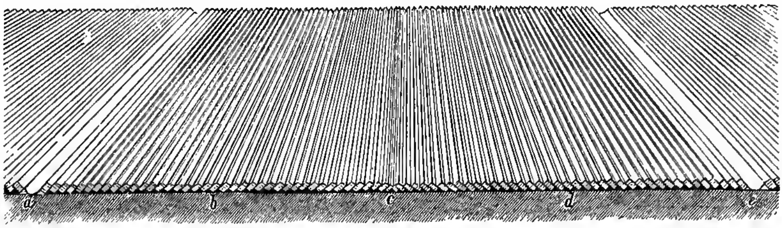


Fig. 39.—*Ploughed ridges two-out-and-two-in.*

a c Furrow-slices of 2 ridges lying to the right.
e c Furrow-slices of 2 ridges lying to the left.
c The crown of the 4 ridges.
a and *e* Open furrows of the 4 ridges.

Time lost in ploughing wide breaks might be easily estimated in fig. 38, where, the feerings c d and e f being 60 yards asunder, the ploughs would have to go round c d and e f until they reach h and i respectively, thus travelling in a progressive increasing distance to 30 yards *for every furrow-slice laid over*, of whatever breadth.

Twice - gathering - up. — Another mode of ploughing is *twice-gathering-up.* Its effect is in fig. 40, where twice-gathered-up furrow-slices rest upon the formerly gathered-up ground. It may be practised both on lea and red-land. On red-land that has been already gathered-up from the flat, it is begun by making feerings in the crowns of the ridges, at b, fig. 34. The furrow-slices of the feerings are laid together, and the ridges ploughed by half-ridges, in the manner of gathering-up from the flat. The half-ridge left by the feerings at the sides of the field must be ploughed by themselves, even at the risk of losing time, because it would not do to feer the first ridge so as to plough the half-ridge as directed to be done in the first gathering-up, in fig. 33, around the feering of the quarter-ridge f c, because the furrows betwixt f and i, when ploughed in the contrary direction they were before, would again lower the ground; whereas the furrow-slices from e to f, and from z to i, being ploughed in the same direction as formerly, the ground would be raised above the level of i f, and disfigure the ploughing of the entire ridge z e. Gathering-up from the flat, in fig. 34, preserves the flatness of the ground; and the second gathering-up would preserve the land in the same degree of flatness, though more elevated, were there depth enough of soil, and the furrow-slices made in their proper form; but a roundness is imposed upon a twice-gathered-up ridge by harrowing down the steep furrow-brows, and by ploughing the furrow-slices of unequal size, from want of soil at the furrow-brows and open furrows.

In twice-gathering-up *lea* no feering is required. The plough goes a little to the left of the crown of the ridge, and lays upon its back a thin and narrow furrow-slice, *a*, fig. 40, to serve as a cushion upon which to rest the future crown furrow-slices *c* and *b*. The horses are then *hupped* sharp round from you, and the furrow-slice *b* is laid so as to rest upon *a*. *Hupping*

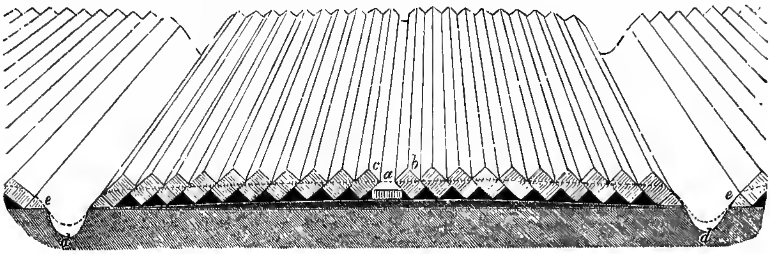


Fig. 40.—*Twice-gathered-up ridges.*

d to *d* Section of the ground by the first gathering-up.

e to *e* Dotted line indicating the rise in the ground after the second gathering-up.

the horses again sharp round from you, the furrow-slice *c* is laid upon the other side of *a*; but *c* and *b* should not meet so as to cover over *a*, but leave a space of 3 or 4 inches between them, the object being to form an open rut for seed, which, were *c* and *b* to meet and make a sharp angle, would slide down when sown, and leave the crown, the best part of the ridge, bare of seed. The ridges are ploughed in half-ridges to the open furrows *d*, which are finished with mould-furrow-slices, but these are formed with some difficulty for want of soil. The dotted line *e e* represents the configuration of the ground before the second gathering-up was begun, and the open furrow at *d* must now be deeper than it was with one gathering-up.

Cleaved-down Ridges.—Exactly opposite to twice-gathering-up is *cleaving* or *throwing-down* ploughing. Open furrows of twice-gathered-up land constitute deep feerings, which are filled up with slices from the mould-furrows

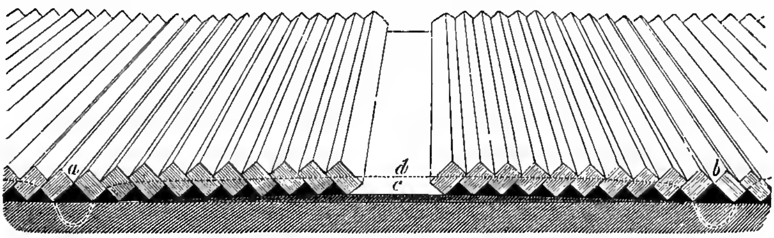


Fig. 41.—*Cleaved-down ridges without gore-furrows.*

d Dotted line showing the former surface of the ground.

a and *b* Dotted line showing the former open furrows.

and furrow-brows of the adjoining ridges; and to fill them up fully, the plough takes a deep hold of those furrows. The furrow-slices are ploughed exactly the reverse way of twice-gathering-up, but also in half-ridges. The effect of cleaving-down is to bring the ground again to the level from which it had been elevated by twice-gathering-up. The open furrows are left at the crowns, at *a*, fig. 40, the mould-furrows being seldom ploughed, cleaving-down being done to prepare land for ploughing again.

But when clay land is cleaved down in winter, it is so sometimes with gore-furrows, and these, with the open furrows, afford a convenient channel, at every half-ridge, for the water to flow off to the ditches; and as twice-gathering-up is practised only on clay soils, and cleaving-down can be executed only after twice-gathering-up, it follows that cleaving-down is only suitable to clay soils. The effect of simply cleaving-down ground is in fig. 41, where are no open furrows at *a* and *b*, and only at *c*; but in fig. 42 the gore-furrows are shown at *a a*, and the open furrow at *b*. Gore-furrows are going fast out of practice since the success of thorough draining, and are necessary only on stiff wet stubble-land.

Cross-ploughing.— *Cross-ploughing* is at right angles to the furrow-slices of ridges. Its object is to cut the furrow-slices into small pieces, so that the land may afterwards be easily pulverised. It is commonly executed in the spring, and should never be attempted in winter; because the altered position of the furrow-slices would retain the rain or melting snow, so that the land would remain wet. But even if cross-furrowing were executed quickly in winter, and the weather allowed the soil to be safely ridged up, the soil would become so consolidated during winter that it would have to be again cross-furrowed in spring before it could be pulverised. The object of cross-furrowing being to pulverise land, it is practised on every kind of soil, and exactly in the same manner.

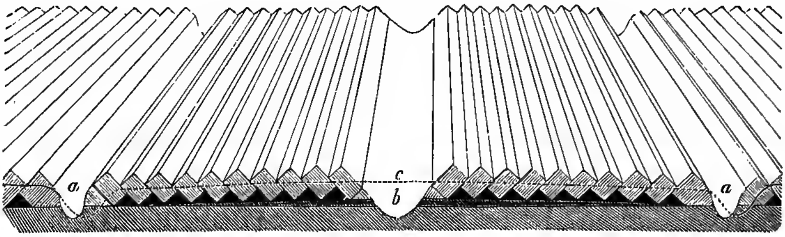


Fig. 42.—*Cleaved-down ridges with gore-furrows.*

c Dotted line showing the former surface of the ground. *a* and *a* Dotted line showing the former open furrows.

It is ploughed in divisions, the feerings being made at 30 yards asunder, and executed in the same manner as for two-out-and-two-in, fig. 38, by going round the feerings, *hupping* the horses constantly from you, until about half the division is ploughed, and then *hieing* them towards you, still laying in the furrow-slices towards the feerings, until the division is ploughed.

In cross-ploughing, no open furrow is left, it being closed with two or three of the last furrow-slices being reversed, and all existence of furrows obliterated by the plough filling loose soil into them with the mould-board, laid over and retained in that position by a firm hold of the large stilt only. Obliteration should be complete, otherwise a hollow at the furrows would be left across the future ridges.

Angle-ploughing.—Another mode, having a similar object to cross-ploughing in pulverising furrow-slices by cutting them into pieces, is *angle-ploughing*, so named because of the feerings being made in a diagonal direction across the ridges of the field. The ploughing is conducted in divisions of 30 yards each, and in exactly the same manner as cross-ploughing, with the same precautions as to the season, and obliteration of open furrows. It is never practised but *after* cross-ploughing, and not always then, and only in clay soil, when cross-ploughing has failed to produce pulverisation or sufficient cleansing of the land.

Bad Ploughing.—These are all instances of good ploughing with rectangular furrow-slices; and were they constantly executed, there would be no instances of bad ploughing, as shown in fig. 43; no high-crowned ridges as at *a*, caused by bringing two feering-slices or two open furrows too close from opposite directions; no *lean* flanks, as at *b*, by making the furrow-slices broader than they should be, with a view to ploughing the ridge quickly, and which constitute hollows that become receptacles of surface-water to sour the land. When the soil is strong, lean flanks are so low, and become so consolidated, that they are almost sure to resist the action of the harrows when passed across the ridge; and in light soil they are filled up with the loose mould by the harrows, at the expense of the surrounding heights. No *proud furrow-brows* as at *c*, by setting up the furrow-slices more upright than they should be, to the danger of being drawn bodily into the open furrow on the harrows catching them too forcibly in cross-harrowing; and no *unequal*-sided open furrows, as at *d*, by turning over one mould-furrow flatter than the other.

Every sort of crop grows unequally on ill-ploughed ridges, growing better on spots where the soil is most kindly, and worse on the hard portions; but the evil effects of bad ploughing are not confined to the season it is executed, for it renders the soil unequally hard when ploughed up again.

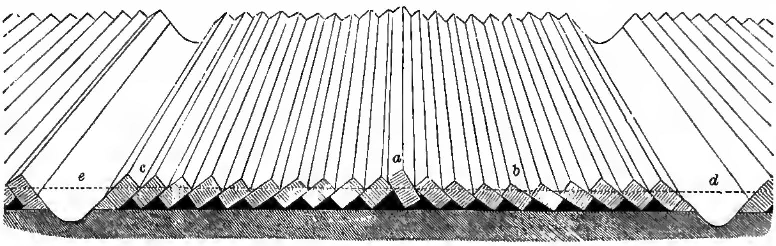


Fig. 43.—*Ill-ploughed ridge.*

a Too high-crowned ridge.
b Too low flank of ridge.
c Too proud furrow-brow.
d Unequal-sided open furrow.
e d Dotted line showing the former surface of the ground and the unequal positions of the furrow-slices by bad ploughing.

Some are of opinion that land when ploughed receives a curvature of surface, whereas correct furrow-slices cannot give the surface any other *form* than it had before it was ploughed. If that form were curved or flat, the new ploughed surface would be curved or flat. In gathering-up a ridge from the flat ground, the earth displaced by the plough occupies a smaller area than it did by the extent of the open furrows; but the displacement only elevates the soil above its former level, and the act of elevation cannot impart a curvature to it. True, ridges on being harrowed become curved on the surface, because the harrows draw the soil into the open furrows, having the least resistance presented to them at the furrow-brows, but the curvature thus given has no connection with the ploughing.

The steam-plough, laying all its furrows in the same direction, by means of its balanced mould-boards, dispenses with ridges and open furrows. The even surface proves advantageous in certain operations—as drilling for potatoes and turnips—and it looks well; but in sowing grain by hand or machine, or drill, the guidance for the breadths in sowing the ridges will be missed, and some expedient must be substituted to have as sure a one as defined ridges.

TURN-WREST OR ONE-WAY PLOUGHS.

For hilly land the turn-wrest plough is a most useful implement. It turns the furrow over in one direction, so that by ploughing with it across steep land, the furrows can all be thrown down-hill, an advantage which every practical farmer will readily understand and appreciate. One of the best of these "one-way" ploughs is that represented in fig. 44, and made by Ransome, Sims, & Jefferies. This plough acts in the same manner as the common plough, when the mould-board is set as seen in the figure, the furrow-slice being turned over to the right hand; and on coming to the land's end, the other mould-board is brought into action on the left-hand side of the plough, and by it the furrow-slice is turned over to the left hand—where it is placed in the same position as did the ploughing in turning over the fur-

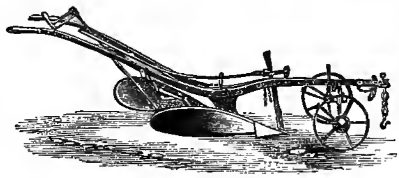


Fig. 44.—*Ransome's One-way plough.*

row-slice to the right hand, while moving in the opposite direction. The even surface without open furrows, executed by this mode of ploughing, is highly favourable to the action of reaping-machines in harvest. But, as has been indicated, its chief value is its adaptability for ploughing steep land. Fig. 45

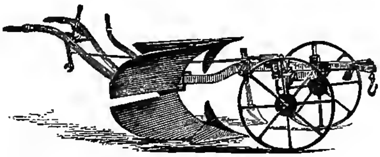


Fig. 45.—*Cooke's One-way plough.*

represents another form of the turnwrest — an excellent implement also, made by Cooke & Sons of Lincoln, and specially designed to turn over wide well-broken furrows.

PLOUGHING STUBBLE AND LEA GROUND.

When the crop has been gathered into the stackyard, the student will perceive that a large proportion of the land is in stubble, some fields containing grass, others none. The stubble which contains no grass is ploughed, the other not, and the ploughing is determined by the nature of the soil and crop.

Ploughing Stubble-land.—It is rare that stubble-land is ploughed in any other mode in winter, than in reversing the form in which it was previously ploughed. If it had been twice gathered up, fig. 40, on clay soil, it should now be cloven down with gore-furrows, fig. 42; if so ploughed on loam, cleaving down without gore-furrows, fig. 41, answers best. If it had been cast on strong soil, it should now be recast with gore-furrows; but if it had been cast on loam, recast it without gore-furrows. If it had been ploughed two-out-and-two-in, renew the furrow-slices, with gore-furrows between every two ridges. And if it had been ploughed crown-and-furrow, reverse the furrow-slices. A good general rule for all winter-ploughing is to reverse the former furrow-slices with gore-furrows on heavy, and without them on lighter soils; and it is the safest rule even on recently thorough-drained land, until sensible effects of draining have been ascertained.

Clay Land not to be ploughed Wet.—Strong clay soil should never be ploughed in a wet state, as it will become very hard in spring, and difficult to pulverise, and even to work.

No Ploughing in Frost and Snow.—Snow should never be ploughed in under any pretext, nor the soil when in a frozen state. Ice and snow concealed under the soil remain a long time unaltered, and spring may be far advanced ere its warmth will reach them, to relieve the soil from its chilled condition.

Stubble-land ploughed Deep.—When soil is tolerably clean and dry, either by thorough-draining or naturally porous subsoil, it is desirable to plough stubble-land deep with three horses instead of two. The horses are yoked according to the arrangement in fig. 26. The form of ploughing may either be crown-and-furrow if the soil is light, or cast together when somewhat heavy. One ploughman can direct three horses well enough. The three horses may easily turn over a furrow-slice 10 to 12 inches deep and with a proportionate breadth, and this should be done when the soil and subsoil are of a suitable nature for this depth of ploughing.

Rain-water Channels.—In every variety of soil, ploughed in the forms just described for winter, care should be taken to have plenty of channels cut in the hollowest places for the surface-water to escape into the nearest ditch. The channels are first made by the plough laying them open like a feering, taking the hollowest parts of the ground, whether across ridges or along open furrows, across the head-ridge into a ditch; and they are immediately cleared out by the hedger with the spade of all *loose earth*, which is spread over the surface. The precaution of channel or gaw cutting should never be neglected in winter in any kind of soil, the clayey soil, no doubt, requiring more gaws than the lighter; but as no foresight can anticipate the injuries consequent on a single deluge of rain, or a great melting of snow, it should never be neglected, and never is by the provident farmer, his great object being to keep his land in the driest condition all winter. It is certain, however, that as land is more extensively thorough-drained, it will require less gaw-cutting; but it is to err on the safe side, to have too many rather than too few of them in winter.

Deep Ploughing.—Modern experience has rather upset the faith which was formerly placed in deep ploughing. This, of course, is a relative and a very indefinite term. What one farmer has considered deep ploughing might not be so regarded by another. Not very long ago there was quite a rage for deep ploughing. It was thought, and indeed so expressed, that the steam-plough, by enabling the farmer to add a few more inches to the workable soil, would thereby vastly increase the productiveness of his land. But it was found that harm instead of good was done by burying useful soil and bringing up in its place sour unkindly subsoil. It has therefore come to be recognised that deep ploughing may easily be carried too far. What the depth of furrow should really be, depends mainly upon the character of the soil and subsoil.

As a general rule, it may be laid down that the furrow should be as deep as the nature of the soil and subsoil will advantageously permit. This rule, it may be said, is still indefinite, but deep ploughing is one of many subtle points in farm management as to which it would be worse than useless to lay down precise and unvarying directions. It must be left to practical men of good judgment to decide what is best to be done in each individual case.

Generally speaking, it may safely enough be said that for ordinary grain crops 7 inches is quite as deep as need be desired. In ploughing stubble-land as a preparation for root crops, the depth should, if possible, be much greater; and where the good soil is too shallow for deep ploughing, other means may be found of stirring of the ground to the desired depth.

Digging and Grubbing.—This stirring of the soil is effected by the digger, the grubber, or cultivator—an implement differing from the plough, inasmuch as it operates by means of tines. Tines, in action, strip the soil, and even subsoil, into ribbons, leaving the ground in the same position as it was before—that is, leaving the good soil on the surface and the subsoil still underneath. This stripping does the soil much good, by changing the relative positions of its component parts, and by opening it up so as to admit the air. Indeed, there are many soils in which the action of the digger is more effectual than that of the plough, and is therefore preferred.

Subsoiling.—Still the digger does not so thoroughly expose the under soil

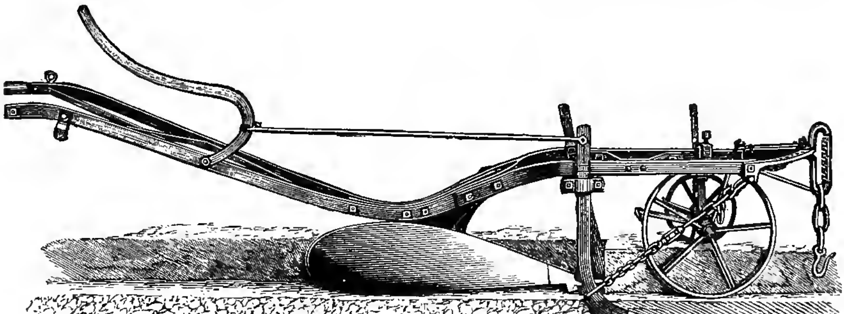


Fig. 46.—*Single plough and patent subsoiler combined.*

and subsoil to the action of the atmosphere as does the plough. Many therefore prefer the more effectual method of stirring soil and subsoil each by itself simultaneously, by means of the subsoil trench-plough. Fig. 46 represents both operations of ploughing and subsoiling performed at one time by Ransome's combined plough and subsoiler. An ordinary furrow-slice is turned over by the wrest, while the tine bearing the subsoiling share precedes it in the open furrow. It may be set to break up the bottom to any depth the horses can pull, while the covering with a furrow-slice immediately prevents any trampling on the stirred soil by the horses the next time they come round.

Very often the subsoiling is done by a separate implement (as is seen in fig. 47) following in the bottom of the furrow turned by the plough. In this case the work can generally be done deeper than where the two form parts of the same implement.

To plough deep *at once* into a subsoil, impregnated with oxides of iron, might run the risk of injuring the scanty upper soil. But such a subsoil has a tendency to *pan*, which subsoiling can best destroy by breaking it up and exposing it to the air, which converts the iron into a harmless peroxide.

Shallow Ploughing.—A preference for the rectangular furrow-slice has been evinced, and this on the safe principle

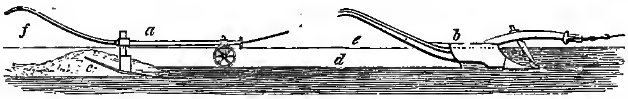


Fig. 47.—*Conjoint operation of the common and subsoil trench-plough.*

b The plough going before.
a Trench-plough following after, with bearing-wheel.
c Tail-board over which the subsoil falls 9 inches.
d Depth of furrow by the plough, 10 or 12 inches.
e Surface of ground.
f Stilts of trench-plough.

that, in suitable soil, deep ploughing ought to be the rule, and shallow the exception.

Shallow ploughing for a seed-furrow is common in the case of fields of grass that have been pastured by sheep, and their droppings form too good a top-dressing to be buried by deep ploughing. The reason is plausible, but is not admitted by all to be entirely unassailable. It is well known that the roots of plants push themselves everywhere in pursuit of nutriment, even through media which afford little nourishment, in order instinctively to reach the one in which they can luxuriate. With the largest vegetable productions, as trees, this is remarkably the case; and with cereals the roots are known to extend 6 feet and more into the subsoil. Hence a strong argument for deep ploughing or stirring. In shallow ploughing weeds are apt to exert an ascendancy over the crops.

Smashing up the Soil.—Amongst the earliest and most energetic advocates of digging or stirring, as opposed to deep ploughing, was Mr William Smith, Woolstone, England. His system has been to stir the soil to the depth of 15 inches with steam-power by means of a grubber, by which he *smashes up* the soil, as he expresses it. He disapproves of the plough, and even of the principle by which it operates, and prefers, and has adopted, and strongly recommends, the grubbing system. The steam-grubber or cultivator has certainly been more successful than the steam-plough, and it is now freely acknowledged that there was much truth in Mr Smith's reasoning, although his wholesale condemnation of the plough would not be generally supported. The chief defect in the grubbing or cultivating system is that in the main it always leaves the surface-soil at the surface, and cannot, even where it is desired and desirable, bring up any considerable quantity of fresh earth to the surface. Cultivating or grubbing, therefore, while a most useful operation, can never to any great extent supersede judicious ploughing.

Ploughing Lea.—The most common form of ploughing *lea* in *strong soil* and light soils is to cast it; whilst on lightest soils the crown-and-furrow is most suitable. Gathering-up is a rare form of ploughing lea, though it is occasionally practised on strong soil.

The oldest lea is first ploughed, that the tough slices may have time to mellow by exposure to the winter air, and for the same reason the strongest land should always be ploughed before the light.

Unseasonable Ploughing. — Lea should never be ploughed when affected by frost or snow, or even rime, or when soft with rain. Ice or rain ploughed down chills the ground to a late period of the season, and when rain softens the ground much, horses cut the turf with their feet, and the furrow-slice is squeezed into a pasty mass by the mould-board. Nor should lea be ploughed when hard with drought, as the plough will take a shallow furrow, and raise the ground in broad thin slabs. A semi-moist state of ground in fresh weather is the best condition of soil for ploughing lea.

Water-runs.—Gaws or water-runs should never be neglected to be cut after lea-ploughing, especially in the first ploughed fields, and on strong land, whether early or late ploughed. To leave a ploughed field to be injured by wet weather, shows great indifference to future unfavourable consequences. No doubt, on thorough-drained land, less dread of evil consequences from neglect of gaw-cutting may be felt; but even in the best drained land it is imprudent to leave isolated hollows in fields in winter without a ready means of getting rid of every torrent of rain that may fall unexpectedly. Land which lies dry all winter may be worked a week or two earlier in spring than land which has been wet.

Headridges.—It is a slovenly practice to leave headridges unploughed for a time after the rest of the field. The neglect is most frequent on stubble-land, but it should be avoided. Ploughing headridges in winter requires some consideration. In stubble, should the former ploughing have been cast, fig. 36, with or without a gore furrow, fig. 37, reversing it, will leave a ridge on each side of the field, which will be most conveniently ploughed along with the headridges by the plough going round parallel to all the fences of the field, and laying the furrow-slices towards the ridges. The same plan may be followed in ploughing lea in the same circumstances.

Should the ploughing in stubble on clay land have been cleaving-down with or without gore-furrows, figs. 41, 42, the headridges should be cloven down with a gore-furrow along the ends of the ridges, and mould-furrowed, fig. 35, in the crowns.

On ridges being ploughed crown-and furrow, the headridges may be gathered up in light soils, and in stubble, on strong soils, cloven down without a gore-furrow along the ends of the ridges.

The half-ridge on each side of the field may be ploughed by going the half of every bout empty; but a better plan is, *where the ridges are short*, to plough half of each headridge towards the ends of the ridges, going the round of the field, and then to plough the other half-ridge with the other half of the headridges in the circuit, laying the furrow-slice still towards the ends of the ridges, which would have the effect of casting the headridges towards the ends of the ridges, and of drawing the soil from the ditches towards the ridges.

When ridges have been ploughed in a completed form in lea, headridges of clay soils should be gathered up, and in light soils cloven down from the gathering.

A difference of opinion is entertained of the manner in which a headridge should be formed, where a great length of ridges, from opposite directions, meets in a common line. The practical question is, whether these ridges should meet in an imaginary line or at a common headridge? An answer may be given thus: When ridges meet from opposite directions, they cannot be ploughed at the same time without risk of the horses encountering one another upon the common headridge; and where no headridge exists, the ridges first ploughed will be trampled upon when the others are ploughed. There should therefore be two headridges — one belonging to each set of ridges.

APPLICATION OF STEAM-POWER TO AGRICULTURE.

Since 1850 a complete revolution has taken place in the use of steam-power for agricultural purposes. It is now used for all kinds of hard work, and on some modern holdings may be found as many as five or six steam-engines of various sorts profitably employed in the various operations of the farm.

In the early days of steam the engines were heavy and cumbrous. As they worked with steam at a very low pressure, they required cylinders of large area to develop the necessary power; but now that higher pressures are invariably employed, the engines can be made much lighter and more compact. Many farm-engines work with steam at a pressure of from 120 to 150 lb. on the square inch. For these high pressures high-class boiler-work is absolutely necessary.

In dealing with this subject it will be convenient to notice the various points in the following order: (1) the boiler—the apparatus by which the steam is generated; (2) the kinds of fuel employed in raising steam, the principles of combustion, and the properties of steam; (3) the construction of the steam-engine and the action of steam; (4) the different types of steam-engines; and lastly, the various methods by which land is cultivated by steam-power.

The Boiler.

The functions of a boiler being to generate steam, its efficiency is estimated by the rapidity with which it does this duty, and the economy of fuel with which the required result is obtained. The form of the boiler—its proportions—the nature, extent, and disposition of the heating-surfaces—have a most important bearing upon its efficiency. The greater the area of the surface of the boiler exposed to the action of the fire and heated gases, the greater will be the amount of water which will be evaporated by it. As a general rule, the comparative efficiency of steam-boilers may be fairly estimated by the relative area of the heating-surfaces which they present to the action of the fire.

Egg-ended Boilers.—Amongst the earlier forms of steam-generator used with agricultural engines was that known as the ordinary cylindrical or "egg-ended" pattern. This consists of a plain shell of wrought iron, of a diameter varying from 3 feet 6 inches to about 5 feet, with a thickness of plate of about ⅜ of an inch, and hemispherical ends riveted in. These boilers are fixed in brickwork seating, and fired externally. The fire-grate is underneath one end of the boiler, and is sometimes so arranged that the flame and hot gases can play freely on the whole of the underneath external surface of the boiler up to about its horizontal axis. In other cases the heated gases pass along a portion only of the under surface, and return by means of a flue or belt passing round the centre of the boiler, by which means the gases are made to traverse a longer distance in contact with the plates of the boiler before they pass away into the chimney. They thus have a better chance of imparting some of their heat to the boiler itself.

This kind of boiler is, however, nearly obsolete; for although there are still large numbers of old ones at work, no one with any regard for economy of fuel would now think of putting down a boiler of this antiquated description.

The mountings of this class of boiler are of almost as simple a character as the boiler itself. They frequently consist of only a safety-valve and a "float"—the former to prevent any dangerous excess of pressure, and the latter to indicate the height of the water within the boiler. The "float" generally consists of a stone suspended inside the boiler, fastened to a rod coming through the boiler-plate. The rod is coupled to a chain which passes over a pulley, and sustains a weight which partly counterbalances the weight of the stone, so that it floats on the surface of the water within the boiler. By observing the position of the balance-weight, which rises and falls with the level of the water in the boiler, it can be seen at a glance whether this is being maintained at the proper height or not.

At the period when these "egg-ended" boilers were in general use, the element of safety was more considered than that of efficiency; but now that every means are used to secure economy as well as safety, this type of boiler has almost become a thing of the past. The usual amount of heating-surface in egg-ended boilers varies from 5 to 7 square feet per nominal horse-power.

Cornish and Lancashire Boilers.—A much more economical and altogether preferable form of steam-generator is that known as the "Cornish" or "Lancashire" type. These, like the former, consist mainly of an outer cylindrical shell of stout iron plates. They have flat ends, and may have one or two large tubes or flues running through their whole length. The outer shells of these boilers vary from 12 to 30 feet in length, and from 4 feet 6 inches to 8 feet diameter. The diameter of the flues varies from 2 feet to 3 feet 6 inches, according to the size of the boiler. The flues contain at one end a fire-grate, with fire-door and other necessary fittings. They are consequently fired internally. The heated gases pass along the interior of the tubes or flues as far as the end of the boiler, and return underneath in a single or double brickwork flue, so that a much larger surface of the boiler-plates is exposed to the action of the flame and heated gases in these boilers than is possible in those of the "egg-ended" description. The heating-surface may also be considerably increased by inserting in the flues beyond the fire-grate and at short intervals a series of cross tubes, or "Galloway tubes," as they are sometimes called. These consist of conical tubes, varying in diameter from 5 or 6 inches at one end to 10 or 12 inches at the other. They are placed transversely in the main flues at different angles, so that they obstruct the free passage of the heated gases. These impinge against the cross tubes, which are of course full of water, constantly exposed to the fiercest action of the heat; and the effect of a number of these cross tubes fixed in the flues of a Cornish or Lancashire boiler is to greatly increase its evaporative efficiency.

These boilers are generally fixed in brickwork seatings, and as they present a greater amount of heating-surface to the action of the flame, and in very close contact with the same, they have the advantage of generating a great deal more steam per lb. of fuel than the "egg-ended" boiler. They are known as "Cornish" boilers when they have but one flue, and as "Lancashire" when they have two. In both classes of boiler the best practice is to allow about 14 square feet of heating-surface to each nominal horse-power. If properly constructed, the wear and tear upon these boilers is not at all excessive. On the other hand, if badly designed, or if the water-supply contain lime or other impurities in suspension or solution which may be precipitated by heat, they are somewhat more difficult to keep clean internally than the old-fashioned "egg-ended" boilers.

Objection to Brickwork Seatings.—The brickwork seatings are a considerable source of wear and tear in both these classes of boiler, as they prevent external examinations being conveniently made, so that in the event of leakage, corrosion may go on for years before being discovered. Indeed it often happens that it is not discovered until too late, and after fatal consequences have resulted both to the boiler and its attendants. Every steam-boiler ought to have both its outer and inner surfaces easily accessible for periodical examination, so that in the event of corrosion taking place, it may be speedily attended to and arrested.

Vertical Boiler.—Another class of steam-generator largely used in agriculture is that known as the vertical boiler. It has the advantages of occupying very little space and being very cheap, although it is by no means economical of fuel. The outer shell of these boilers consists of a plain vertical wrought-iron cylinder, containing an internal circular chamber or fire-box somewhat smaller in diameter than the outer shell, so that the whole surface of the fire-box is continually surrounded by an envelope of water, to which the heat is communicated directly through the plates of which the fire-box or chamber is formed. From the centre of the crown of the fire-box a vertical flue or uptake rises, and passes through the flat or convex plate which forms the crown of the outer shell of the boiler. This pipe not only serves as a chimney, but acts as a stay to prevent the pressure of steam in the boiler from depressing the crown of the fire-box, or bulging outwards the crown-plate of the boiler. It will thus be understood that the vertical boiler gives a greater proportion of fire-box heating-surface (which is the most valuable of all) than either of the two previously described classes of boilers. Unfortunately it gives us very little else than fire-box heating-surface, as, except for the short length of uptake already described, and which passes through the water and steam space of the upper part of the boiler, it presents no other heating-surface whatever.

In order to make up to some extent for this deficiency, it is usual to fix in the fire-boxes of these boilers what are known as "cross tubes." These resemble in some respects the "Galloway tubes" already described. They consist of hollow iron tubes, 8 or 9 inches in diameter, passing through the interior of the fire-box from one side to the other at different angles, so they are constantly exposed to the full heat of the interior of the fire-box, and greatly increase the efficiency of the boiler as a steam-generator. These tubes are, of course, always full of water, being in communication with the interior of the boiler. There is, however, a limit to the number which can be got into a boiler, and even in the most favourable cases the heating-surface in this class of boiler seldom exceeds 10 square feet per nominal horse-power, which is a very small allowance, and accounts for the low evaporative duty obtained from them.

Hundreds of patents have been taken out for improving the efficiency of vertical boilers. Some, such as the Field tubes, have been very successful, but few are generally practicable, and most are of no value whatever.

Simplicity in Engines.—In agricultural machinery simplicity of construction is of the utmost importance, and in cases where economy can be attained only at the cost of simplicity, it may be advisable to sacrifice somewhat of the former in order to make sure of the latter. It must be borne in mind that agricultural steam-engines are often put into the hands of men unskilled in the management of machinery, and sometimes very careless and negligent in the use of the expensive apparatus which they are called upon to direct. The advantages of simplicity are therefore obvious.

Tubular Steam-generators.—Many leading engineers on both sides of the Atlantic have bestowed much attention upon the construction of steam-generators, built up of tubes of comparatively small diameter so arranged that, while the inside of the tubes is filled with water, the outer surfaces are exposed to the fierce heat of variously arranged furnaces. These boilers have the advantage of extraordinary strength, and wonderful rapidity in the generating of steam; but they have never come into anything like general use. This is no doubt owing to the complicated nature of their construction, the numerous joints which it is necessary to make, their liability to prime, and the extreme difficulty in effecting any requisite repairs. They do not therefore possess any particular merits for agricultural purposes.

Locomotive Multitubular Boiler.—The most important as well as the most generally efficient description of steam-generator is what is known as the locomotive multitubular type. It consists of an internal chamber or fire-box of rectangular shape entirely surrounded by water, as in the case of the vertical boiler already described. The heated gases after leaving the fire-box pass through a large number of small iron or brass tubes, disposed horizontally along the inside of the barrel of the boiler, and forming a connection between the fire-box and the smoke-box. These tubes are entirely surrounded by water, contained within the cylindrical portion of the boiler. The hot gases in passing along these tubes from the fire-box to the smoke-box impart a great deal of their heat to the water through which they pass, thus increasing the evaporative power of the boiler.

This form of generator has proved in practice the most economical extant; while for safety, convenience of size, and weight, it leaves little to be desired. Recent experiments have shown that with this class of boiler, specially constructed for agricultural purposes, as much as 12½ lb. of water can be evaporated with 1 lb. of good Welsh coal. This is an exceedingly good result, and is no doubt mainly due to the large amount of heating-surface which these boilers possess, which varies from 18 to 20 square feet per nominal horse-power.

Advantages of the Locomotive Type.—A considerable amount of prejudice exists in the minds of many agriculturists against this very useful and effective type of boiler. It seems to be based upon the supposition that it is either more dangerous, more difficult to fire, or more liable to run short of water than the more clumsy types already described. As a matter of fact, nothing could be more mistaken than such ideas or prejudices. With regard to danger, a boiler of this class, properly constructed and efficiently stayed, has a much larger factor of safety than any of the other types of boiler already described, and it may be worked without danger at a much higher pressure of steam than it would be judicious to use in any of the others. The difficulty of firing, instead of being greater, is very much less. Twice the quantity of water can be evaporated with the same weight of fuel by the one boiler as by the other, so that the mechanical labour of stoking is reduced by one-half. The question of height of water is simply one of degree. A careless driver could no doubt ruin one of these boilers quickly enough by neglect or inattention, but the same carelessness if applied to the older-fashioned types of boiler would lead to exactly the same result in an almost equally short time. Except as the result of the grossest ignorance or culpable neglect, there is no more danger with the one description of boiler than with the other.

Amongst the many advantages of the locomotive type of boiler must be mentioned the facility with which all the parts can be examined, and the accessibility, both internally and externally, for repairs. No masonry foundations are required, so that the expense of setting them down, as well as the space occupied by them, is very much less than that of any other description of boiler of equal power. Their use is therefore to be recommended in all cases wherever practicable.

Boiler-mountings.—Whatever kind of boiler is used, it is of the utmost importance that the mountings should be both sufficient and efficient. No respectable boiler-maker would now turn out a boiler without double safety-valves, safety fusible plug, steam-pressure gauge, water-gauge to show the level of the water in the boiler, and test-cocks to check the working of the water-gauge, which is liable to get choked with dirt, and so mislead the attendant. A man-hole as large as possible should be provided on all boilers, to give easy access for examination and repairs. These man-holes were formerly simply an oval hole cut in the top or side of the boiler. No compensation was made for the large amount of material cut away to form this hole, which naturally considerably weakened the structure of the boiler, and has thereby caused many explosions. In all cases the man-hole should be strengthened by riveting a stout iron ring round the opening, or, better still, by having a strong cast-steel or wrought-iron man-hole mouthpiece riveted round the opening, having the cover bolted to the top flange.

Proportions of the Fire-grate.—A very important point in steam-boiler economy, and one which is very often overlooked in the fixing and working of steam-boilers, is the proportion of fire-grate, the thickness and length of the fire-bars, and the spaces between them. In practice it is a disadvantage to have a fire-grate longer than 6 feet, and the width and consequent area of course depend upon the size of the boiler, and the amount and quality of the fuel to be consumed. The following proportions of grate area, per nominal horse-power, may be taken as approximately suitable for the different boilers having the respective amounts of heating-surface already given:—

Egg-ended boilers should have about		1¼	square feet of grate area per nominal horse-power.		
Cornish	"	1	"	"	"
Lancashire	"	1	"	"	"
Vertical	"	1	"	"	"
Loco-type, multitubular do.		⅝	"	"	"

As a general rule, fire-bars ¾ inch thick, with ⅜ inch air-spaces between them, give a very fair result; but narrower bars and still narrower spaces may be used where the fuel is good and clean, and where a high evaporative efficiency is aimed at.

Skill in Firing.—With all boilers the efficiency very much depends upon the skill or otherwise of the stoker. This was shown in a marked manner at the trials of steam-engines held by the Royal Agricultural Society of England at Newcastle in 1887, where the difference in fuel economy which could be attained by skilful firing, as compared with careless or reckless firing, was most manifest.

In an ordinary way a thin fire, say 3 or 4 inches thick, frequently replenished with fuel, will give a much better evaporation per pound of coal than a thick fire replenished by larger quantities at long intervals.

Wear and Tear in Boilers.—A very important matter for the consideration of users of steam-boilers is the question of wear and tear. No doubt certain boilers are more economical than others in this respect. It must, however, be borne in mind that the treatment which boilers receive at the hands of their attendants in nearly every case determines the amount of wear and tear. Many boilers which have been at work for years in the hands of careful men show no signs of depreciation further than those due to natural causes, such as corrosion, &c.; while others of similar construction, which have been subjected to careless treatment, will have cost a large amount for repairs in the same time.

Durability of the Locomotive Type.—Provided the boiler is sufficiently large for the work it has to do, the locomotive multitubular type will be found as economical of repairs and renewals in the long-run as any other description. Boilers of this class, supplying steam to the extent of a considerable (say 20 or 30) nominal horse-power, have been at daily work for 20 years without costing as many pounds for repairs, and no better result could be expected under this head from either "Cornish" or "Lancashire" boilers doing the same amount of work.

Weak Points.—It is important that boiler-users should make themselves acquainted with the weak points of their construction, so that they may know where to look for signs of wear and tear.

Corrosion in Built-in Boilers.—In the egg-ended description of boiler, the natural limits to the lasting qualities are those of corrosion, and wear and tear from expansion and contraction. The former may go on for years unsuspected and undiscovered. The boiler being embedded in a huge pillar of brickwork, with a very small portion of its surface exposed for examination, may be secretly eaten almost through before the owner's attention is directed to it. Cases of such corrosion are extremely common, and account for a great many fatal explosions. Should there be a leaky rivet or joint in any of the surfaces covered by the brickwork, the water which escapes serves to keep the brickwork seating damp, and the corrosion goes on very quickly, and will soon eat through the boiler-plates, no matter how thick they may have originally been.

Expansion and Contraction.—The wear and tear from expansion and contraction is one which cannot very well be guarded against. It is due to the property of the metal of which the boiler is made to expand under heat and contract when cooled. In externally fired boilers, that portion subject to the influence of fire naturally becomes heated before the other portions which are more remote from the action of the fire. The boiler being thus hot on the under side and cold on the top, becomes considerably strained, inasmuch as the under side has been elongated a little, causing a buckling or bending action. Then, again, when the fire has gone out, and the boiler has cooled down, the parts resume their normal position, and the strain due to the buckling action of the boiler ceases. This expanding and contracting action (slight though it may be), repeated at frequent intervals, has a very marked effect upon the plates of which the boiler is made. They not only become brittle and liable to crack, but in many cases the cracks quickly manifest themselves, and it is no uncommon thing to find many of the plates dangerously cracked between the rivet-holes.

The same causes which tend to destroy the plain "egg-ended" boiler are also present in the "Cornish" and "Lancashire" types. Corrosion, of course, is always most active in the outer shell, which is most exposed to the detrimental effects of the brickwork seating. The effects of expansion and contraction are more observable in the flues, where the heat of the fire is most active.

Corrugated Boiler - flue. — Many plans have been tried for giving a certain amount of elasticity to the flues, so that when they become heated and commence to expand, they should do so without damaging the ends of the boiler to which they are attached, and which they are always tending to thrust outwards. Amongst these, the most successful is undoubtedly the corrugated boiler-flue, perfected by Mr Samson Fox, whose name will always be associated with this particular form of furnace-flue.

Internal Tear and Wear.—The action of internal corrosion is more serious in "Cornish" and "Lancashire" boilers than in the older type. This is no doubt owing to the greater difficulty of keeping the inside of the boiler perfectly clean, and free from sediment. In internally fired boilers there is also a source of wear and tear due to the burning of the fire-box plates, caused by scale and sediment lodging upon the plates in contact with the fire. Wherever the sediment lodges, it keeps the water away from contact with the plates, which are naturally quickly destroyed. The nature of the iron is speedily burnt out of it, causing the plates to crack in all directions.

"Grooving."—A very frequent source of failure in all kinds of boilers is that known as "grooving." The causes of this action are most difficult of explanation, but the fact remains that the internal examination of a boiler will often reveal deep grooves in the plates forming the outer shell. Sometimes this action takes place on the bottom plates of the boiler, and sometimes at and around the water-line. The grooves are sometimes longitudinal, sometimes transverse. They are often so deep as to cut nearly through the plates, and occasionally so narrow that they can be observed only by very carefully scraping all the scale from the surface of the plates. The appearance of the groove sometimes shows a clean V groove, as sharp as if it had been cut in with a chisel.

Certain kinds of water are supposed to have more tendency to cause this action than others, but in many cases it is certainly due to the racking strain arising from the expansion and contraction already referred to. In every case it is a source of great danger, and emphasises the necessity of periodical internal as well as external examination of all boilers.

Examining Locomotive-type Boilers. — The prejudice against the locomotive multitubular boiler for stationary engines is no doubt largely due to the fact that it is somewhat more intricate in its construction than the other kinds of boilers. The annular water-space round the fire-box is certainly more difficult of access than the plain cylindrical interior of the old "egg-ended" type. Nevertheless, in properly constructed locomotive-type boilers, every part is sufficiently easy of access for perfect cleansing and examination. The inside of the circular or barrel portion can generally be examined from the man-hole. The tubes can be taken out for scaling, and replaced when necessary, and at such times a complete internal examination of the boiler-shell can be made.

The weak spots in this class of boiler are the fire-box and tubes — the latter especially. They require to be made of very thin material, so as to offer as little resistance as may be to the passage through them of the heat which is to be applied to the generating of steam. They are therefore sooner destroyed by the action of ordinary corrosion than the other parts of the boiler, which are made of much thicker material. Apart from the fact that a set of tubes can be taken out, cleaned, and replaced a considerable number of times, it may be remarked that the cost of a completely new set is comparatively little, and will be saved many times over in the economy of the coal bill.

With regard to the other portions of the boiler, the depreciation from corrosion and wear and tear is so slight that many locomotive-type boilers have been at work for 30 years without the outer shell being dangerously affected. It may therefore be taken that the cost of repairs and renewals to boilers of this class which have been properly cared for will amount to a very small sum in proportion to the amount of work done by them, and will come out favourably if compared with the cost of repairs to any of the other classes of boiler already described, and worked under similar conditions. On the other hand, the saving in fuel, &c., effected by their use, is great beyond all comparison.

Soft Water best for Boilers.—The effect of different kinds of water upon the tubes of a boiler of the locomotive multitubular type is very marked. Soft water, of course, is the best; and where this can be obtained, the life both of the tubes and the shell of the boiler will be very long. In other cases where the water contains injurious acids, the destruction of the tubes and outer shell begins at once. Deposits of scale and dirt upon the tubes and in the annular water-space surrounding the fire-box are a frequent cause of premature failure in boilers—causing the material to burn and crack, as already described in connection with the other descriptions of boiler.

Neglect of the precautions suggested by everyday experience—such as failing to keep the boiler properly washed out, and allowing the accumulation of solid matter in the water-spaces—speedily causes overheating and excessive wear and tear.

Having thus described the principal kinds of boilers used in agriculture, and referred to the causes of failure, and indicated where such failures may be looked for, and how they may be identified, we will now consider the efficiency of the different kinds of fuel, the theory of combustion, and some of the properties of steam.

Fuel—Combustion—Properties of Steam.

Coal.—Coal, of course, takes the leading place as a material for generating heat. In this country we have many varieties and qualities of this substance, but the purest and best is that found in the South Wales coal-field. Not only does the evaporative power of different coals vary greatly, but the useful effect which is obtained from the same qualities of fuel also varies with the construction of the furnaces, the conditions under which they are consumed, and the amount of air which is admitted in each case to support the combustion.

Oxygen and Combustion.—The great supporter of combustion is the oxygen which is ever ready to hand in large quantities in the atmospheric air. This combines with the combustible constituents of the fuel at a sufficient temperature, and when this combination takes place in proper proportions, perfect combustion is the result.

Smoke Wasteful.—Where there is an insufficient supply of air, the combustion will be imperfect; and, with most kinds of coal, a portion of the unconsumed products of combustion will be carried off in the form of smoke. This not only pollutes the atmosphere to a greater or less extent, but causes an actual waste of fuel. Smoke consists of unconsumed particles of carbon; and all that is necessary for its consumption is the admission of a sufficient supply of air, so that it comes in contact with the carbon while the latter is at a sufficiently high temperature to combine with the oxygen in the air, which combination then passes off as carbonic acid gas, which is invisible.

Amount of Air for perfect Combustion.—The amount of air necessary for the complete combustion of 1 lb. of coal is 11½ lb., or 150 cubic feet. It is therefore necessary, in order to secure full economy, that there shall be sufficient draught to cause this quantity of air to pass through the fire. In the absence of a sufficient supply of air, not only is smoke emitted, but carbonic oxide is formed, which carries away with it in a gaseous state, and unutilised, a large portion of the heating qualities of the fuel.

On the other hand, too great a draught causes an excessive quantity of air to pass through the fire, which is also a source of waste, as the heating of a greater volume of air than is necessary for the perfect combustion of the fuel absorbs a large amount of heat which should be applied to heating the water in the boiler and converting it into steam.

Kinds of Fuel compared.—For convenience of stating and comparing the relative heating-value of different kinds of fuel, the quantity of water which can be evaporated by 1 lb. of the particular fuel from a temperature of 212° is generally taken as a standard, and by it the following theoretical values of different kinds of fuel may thus be expressed:—

Description of fuel.	Pounds of water evaporated from a temperature of 212° by 1 lb. of the fuel.	Units of heat contained in 1 lb. of the fuel.
Petroleum	22.0	21,260
Best Welsh coal (Ebbw Vale)	16.8	16,240
Patent fuels (average)	15.6	15,100
Best Newcastle steam coal	15.3	14,820
Scotch coal	14.7	14,200
Coke	13.0	12,560
Dry peat	10.0	9,670
Dry wood	7.5	7,250

These theoretical values are, however, never realised in practice. The best recorded results fall at least 25 per cent short of the above standard, and in most cases it will be found that not more than 50 per cent of the theoretical value of the fuel is being utilised for the production of steam.

Heat the Source of Energy.—Heat, which is the great agent in the production of steam, may be said to be the source of all energy. It is many years since scientific men demonstrated this truth, but only in recent years has it been accepted, and the relation between heat and work recognised by practical men. The English standard unit of heat is the amount of heat necessary to raise the temperature of 1 lb. of water 1° Fahr. Joule and others proved by experiment that a certain force, represented by a weight of 772 lb. falling a distance of 1 foot, was equivalent to an expenditure of heat sufficient to raise the temperature of 1 lb. of water by 1° Fahr.; so that the unit of heat may be described as the equivalent of 772 foot-pounds.

"Foot-pound" and Horse-power.—The "foot-pound" is the convenient expression fixed upon by James Watt as the unit of work, and the meaning of the expression is simply "one pound lifted to a height of one foot in one minute." Watt estimated the work of one horse to be equal to 33,000 of these units of work,—that is, 33,000 lb. raised to a height of 1 foot in one minute, or 330 lb. raised 100 feet in one minute, or 1000 lb. raised 33 feet in one minute—and so on. This standard is still accepted, and in all mechanical calculations 33,000 "foot-pounds" is taken as the actual power of a horse.

Actual and "Nominal" Horse-power.—It may be here stated that there is a great difference between the actual horse-power of a steam-engine and the "nominal" horse-power. The former is a clearly defined duty, but the latter is merely a trade-term, vague and indefinite. It is generally based upon the diameter of the cylinder of the engine, without regard either to the pressure of the steam or the stroke of the piston. Moreover, almost every maker of engines has his own standard of piston-area per nominal horse-power, thus increasing the vagueness of the term.

The Royal Agricultural Society of England probably gives the most sensible proportion of piston-area—viz., 10 circular inches per nominal horse-power. By giving the area in circular inches, the power may be more easily calculated than in square inches, as of course it is obtained by merely multiplying the diameter of the cylinder by itself. Thus a 9-inch cylinder gives 81 circular inches, which, divided by 10, is equal to 8.1 nominal horse-power. A 10-inch cylinder gives 10 nominal horse-power, and a 12-inch cylinder 14.4 nominal horse-power.

Amount of Fuel per Horse-power.—It will be seen by reference to the above table that a pound of Welsh coal contains 16,240 units of heat, and as each unit of heat is equivalent to 772 foot-pounds, the theoretical value (or duty) of one pound of this description of fuel is 12,537,280 foot-pounds, equal to about 6⅓ actual horse-power per hour. Hitherto, however, the best engineers have been entirely unable to construct engines which would give off anything like the amount of work due to this theoretical duty of the fuel. In the very best recorded experiments, the very best duty got out of the best fuel under most favourable circumstances has been about 1 horse-power per hour from 1 lb. of coal. This is equal to only 1,980,000 foot-pounds, or less than one-sixth of the theoretical value of the coal. The data published by the Royal Agricultural Society of England have been considered unreliable, in consequence of the inaccuracy of their testing apparatus; but independent scientific tests give about twice the above consumption as necessary for the best constructed agricultural engines (viz., about 2 lb. of coal per horse-power), which thus give off only about one-twelfth of the theoretical duty of the fuel.

Dissipation of Heat.—The causes of this enormous loss of energy are legion, but they are mainly due to the waste of heat in the various processes of combustion, and the loss of heat by radiation. No sooner has the heat been generated by combustion, than it manifests a tendency to disappear. Where the furnace in which it has been generated has free communication with the atmosphere, the heat speedily escapes and dissipates itself in the surrounding air. Where it cannot escape so freely, it imparts itself with greater or less readiness to whatever comes in its way. A bar of cold iron thrust into a hot fire speedily robs the fire of some of its heat, which it goes on absorbing until it becomes red-hot, or even burnt away. If the red-hot bar be taken out of the fire and held in the open air it gradually gives off its heat to the surrounding atmosphere, which it warms by *radiation.*

Radiation is the term used to describe the action of the heat in passing off from a heated body into the atmosphere. If the bar be quickly plunged into a trough of cold water it is speedily robbed of its heat, which is absorbed by the water, which is thereby increased in temperature to the extent due to the amount of heat absorbed.

Conductors of Heat.—Some materials are better conductors of heat than others. For example, a bar of copper, which is a good conductor, plunged into a hot fire, would absorb a greater amount of heat in a given number of seconds than a similar-shaped body of a more refractory material, such as fireclay.

Economical Use of Heat.—It will thus be seen that in order to get the best duty out of fuel it must be properly consumed, so that the utmost possible amount of heat may be generated, and the heat must be so utilised that the greatest evaporative duty may be got out of it. For this purpose boilers are designed and fixed in such a way that the heated gases shall be kept in close contact with the boiler-plates or heating-surfaces for as long a period as possible, so that they may communicate as much as possible of their heat to the water in the boiler before they are allowed to escape into the atmosphere.

Preventing Loss by Radiation.—But after the heat has been generated from the fuel, and effectually applied to the production of steam, it is of the utmost importance that all loss of heat by radiation from the boiler, steam-pipes, and cylinder of the engine should be prevented, as every unit of heat so lost is equivalent to a loss of energy equal to 772 foot-pounds. No part of the boiler should therefore be exposed to the cooling action of the atmosphere, but all such exposed parts, as well as the steam-pipes and cylinder, should be carefully covered over with some non-conducting material, so as to prevent as far as possible all loss of heat, and consequent waste of fuel.

High-pressure.—High-pressure steam —*i.e.*, from 80 to 140 lb. on the square inch—is now universally employed in all first-class engines, for the reason that only a comparatively slight extra amount of fuel is necessary to raise a cubic foot of steam to a pressure of 120 lb. on the square inch beyond what is necessary to raise it to 45 lb. on the square inch. The power exerted by high-pressure steam is not only enormously greater to begin with, but the energy it exerts by its expansive power, after the admission to the cylinder has been arrested or cut off, is very great as compared with the lower pressure.

Condensing Waste Steam.—During the process of expansion the steam is not only exerting a considerable energy, but it is parting with a proportionate amount of its heat, which decreases in a due ratio with the pressure. Nevertheless, when the utmost has been got out of the steam by expansion, there still remains in it a certain amount of heat, which may be used for heating the feed-water on its way to the boiler. Or, better still, it may be conducted by means of pipes to a condenser, where its remaining heat is finally absorbed by the water of condensation. The result of this condensation is, that a vacuum is formed in the cylinder (on the opposite side of the piston from that upon which the steam-pressure is acting), which is equivalent to a force equal to the pressure of the atmosphere (say 15 lb.) exerted on every square inch of piston-area.

Condensing Engines. — For fuel economy, therefore, high-pressure steam, used expansively and condensed, will give the very best result. The principal obstacle in the way of the universal use of condensing engines is the necessity for a considerable supply of cold water. The action of the condenser, although not fully understood by many steam-users, is extremely simple. The waste-steam pipe, instead of conducting the exhaust-steam into the atmosphere, conducts it into a small chamber rather more than half the cubic capacity of the cylinder, where, on entering, it is met by a stream of cold water, which immediately cools it and causes it to *condense*. In other words, the condensing chamber exactly reverses the action of the boiler, in which the water was originally converted into steam. The stream of cold water absorbs nearly the whole of the heat contained in the exhaust-steam, which then ceases to be steam, and resumes its original form of water. But the space occupied by the steam in its vapoury form is many times greater than the bulk which it assumes on resuming its watery form; so when the steam is condensed the most of the space previously occupied by it becomes void, and a vacuum is formed which exerts a suction on the side of the piston from which the steam had been exhausted, and consequently exerts a power auxiliary, and sometimes superior, to that due to the pressure of the steam.

If a perfect *vacuum* could be obtained, the force of the suction due to it would as stated be equal to the pressure of the atmosphere. A perfect vacuum is, however, never attained in steam-engine practice. The nature of the vacuum is generally expressed by the height of a column of mercury. Thus the weight of the atmosphere and the power of a perfect vacuum would both be equivalent to a column of mercury 30 inches high. A vacuum equal to 27 inches of mercury is a usual thing in fairly efficient condensing engines.

The use of a condenser involves a little extra first cost, and a few extra working parts, but these are of little importance in comparison with the economy of fuel which results from condensation. The extra parts consist of the condenser itself, with an air-pump, and the necessary valves in connection therewith. It will be easily understood that in a very short time the influx of cold water, and the water resulting from the condensed steam, would soon fill up the condenser and choke it. Some means must therefore be taken to get rid of its contents, which are pumped out by the air-pump. In small engines, up to, say, 50 horse-power nominal, the condenser may be most conveniently arranged behind the cylinder, and in a line with it, so that it can be worked by a tail-end rod from the piston. This rod passes through the back cylinder cover, and is coupled up direct to the bucket of the air-pump, forming a very simple, neat, and effective arrangement.

Construction of the Steam-engine, and the action of the Steam.

Before proceeding to describe in detail the various kinds of engines used in agriculture, it may be well to explain briefly the action of the steam. The economical use of steam is quite as important as its economical production, for it would be manifestly absurd to take great pains with the design and construction of boilers to generate steam economically, and then, by the use of badly designed or badly constructed engines—by wastefully using it in the process of converting it into useful work—to lose all the benefit which had been gained.

After having been compressed in the boiler to the requisite pressure, the steam is conveyed in pipes to the motor, or engine in which it is to be utilised. Owing to the rapidity with which steam parts with its heat, these pipes, whether long or short, should be carefully covered with some non-conducting material, so that the loss by radiation and consequent condensation in the steam-pipes may be reduced to a minimum. The motor or engine consists primarily of a cast-iron cylinder in which the steam exerts its force, and of the various moving parts by which that force is converted into useful work. The cylinder of the steam-engine, which is shown at A in fig. 48, is

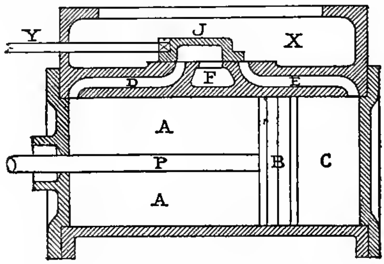


Fig. 48.—*The steam-engine cylinder.*

bored out to a perfectly smooth surface. A piston or plug (B) is made to fit accurately inside the cylinder, and is fitted with expanding rings, so that the pressure of steam can exert its force on either side without blowing past the piston. The steam is admitted alternately on different sides of the piston, and by its pressure it forces the piston to move from one end of the cylinder to the other. The distribution of the steam, whereby it is alternately admitted to the opposite ends of the cylinder, is regulated by a small slide-valve J, working in the steam-chest X of the cylinder, which receives the steam from the steam-pipes in which it was conveyed from the boiler. The slide-valve, which is moved back and forward by means of a rod Y, not only admits the steam at one end of the cylinder, but allows it to escape out of the other end after it has done its work.

In the sketch, the valve J is shown in such a position that there is a free communication from the steam-chest X to the right-hand end of the cylinder C by means of the steam-port, or passage E. The space F in the diagram is the exhaust-port, communicating with the atmosphere, through which the spent steam, which has already done its work at the other end of the cylinder, is allowed to escape by means of the steam-port D. When a sufficient supply of steam has been admitted to the end of the cylinder at C, and has forced the piston B to the other end of the cylinder, the position of the slide-valve J is changed, so that it not only closes the admission of steam to the end C of the cylinder, but it opens the steam-passage D to the high-pressure steam at the other end, and makes a communication between the passage E and the exhaust F, by which the spent steam escapes from C, and allows the piston B to be forced back again to C from the other end of the cylinder.

This reciprocal motion having been obtained, it is necessary to control and regulate it so that it may be turned to useful purposes. The most useful method of utilising the force is to convert the reciprocating into a rotary motion, whereby, with the aid of a belt or some kind of gearing, the motion may be communicated to any desired machine. The reciprocating motion is converted into rotary motion by means of a connecting-rod and crank.

The connecting-rod is jointed at one end to the piston-rod, P, fig. 48, which, we have seen, has a reciprocating motion imparted to it by the force of the steam acting on the piston, and at the other end it is attached to a crank, a species of handle familiar to all who have watched the working of a steam-engine. The reciprocating motion of the piston-rod is communicated through the connecting-rod to the crank-pin by alternate pulls and pushes, causing it and the axle upon which it is fixed to rotate.

In order to prevent the intermittent motion due to the sudden action of the steam upon the piston, which would cause a jerky movement of the crank, a heavy fly-wheel is keyed upon the crank-shaft or axle. This wheel serves to steady and regulate the motion of the crank, and prevents the waste of power which would assuredly take place, even if it were possible to communicate the jerky motion of the piston direct to a machine. The fly-wheel is simply an accumulator storing up the energy imparted by the piston to the crank when exerting its utmost power, and imparting it to the shaft when the piston is exerting its smallest power. Thus, although the crank-shaft without a fly-wheel would rotate with a jerky and irregular motion, the movement when furnished with such a wheel is steady and uniform.

The engine must also be fitted with a suitable arrangement of gear to work the slide-valve, which is generally driven by an excentric keyed upon the engine-shaft, and so set with regard to the position of the piston in travelling backwards and forwards in the cylinder, as not only to open the steam passage for the admission of the high-pressure steam to do its work on the piston, but also to allow the steam which has already done its work to escape through the exhaust into the atmosphere or into the condenser.

The arrangement of steam-distribution here described is a very simple and fairly effective one. It is that which is used upon nine-tenths of the engines in ordinary use, and answers well for all practical purposes. It is not, however, by any means the most perfect or economical arrangement for the purpose, as there are many beautiful and efficient expansion arrangements in everyday use on the better class of large engines, for a description of which space cannot be spared here.

The object aimed at in all these arrangements is the same—viz., to obtain the advantage of the expansive action of the steam upon the piston. This can be fully realised only by suddenly admitting it with its full pressure into the cylinder when the piston is at the beginning of its stroke, and cutting it off equally quickly when a sufficient quantity has been admitted to do the necessary work. The steam, being an expansive body, continues to exert a considerable though gradually diminishing force in the cylinder long after its further admission from the steam-chest to the cylinder has been arrested. It is by taking the fullest advantage of this expansive power that the greatest economy in working can be obtained.

Expansive Action of Steam in Single Engines.—In using steam expansively in a single-cylinder engine, there is a considerable loss caused by the cooling action of the expanded steam upon the inner surface of the cylinder. The temperature of steam is in exact proportion to its pressure, so that when high-pressure steam is admitted to a cylinder, it possesses a correspondingly high temperature. But when it has been cut off early in the stroke, and has done its work by expansion until the moment of its release approaches, the pressure and corresponding temperature will have been greatly reduced. The metal of which the cylinder is composed is a fairly good conductor of heat, and the moment the hot high-pressure steam is admitted the temperature of the metal is immediately raised. But when this hot steam has become cooler by the reduction in temperature due to expansion, the cylinder (which has the same facility of parting with its heat which it has of absorbing it) is instantly cooled by imparting some of its heat to the cold steam. The consequence is, that when the next supply of hot high-pressure steam comes in contact with the cool surface of the cylinder, it is partially condensed, and its initial pressure and consequent force is considerably decreased.

Compound Engines.—To minimise this effect, recourse has been had to what is known as the "*compound*" system. This consists of making the engine with two or more cylinders. The first, and smallest, is that into which the high-pressure steam is primarily admitted. Here it is allowed to exert its full force upon a piston of comparatively small area for a considerable portion of its stroke, so that when the moment of its release arrives, the pressure has not been greatly reduced by expansion. Consequently the inner surface of the cylinder has not been so much cooled as to cause any considerable condensation on the admission of the hot high-pressure steam for the next stroke. After having thus done a portion of its work in the first cylinder, the steam passes into a second one of larger diameter, where it further exerts its power at a lower initial pressure on a larger piston, in which it gives off its utmost expansive power before it is discharged into the air or into the condenser.

The advantage of compounding is thus obvious. It not only prevents a large measure of injurious condensation of valuable high-pressure steam by providing for its expansion in a second cylinder, but it distributes the strains on the working parts more evenly, and ensures steadier and smoother running than is generally obtainable with single-cylinder engines working with steam at high pressures.

In *compound* engines the cylinders are so proportioned that the small one working at the higher pressure gives off about the same amount of power as the larger one working at the lower pressure. This equalises the strains upon the crank-pins and other portions of the mechanism, and reduces the wear and tear and liability to breakages. By confining the action of the high-pressure steam to the comparatively limited area of the smaller piston, the violent and injurious shock at the beginning of each stroke is very much less than if the whole power of the steam had been utilised in a single cylinder of larger diameter, even although by expansion of the steam the total power given off should be the same in each case. Moreover, when a condenser is used, the effect of the vacuum is very much greater by acting upon the increased area of the larger piston, which, of course, is the one in communication with the condenser. In engines of large power the compound principle has been extended till three cylinders in a series are very common, and give excellent results; while four and six cylinders have been tried for large marine engines.

Different Types of Engines.

Vertical Engines.—In the early days of steam on the farm, large independent vertical engines were generally used; but they are now, like their contemporary the egg-ended boiler, almost obsolete. Formerly, when all considerable powers were transmitted by spur-gearing, the vertical engine was used with advantage, as the height of the crank-shaft above the ground was convenient for the arrangement of the various wheels and pinions by which its power was to be given off. Now, however, all such powers as are likely to be required for driving any kind of agricultural machinery may be more easily, silently, and quite as effectively transmitted by belting, so that the height of the motive shaft is of no consequence, as in any case it simply means a few feet of belting more or less. Unless, therefore, there are other reasons to the contrary, no one would now choose an engine of the vertical construction for ordinary farm-work.

Horizontal Engines.—The horizontal engine is distinguished for convenience of fixing, accessibility for cleaning or repairs, and absence of vibration in running. It is therefore generally employed where the work is of a permanent nature. It consists of a strong cast-iron bed-plate, which may be bolted down to a brickwork or masonry foundation. This bed-plate forms a support for the cylinder, motion-bars, crank-shaft bearing, and condenser, if any. The joints of these various parts should all be planed, and fitted to facing-pieces cast solid with the bed-plate, which should also be planed true to receive them. They are then bolted firmly together with turned bolts, so that the thrust-and-pull of the piston does not cause any shake or vibration of the different parts. The crank-axle, which bears at one end upon the plummer-block on the bed-plate, is supported at the other by a bearing fastened to a wall-box built into the engine-house wall. The fly-wheel is carried upon this shaft, as well as the excentrics for working the valves and pump.

In an ordinary farm-engine, which is required to revolve only in one direction, no provision is made for reversing gear, which, if necessary, could be attached by the addition of another excentric and the ordinary link motion. The governors, which are a most important part of the engine, are generally driven by a belt from the crank-shaft. They may be made either to act upon a throttle-valve, which regulates the admission of steam to the steam-chest, or they may be made to act directly upon the slide-valve itself, controlling the period of admission of the steam to the cylinder. This latter is decidedly the best means of regulating the speed of an engine; because it will be seen, from the remarks already made upon the use of high-pressure steam, that to obtain the full benefit of expansion it should be admitted at full boiler-pressure to the cylinder, and then suddenly cut off. But where the governors act upon a throttle-valve, they exercise their functions by reducing the initial pressure of steam admitted to the steam-chest (technically called wiredrawing); whereas, in the other case, the full boiler-pressure is admitted direct to the piston, and the power and speed are regulated by the period at which such admission is closed by the action of the governor upon the slide-valve.

A most simple and effective governor, acting directly on the slide-valve and controlling the cut-off of the steam, is that invented and perfected by Mr Wilson Hartnell and Messrs E. R. & F. Turner, and known as the Hartnell-Turner governor, which has been applied with most satisfactory results to thousands of agricultural engines. In this governor the usual balls revolving round a central spindle are dispensed with. The apparatus consists of two plates forming a disc or drum keyed upon the crank-shaft of the engine. Between them are two weights acting upon excentric trunnions, and held in position by spiral springs. Until the requisite speed has been attained these weights lie inactive against the crank-shaft; but as soon as the required speed is attained, the springs, which are regulated so as to become compressed by the centrifugal force of the weights, allow the latter to fly outwards, and thus alter the position of the excentric trunnions upon which they are mounted. This gives a forward movement to the excentric for working the valve, and so causes it to cut off the admission of steam to the cylinder at an earlier period than before. This naturally retards the speed of the engine. As soon as the speed falls below the proper limit, the force of the springs causes the weights to resume their former position, and thus lengthens the period of admission of steam, and so increases the speed of the engine.

When a condenser is not used, the exhaust-steam should be utilised for heating the boiler feed-water in a proper feed-heater before being carried by the waste-pipe through the roof or into the engine-chimney. When a condenser is used, the waste steam is conveyed to it by pipes, and is there condensed, as already described.

Horizontal Condensing Engine.—For engines of 20 horse-power and upwards, where sufficient space is available, and where the character of the work is permanent, the most convenient and economical plan is to put down a horizontal condensing engine, and a double-flue "Lancashire" boiler to correspond.

Vertical Boiler and Engine.—For the smallest sizes of engine, say from 1 to 6 horse-power, where economy of space may be a great consideration, and where economy of fuel is not of great importance, the vertical boiler is frequently used in conjunction with a vertical engine with inverted cylinder working

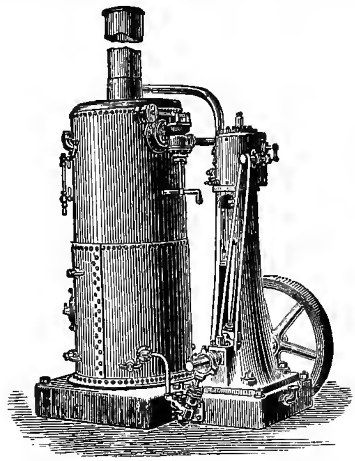


Fig. 49.—*Vertical boiler and engine.*

downwards on to a crank-shaft, as in fig. 49, made by Marshall & Sons, Gainsborough.

It is also occasionally used in conjunction with a small horizontal engine bolted to the foundation-plate upon which the boiler rests. These types of engines are very convenient for dairy purposes and for food-preparation, chaff-cutting, grinding, &c.; but they are wasteful of fuel, as was shown at the trials of farm-engines at the Glasgow Show in July 1888, where one of these engines used more than three times as much fuel as the prize engine, which had a boiler of the locomotive multitubular type.

Semi-portable Engine.—What is known as the semi-portable or semi-fixed type of engine is one which has been deservedly growing in popular favour during recent years. There are two descriptions of this class of engine—one in which the cylinders and working parts are bolted to the top of the boiler, as in the case of the ordinary portable engine;

and the other in which the working parts are erected upon a foundation-plate, and placed underneath the barrel of the boiler, as shown in fig. 50. Both these types of engine have their special advantages. The former combines lightness of weight and fewness of parts with a ready accessibility for overhauling, examination, and repairs, and is very suitable for all purposes where small powers, say up to 10-horse nominal, are required. The description of this engine practically corresponds with that of the ordinary portable, with the exception of the wheels, which are taken off, and in their place are substituted a cast-iron ash-pan underneath the fire-box, fitted with a draught-regulating door; and a pillar of cast-iron or brickwork, which is placed underneath the perch-bracket at the front

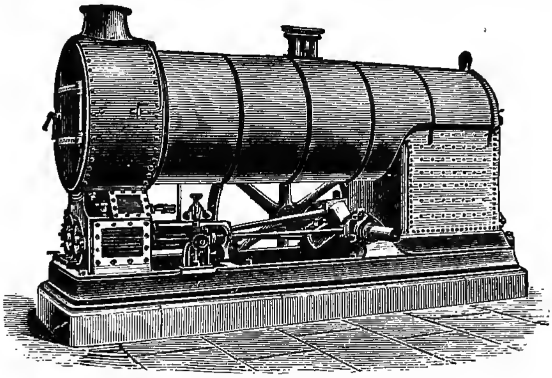


Fig. 50.—*Semi-fixed engine and boiler combined.*

end of the boiler. The type of semi-fixed engine with working parts underneath the boiler as illustrated is very convenient for powers varying from 10 to 50 nominal horse. It is made by J. & H. M'Laren, Leeds.

Many well-known firms of agricultural engineers have brought great skill in design and excellence of workmanship to bear upon the construction of these engines, until they have attained a perfection of working which can scarcely be equalled, and has never been excelled, in any other type of steam-engine. It may be interesting as a historical fact to record that the first engine of this type was constructed some thirty years ago by Messrs Manning, Wardle, & Co., the well-known locomotive engineers of Leeds, from the designs of their manager, the late Mr Robert M'Intyre.

Amongst the great advantages possessed by this class of engine may be named the following: Expensive foundations are dispensed with, as the engine can be set so as to work steadily and well merely fixed upon two baulks of timber; economy of space, inasmuch as both engine and boiler can be fixed in the room which would be necessary for either one or the other if they were fixed separately; and facility for removal if required, as it can be lifted bodily on a trolly, or mounted on a set of temporary wheels and axles, by which it can be moved from place to place. No brick chimney is required, as the wrought-iron chimney, which should be sent out with each engine, in conjunction with the blast caused by the exhaust-steam, is sufficient to give the necessary draught for the perfect combustion of the fuel. The larger powers of these engines are generally made on the compound principle, which has been already described.

Where economy is a desideratum, these, like all other steam-engines, should be fitted with the best automatic expansion arrangements and condensers, so as to economise to the utmost the consumption of steam, and consequent expenditure of coal and water. The locomotive type of boiler, which is acknowledged to be the most economical steam-generator extant, combined with perfect-expansion gear, and proper proportion of the various working parts, whereby the loss from friction and other causes is reduced to a minimum, unite to make this class of engine one of the most suitable and popular forms for use in agriculture.

Portable Engines.—The portable engine (fig. 51), which has been employed to such a great extent for farm-work, is almost too well known to call for any description. It has stood the test of 30 years' steady work, during which time it has developed to the almost perfect

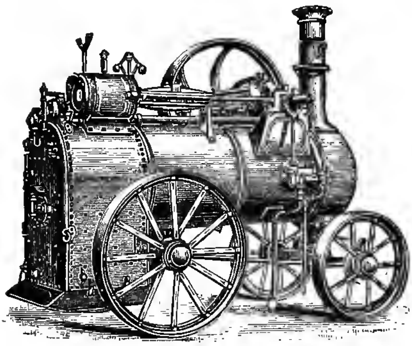


Fig. 51.—*Portable steam-engine.*

machine which it now undoubtedly is. The boiler is of the locomotive type, covered with wood and sheet-iron to prevent radiation of heat. The fire-box should be large, not only for the purpose of giving a large area of available heating-surface, but also to give sufficient grate-area to burn the necessary amount of fuel without forcing and consequent waste. The tubes are generally made of iron fitted at both ends to the tube-plates, which have been bored out to receive them, expanded in position with tube-expanders, and protected from the fire by steel ferrules. All fire-boxes ought to be provided with a lead safety-plug which, when the level of the water in the boiler gets dangerously low, is melted, the fire being thus put out. The cylinder ought to be steam-jacketed, and all the various covers so arranged that they can be easily and quickly removed for examination of the various working parts, without the necessity of blowing off the steam. The portable engine illustrated is that made by Ransome, Sims, & Jefferies, Ipswich.

The crank-shaft is invariably bent out of a single solid round bar, so that the fibre of the iron or steel is always in the best position to resist the strain, and consequently the chances of breakage are reduced to a minimum. The crank-shaft brackets are generally made of wrought-iron riveted to the barrel of the boiler, and carry the journals or bearings in which the crank-shaft revolves. These ought to be made of phosphor-bronze, as it has a much greater wearing power than even the best gun-metal. The slide-bars, slide-rods, &c., should all be made of the best iron, case-hardened, otherwise the wear and tear and consequent deterioration will be very rapid and great.

The Hartnell-Turner type of governor, which has already been described, is also applicable to this class of engine, and, in practice, may be said to give the highest efficiency. The excentric should be so arranged that, in case of need, it can in a few moments be set so that the engine will work in either direction. This can be done without trouble by making the excentric loose upon the crank-shaft, and keying the circular disc alongside of it securely to the shaft. This disc has two holes, by one of which the excentric may be bolted for the forward gear, and by the other for the backward gear.

It is a matter of necessity that each engine should be fitted with two safety-valves, one at least being in a locked-up iron casing, so that it cannot be tampered with by the attendant. They should also have a steam jet for drawing the fire quickly when raising steam; a man-hole and cover for convenience of cleaning, examining, and repairing the boiler; and mud-holes for washing-out purposes.

The engines are generally provided with a waterproof cover, so that they may be left out in the rick-yard or in the field in all weathers. They are also fitted with a drag-shoe, for use when going down steep hills. In very hilly countries the engine is also fitted with a screw-brake for this purpose.

Highland and Agricultural Society's Trials.—At its annual show at Glasgow in July 1888, the Highland and Agricultural Society of Scotland conducted a very useful trial of agricultural steam-engines. A prize of £75 was offered for the best fixed steam-engine of 6-horse-power nominal, with boiler combined or separate, suitable for erection in a farm-steading, the price being limited to £150, delivered at Glasgow. The Society decided to award the prize to the engine which embodied in the highest degree the following points of merit of the relative value stated :—

	Points.
Price	20
Simplicity of construction and fewness of working parts	25
Economy of fuel	20
Rapidity of raising steam . . .	5
Facility of erection and cheapness of foundations	5
Economy of water	5
Steadiness and regularity in running	15
Economy of lubricant	5
Total .	100

Four engines were tried on the brake, and the results of the trial were such as to demonstrate the imprudence of purchasing any class of engine merely because it happens to be offered at a low price. Between the lowest and the highest price the difference did not amount to more than £35, or thereby; while as to economy of working, the result was out of all proportion.

The prize was awarded to Messrs J. & H. M'Laren, Midland Engine Works, Leeds, for a 6-horse-power nominal engine and boiler combined, which, during the trial, worked at 14 actual or brake horse-power, with a consumption of 4.13 lb. of Scotch coal per brake horse-power per hour, and a water consumption of 33.97 lb. per brake horse-power per hour. The engine which did worst in the trial consumed 13.63 lb. of coal and 63.79 lb. of water for every brake horse-power given off, which means that the one engine would use £10 worth of coal to do a certain amount of work for which the other engine would require over £30 worth,—showing clearly that a few pounds extra in the first cost of an engine might be saved off the coal-bill in a very few months' working.

The engine which took the prize was mounted on the top of the boiler with which it is combined. It can, however, be lifted bodily off the top of the boiler and fixed as an ordinary self-contained horizontal engine, so that it can be placed inside the barn or other building, and the boiler put in an outhouse and coupled up to the engine with pipes. This engine was fitted with a very efficient feed-heater, which heated the water nearly up to boiling-point before it entered the boiler, which, of course, effects a great saving of fuel.

Traction-engine.—The traction-engine, fig. 52, made by J. & H. M'Laren, is now largely used in agricultural operations, although not yet to the same extent as the portable engine. The reasons for this are probably because it costs about twice as much as a portable engine of equal power; that there are many legislative restrictions imposed upon their use on public roads; and that, until comparatively recently, they were made so clumsy and heavy that they were difficult to manipulate. Now, however, that steel-casting has been brought to such great perfection, the spur-gearing is generally made of that material, which gives much greater strength with very much less weight. Additional experience has also enabled the makers of traction-engines to simplify their construction to such an extent that they are not only very much lighter, but less cumbrous in appearance, and more easy to handle. Indeed they have long passed the experimental stage, and are rapidly superseding the portable engine for driving travelling threshing-machines.

Traction-engines have the great advantage not only of moving themselves from farm to farm, but also of hauling their machine and straw-elevator with them, so saving the user the trouble and risk attendant upon moving these heavy articles by horses. The locomotive type of boiler is almost invariably adopted for traction-engines, and as the working steam-pressure is generally from 100 to 130 lb. on the square inch, it requires to be made of the very best materials, and put together in the strongest possible way. They should be able to stand a test-pressure, by cold water, of 240 lb. on the square inch, without showing any signs of weakness.

The power of the traction-engine is conveyed from the crank-shaft to the travelling-wheels by means of spur-gearing, which ought to be of the best quality of cast-steel. It is a great advantage for the engine to be fitted with double speed to the road motion, the slow gear causing it to travel at the rate of two miles per hour, and the fast speed at four miles per hour. The advantage of this arrangement is, that when the engine is travelling on level roads with a good load, it can maintain the higher rate of speed, but might not be able to do so if it should be necessary to mount a stiff hill. In that case, however, the slower and more powerful speed can be thrown into gear, thus giving the engine a greater "purchase" or leverage, and enabling it to mount the hill without distress.

This variation of the speed is accomplished by means of two pinions of different size sliding upon keys on the crank-shaft. One or other of these pinions, as the case may be, gears into a double-speed wheel fixed on the second motion shaft. This double-speed wheel consists of two spur-wheels of different diameters cast together, of such a size that, when the smaller crank-shaft pinion is thrown into gear, it works in contact with the larger of these two wheels, imparting a slow motion to the engine; and when the larger pinion on the crank-shaft is thrown over into gear, it communicates the motion to the smaller of the double-speed wheels, thus increasing the rate at which the engine will travel.

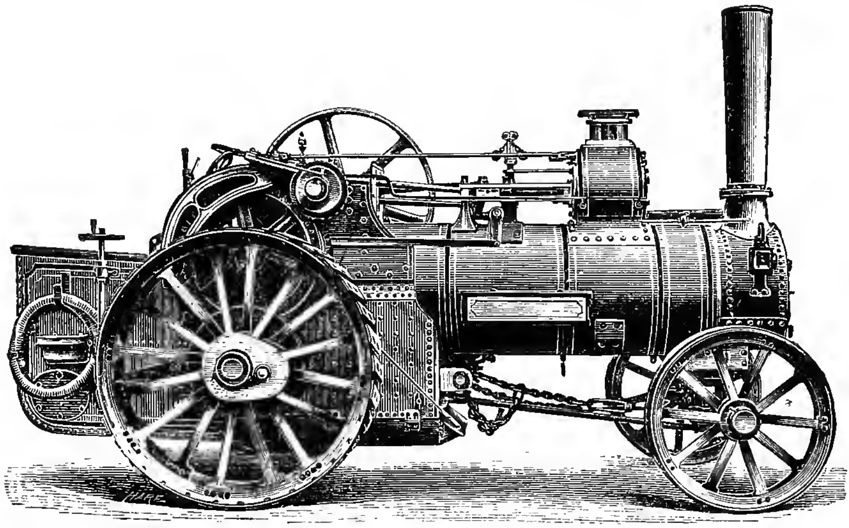


Fig. 52.—*Agricultural locomotive or traction-engine.*

When it is desired to change the speed, it is only necessary to stop the engine for a moment, and by simply moving a lever, either pinion may be thrown out and the other thrown into gear; or they may both be thrown out of gear, when the engine will remain stationary, and may be used for driving any description of machinery by means of a belt from the fly-wheel.

For guiding the engine when travelling upon the road, it is necessary that it should be fitted with some description of steerage. This generally consists of a shaft across the front of the fire-box shell, underneath the barrel of the boiler, having upon one end a worm-wheel. This worm-wheel is worked by a worm on the end of a shaft, which is carried back to the place where the driver stands. This shaft has, at the opposite end to the worm, a hand-wheel, by means of which the driver, by a very slight effort, can turn it either way, thus causing the steerage shaft to revolve in whatever direction may be required. By connecting-chains from this steerage-shaft to the front axle, the front wheels may be drawn into either lock, so that when the engine is in motion it can be guided either to the right hand or to the left, and will turn a very acute angle, or in a very small circle.

In order to facilitate turning sharp curves, what is known as a differential gear has been applied on the main axle of these engines. This consists of a pair of bevel-wheels face to face, the one keyed firmly upon the axle, the other keyed or otherwise secured to one of the driving-wheels, which is loose upon the axle. There are two bevel-pinions fixed upon pins or studs, and carried between and in contact with the two aforesaid bevel-wheels.

The power of the traction-engine is communicated through these bevel-pinions to the bevel-wheels in such a way that either of the road-travelling wheels may move a little quicker than the other without surging or waste of power. Thus, in turning sharp curves, the inner wheel may travel slowly, and the outer wheel may travel quicker, having the greater distance to move. This complicated motion was invented forty or fifty years ago for use in cotton-spinning, and is now employed largely, not only on traction-engines, but for vehicles, such as tricycles, &c., which have to work under similar conditions. The arrangement relieves the axle of a large amount of strain which would otherwise be caused by the inner wheel slipping, and when necessary it can be so locked that both wheels will revolve with the axle. This is of great service when the engine is sunk in a soft place, and all the power is required to be applied on one side to lift it out.

Every traction-engine should be fitted with a winding-drum fixed on the main axle, containing about 50 yards of steel rope. By throwing the road-wheels out of gear, and putting the winding-drum in motion, the rope may be used for a great variety of useful purposes. For instance, in soft stack-yards the engine may be moved on to the hard road after work has been finished, and the threshing-machine drawn up to it by the rope, thus avoiding cutting up the ground by the shunting necessary to couple up the engine direct to the machine. The machine or traction-waggons may also be drawn out of awkward places, where it would not be practicable or convenient to take the engine. For road-work the drum is also extremely useful, as a much larger load can be attached to the engine; and in the event of a steep hill having to be encountered, the engine may be detached and taken to the top, then the rope can be unwound and secured to the load, and the latter drawn up and coupled to the engine again. The rope may also be used for hauling timber out of plantations, pulling up roots of trees or the stumps of hedges, or, by being passed over a pulley, it can be used for loading timber, &c., &c.

These traction-engines should also be furnished with a water-lifter, which is a little instrument on the same principle as the Giffard Injector. It consists of a small outer casing of metal, having a water inlet pipe on one side and a steam inlet pipe on the top. The steam is blown through a conical nozzle inside the instrument, and in its passage creates a vacuum, which sucks the water through the inlet and throws it forward into the tank. It is generally fitted with a length of india-rubber suction-hose, so that in a few moments the tank of an engine can be filled with water from any convenient brook or pond. This not only saves a great deal of time and manual labour in filling the tank with water, but it ensures the water being delivered into the tank, and consequently into the boiler, in a much cleaner state than where buckets are used for filling the tank. It can also be used in very shallow places where there is only sufficient water to cover the nozzle on the end of the suction-pipe, and where any attempt to lift the water with buckets would stir up the sediment, and lead to a great deal of dirt and grit being deposited in the tank, which would eventually find its way into the boiler.

Traction-engines can be employed for driving every class of machinery used on the farm, such as for threshing, steam-cultivation, &c., and also for hauling the produce of the farm to the nearest town or railway station, and bringing back manure, feeding-stuffs, lime, &c.

They are also used by contractors for threshing, who drag the machine about with them from place to place, and thus do away with a great deal of hard work which formerly used to be very trying to horses.

STEAM-CULTIVATION.

One of the most important and interesting uses to which the steam-engine has been applied is that of the cultivation of the soil. By its agency the land may be ploughed, grubbed (or cultivated), harrowed, and rolled, much more expeditiously than would be possible with the ordinary number of horses usually kept upon the farm. The owner of a steam-plough tackle is therefore in a position to take full advantage of any brief intervals of suitable weather which may occur in an otherwise unfavourable season, for the preparation of his land and getting in his crop. The greatest advantage of the steam-plough is obtained in dealing with strong land, where a large amount of working is required to bring it into condition.

Injury by too deep Ploughing.—At the same time, the power which is available for tearing up the soil requires to be judiciously exercised, as many British farmers have found to their cost. When the steam-plough was introduced, some seemed to expect that it would revolutionise agriculture, and many farmers, unaware of, or neglecting the real principles of cultivation, had their land ploughed to the utmost depth of which the tackle was capable. In rich loamy lands where there was a sufficient depth of fertile soil, this was no doubt attended with advantageous results. But in shallower and strong clay lands, where the ground had been cultivated by horse-power to the full depth of its fertility, the consequences were most disastrous. In such cases the injudiciously deep ploughing amounted to nothing short of burying what little good soil there was under a great depth of cold sour stuff, which it would take years of expensive working and manuring to bring into fertile condition.

Prejudice against Steam-ploughing.—This circumstance naturally aroused considerable prejudice against steam-ploughing, and now one often hears farmers state that they would not employ a steam-plough on any account, adding that in such and such a year they had a field entirely spoiled by it. But in most cases it will be found that the blame is not due to the steam-plough itself, but to the imprudent manner in which it has been employed.

It used also to be claimed for the steam-plough that by its use the land could be cultivated at all times and in any condition. No doubt the mechanical operation of stirring or turning over the soil could be done at any season, and in any condition; but the mere fact of cultivating land by steam instead of by horses makes no difference in the effect of the cultivation. If a certain class of soil, say a strong clay, cannot, without disadvantage, be ploughed by horses, it cannot advantageously have the same operation performed upon it by steam.

Complaints have also been urged against the steam-plough on account of the weight of the engines disturbing and deranging the drains. These complaints may be well or ill founded, according to the state of the ground when the steam-plough is used, the suitability of the tackle for the ground on which it is to be used, and the expertness or clumsiness of those who have charge of it.

Advantages of Steam-ploughing.—When the steam-plough is judiciously used, its employment is attended with the utmost advantage to the farmer. By its means large areas of land can be quickly and cheaply prepared for the seed. The moment the first of the cereals are cleared from the land, the steam-plough can and should be set to work, the horse-power of the farm having still some weeks' work to do in completing the saving of the harvest. It enables the number of horses necessary for a large farm to be considerably reduced, thus effecting an important saving in forage and wages. It can also be used to break up the subsoil, so as to greatly assist the drainage. The changes made in this respect in certain lands in which there was a "pan" underneath the soil are very remarkable. In land on which the water used to stand for days after a heavy rainfall, before the steam-plough was used, it now gets so freely away that after a few hours no water can be seen, even though it may have rained heavily for several days. This breaking up of the subsoil can be accomplished without having the useless matter of the subsoil brought to the surface.

The following are the different systems of steam cultivation :—

Double-engine System.

For large occupations, or for letting out on hire, the double-engine system is no doubt the best, owing to the ease and rapidity with which it can be moved from field to field and set to work; to the large area of land which can be cultivated, owing to the economy of time in shifting; and to the large percentage of power brought to bear upon the implements, which may be much broader in proportion for this than for any other system.

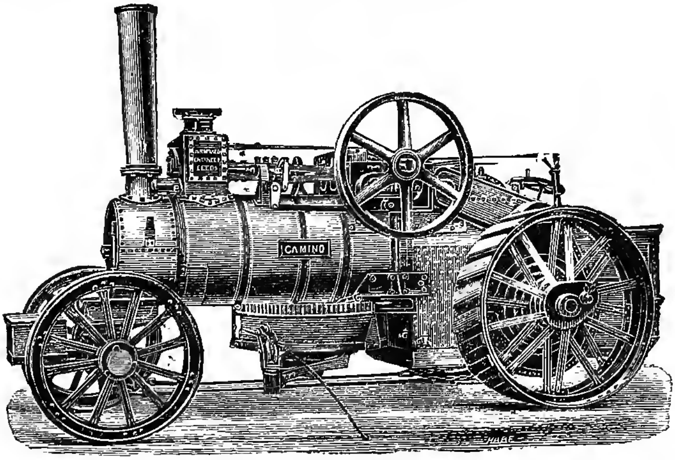


Fig. 53.—*Ploughing engine.*

The tackle consists of a pair of traction-engines, as manufactured by J. & H M'Laren, Leeds, and shown in fig. 53. They are fitted with winding-drums underneath the barrel of the boiler, worked by bevel-gearing from the crank-shaft, each drum containing from 400 to 500 yards of specially strong steel-wire rope. The engines are placed on opposite headlands of the field to be cultivated, as shown in the engraving, fig. 54, and they work alternately—the one hauling the implement across the field, while the other is paying out the tail-rope and moving forward into position for the next "round."

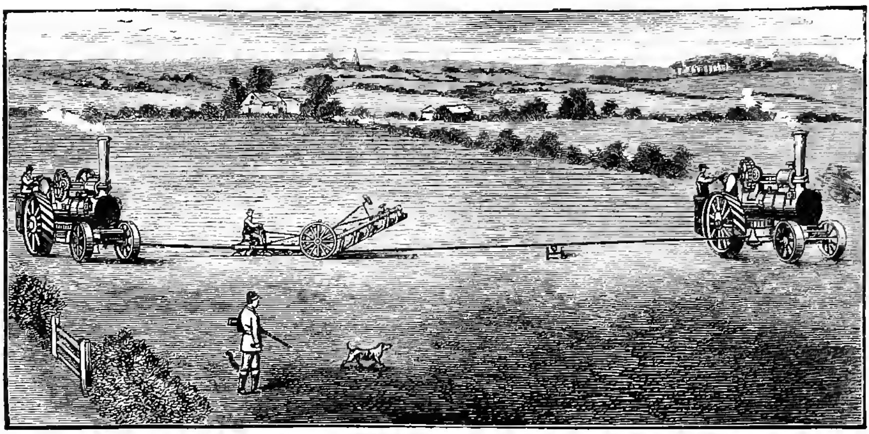


Fig. 54.—*Double-engine steam-plough.*

The whole power of the engine can thus be directly applied to the implement by means of the wire rope. This rope is evenly coiled upon the drum by means of coiling-pulleys, which swing upon an arm on the same centre as the drum, so that they accommodate themselves to any angle at which the rope may be working, and which move up and down automatically as may be required for the "lay" of the rope.

Steam-plough Engines.—Like the traction-engines already described, the steam-plough engines should be fitted throughout with cast-steel spur-gearing for the road motion, and double speed for travelling on the road. Where the work of cultivation is excessively heavy, the spur-gear for the ploughing motion should also be of steel. Steel axles and shafts should also be used, as they are not only stronger than iron but much stiffer, and consequently not so liable to bend. The road-travelling wheels should be of extra width to prevent sinking in soft land. The engines should be fitted with an injector, as well as a pump, for feeding the boiler. A water-lifter with india-rubber suction-hose should be fixed in the tank for replenishing it with water; and as a pretty large stock of spare tools and duplicates are generally carried with each engine, a tool-box of large capacity is generally fixed upon the front axle.

Cost of Steam-ploughing Plant.—The most convenient size of steam-ploughing engines for very large holdings, and for letting out on hire, is about 14 horse-power nominal. These will haul a 6-furrow plough with ease, turning over from 12 to 14 acres for a good day's work, or an 11-tined turning cultivator, tearing up and loosening the soil to a depth of from 7 to 9 inches, to the extent of about 25 acres for an average day's work. The *cost* of the complete plant, consisting of the two engines (with 400 yards of steel rope on each), 6-furrow plough, with steel skifes, 11-tined turning cultivator, and 6-framed flat reversible harrow, amounts to about £1800. Assuming the owner of such a set of tackle to have sufficient employment for it, the amount of work done by it, and the net cost price to the proprietor, would be about as follows, assuming the tackle to work 120 days in the year:—

Cost of working steam-plough for season of 120 days.

Dr.		
By interest on £1800 capital expenditure at 5 per cent per annum . .		£90 0 0
" depreciation, wear and tear, repairs, renewals, and redemption of capital, say 10 per cent per annum		180 0 0
" 2 enginemen and 1 ploughman, at 4s. per day each . .	0 12 0	
" 1 man and horse leading water to engines, per day .	0 7 6	
" coal for two engines per day, and leading (say)	0 16 0	
" oil, waste, stores, &c.	0 4 6	
Total wages per day	£2 0 0	
Making for 120 days . . .		240 0 0
Total annual expenses . . .		£510 0 0
Cr.		
To 40 days' ploughing, 12 acres per day=480 acres, at 6s. 6d.	£156 0 0	
" 60 " cultivating, 25 acres per day (once over)=1500 acres, at 3s. 6d.	262 10 0	
" 20 " harrowing, 40 acres per day (once over)=800 at 2s. 3½d.	91 13 4	
		£510 3 4

This leaves a balance of 3s. 4d. in favour of the tackle, after doing the work at the extremely low net cost price of 6s. 6d. per acre for ploughing, 3s. 6d. per acre for cultivating, and 2s. 3½d. per acre for harrowing. The cost of hiring steam-ploughing tackle from contractors for the same work, including cost of fuel and leading coal and water, would be about as follows:—

Ploughing—8 inches deep	10s. 6d.	per acre.
Cultivating *twice over* .	12s. 0d.	"
Harrowing *twice over* .	6s. 0d.	"

These prices are based on the standard of fair medium loamy soils. For stiff clays or specially hard or stony ground, of course they would not apply, the prices in these cases depending entirely upon the governing circumstances.

Tackle for 1000 Acres.—For holdings of about 1000 acres, a pair of 8 nominal horse-power ploughing-engines would probably be the most convenient size. They will haul a 5-furrow balance-plough, or a 9-tined turning cultivator, doing from 8 to 12 acres of ploughing, and from 15 to 20 acres of cultivating, per day.

The *cost* of this tackle, including the two engines, with 400 yards of rope on each, 5-furrow balance-plough with steel skifes, 9-tined turning cultivator, and 5-framed flat reversible harrow, is about £1500.

The 8-horse size of tackle has the further advantage that the engines are more convenient for road-haulage, threshing, &c. With a little trouble the ploughing-drums can be detached, and the engines correspondingly lightened, when they can be used for most of the purposes of ordinary agricultural locomotives, for which the stronger engines are too heavy and unwieldy.

All the different sizes can, however, be used for the ordinary work of the farm —such as driving threshing, grinding, sawing, or other machinery—by means of a belt from the fly-wheel.

Single-engine Systems.

There are various systems of steam-ploughing tackle before the public for working with one engine only. The most successful appear to be those manufactured by Messrs Barford & Perkins of Peterborough. They may be divided into two classes: (1) That in which the implements are worked by ropes from a self-moving engine having double drums mounted upon it; and (2) That in which the implements are worked by ropes from a portable windlass, carrying the two drums, which are driven by means of a pitch-chain or universal coupling from the crank-shaft of an ordinary traction or portable engine.

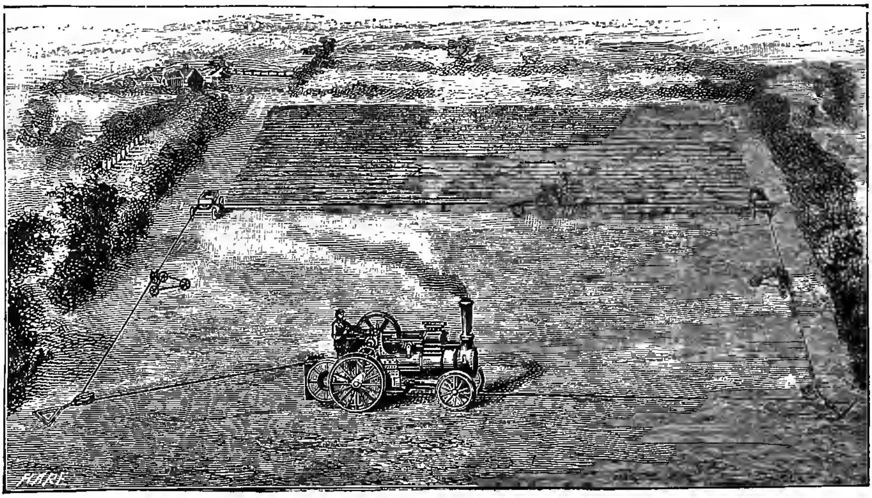


Fig. 55.—*Single-engine steam-plough.*

The former system (No. 1), as illustrated in fig. 55, consists of a traction-engine carrying two winding-drums, one on each side of the tender. These drums are driven direct from the road driving-gear of the traction-engine, the travelling wheels being thrown out of gear while the engine is required for ploughing. The drums each contain about 900 yards of steel rope—sufficient to set round a field of about 20 acres. They are fitted with automatic brakes, which fly off of their own accord when the drum is winding up the rope (*i.e.*, hauling the implement), and drop into contact when the motion is reversed and the drum begins to pay out the tail-rope. The drums are mounted upon excentric studs, and can be easily thrown in and out of gear by levers under the control of the engine-driver.

The tackle used in connection with this engine consists of certain snatch-blocks with claw-anchors, two self-acting travelling anchors, sundry steel-rope porters, and the implement, plough, cultivator, or harrow, as the case may be.

The self-moving anchors consist of a strong guiding-pulley carried on a suitable wrought-iron or wood frame. This frame, when the anchor is in use, travels on 4 sharp disc-wheels, which sink into the ground, and prevent the anchor pulling sideways with the strain of the rope. In order to press these discs well into the ground and prevent it tipping over, the anchor is generally weighted with stones, or other heavy material, carried in a box fixed on it for the purpose.

The front axle is provided with a simple form of steerage, which enables the anchor to be guided along uneven and crooked headlands. The hind axle, which revolves when travelling, is fitted with a series of 4 sets of claw-tines which are fixed thereto and revolve with the axle. This axle also carries a pawl-wheel, which can be locked and unlocked by means of a pawl-lever. This lever can be worked by hand, or it can be controlled automatically by the steel rope. In the latter case, a ball is fixed on the steel rope, a few yards in advance of the implement. When the implement approaches the headland, this ball strikes a forked lever turning on the same centre as the guide-pulley. This forked lever raises the pawl-lever out of gear, and the forward strain on the steel rope causes the anchor to advance as far as may be required for the next round. The movement of the engine is then reversed, and the pulling rope now becomes the tail-rope, causing the implement to travel in the opposite direction.

As the implement begins to travel in the opposite direction, the pawl-lever again drops into gear with the pawl-wheel and locks it, causing the claw-tines (which have revolved harmlessly with the forward motion of the anchor) to take a firm hold in the ground like the claws of a claw-anchor, so that when the tension again comes round the self-moving anchor in question, it cannot pull forward till the pawl-catch is again liberated.

An accident through the plough being pulled into the self-moving anchor is manifestly impossible, as the ball on the steel rope liberates the anchor before the plough can reach it; and the worst consequences of any neglect on the part of the engine-driver to stop the engine would be that the anchor would be hauled too far along the headland, with the plough following a yard or two behind.

The mode of working this system will be easily understood by a reference to the drawing, fig. 55. The engine is placed in a convenient position at one end or side of the field. The steel rope is taken off one drum and led out in front of the engine, and round a fixed snatch-block pulley secured by a claw-anchor in one corner of the field. It is then led at right angles down the side of the field to the far corner, where the self-moving anchor is fixed. Round the pulley of this anchor the rope is led, and attached to the implement.

The other steel rope on the other drum is led out behind the engine, and round the other side of the field in a similar manner, and attached to the implement. The implement is then drawn to and fro between the self-moving anchors, which gradually move forward the width of the implement at each round till the whole of the field has been cultivated. The position of the engine and the anchors, &c., can then be changed, and the land can be cultivated or ploughed crosswise if required.

The cost of a complete set of tackle for working on this system, including an 8-horse-power double-drum traction-engine, 1800 yards of steel rope, necessary anchors and snatch-blocks, four-furrow plough, and 7-tined turning cultivator, is £900. The advantages it possesses over other sets of single-engine tackle are,—fewness of parts composing the tackle, facility of setting to work (the engine is set the moment it is steamed to its place), small number of hands required to work it—two men only, one for the engine and the other for the implement.

The engine has also the great advantage of being much lighter than any other double-drum engine, owing to the drums being driven off the road-gearing instead of by heavy independent shafts and gearing. The drums can also be dismounted in an hour or two at the end of the ploughing season, and the engine, relieved of all extra weight, can then be used without encumbrance as an ordinary farm traction-engine.

In order to prevent excessive wear and tear upon the ropes, they should be carried on rope-porter pulleys, placed at such intervals as will prevent the ropes trailing on the ground, which is very injurious to them, especially in sharp gritty soils. In such land it will pay to keep an additional hand to attend to these porters, taking them out in front of the advancing implement, and putting them in again after it has passed.

Messrs Barford & Perkins's No. 2 system is identical in its operation with the system just described, the only difference being in the application of the motive power, see fig. 56. This system has the great advantage that it can be worked by an ordinary portable engine. The winding-drums are carried on a separate windlass, which is dragged into position by horses. The power is conveyed from the engine to the windlass by means of a pitch-chain, and the drums are worked by spur-gearing from the main driving-shaft. They are fitted with brakes for paying out the steel rope, and, as in the former case, one drum is winding on or pulling up the implement, while the other is unwinding or paying out the tail-rope. The mode of working will be easily understood by a reference to the engraving (fig. 56).

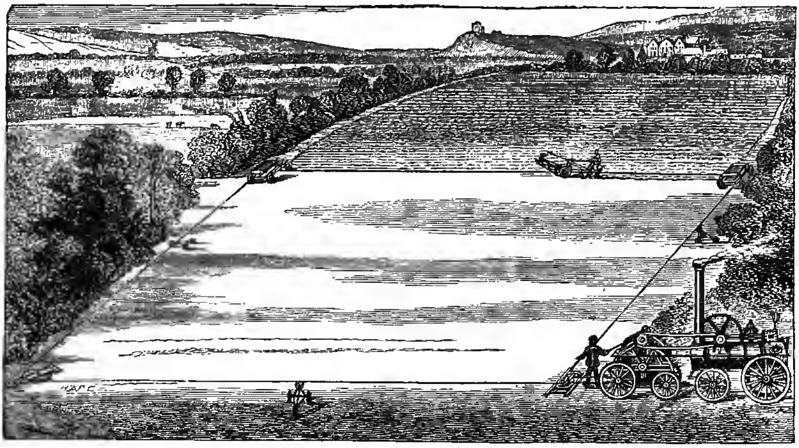


Fig. 56.—*Single engine and windlass steam-plough.*

The price of a set of tackle of this description, with windlass, 1800 yards of steel rope, 5-tined turning cultivator, and necessary appurtenances, but exclusive of engine, is about £360. This set has therefore the advantage of being comparatively cheap, and can be worked at small expense, only two men being absolutely necessary to work it. There is, however, a good deal more tackle to be moved into position by horses, and considerably more time required for fixing and getting ready for work. Nevertheless many hundreds of such sets have been sold for farmers' own use; and on small occupations, or where the land is not too strong, their use has been attended with great advantage.

STEAM-DIGGING.

One of the most modern developments of the use of steam on the farm has been its successful application to "digging" the soil. Hitherto all efforts had been directed to the provision of a substitute for the spade, and however perfect the action of the steam-plough or steam-cultivator may have been, it was very inferior in point of efficiency to spade-cultivation.

The problem of "digging" by steam has occupied the attention of many mechanical minds of the first order, but the credit of its practical solution is largely due to Mr T. C. Darby of Pleshy Lodge, Chelmsford. This gentleman is a tenant-farmer with strong mechanical tastes, and having set himself to the production of a steam-digger, he devoted large sums of money and years of patient toil to the perfection of his ideas.

The benefits of digging the soil as against ploughing it, must be evident to all who are familiar with these two modes of cultivation, and who have carefully considered the subject. Apart from the waste of power in drawing a plough through the ground, as compared with that required for turning over the same depth of soil by means of digging-forks, the quality of the work done in the latter case is much superior to that of the former. The ground is more perfectly pulverised, and left in a better form for the action of the atmosphere; while, owing to the "lifting" action of the clod, which is raised and turned over by the motion of the digging-forks, the subsoil is left more open for the escape of surface-water and the penetration of the roots of the plants. This action leaves no "pan"; but as the spit of earth about to be turned over has been torn, as it were, from the subsoil on which it rested, and to which it adhered, the subsoil is partly shaken up and loosened with the most beneficial effect.

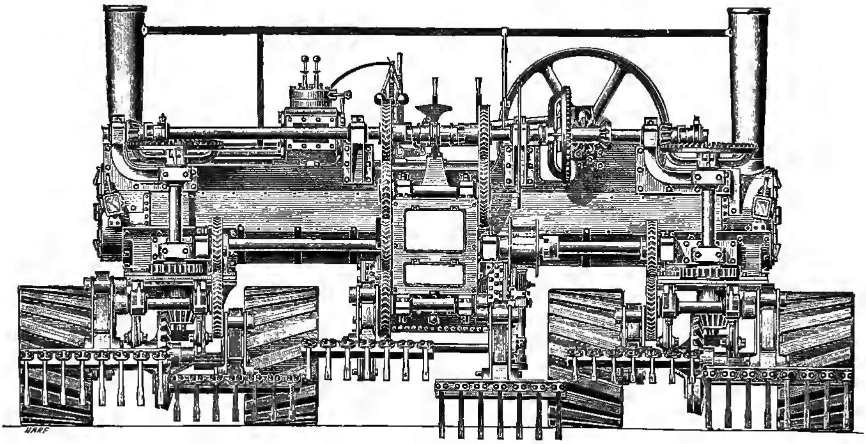


Fig. 57.—*The Darby digger.*

Darby's Digger.—The steam-digger first came prominently into notice at the Carlisle Show of the Royal Agricultural Society of England in 1880. In that year Messrs M'Laren of Leeds manufactured and exhibited a digger on Mr Darby's system, for which they were awarded the Society's special silver medal. There had been no trials of steam-cultivating machinery for the previous nine years, the last having been held at Wolverhampton in 1871. At the Carlisle trials in 1880, it was found that the *Darby digger* did the same amount of work with an expenditure of over 15 per cent less power than the steam-plough tackle which took the first prize at Wolverhampton in 1871.

It is matter for regret that the great Agricultural Societies, especially the Royal of England, give so little encouragement to the makers of agricultural machinery. The amount distributed in recent years in prizes to implement-makers is but a fraction of that distributed to the exhibitors of stock, and the consequence is, that for many years no marked improvement has been made in agricultural machinery. Farmers are reluctant to purchase new machines until they have been well tested, and it is a duty the societies owe to their members to encourage the invention of useful implements, and by official tests to ascertain their capabilities, so that their members may be guided what machines to select and warned what to avoid. But for their remissness in this respect, many useful farm-implements which have never got beyond the experimental stage would have been perfected, and machinery would have been made practically available for many operations of the farm which are still done only by hand.

Cost of Steam-digging.—Notwithstanding the slight encouragement received from agricultural societies, Mr Darby has continued to improve his machine, so that now he claims to be able to dig about 10 acres per day with one machine, at a net cost—including men's wages, coal, interest on capital, and depreciation—of about 9s. per acre. The cost of his digger is £1200.

The Darby digger, fig. 57, consists of a steam-engine having working parts similar to those of an ordinary traction-engine fixed on the top of a double locomotive boiler, similar to those known as the *Fairlie type*, from their having been employed by the late Mr Robert Fairlie for the locomotives of many of the lines of railway with which he was connected.

By means of steel spur-gearing this power is communicated to a long horizontal shaft running parallel with the centre line of the boiler. The power is transmitted from this shaft to the digging-cranks by means of wheels and pinions of cast-steel. Each digging-fork is about 3½ feet wide, and as there are six such forks, the machine is capable of digging a width of 21 feet at a time. The depth may be varied within certain limits down to a maximum of about 14 inches. By means of mechanical arrangements the action of the digging-forks resembles as nearly as possible that of digging by hand with a spade or fork.

The machine travels sideways when at work digging—hence its designation *Broadside* digger. It travels at the rate of half a mile per hour, so that, excluding stoppages and time lost at the ends turning, it would dig a little over an acre per hour. It is guided by means of a steerage on the opposite side of the boiler from the digging-forks. When required for travelling on the road, its travelling-wheels are turned at right angles to the centre line of the boiler, instead of being parallel with it as when the machine is at work; and in this manner it travels along ordinary roads without taking up any more width of road than an 8-horse traction-engine of the usual construction.

In Essex, where Mr Darby and his machine are better known than in any other part of England, the digger is a general favourite. Many farmers prefer it to any other system of steam-tillage, and express the opinion that the crops are better and weeds fewer after the use of the digger, than is the case with any other mode of cultivation.

Proctor's Digger.—Mr Frank Proctor, The Elms, Stevenage, Herts, has also, among others, given much attention to the production of steam-diggers. The arrangement of his digger will be readily understood by reference to its illustration in fig. 58. It consists, it will be seen, of an ordinary traction-engine geared into a crank-shaft which works three forks at the rear, so that wherever the engine travels the land is left dug up behind. These forks can be thrown out of gear, or hinged up, or entirely disconnected from the engine when required, and thus the machine can be used either as an ordinary traction-engine for threshing and other purposes, or as a steam-digger. An important point claimed for this system is its comparative cheapness. The cost of an 8-horse-power digger is £800. Mr Proctor states that his digger of this size will dig about 10 acres per day of 10 hours, consuming about 11 cwt. of coal, and requiring the attendance of two men.

Weeds killed by Digging.—The late Mr John Algernon Clarke gave a very rational explanation of the curious fact of the comparative absence of weeds on land broken up by the digger. In examining work which had been done by this machine, he observed that the fork, lifting the spits of earth, drew out most of the long roots of the weeds from the subsoil, and threw them over to the action of the sun, which withered and killed them, and as the roots were not left in the ground they could not spring up again. On the other hand, the plough in cutting through the ground at a certain depth merely turned over those weeds whose roots did not penetrate below the sole or pan of the furrow, and cut in two the roots which went lower than this, leaving the ends in the ground ready to spriug forth again at the first opportunity.

Advantages of the Digger.—An important advantage of the steam-digger is that it requires very little attention to work it. One man is sufficient for the purpose, and one attendant with a horse to supply the digger with coal and water. The time occupied in turning at each end of the field is a little over two minutes, but the digger may be worked continuously without stopping, either by commencing in the centre of the field and working round and round till the whole is finished, or by commencing to dig round the outside of the field and working inwards to the centre. The cost of wear and tear may fairly be assumed to be very light, as there are no steel ropes to maintain, nor any loose tackle or implements to keep in order, all of which are fertile sources of expense in other systems of steam-cultivation.

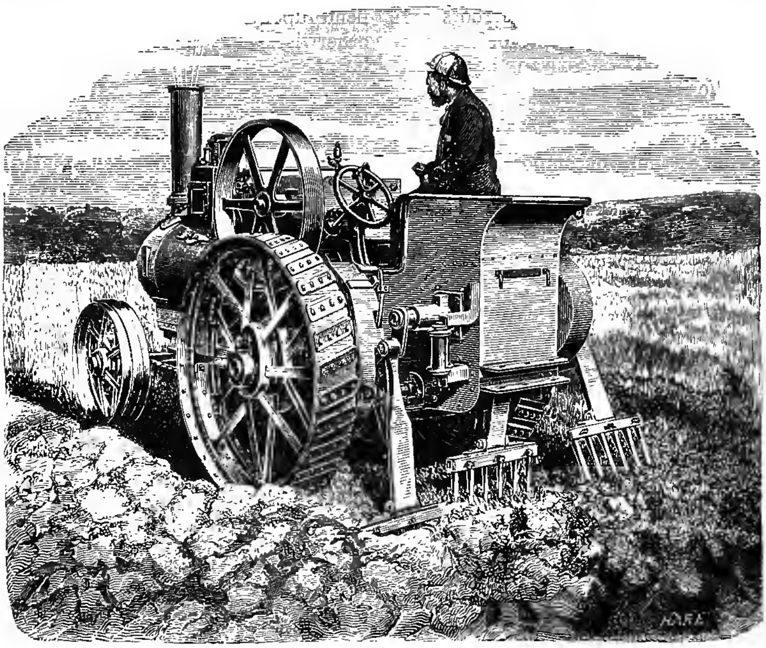


Fig. 58.—*Proctor's digger.*

STORING ROOTS.

Advantages of Storing Roots.—The advantages which arise from the storing of roots are manifold. Chief amongst these are, the preservation of the crop from the effect of the frosts and thaws of winter, the procuring of a regular supply of fresh and clean food for the animals upon the farm, the prevention of the growth of the tops in spring, and keeping the land free from carting and consequent poaching in unsuitable weather. Roots, like fruit, ought to be stored before they become over-ripe; the months of October and November are therefore the most suitable for the work. The other operations of the farm allow time for it at this season; and the crop is generally in a fit state of maturity, as well as the land being dry.

Chemistry informs us that roots and fruit which are to be kept for any considerable period ought to be pulled before the starch which is present in their composition is changed into sugar, as this process goes on after they are pulled, and thus decomposition is retarded, as there is little or no liability to decay until this change in their substance is completed.

Turnips Consumed on the Ground by Sheep.—When different sorts of live stock are supported on the same farm, as is the case in mixed husbandry, the sheep are usually provided with the turnips they consume upon the ground on which they grow, which saves the trouble of carrying off a large proportion of the crop, and the proportion removed is for the use of the cattle in the steading. The proportions carried off are not taken from the ground at random, but according to a systematic method, which requires attention.

One object in leaving turnips on the ground for sheep is, to afford a greater quantity of manure to the soil than it received in its preparation for the turnip crop; and as sheep can withstand winter weather in the fields, and are not too heavy for the ground, they are selected to consume them on it. This is a convenient method of feeding sheep, affording them ample accommodation, giving them their food on the spot, and returning great part of the food to the land in the form of manure.

Quantity of Roots to be left for Sheep.—The quantity of roots left upon the field to be consumed by sheep depends upon the weight of the crop, and whether the land is in a high state of fertility or not.

In ordinary practice on a mixed farm, worked on the five-shift rotation, one-half the crop will be required to be consumed by cattle to convert all the straw into manure. The other half then remains to be consumed where grown by sheep, which are left in the manner described in the paragraphs which follow. When a small crop is the result of the growth of the season, the foregoing plan must be modified, and two-thirds or even a larger portion of the crop may have to be left for the sheep; but this will depend upon the soil, whether fertile or otherwise. However arranged, it must be always kept in view that cattle will thrive much better on artificial feeding than sheep, and that it is sound economy to give a certain portion of dry food, along with roots, to cattle and sheep, so that the proper ratio of nutrients be established, and every constituent of the food be economised and waste prevented.

Ascertaining Weight per Acre.—To ascertain the weight of roots per acre, the following method may be adopted, which is simple and effective: Let a couple of drills be pulled in three parts of each field, and the turnips carted off; count the loads, and allow 8 cwt. to be the weight of each cart-load; the matter then becomes a simple question to ascertain the tons per acre, after which the farmer can readily apportion the quantity to be consumed by sheep and cattle.

Thus consideration is required to determine the proportion of the turnip crop to be pulled, the standard proportion being one-half.

Plan of Stripping Turnips.—Fig. 59 shows how turnips are stripped off the ground in the various proportions. The *half* can be pulled in various ways, but not all alike beneficial to the land: for example, it can be done by leaving 2 drills *a* and taking away 2 drills *b*; or by taking away 3 drills *e* and leaving 3 drills *f*; or by taking away 6 drills *i* and leaving 6 drills *h*; or by taking 1 drill *l* and leaving 1 drill *k*.

In ordinary farm practice, where half the crop is to be eaten off by sheep, the plan of taking 6 drills and leaving 6 drills is generally adopted, as in the other methods shown in fig. 59, there is not sufficient space left clear of roots to allow a cart and horse to turn without damaging the roots. The advocates of taking 2 drills and leaving 2 drills have overlooked this, and in consequence more damage would be done to the growing roots than any seeming injury done by the sheep to the outside rows, where 6 drills are left.

The first break of turnip given to the sheep ought to be as large as possible, and therefore 8 drills should be taken and 4 drills left. This plan should also be adopted when it is desirable to leave a smaller quantity for consumption by sheep than one-half, which may be either due to a high state of fertility of the soil or to a short crop of turnips.

Whatever the proportion removed, the rule of having 2 or more empty drills for the horses and carts to pass along when taking away the pulled turnips, without injury to those left, should never be violated.

The plan of leaving 2 and taking 2

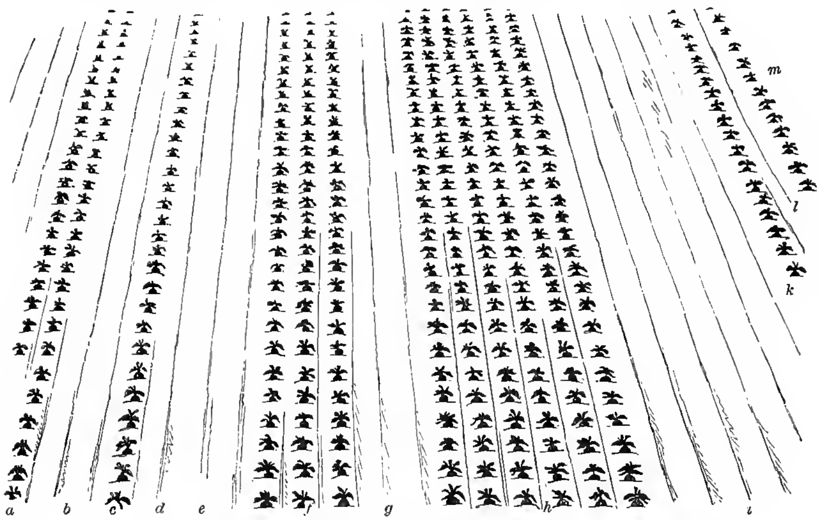


Fig. 59.—*Methods of stripping the ground of turnips in given proportions.*

a 2 drills left, and *b* 2 drills pulled, when half is left on.
b 2 drills pulled, and *c* 1 drill left, when one-third is left on.
d e 3 drills pulled, and *c* 1 drill left, when one-fourth is left on.

drills, when the half of the crop is to be eaten on, will be best shown in fig. 60, where the drills are represented on a large scale. One field-worker clears 2 drills at *a*, in rooting and topping, and another simultaneously other 2 at *b*; and in doing so, the turnips are dropped in the act of rooting and topping, in heaps at regular distances, as at *c* and *d*, amongst the standing turnips of the two drills *e* and *f*, on the right hand of one worker, and on the left of the other; and thus every alternate 2 drills left unpulled become the receptacle of the turnips pulled by every 2 workers from 4 drills. The cart then passes along *a* or *b* without touching the turnips on *e* and *g*, or on *f* and *h*, and clears away the heaps from the line *c d*.

In the figure the turnips are represented much thinner on the ground than they usually grow, to be more conspicuous; but the size of the bulb in proportion to the width of the drills is preserved both in the drills and heaps. The seats of the pulled turnips are shown upon the bared drills.

Pulling Turnips.—The most common state in which turnips are thrown in the temporary heaps, *c* and *d*, is with their tops on, and the tails or roots cut away.

In this condition they are most suitable for sheep, when the weather will not allow of their being kept on the turnip break. When this occurs the sheep ought to be laid upon old lea or pasture, and the turnips sparted or scattered thinly out of the carts in rows at regular intervals.

The cleanest state for the turnips themselves, and the most nutritious for cattle, is to take away both the *tops* and *tails*.

Turnip-tops as Food.—The tops of turnips possess greater value as manure than as food, and should therefore, as a rule, be left to be ploughed in on the ground. But when food for sheep is scarce, the tops may be given to ewes up to the latter end of December. This practice good farmers have for years pursued with excellent results. Then many farmers have the idea that turnip-tops make good feeding for young beasts or calves at the beginning of the season—not from the knowledge that the tops really contain a larger proportion of bone-producing matter than the bulbs, as chemical analysis informs us, but from a desire to keep the turnips for the larger beasts, and to rear the young ones in any way. But such a notion is a mistaken one, as might easily be proved

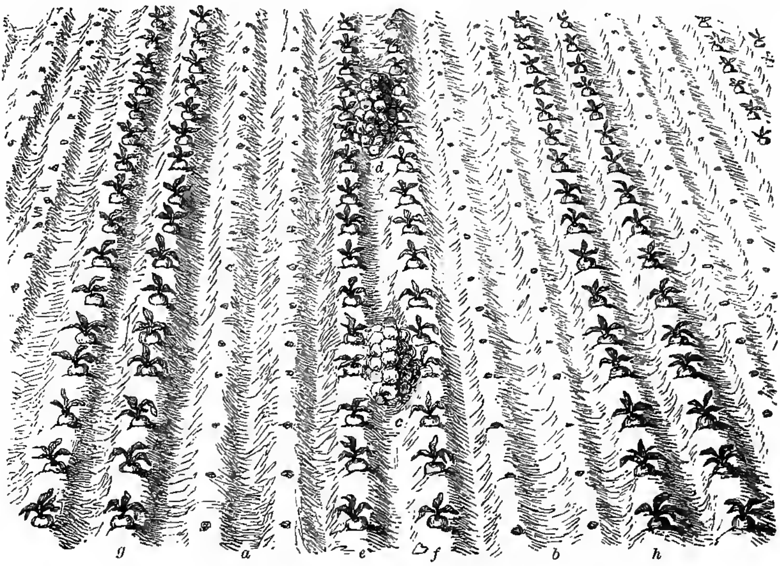


Fig. 60.—*Method of pulling turnips in preparation for storing them.*

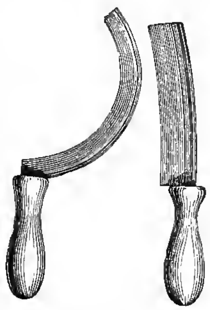
a and *b* 2 pulled drills. *e* and *f* 2 drills left with turnips. *c* and *d* 2 heaps of prepared turnips.

by giving one lot of calves turnip-tops and another bulbs without tops, when the latter will show a superiority in a short time, both in bone and flesh. No doubt the large quantity of watery juice the tops contain at this season makes young cattle devour them with eagerness on coming off perhaps a bare pasture; and indeed any cattle will eat the tops before the turnips, when both are presented. But experience favours the condition that the time in consuming turnip-tops is worse than thrown away, inasmuch as tops, in their cleanest state, are apt to produce looseness in the bowels, partly, perhaps, from the sudden change of food from grass to a very succulent vegetable, and partly from the dirty, wetted, or frosty state in which tops are often given to beasts. Looseness never fails to bring down the condition of cattle in so considerable a degree, that great part of the winter may pass away before they recover from the shock their system receives.

Sheep are not so easily injured by turnip-tops as cattle, on account, perhaps, of their costive habit; but in the spring it is dangerous to let sheep consume them freely, as fatal results have often followed.

Turnip-tops as Manure.—Tops are not thrown away when spread upon the ground—indeed, as already stated, they are more valuable as manure than as food, and should therefore, as a rule, be left to be ploughed in on the field. Mr Grey of Dilston found that in one instance 2 bushels, and in another 3 bushels, per acre more of wheat was obtained when the turnip-shaws were ploughed down than when they were carried off the field.

Turnip-lifting Appliances.—The tops and tails of turnips are easily removed by means of very simple implements. Figs. 61 and 62 represent these in their simplest form, fig. 61 being an old scythe reaping-hook, with the point broken off. This makes a light instrument, and answers the purpose pretty well; but fig. 62 is better. It is made of a worn-out patent scythe, the point being broken off, and the iron back to which the blade is riveted driven into a helve protected by a ferrule. This is rather heavier than the other, and on that account removes the top more easily.



Figs. 61, 62.—*Implements for topping and tailing turnips.*

A superior implement to either is seen in fig. 63. The necessity for another implement of the kind arises from the fact, that when the top of a turnip has dwindled into a comparatively small size, it affords an inadequate hold for pulling the turnip from the ground; and when the attempt is found by the worker likely to fail, she naturally strikes the point of the instrument into the bulb to assist her, and the consequence is, that a deep gash is made in the turnip, which, being stored for months, suffers by premature decay arising in the wounded part. If the turnip requires any effort to draw it, the claw *c* is inserted gently *under* the bulb, and the lifting is easily effected with certainty.

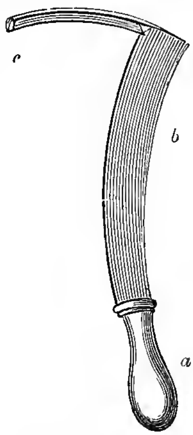


Fig. 63.—*Turnip trimming-knife.*

a Handle.
b Cutting edge.
c Claw welded to the extremity of the back.

The mode of using these implements in removing tops and tails from turnips is this: When 2 drills are pulled and 2 left, the field-worker moves along between the 2 drills of turnips to be pulled, at *a*, fig. 60, and pulling a turnip with the left hand by the top from either drill, holds the bulb in a horizontal direction, as in fig. 64, over and between the drills *e* and *f*, fig. 60, and with the knife first takes off the root with a smart stroke, and then cuts off the top between the turnip and the hand with a sharper one, on which the turnip falls into the heaps *c* or *d*, the tops being thrown down on the cleared ground. Thus, pulling one or two turnips from one drill, and then as many from the other, the two drills are cleared from end to end. Another field-worker is a companion by going up *b*, pulling the turnips from the drills on either side of her, and dropping them, topped and tailed, into the same heap as her companion.

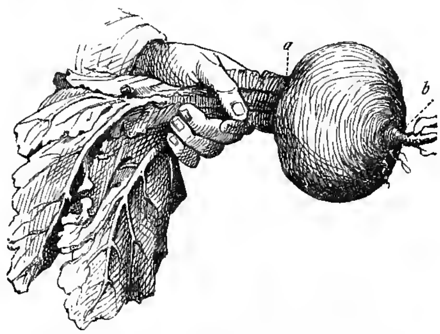


Fig. 64.—*Mode of topping and tailing turnips.*

b root, first cut off. *a* top, where cut off.

Checking Turnip-growth in Spring.—It frequently happens, especially in spring, when the second growth of the turnips requires to be checked, that the ordinary method of pulling and cleaning the turnips cannot be quickly enough performed to prevent the crop becoming useless. More speedy means must therefore be adopted. The old style of slashing the tops off with a scythe or hook does not overcome the difficulty. Mr George Brown, Watten Mains, Caithness, has for some years pursued the following plan with a fair amount of success. A common scuffler is taken, and after the cutting part of the hoes is extended to about 12 inches, the hoes are reversed—that is, change the side, so that the cutting part is turned out instead of inwards. Operations may then be commenced, after fixing the body of the implement to the required breadth between the drills. The hoes cut the tap-root beneath the surface without disturbing the bulb, which remains in the position it grew. The growth is thus completely checked, and the bulb will remain fresh, as there is a sufficient number of the small roots left to provide the moisture lost by evaporation, but not enough for continued growth. Many farmers run the chain-harrows across the rows, which leaves the crop lying on the surface, ready to store; but the bulbs require to be cleaned and partly trimmed before being used.

Turnip-lifters. — An implement known as the "Turnip-lifter," which tops and tails the turnips, was brought out some years ago. This implement would come into more general use if it were made to do the work throughout the season. When the shaws are strong and plentiful, these seem to clog the parts of the machine which tops the turnips, and on this account the usual workers have, as a rule, to be kept on the farm. Yet good work is in many cases done with this ingenious implement. A very useful machine of this kind, made by T. Hunter, Maybole, is represented in fig. 65.

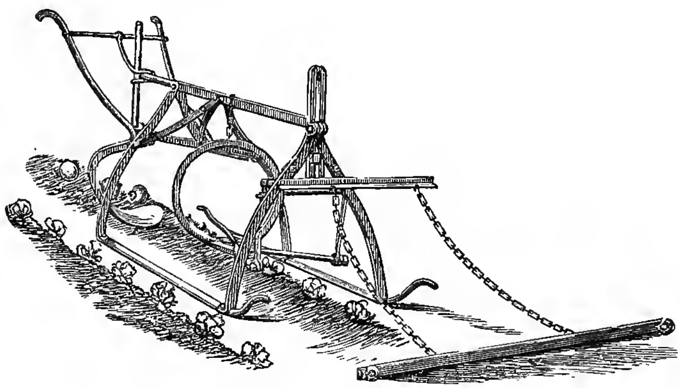


Fig. 65.—*Turnip-lifter.*

Further Hints to Turnip-lifters.—Due care is taken, on removing tops and tails, that none of the bulb be cut by the instrument, as the juice of the turnip will exude through the incision. When turnips are consumed immediately, an incision does no harm; but slicing off a portion, and hacking the bulb, indicates carelessness, which, if persevered in, will be confirmed into an injurious habit, when turnips are to be stored.

When two-thirds of the turnips are pulled at *b*, fig. 60, and one-third left at *f*, the field-worker goes up *b*, and, pulling the 2 drills there, drops the prepared turnips between *c* and *d*.

When three-fourths are pulled, at *a e*, and one-fourth left at *f*, the turnips may still be dropped in the same place between *c* and *d*, the field-worker pulling the three drills on *a* and *e*, and the horse walking along *a* on taking them away.

When 6 drills are pulled at a time, 3 women work abreast, each pulling 2 drills: 2 of these workers drop the turnips into the centre drill of the 4 rows they are pulling. The other worker drops the turnips of the remaining 2 rows in the drill, next the growing crop, and on the return journey the turnips from the 2 rows next the drill are dropped along with them, the other 2 workers going on as formerly. The turnips are thus put into lines containing

4 drills each, and carting may be proceeded with as already described.

When the field is to be entirely cleared of turnips, the clearance is begun at the side nearest the gate; and if the workers move abreast, as directed just above, the carting on the land will be the least.

A Sheltered Spot for Sheep.—A field is begun to be stripped for sheep before the pastures are bare, and that part should be chosen which will afford them best shelter whenever the weather becomes stormy. A plantation, a good hedge, a bank sloping to the south, or one in a direction opposite to that from which high winds prevail in the locality, or a marked inequality in the form of the ground, will each afford shelter to sheep in case of necessity. On the sheep clearing the turnips from this part first, it will always be ready as a place of refuge against a storm.

Carting Turnips.—On removing prepared turnips from the ground, the carts are filled by the field-workers, as many being employed as will keep the carts agoing,—that is, to have one cart filled by the time another approaches the place of work in the field. If there are more field-workers than are required to do this, they should be employed in topping and tailing. The topped and tailed turnips are thrown into the cart by the hand, and not with forks or graips, which would puncture them. The cart is driven between the rows or lines of turnips, fillers being placed on each side. The carter manages the horses and assists in the filling, until the turnips rise as high in the cart as to require trimming, to prevent falling off in the journey.

Lifters one Yoking ahead of Carters.—As it is scarcely probable that there will be as many field-workers as to top and tail turnips and assist in filling carts at the same time, as to keep all the carts agoing, it will be necessary for the toppers and tailers to begin as much sooner—whether a yoking or more—as to keep the carts agoing when they begin to drive away; for it implies bad management to make horses wait longer in the field than the time occupied in filling a cart. The driving away should not commence at all until a sufficient quantity of turnips is prepared to employ from four to eight carts one yoking; nor should more turnips than will employ that number of carts for that time be allowed to lie upon the ground before being carried away, in case frost or rain prevent the carts entering the field for a time.

Some employ one or two carts in an afternoon's yoking, to bring as many turnips as will serve the cattle for two or three days at most, and these are brought with the tops on, after much time has been spent in the field in waiting for their pulling and tailing. This is a slovenly and dirty mode of providing this valuable provender for cattle.

Dry Weather best for Turnip-storing.—Dry weather should be chosen for pulling turnips, not merely for preserving them clean and dry, but that the land may not be poached. When so poached, sheep have an uncomfortable lair, ruts forming receptacles for water not soon emptied; for let land be ever so well drained, its nature cannot be entirely changed—clay will always have a tendency to retain water on its surface, and loam will rise in large masses with the wheels. No turnips should therefore be led off fields during or just after rain; nor should they be pulled at all until the ground has become consolidated. They should not be pulled in frost, and if they are urgently required from the field in frost or rain, a want of foresight is manifested by either the farmer or his manager, or by both.

On the weather proving unfavourable at the commencement of stripping, or an important operation intervening—as wheat-seed—no more turnips should be pulled and carried off than will suffice for the daily consumption of the cattle in the steading; but whenever the ground is dry at top and firm, and the air fresh, no opportunity should be neglected of storing a large quantity.

Importance of Storing Roots.—To store turnips in the best state, should be regarded a work of the first importance in winter; and it can be done only by storing a considerable quantity in good weather, to be used when bad weather comes. When a store is prepared, the mind remains at ease as to the state of the weather, and having a store does not prevent taking supplies from the field as long as the weather permits the ground to be carted upon with impunity, to be immediately consumed, or to augment the store. No farmer would dissent from this truth; yet many violate it in practice! The excuse most readily offered is want of time when the potato-land should be ploughed and sown with wheat; or when the beasts are doing well enough upon the pasture; or when the turnips are continuing to grow. The potato-land should be sown when ready; but the growing state of the turnips has no force when adduced against reducing the condition of cattle; nor is the plea of the pasture being yet good enough for cattle tenable, for rough pasture is more useful to ewes in winter than to cattle in late autumn.

Methods of Storing Turnips.—The storing of turnips is well done in this manner. Choose a piece of lea ground, convenient to access of carts, near the steading, on a 15-feet ridge, running N. and S., for the site of the store. Fig. 66 gives the form of a turnip-store. The cart with topped and tailed turnips is backed to the spot of the ridge chosen to begin the store, and there emptied of its contents. The ridge being 15 feet wide, the store should not exceed 10 feet in width at the bottom, to allow a space of at least 2½ feet on each side towards the open furrow of the ridge, to carry off surplus water. The turnips are piled by hand up to the height of 4 feet, but will not pile to 5 feet on that width of base. The store may thus be formed of any length; but it is more desirable to make two or three stores on adjoining ridges, than a very long one on the same ridge, as its farthest end may be too far off to use a wheelbarrow to remove the stored turnips.

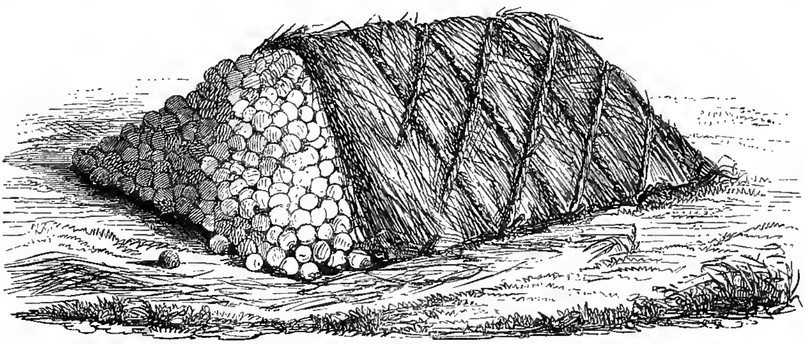


Fig. 66.—*Triangular turnip-store.*

There are various ways of thatching turnips. In some cases straw drawn out lengthwise is put 6 inches thick above the turnips and kept down by means of straw ropes arranged lozenge-shaped, and fastened to pegs driven in a slanting direction into the ground, along the base of the straw. Or a spading of earth, taken from the furrow, may be placed upon the ends of the ropes to keep them down. The straw is not intended to keep out either rain or air—for both preserve turnips fresh—but to protect them from frost, which causes rottenness, and from drought, which shrivels them. Others merely cover the roots with a layer of earth about 8 inches deep, and if care is exercised to see that the roots are quite dry before being covered, this system suits very well. To avoid frost, the end and not the side of the store should be presented to the N., which is generally the quarter for frost. If the ground is flat, and the open furrows nearly on a level with the ridges, so that a fall of rain might overrun the bottom of the store, a furrow-slice should be taken out of the open furrows by the plough, and laid over to keep down the ropes, and the furrow cleared out as a gaw-cut with the spade.

Turnips may be heaped about 3 feet in height, flat on the top, and covered with loose straw; and though rain pass through them readily, they will keep very fresh.

Pits in the Field.—In very many cases turnips are speedily and effectually stored by being thrown into small heaps on the land, with one or two loads in each heap, and covered with earth. Heaps of one load are most convenient, as they can be most easily thrown together. This method is called pitting, and is done without the aid of horses and carts. It is useful to place a tuft of straw in the apex of each pit as a ventilator.

Taking Roots from the Store.—When turnips are to be used from the store in hard frost, the straw on the S. end is removed, as seen in fig. 66, and a cart, or the cattle-man's capacious light wheelbarrow, backed to it; and after the requisite quantity for the day has been removed, the straw is replaced over the turnips.

Storing in Furrows.—One plan of storing is to pull the roots from the field in which they have grown, and set them upright with their tops in a furrow made with the plough, and cover the bulbs with the next furrow-slice, while another plough is making a furrow 6 drills apart. This plan, with slight alterations, has been followed in many parts of Scotland. Instead of leaving the tops, the bulbs are both topped and tailed. The plough returns in the furrow, opening up both sides as deeply as possible, and into this furrow the turnips from the drills at each side are thrown, the plough then covering up the whole. Turnips stored in this manner cannot be left long before using. It is a speedy but not very effective method.

Temporary Storing on Lea.—Another still more temporary method of storing is to pull the turnips and carry them to a bare or lea field, and set them upright beside one another, as close as they can stand, with tops and roots on. This plan cannot save turnips from hares or rabbits. A turnip-field can be bared in this way for a succeeding crop. An area of 1 acre will thus contain the growth of 4 or 5 acres of the field. But turnips cannot be so secure from frost here as in a pit or store; and after the trouble of lifting and carrying them has been incurred, it is much better to take them to a store at once, where they would always be at hand.

Storing in Houses Objectionable.—Defective as these temporary plans are, compared to triangular or flat-topped stores, they are better than storing turnips in houses, where they engender heat and sprout on the top, and seldom fail to rot.

Storing in Hurdle Enclosures.—The following method is frequently adopted for a temporary store. Ordinary hurdles are taken, and the spaces between the bars wattled up with the old straw ropes that have been used for thatching. These hurdles, when thus finished, are set with stays 9 or 10 feet apart, one of the ends being closed by a hurdle being placed across. Into the enclosed space the turnips are backed in the carts and tilted, after which they are trimmed until about 4 feet high. The store may be made any length by adding hurdles; the whole being finished, by throwing over the top old thatch, straw ropes, &c. Rain and air which permeate through the mass do no injury, but rather the opposite, as their tendency is to keep the turnips fresh and sappy.

Earthing-up Turnips.—The double mould-board plough is frequently employed to place earth upon the turnips in the drills, as a mode of temporary storing. The extra time required in pulling turnips after this process involves some loss, but the earthing-up protects the roots from damage by game and frost.

Preparing for a Storm.—Although storing is the proper method of securing turnips for a storm of rain or snow, when the turnip-field should not be entered by a cart, yet, as a storm may suddenly arise, food should be provided for the cattle. Rain, snow, and frost, give prognostics of their approach; and when they announce themselves, some farmers send all the field-workers and ploughmen to the turnip-field, and pull the turnips in the manner described in fig. 60, removing only the tails, and throwing the turnips with tops into heaps of from 3 to 6 cart-loads each, according to the bulk of the crop, taking care to finish each heap by placing the tops of the outward turnips around the outside, as a protection to the bulbs from the frost, should that be unaccompanied with snow. But if sharp frost set in, this plan cannot be adopted, as the heaps become miniature ice-houses, and the bulbs freeze more quickly and harder than if they had been left growing. A very slight covering of snow prevents the bulbs freezing to any great extent, if they are left alone; and if a farmer be placed in this position, the better plan is to pick the turnips out of the rows daily until fresh weather sets in.

Pulling Mangels.—In *pulling* mangel-wurzel, care should be taken to do no injury to the roots. Cleansing with the knife should on no account be permitted; rather leave some earth on the root. The drier the weather is, the better for storing the crop. The roots are best prepared for the store by twisting off the top with the hand, as a mode of preventing every risk of injuring the root. Mangel-wurzel not being able to withstand severe frost, should be entirely cleared from the field before its occurrence.

The best way of pulling them is in the order indicated in fig. 60, at *a*, where two drills are pulled by one worker, and the adjoining two drills by another; and the prepared roots placed in heaps in the hollow intermediate to the four drills, the leaves being also thrown into heaps between the roots. "The leaves thus treated, when intended to be fed either by sheep folded on land, or carted off and thrown on pastures for cattle or sheep, are always clean and fit food for stock, which they are not when thrown over the land and trampled on. Mangel-wurzel standing on the ground, and protected by the broad leaves, will stand frost (if not very severe) without injury; but a very slight frost will damage those roots which are pulled, therefore it is wise to cart the roots away." If the leaves are not desired to be used as food, they may be scattered over the ground. Mangel-leaves do not affect and injure young cattle as turnip-leaves do.

Carting Roots.—On removing any kind of roots, the cart goes up between two rows of pulled roots, and thereby clears a space at once of the breadth of eight drills. In this manner the work proceeds expeditiously, and with little injury to the land by trampling. To save the land still further, and also to lessen the draught to the horses, the carts should be driven up and down the drills and not across them, whether going with a load or returning empty.

Cost of Pulling and Carting Mangels.—The pulling and driving a crop of 20 tons of mangel-wurzel is stated to cost from 9d. to 1s. per ton, and a bad crop will cost considerably more. From 25 to 45 tons per acre of mangel have been obtained in France, and 42 tons in Ireland.

Storing Mangels.—As to *storing* mangels, Mr Baker, of Writtle, recommends "stacking the roots upon a base not exceeding 3 yards in width, but from 6 to 7 feet is better. The roots should be packed with the crowns outward, in the form of a roof, diminishing upwards until they arrive at a narrow ridge at top, rising from the base from 6 to 8 feet in height. If a wider base is selected, it will be necessary to introduce a fagot upright, in the middle of the heap, at about every 6 feet apart, so as to carry off the heat; for should fermentation set in—which in some seasons it is apt to do, unless due precaution is taken to prevent it—the results would be to spoil the roots. When the clamp or row is completed, it should be well covered over with straw, about 6 inches in thickness, and then with the soil dug up immediately around to the thickness of about 8 inches, leaving an opening over each fagot secured at first partially from frost by a wisp of straw only. It is, however, thought advisable by some cultivators to defer earthing the heaps to the top for about 2 feet downwards until a later period, and all hazard of fermentation is over."

Mangels Stored in Houses.—Mr Baker says: "When it is stored in a building made secure from the frost for the purpose, but little further care is necessary, as I have never known an instance of its being injured by fermentation, *provided the top of the heap remain uncovered.* In my storing-house I frequently cart in from 400 to 500 tons in one heap of 20 feet in width. The walls are formed of the earth excavated; a roof with a thick coating of thatch covers the whole, and the carts enter by folding-doors at one end. It may be safely packed to any thickness and height, if afterwards protected only with straw. For this purpose barley-straw answers best."

A Suffolk farmer has stored his mangel-wurzel in a boarded barn, the inside of which is first lined with barley-straw 18 inches thick, to protect them from frost, *leaving the top uncovered.* Then lay 12 feet deep, 18 feet wide, by 30 feet long. He has pursued this plan several years, and it has preserved them admirably up to March, or even longer. He never knew them to heat, or take more harm than by the common method of earthing them up. He should not be the least afraid of putting them in a brick barn, taking care to leave the top doors open during the day.

Another farmer says: "Respecting the storing of mangel-wurzel, it is quite safe in placing 100 tons together in a barn, if done when the roots are dry and the green removed, by allowing air from a window for the first week or ten days, afterwards *covering well up with straw* to prevent the frost from penetrating. In this manner I have kept the roots quite sound until the month of June following."

Cover with Dry Straw.—Opposite opinions are thus expressed as to covering. Upon the whole, it might be safest to cover with dry straw. A farmer gives this warning in regard to the state of straw: "In storing mangel for winter, my straw was carried to the spot in order to thatch the mangel before the covering of mould was put on. Some of this straw laid out and got thoroughly wet. Where the wet straw was used the mangels are rotten; where the dry straw, they are safe and sound."[1]

Storing Cabbages.—Cabbages are generally consumed direct from the ground in a green state. They are not so easily stored for future use as are turnips or mangels; still there are some methods by either of which they may be safely preserved for several months. The mistaken idea that cabbages cannot be successfully stored or protected from frost except in a barn or other building specially prepared for them has, no doubt, prevented the more extensive cultivation of this most useful crop.

Amongst the various methods of storing cabbages which have been practised and recommended are the following: Taking them up and replanting them in a sloping manner, and covering them with straw; pitting them; hanging them up in a barn; turning them head downwards, and covering them with earth, leaving the roots sticking up in the air. But every one of these plans is attended with great labour, and some of them forbid the hope of being able to preserve any considerable quantity.

The most successful plan is this: Throw up a sort of land or ridge with the plough, and make it pretty hard on top. Upon this land lay some straw. Then take the cabbages, turn them upside down, and, after taking off any decayed leaves, place them, about six abreast, upon the straw. Then cover them, not very thickly, with straw, or leaves raked up in the woods, throwing here and there a spadeful of earth on the top, to keep the covering from being blown off by the wind. Only put on enough of straw or leaves to hide all the green, leaving the cabbage-roots sticking up through the covering.

Stored in this way, cabbages of all sorts will be found to keep well through the winter. And not only do they keep better in this than any other way, but they are at all times ready for use. They are never locked up by frost, as often happens with those pitted in the earth; and they are never found rotting, as is often the case with those stored with their heads upwards and their roots in the ground.

The bulk of this crop is so large, that storing in buildings of any sort is not to be thought of. Besides, the cabbages so put together in large masses would heat, and rot quickly. In some gardens, indeed, cabbages are put into houses, where they are hung up by the roots; but they wither in this state, or soon putrefy.

By adopting the mode of storing recommended above, however, all these in-

[1] *Bell's Week. Messen.*, March 8, 1858.

conveniences are avoided. Any quantity may be so stored, in the field or elsewhere, at a very trifling expense compared with the bulk of the crop.[1]

Lifting Cabbages.—Some recommend the cabbages to be pulled up by the roots; others prefer cutting the stem close to the ground and leaving the root in the ground, which will throw up a fresh growth of leaf early next spring. Mr Charles Howard, Biddenham, Bedford, says he has found these sprouts most valuable for ewes in early spring. Where the sprouts are not desired for food, the better plan is to pull up the roots along with the cabbages, as the spring growth tends to exhaust the soil.

Utilising Cabbage-stalks.—In regard to cabbage-*stalks*, after cutting off the cabbages, a farmer says: "I do not get these 'out of the way as quickly as possible,' by shooting them into a ditch to rot and wash away, as is too often the case. I lay them thin to dry, and then clamp and char them for absorbing urine, and drilling with a compost drill, or broad-casting, where most likely to be advantageous."

Storing Belgian Carrots.—*Belgian* carrots, which are white, will stand the winter without harm. By the first week in December they will have attained their greatest growth.

Storing Red Carrots.—Common *red carrots* are taken up before the frost appears, and stored for winter use. They are best taken out of the ground with a three-pronged fork when sown on flat ground; but on drills the plough, without the coulter, answers the purpose nearly as well, and executes the work much more quickly, though the extremities of the longest carrots may be broken off. On being taken up in either way, the tops are wrenched off by the hand, and may be given to cattle, or strewn over the ground to be ploughed in.

Carrots, not being so easily affected by frost as mangel-wurzel, may be stored in an outhouse mixed with dry sand, or in a triangular heap, and covered with straw, or with straw and earth.

Storing Parsnips.—The *parsnip* may be taken up from the flat or the drill, and stored in precisely the same manner as carrots. They are not much affected by frost, and will keep fresh in the store till April. Care, however, should be taken that none of the leaves remain attached to the roots.

Parsnip-leaves as Food for Cows.—"In October, the *leaves* of parsnip, as they *begin* to decay, should be cut off, and given, when dry, to cows: it is important to see that they be dry, as, when moist from rain or dew, they are apt to inflame the udder. The leaves come in as a convenient auxiliary to grass at this period; and, if given *moderately*, a good armful per day to each cow will impart as much richness to the milk as the parsnip itself."[2]

Storing Kohl-rabi.—Of *kohl-rabi*, Mr Green, Stratford-on-Avon, says: "The bulbs may be taken up and stored the same as swedes, or remain on the field, according to the farmer's convenience: 20 tons an acre may be considered a good crop."

VARIETIES OF TURNIPS.

The varieties of turnips cultivated in this country are very numerous. They are divided mainly into swedes, yellow turnips, and white turnips, the names of the two latter being derived from the colour of the flesh. One kind from each of these classes is generally cultivated on every farm, although the yellow is omitted in some districts, and the swede in others. Where the swede is known, its culture is seldom relinquished, and its area is extending.

Order of Using Turnips.—White varieties come earliest into use, and will always be esteemed on account of their rapid growth and early maturity; and though unable to withstand severe frost, their abundance of leaf serves greatly to protect the roots from the effects of cold. Being ready for use as soon as pasture fails, they afford the earliest support to both cattle and sheep; and only such a quantity should be stored of them as will last to the end of the year.

Yellows then follow, and usually last for about two or three months.

[1] *Farming World*, 317, October 28, 1887.

[2] Lawson's *Agric. Man.*, 237, and *Suppl.*, 49.

Swedes finish the course, and should last until the grass is able to support young cattle at the end of May or beginning of June, to which period they will continue fresh in store, if stored in the manner recommended in fig. 66, or any of the other effective methods.

Time for Storing Swedes.—It has been contended that the best time for storing swedes is before vegetation makes its appearance, in March or April, when they are heaviest. By experiments made in England, it was found in weighing swedes on the 16th of November 1858, and again on the 16th of February 1859 from the same field, that the crop had increased in weight in that time no less than 2½ tons per acre. This experiment corroborates what has already been stated in the table of specific gravities, that swedes attain weight until vegetation recommences in April. If there were no danger of damage by frost, it would therefore be prudent to delay storing swedes until the end of February. There is, however, great risk of damage from frost, and it is safer to store the roots early in winter before severe frosts set in.

White Varieties.—Of all the varieties of white turnips, the white globe (*Brassica rapa, depressa, alba*, of De Candolle), *a*, fig. 67, is one of the best for early

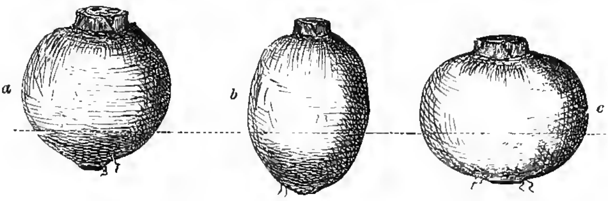


Fig. 67.—*White globe.* *Purple-top swede.* *Aberdeenshire yellow bullock.*

maturity, sweetness, juiciness, size of root, weight of crop, and elegance of form. Its form is nearly globular, as its name indicates; skin smooth, somewhat oily, fine, and perfectly white; neck of top and tap-root small; leaves long (frequently 18 inches), upright, and luxuriant. Though the root does not feel particularly heavy in the hand, it does not emit a hollow sound when struck, as the white tankard-turnip does; its flesh is somewhat firm, fine-grained, though distinctly exhibiting fibres radiating from the centre, the juice easily exuding, and the rind thin. Its specific gravity was determined by Dr Skene Keith at 0.840.

Besides this white there are the light green-topped white, which is good and beautiful, and the red-topped white, which seems coarse, though perhaps hardy.

Yield per acre of White Turnips.—Our crops of white-globe turnip must ordinarily consist of middle-sized bulbs, or contain many blanks. Taking the distance between the turnips at 9 inches—being that to which white turnips are usually thinned out—and the usual distance between the drills at 27 inches, an area of 243 square inches of ground is allowed to each turnip. Hence there should be 25,813 turnips per imperial acre; and taking 20 tons per acre as a fair crop, each turnip should only weigh 1 lb. 8 oz.! Now, suppose each turnip should weigh 6 lb., the crop will be 69 tons 1 cwt., instead of 20 tons per acre. The inevitable conclusion is, either that blanks occur to the enormous extent of 9445 turnips, or the average distance between the turnips must be 20 inches instead of 9; but as we are sure that turnips are not at 20 inches asunder, we must go to the other alternative that there are only 9445 turnips to the acre, which should make each turnip only 4 lb. 6 oz. When actual results fall so very far short of expectation, the inquiry is, Whether the deficiency is occasioned by the death of plants after singling? or the average weight of each turnip is much less than we imagine? or the distance left by the singling is greater than we desire?—or from all these causes combined? From whichever cause, singly or combined, it is worthy of serious investigation by the farmer, whether or not the fate of the crop really depends more on occult circumstances than mode of culture? Let us examine this a little:—

Weights and Sizes of White Turnips.—Weights and sizes of white turnips have been ascertained with sufficient accuracy. White globes exhibited at the show of the Highland and Agricultural Society at Inverness in October 1839 gave a girth varying from 28½ to 34 inches, and a weight varying still more—from 8 lb. to 15½ lb. each root; and 3 roots of the same girth of 30½ inches weighed respectively 8 lb., 9¾ lb., and 14½ lb.[1] After such a statement, it is evident that crops of the same bulk weigh very differently; turnips from the same field exhibit different feeding properties, and different localities produce turnips of different bulk and weight. Whence arise those various results? The above weights are not the utmost to which this turnip attains, examples occurring from 18 lb. to 23 lb.;[2] and we have pulled one from among swedes weighing 29 lb., including the top. And yet from 30 to 40 tons per imperial acre are regarded a very great crop of this kind of turnip.

Greystone Turnips.—The greystone white turnip has a purplish top, and being of the form of the white globe, may have been derived from it. It attained at Yester in 1863 a crop of 40 tons per imperial acre, with 6½ cwt. guano and guano phosphate, half and half, along with farm-dung. It is extending in culture. There are several other white varieties in use which are found very suitable for providing early food when pasture runs short.

Yellow Varieties.—Of yellow turnip, perhaps the most general favourite is the green-top Aberdeen Yellow Bullock (*Brassica rapa, depressa, flavescens*, of De Candolle). This is a good turnip, of the form of an oblate spheroid (*c*, fig. 67); the colour of the skin below ground, as well as of the flesh, is a deep yellow orange, and that above ground bright green. The leaves are about 1 foot long, dark green, rather soft, spreading radiantly over the bulb, and collected into a small girth at the top of the turnip; the tap-root is small. Its specific gravity, as determined by Dr Keith, is 0.940. This root feels firm and heavy in the hand, with a smooth fine skin, the flesh crisp, but not so juicy nor the rind so thin as in the case of the globe. There are several other very useful varieties, such as the purple-top yellow, and various hybrids.

Yield of Yellow Turnips.—Selected specimens exhibit a circumference of from 27 to 30 inches, with a weight varying from 6 lb. to 8½ lb., but specimens may be found weighing from 9 lb. to 11 lb. with the same diameter, showing a difference of 2 lb. in weight. Yellow turnips seldom yield so heavy a crop as either the globe or swede, 30 tons the imperial acre being a great crop; but their nutritive property is greater than that of the white. In the northern parts of the kingdom, where light soils predominate, they are grown in preference to the swede; but with proper culture the swede will exceed the yellow in weight and nutrition on most soils and localities. Occasionally as much as 33 tons per acre of purple-top yellows are raised.

Varieties of Swedes.—Of the varieties of the swede, the Purple-top (*Brassica campestris, napo-brassica, rutabaga*, of De Candolle) has obtained the preference; and for weight of crop, nutritive property, and durability of substance, it is an excellent turnip. It is of an oblong form (*b*, fig. 67), having the colour under ground and of the flesh a deep yellow orange, and the part above the ground a dusky purple. The leaves are about 1 foot long, standing nearly upright, of a bluish-green colour, and growing out of a firm conical crown, which forms the neck of the bulb. The skin is somewhat rough, the rind thicker than in either the white or yellow turnip, and the flesh very crisp. This turnip feels heavy and hard in the hand. According to Dr Keith, the specific gravity of the orange swede is 1.035, and of the white 1.022. Dr Keith found the swede heaviest in April, at the shooting out of the new leaves; and after its flower-stem was fairly shot in June, the specific gravity of the root decreased to 0.94—that of the yellow turnip. This differential fact indicates

[1] *Jour. Agric.*, x. 456.
[2] Lawson's *Agricul. Man.*, 253, 254.

the comparative values of those turnips. In recent years many valuable new varieties of swedes, as of other roots, have, with great benefit to farmers, been brought into use by leading seedsmen.

Yield of Swedes.—Picked specimens of swedes have exhibited a girth of from 25 to 28 inches, varying in weight from 7 lb. to 9½ lb.; but the weight varies in a different proportion to the bulk, as one of 25 inches gave 9½ lb., whilst another of 26 inches only weighed 7 lb. It is no uncommon thing to see swedes from 10 lb. to 12½ lb. A crop of 16 or 20 tons may be obtained by ordinary culture, but on first-class well-managed land from 28 to 34 tons per imperial acre are occasionally obtained. In 1863, 41½ tons per acre of purple-top swedes were raised on the Nether Mains of Pitfour in the Carse of Gowrie. A crop of 50 acres of swedes within the policy of Wedderburn, Berwickshire, was in 1815 let to be consumed by cattle and sheep, the wethers to pay 6d. a-head per week, and it realised no less than £21 per imperial acre! The crop, unfortunately, was not weighed, but it was estimated at over 58 tons per acre. Take the calculation in another form, and see the result of £21 at 6d. a-head per week, which implies the support of 32 sheep to the acre; and take Mr Curwen's estimate of a sheep eating 24 lb. a-day for 180 days, or 26 weeks,[1] and we find the crop should have weighed 61 tons 12 cwt.

Quantity of Turnips eaten by Sheep.—The quantity of turnips eaten by sheep is, however, variously stated. Sir John Sinclair gives a consumption of 21 acres of 44 tons each, by 300 sheep in 180 days, or nearly 38 lb. a-day for each sheep.[2] If we take the usual allowance of 16 young sheep to an ordinary acre of 30 tons, which is 23⅓ lb. a-day to each, or ten old sheep, which is 37⅓ lb. to each, both respectively are near the results given by Mr Curwen and Sir John Sinclair, the difference between them being exactly that consumed by old and young sheep. Whether we take 24 lb. or 38 lb. as the daily consumption of turnips by sheep, there is no doubt whatever of the £21 per acre having, in the case referred to, been received for their keep.

Proportion of Leaf and Root.—The proportion the top bears in weight to the root is little in the swede, as evinced in the experiments of Mr Isaac Everett, South Creake, Norfolk, on a crop of 17 tons 9 cwt. Grown at 18 inches apart, and 27 inches between the drills, it was 3 tons 3 cwt. of tops, on the 15th December, after which they were not worth weighing; and, what is remarkable, the tops are lighter in a crop raised on drills than on the flat surface—that is, whilst 28 tons 8 cwt. of topped and tailed turnips afforded only 5 tons 10 cwt. of tops from drilled land, a crop of 28 tons 16 cwt. from the flat surface yielded 6 tons 16 cwt. of tops.[3] Sir John Bennett Lawes and Dr Gilbert have determined, in the Rothamsted experiments, that common turnips, such as Norfolk whites, yield a much higher proportion of leaf to root than swedes; and if the leaf be unduly developed, there may even be more nitrogen, and more total mineral matter, remaining in the leaf to serve only as manure again, than accumulated in the root to be used as food. In the case of swedes, however, not only is the proportion of leaf to root very much less under equal conditions of growth, but the amount of dry matter, of nitrogen, and of mineral matter, remaining in the leaf, is very much less than in the root. In one case, with a highly nitrogenous manure, whilst there was with an average of 10¼ tons of white turnip roots nearly 6¼ tons of leaves, there was with swedes, with more than 12 tons of roots, not quite one ton of leaf. In a series of experiments, moreover, with different manures, whilst white turnips gave from 300 to 600 parts of leaf to 1000 of root, the highest proportion by weight of leaf to root in the case of swedes was 78½ to 1000. Whilst in yellow or white turnips a very large amount of the matter grown is accumulated in the leaf and only serves as manure again, in swedes a comparatively small amount of the produce is useless as food for stock.

Keeping Properties of Turnips.—

[1] Curwen's *Agricul. Hints*, 39.
[2] Sinclair's *Husband. Scot.*, ii., Appendix, 47.
[3] *Jour. Eng. Agric. Soc.*, ii. 279.

The yellow turnip will continue fresh in the store until late in spring, but the swede has a superiority in this respect to all others. A remarkable instance of the swede keeping in the store, in a fresh state, was observed in Berwickshire, where a field of 25 acres was pulled, rooted, and topped, and stored in the manner as in fig. 66, in fine dry weather in November, to have the field sown with wheat. The store was opened in February, and the cattle continued on them until the middle of June, when they were sold fat, the turnips being then only a little sprouted, and somewhat shrivelled, but sweet to the taste.

Large Swedes best.—One property possessed by the swede stamps a great value upon it for feeding stock; the larger it grows the larger proportion of nutritive matter it contains, affording a sufficient stimulus to the farmer to raise this valuable root to the largest size attainable.

With yellow and white varieties the experience on this point has been different.

Specific Gravity of Turnips.—All turnips, except swedes, are lighter than water. This is remarkable, because all the ingredients composing turnips—sugar, gum, proteine compounds, fibre, &c.—are heavier than water; the conclusion is, that all turnips except swedes contain a large proportion of air.

Composition of Heavy and Light Turnips.—The comparative composition of heavy and light turnips is as follows:—

Swede, specific gravity 1.015.

Pectic acid and lignine	247.0
Proteine compounds	19.0
Ash	12.0
Total fibre	278.0
Water	9,101.0
Proteine compounds	58.0
Sugar, gum, &c.	563.0
Total juice	9,722.0
Ash	50.000
Phosphates	10.000
Phosphoric acid in alkaline salts	0.300
Nitrogen in fibre	3.200
Nitrogen in juice	9.280
Specific gravity of juice	1.037
Dry matter in 100 parts of juice	7.480

Tweeddale purple-top yellow, specific gravity 0.782.

Pectic acid and lignine	283.5
Proteine compounds	16.9
Ash	22.6
Total fibre	323.0
Water	9,313.0
Proteine compounds	33.3
Sugar, gum, &c.	330.7
Total juice	9,677.0
Ash	72.000
Phosphates	12.000
Phosphoric acids in alkaline salts	0.500
Nitrogen in fibre	2.700
Nitrogen in juice	5.300
Specific gravity of juice	1.028
Dry matter in 100 parts of juice	8.870
Total nitrogen in swede	12.300
Total nitrogen in purple-top	8.000
Total fibre in swede	278.000
Total fibre in purple-top	323.000

Ash of Swedes.—Messrs Way and Ogston found the ash of a crop of Skirving's swede, of 20 tons per acre, to contain these ingredients:—

		Mineral matter removed by an acre of crop. lb.
Silica	2.69	9.4
Phosphoric acid	9.31	31.3
Sulphuric acid	16.13	54.2
Carbonic acid	10.74	36.2
Lime	11.82	39.7
Magnesia	3.28	11.0
Peroxide of iron	0.47	1.6
Potash	23.70	79.6
Soda	14.75	49.6
Chloride of sodium	7.05	23.7
	99.94	336.3[1]

Ash of Yellow Turnips.—The composition of the ash of the yellow turnip was this:—

	Leaves.	Roots.
Peroxide of iron	2.67	1.37
Lime	6.76	12.12
Magnesia	13.73	4.97
Potash	15.47	28.03
Soda	...	6.82
Chloride of sodium	17.81	9.61
Phosphoric acid	11.32	10.16
Sulphuric acid	13.93	13.07
Carbonic acid	14.73	10.74
Silicic acid	3.58	3.11
	100.00	100.00

[1] *Jour. Eng. Agric. Soc.*, viii. 144.

Actual quantities of these substances in the ash in an imperial acre :—

	Leaves. lb.	Roots. lb.
Peroxide of iron	5.60	10.08
Lime	14.24	88.92
Magnesia	28.92	36.44
Potash	32.60	205.64
Soda	...	50.04
Chloride of sodium	37.52	70.48
Phosphoric acid	23.84	74.52
Sulphuric acid	29.36	95.84
Carbonic acid	30.04	78.76
Silicic acid	7.52	22.80
	209.64	733.52

Ash of Green-tops.—The analysis of the ash of the green-top white turnip is thus given by Messrs Way and Ogston :—

		Mineral matter removed by an acre of crop. lb.
Silica	0.96	2.6
Phosphoric acid	7.65	20.5
Sulphuric acid	12.86	34.5
Carbonic acid	14.82	39.7
Lime	6.73	18.0
Magnesia	2.26	6.1
Peroxide of iron	0.66	1.8
Potash	48.56	130.0
Chloride of sodium	5.44	14.6
	99.94	267.8

Ash of Greystone Turnips.—The composition of the ash of the greystone turnip—after deduction of carbonic acid, sand, and charcoal—was, on clay and sandy soils, thus found by Dr Anderson :—

	Clay.	Sandy.
Peroxide of iron	2.74	2.85
Lime	15.90	13.24
Magnesia	1.61	2.46
Potash	45.01	44.86
Soda	3.15	3.20
Chloride of sodium	9.72	9.69
Phosphoric acid	18.03	18.94
Sulphuric acid	3.02	3.62
Soluble silica	0.82	1.14
	100.00	100.00

The proportion of bulb to top in turnips has been ascertained by Messrs Way and Ogston in these ratios; in 100 of root, the top bore these proportions :—

	Per cent.
Swedes	10.05
Yellows	16.09
White	22.18

Thus swedes yield more root in proportion to their tops than white turnips, in the ratio of 10.5 to 22.18 per cent.[1] Compare with this what is said on this subject in a preceding paragraph under heading of "Proportion of Leaf and Root."

Ash of Yellow-globe Mangels.—Messrs Way and Ogston found the ash of the yellow-globe mangel to consist of these ingredients in a crop of 22 tons per acre :—

		Mineral matter removed by the crop in an acre. lb.
Silica	2.22	11.1
Phosphoric acid	4.49	22.5
Sulphuric acid	3.68	18.5
Carbonic acid	18.14	91.0
Lime	1.78	8.9
Magnesia	1.75	8.8
Peroxide of iron	0.74	3.7
Potash	23.54	118.2
Soda	19.08	95.7
Chloride of sodium	24.58	123.3
	100.00	501.7

Ash of Long Red Mangels.—They found the ash of the long red mangel to consist of these constituents in a crop of 24 tons per acre :—

		Mineral matter removed by an acre of crop. lb.
Silica	1.40	4.8
Phosphoric acid	1.65	5.7
Sulphuric acid	3.14	10.7
Carbonic acid	15.23	52.3
Lime	1.90	6.5
Magnesia	1.79	6.1
Peroxide of iron	0.52	1.8
Potash	21.68	74.3
Soda	3.13	10.7
Chloride of sodium	49.51	169.8
	99.95	342.7

Ash of Cabbage.—Dr Anderson gives the composition of the ash of cabbages thus :—

	Outer leaves.	Heart.
Potash	14.96	38.74
Soda	...	1.05
Chloride of potassium	8.71	...
Chloride of sodium	9.16	5.73
Lime	24.68	11.64
Magnesia	3.22	2.91
Oxide of iron	1.89	0.43
Sulphuric acid	16.56	13.99
Phosphoric acid	2.95	5.47
Carbonic acid	15.10	19.21
Silica	2.77	0.83
	100.00	100.00

[1] *Jour. Eng. Agric. Soc.*, viii. 171.

Ash of Carrots.—Messrs Way and Ogston ascertained the ash of the white Belgian carrot, in a crop of 27 tons per acre, to contain:—

		Mineral matter removed by an acre of crop. lb.
Silica	1.10	5.5
Phosphoric acid	7.86	39.0
Sulphuric acid	6.95	34.5
Carbonic acid	17.72	88.1
Lime	8.26	41.0
Magnesia	3.20	15.9
Peroxide of iron	1.66	8.3
Potash	28.00	139.2
Soda	17.53	87.2
Chloride of sodium	7.65	38.0
	99.93	496.7

Comparative Mineral Ingredients of Turnips, Mangels, and Carrots.—It is interesting and instructive to be made acquainted with the composition of individual crops, but it is still more instructive to have a comparison of the mineral matters contained in a given weight of different crops. Here is a comparative view per cent of the mineral matters contained in *one ton* of turnip, mangel, and carrot, by Messrs Way and Ogston:—

	Turnip.	Mangel.	Carrot.
Silica	0.34	0.54	0.24
Phosphoric acid	1.77	0.66	1.73
Sulphuric acid	2.33	0.65	1.31
Lime	1.76	0.41	1.77
Magnesia	0.47	0.43	0.80
Peroxide of iron	0.07	0.12	0.22
Potash	6.07	4.99	6.59
Soda	1.46	3.02	2.71
Chloride of sodium	1.49	5.29	1.42
	15.76	16.11	16.79

Ash of Parsnips.—Dr Richardson determined the composition of the ash of the parsnip to be this:—

Potash	36.12
Soda	3.11
Lime	11.43
Magnesia	9.94
Phosphoric acid	18.66
Sulphuric acid	6.50
Phosphate of iron	3.71
Silica	4.10
Chloride of sodium	5.54
Loss, &c.	0.89
	100.00[1]

Ash of Kohl-rabi.—Messrs Way and Ogston found the composition of the ash of kohl-rabi to be this:—

Potash	36.27
Soda	2.84
Lime	10.20
Magnesia	2.36
Peroxide of iron	0.38
Phosphoric acid	13.46
Sulphuric acid	11.43
Carbonic acid	10.24
Chloride of sodium	11.90
	99.08

For further analysis of roots of all kinds, see "Foods."

Nutritive Matter in different kinds of Roots.—A white-globe turnip of 7 inches in diameter affords 72½ grains, whereas one of 4 inches yields 80 grains of nutritive matter, the smaller being the more nutritive.

A large swede contains 110 grains, and a small one only 99 grains of nutritive matter, the larger swede being the more nutritive.

Nutritive Matter in an Acre of Roots.—The nutritive matter contained in an imperial acre of turnips is great. In a crop of 20 tons, or 45,000 lb., there are 900 lb. of woody fibre; 4000 lb. of starch, sugar, gum; 670 lb. of gluten; 130 lb. of fat or oil; and 300 lb. of saline matter. Turnips contain a very large proportion of water, and this, enhancing the cost of transport, makes it desirable to have them consumed on the spot where they are grown.

Keeping Properties and Feeding Value of Swedes.—Mr Gilbert Murray, Elvaston, Derby, ascertained by experiment that "determination of the specific gravity of the entire bulb of the swede turnip gives its *keeping* properties; and the specific gravity of the expressed juice indicates at once the real *feeding* value of the specimen examined;" and the following are the specific gravities of the bulb and juice of six specimens of swedes, raised on purpose:—

Specific gravity, bulb.		Specific gravity, juice.	
1.003	0.099	1.018	1.016
0.991	0.984	1.019	1.016
1.101	0.947	1.024	1.018[2]

Ill-shaped Turnips.—In *a*, fig. 68, is shown an ill-formed turnip, as also one,

[1] Wilson, *Our Farm Crops*, 12, Part VII.

[2] *Jour. Eng. Agric. Soc.*, xxiii. 361.

b, which stands so much out of the ground, represented by the dotted line, as to be liable to injury from frost. The turnip *a* is ill-formed, inasmuch as the part around the top is hollow, where rain or snow may lodge, and find their

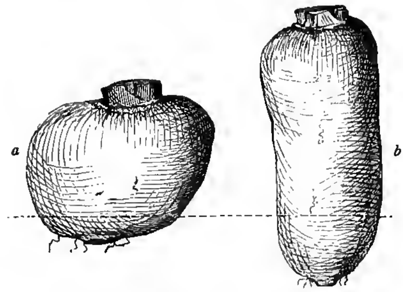


Fig. 68.—*Ill-shaped turnip.* *Tankard-turnip.*

way into the heart, and corrupt it, as is actually found to take place.

When to Store White Turnips.—All white turnips, when allowed to remain on the ground after they have attained maturity, become soft, spongy, and susceptible of rapid putrefaction, which reduces them to a saponaceous pulp. This affords a good motive to store white turnips when they come to maturity, which is indicated by the leaves losing their green colour.

There are some sorts of white turnips always spongy in the heart, and among these may be classed the tankard, *b*, fig. 68; as also a flat red-topped white and a small flat white, both cultivated by small farmers; because, being small, they require little manure to bring them to maturity.

Number of Turnips per Acre.—It may be useful to give a tabular view of the number of turnips there should be on an imperial acre at given distances between the drills, and between the plants in the drills, and of the weight of the crop at specified weights of each turnip, to compare actual receipts with defined data, and to ascertain whether differences in the crop arise from deficiency of weight in the turnip itself, or in the plants being too much thinned out. The distance between the drills is the usual 27 inches; the distance between the plants is what is allowed to the different sorts of turnips. As the imperial acre contains 6,272,640 square inches, it is easy to calculate what the crop should be at wider and narrower intervals between the drills:—

Usual distance between the drills.	Usual distances between the plants.	Area occupied by each plant.	Number of turnips there should be per imperial acre.	Weight of each turnip.	Weight which the crop should be per imperial acre.	
Inches.	Inches.	Square inches.		lb.	tons.	cwt.
27	9 between the plants of white turnips.	243	25,813	1	11	10½
				2	23	1
				3	34	11½
				4	46	2
				5	57	12½
				6	69	3
				7	80	13½
				8	92	4
27	10 between the plants of yellow turnips.	270	23,232	1	10	7
				2	20	14
				3	31	1
				4	41	8
				5	51	15
				6	62	2
				7	72	9
				8	82	16
27	11	297	21,120	1	9	8
				2	18	18½
				3	28	5
				4	37	14½
				5	47	2
				6	55	11½
				7	65	19
				8	75	8½
27	12 between the plants of swedes.	324	19,360	1	8	12¾
				2	17	
				3	25	17¼
				4	34	11
				5	43	3¾
				6	51	16½
				7	60	9¼
				8	69	2

Careful and Careless Thinning of Roots.—On comparing a common crop of 20 tons of swedes with these data, and keeping in view the distance of 12 inches between the plants, the inevitable conclusion is, that the average weight of turnips must be less than 3 lb., or the distance between them greater than 12 inches. In the one case, skill in raising a crop is almost rendered nugatory; and in the other, negligence in wasting space in the thinning out appears conspicuous. An amendment in both particulars is therefore required, and fortunately attainable; for as a slight difference in either makes a great difference in the weight of a crop, the turnip should be heavy, and the distance invariable. For example, 5-lb. turnips, at 9 inches asunder, give a crop of 57 tons 12½ cwt.; whereas the same weight of turnip at 11 inches apart gives only a little more than 47 tons. Now, how easy is it for careless workers to thin out the plants to 11 instead of 9 inches! and yet, by so doing, 10½ tons of turnips are sacrificed. Again, a difference of only 1 lb. on the turnip—from 5 lb. to 4 lb.—at 9 inches asunder, makes a difference of 11½ tons per acre. So that a difference of only 1 lb. in each turnip, and 2 inches in the distance between them, makes the united sacrifice of 22 tons per acre, from what might be obtained! Who will deny after this, that minutiæ require the most careful attention of the farmer?

Errors in Estimating Weight of Roots.—It is quite possible for great errors to be committed in measuring a crop of turnips as it stands, instead of topping and tailing a whole field, and weighing every cart-load separately. For example: Suppose 1 yard is measured *from a turnip* along a drill, 1 yard will embrace 5 turnips of white and 4 of swedes; but if the measurement is taken from *between two turnips*, 1 yard will only embrace 4 turnips of white and 3 of swedes, making, in the white, a difference of 1 turnip in 5, and in the swedes 1 in 4; and if the weight of an acre is calculated on such data, the crop, in the case of the white will be 1/5, and in that of the swedes ¼, beyond or below the truth. Again, if the yard be placed *across two drills*, their produce will be included within the yard, the distance between the drills being only 27 inches; but if the yard be placed across one drill only, then its produce alone will be included, as the yard will not reach to the drill on either side; and if the produce of the whole field is calculated on such data, the result, in the second mode of measurement, will just give half the amount of the first. These ways of estimating a crop, when thus plainly stated, appear ridiculous; but they may be causes of error by persons who are not aware of the powers of numbers when squared. A part of a field measured may give a different result from the whole, or from another part, as a crop on a rising knoll, compared with that in a hollow, where it may be twice as much as the other. Filling one cart-load and weighing it, and filling other loads to a similar bulk, without weighing them, is fallacious, when it is known that turnips grown on the same field differ much in weight. There is, therefore, no certain mode of estimating the weight of turnips in a field but by weighing every cart-load taken from it.

HISTORY OF THE TURNIP.

The history of the turnip, like that of most other cultivated plants, is obscure. According to the name given to the swede in this country, it is a native of Sweden; the Italian name *Navoni de Laponia* intimates an origin in Lapland; and the French names *Chou de Lapone*, *Chou de Suède*, indicate different origins. Sir John Sinclair says: "I am informed that the swedes were first introduced into Scotland *anno* 1781-2, on the recommendation of Mr Knox, a native of East Lothian, who had settled at Gottenburg, whence he sent some of the seeds to Dr Hamilton."[1] There is no doubt the plant was first introduced into Scotland from Sweden, but its introduction would seem to have been prior to the date mentioned by Sir John Sinclair. The late Mr Airth, Mains of Dunn, Forfarshire, stated that his father was the first farmer who cultivated swedes in Scotland, from seeds sent him by his eldest son, settled in Gottenburg. Whatever may be the date of introduction, Mr Airth cultivated them in 1777; and the date may be taken as corroborated by the silence of Mr Wight regarding its culture by Mr Airth's father when he undertook the survey of the state of husbandry in Scotland, in 1773, at the request of the Commissioners of the Annexed Estates. He would not have failed to report so remarkable a circumstance as the culture of so useful a plant, so we may infer that its culture was unknown prior to, and in, 1773. Mr Airth sowed the first portion of seed he received in beds in the garden, and transplanted the plants in rows in the

[1] Sinclair's *Hus. Scot.*, i. 278, note.

field, and succeeded in raising good crops for some years, before sowing the seed directly in the fields.

It is probable that the yellow turnip originated, as supposed by Professor Low, in a cross between a white and the swede,[1] and, as its name implies, the cross may have been effected in Aberdeenshire. The origin of the yellow turnip must therefore, on this supposition, have been subsequent to the introduction of the swede.

It is rather remarkable that no turnips should have been raised in this country in the fields until the end of the 17th century, when it was lauded as a field-root as long ago as the time of Columella, and even then the Gauls fed their cattle on them in winter. The Romans were so well acquainted with turnips, that Pliny mentions having raised them 40 lb. weight.[2] Turnips were cultivated in the gardens in England in the time of Henry VIII.[3]

SHEEP IN WINTER.

SHEEP ON TURNIPS IN WINTER.

Room having been prepared on turnips for sheep to be fed upon them, by removing half the crop in the manner described in fig. 59, the first thing to be done is to carry the articles on carts to the field to construct a temporary enclosure of a given space. It is the duty of the shepherd to erect the enclosure, and he requires in any case but little assistance from other labourers.

Enclosing Sheep on Turnips.—There are two ways of enclosing sheep upon turnips; with *hurdles* made of wood, and *nets* made of twine. Since the introduction of nets, the older method of enclosing with wooden hurdles has become exceptional, and is now seldom adopted unless where the enclosure or division is to stand for a considerable time, or for temporary fanks for sorting sheep. Still it may be useful to explain how the enclosures are formed of these wooden hurdles.

Wooden Hurdles.—Fig. 69 represents 2 Scotch hurdles set as they should be, and the mode of setting them is:

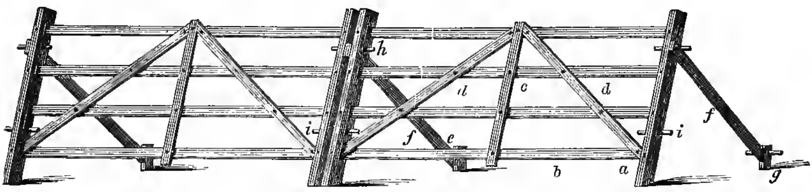


Fig. 69.—*Wooden hurdles or flakes set for confining sheep on turnips.*

The shepherd requires the assistance of another person for this purpose. The hurdles are set down in the line of the intended fence. The first hurdle is raised by its upper rail, and the ends of its side-posts *a* are sunk a little into the ground with a spade, to give them a firm hold. The second hurdle is let into the ground in the same manner, both being held in that position by the assistant. One end of a stay *f* is then placed between the hurdles near the tops of the heads, and the stay and hurdles are fastened together by the wooden pin *h* passing through holes in both side-posts and stays. Another pin *i* is passed through a lower part of the side-posts. The hurdles are then inclined away from the ground fenced, until the upper rail shall stand 3 feet 9 inches above the ground. A short stob *e* is driven into the ground

1 Low's *Ele. Agric.*, 290.

2 Dickson's *Hus. Anc.*, ii. 250-4.

3 Phillips's *Hist. Cult. Veg.*, ii. 365.

by the hardwood mallet, fig. 70, at a point where the stay *f* gives the hurdles the above inclination, and a pin fastens the stob and stay together, as seen at *g*. After the first two hurdles are thus set, the operation is easier for the next, as one hurdle is raised after another, and fastened to the last, until the entire line

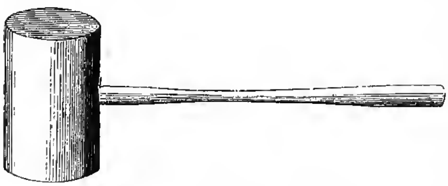


Fig. 70.—*Shepherd's hardwood mallet.*

is completed. The other component parts of a hurdle are *b* long rails, *c* stay-rail, *d d* diagonals.

Objections are made against this kind of hurdle, as being inconvenient to carry from one part of a field to another in carts — their liability to be broken in consequence — the shepherd being unable to set them without assistance—the time they consume in setting—being easily upset by a high wind blowing from behind them — and the constant repair they require in replacing pins, stays, and stobs. When carefully laid aside at the end of the season, these hurdles will last several years. They are best made of larch, and the separate parts are now prepared by machinery, and can be purchased and put together anywhere at small cost.

English Wooden Hurdles.—A very common hurdle used in England is shown in fig. 71. It is formed of any sort of

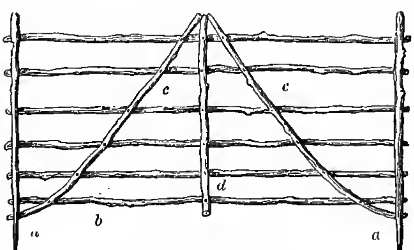


Fig. 71.—*English hurdle.*

willow or hardwood, as oak-copse, ash-saplings, or hazel. It consists of 2 heads *a a*, 6 slots *b*, 2 stay-lots *c c*, and an upright slot *d*. The slots are mortised into the heads and nailed with flattened fine-drawn nails, which admit of being very firmly riveted, upon which the strength of the hurdle mainly depends. Although the horizontal slots are cut 9 feet long, the hurdle, when finished, is only somewhat more than 8 feet, the slot ends going through the heads 1 or 2 inches: 2 hurdles to 1 rod of 16 feet, or 8 to 1 chain of 22 yards, are the usual allowance.

Erecting Hurdles. — The hurdles being carted to the field, they are laid down flat, end to end, with their heads next to, but clear of, the line in which they are to be set. A right-handed man generally works with the row of hurdles on his left. Having made a hole in the line of hurdles, for the foot of the first hurdle, with the *fold-pitcher*, fig. 72, which is an iron dibber, 4 feet long, having a well-pointed flattened bit, in shape similar to the feet of the hurdles, he marks on the ground the place where the other foot is to be inserted, and there with his dibber he makes the second hole, which, like all the others, is made 9 inches deep. With the left hand the hurdle is put into its place, and held upright while lightly pressed down by the left foot on the lowest slot. This being done, the third hole is made opposite to, and about 6 inches from, the last. The dibber is then put out of hand by being stuck in the ground near where the next hole is to be made; the second hurdle is next placed in position, one foot on the open hole, and the other foot marks the place for the next hole, and so on throughout the whole row. When the place of the second foot of a hurdle is marked on the ground, the hurdle itself is moved out of the way by the left hand, while the hole is made by both hands. When the whole row is set, it is usual to go back over it, giving each head a slight tap with the dibber, to regulate their height and give them a firmer hold of the ground.

Fig. 72.—*Fold-pitcher in hurdle-setting.*

To secure the hurdles steady against the rubbing of sheep, couplings are put over the heads of each pair where they meet, which is a sufficient security.

These couplings are made of the twigs of willow, holly, beech, or any other tough shoots of trees, wound in a wreath of about 5 inches diameter.

Nets for Enclosing Sheep.—Nets, made of twine of the requisite strength, form a superior enclosure for sheep; and, to constitute them into a fence, they are supported by stakes driven into the ground.

The *stakes* are best formed of thinnings of ash-trees which have been planted thick together, and grown tall and small, 3 inches in diameter and 4 feet 9 inches long—allowing 9 inches of a hold in the ground, 3 inches between the ground and the bottom of the net, and 3 inches from the top of the net to the top of the stake; or they may be made of larch weedings, 4 inches in diameter and 4 feet 9 inches long; but every kind of wood they are made of should be seasoned with the bark on before being cut into stakes. They are pointed at one end with the axe, and that end should be the lowest one when growing as a tree, as the bark is then in the most natural position for repelling rain.

Setting Sheep-nets.—A net is set in this manner: If the ground is in its usual soft state, the stakes may simply be driven into the ground with the hardwood *mallet*, fig. 70, in the line fixed on for setting the net, at distances of 3 paces asunder. The wood of the apple-tree makes the best mallet, as not being apt to split. Should the soil be thin and the subsoil moderately hard, a hole sufficiently large for a stake may be made in the subsoil with the tramp-pick used in draining; but should it be very hard and a larger hole be required than can be easily formed by the tramp-pick, or should the ground be so dry and hard as to require the use of any instrument at all, the most efficient one for the purpose is the *driver*, fig. 73, formed of a piece of pointed hardwood, strongly shod with iron, with its upper end protected by a strong ferrule of iron to prevent its splitting by the strokes of the mallet. The stakes are driven in until their tops may not be less than 4 feet high, along as many sides of the enclosure as are required at the place to form a complete fence.

Fig. 73.—*Driver for stakes.*

The net is set in this manner: Being in a bundle, having been rolled up when not required, the spare ends of the top and bottom ropes, after the stake is run through the outer mesh of the net, are tied to the top and bottom of a stake driven close to the fence, and the net is run out loose in hand towards the right as far as it will extend on the side of the stakes next the turnips. On coming back to the second stake from the fence, with your face to the turnips, the bottom rope first gets a turn to the left round the stake, then the top rope a similar turn round the same stake, so as to keep the meshes of the net straight. The bottom rope is then fastened with the shepherd's knot to this stake, 3 inches from the ground, and the top rope with a similar knot near the top of the stake, adjusting the net along and upwards; and so on, with one stake after another, until the whole net is *set up*, care being taken to have the top of the net parallel with the surface of the ground throughout its entire length.

Shepherd's Knot.—The shepherd's knot is made in this way: Let *a*, fig. 74, be the continuation of the rope fastened to the first stake; then, standing on the opposite side of the stake from the net, press the second stake with the left hand towards *a*, and at the same time tighten the turn of the rope round the stake with the right hand by taking a hold of the loose end of the rope *d*, and putting it between *a* and the stake at *c*, twist it tight round the stake till it comes to *b*, where it is pulled up under *a*, as seen at *b*, and there its elastic force will secure it tight when the stake is let go. The bottom rope is fastened first, to keep the net at the proper distance from the ground, and then the top rope is fastened to the same stake in the same manner, at the width the net admits, at stake after stake. If both the cord and stake are dry, the knot may slip as soon as made; but the part of the stake at *b* where the

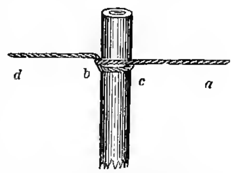


Fig. 74.—*Shepherd's knot, in fastening a net to a stake.*

knot is fastened on being wetted, the rope will keep its hold until the cord has acquired the set of the knot. It is difficult to make a new greasy rope retain its hold on a smooth stake even with the assistance of water, but a little earth rubbed on the stake will neutralise the greasy effect. A net may be set up either towards the right or the left as the starting-point may be situate, but in proceeding in either direction the top and bottom ropes should be wound round the stakes, so as the rope shall be uppermost towards the direction in which the net is to be set up. Thus, in fig. 74, the end of the rope *d* is above the rope at *a*, and continues uppermost until it reaches the next stake to the left, when it becomes undermost as *a* is here.

Precautions in Setting Nets.—Some precautions are required in setting a net. If the net is new, it may be set tight, because all the cords will stretch considerably; but if old, the least damp or rain will so tighten them as to cause them to break. If the net is damp, it may be set tight, because rain cannot make it tighter; and if not then set tight, dry weather will loosen all the knots, and cause the cords to slip down the stakes; and although it be not slackened to that degree, it will shake about with the wind, and bag down and touch the ground. This, however, may be remedied by taking a turn or two of the upper rope over a few of the stakes at regular intervals. In wet weather, shepherds take the opportunity of a dry moment for setting a dry net in anticipation along a new break of turnips, and they also hang up wet nets to dry on the stakes drawn along another break. Nets should never be wound up in a wet state, even for a short time, as they will soon contract mould and rot.

On connecting the setting of one net to another, its top and bottom ropes are fastened to those of the last net, and the ends of the nets themselves are brought together by lacing the meshes of both with a part of the twine left there for the purpose, as at *a*, fig. 75, or by lacing the

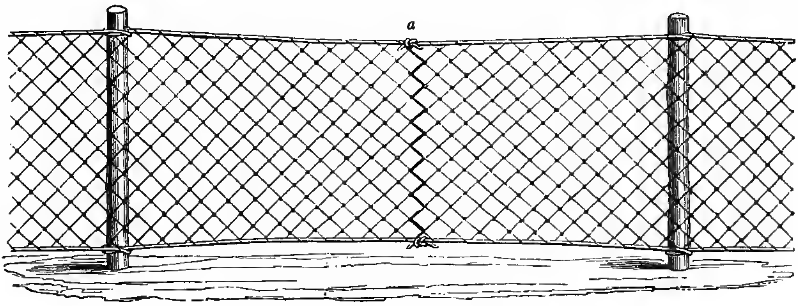


Fig. 75.—*Net set for confining sheep.*

meshes themselves. The spare end of one of the ropes is also often used for this purpose. One net is set after another, until the whole area is enclosed. Where there is a turn in the line of nets in going from one side of the enclosure to another, if a large piece of the net is still left at the turn, it may be brought down the next side; and the stake at the corner should be driven very securely, to resist the strain upon it by the nets pulling from different directions, and such a strain will be the most powerful in damp weather. But a safer and better plan is to take a fresh net at the turn, set it up by fastening it to a stake for itself, and coil up the end of the first net along the tops of its own stakes. All surplus ends of nets, when wet, should be hung upon the backs of the stakes to dry. Part of the nets will cross ridges, and part run along them. Where they cross flat ridges, the bottom of the nets will be nearly close to the open furrows. Where they cross high ridges, a stake should be driven at the side of the open furrow, and another at the crown of the ridge, and the bottom rope made parallel to the surface of the ground. Some sheep acquire the habit of creeping under the net where they find an opening.

In setting nets, each side of the enclosure should be in a straight line, the surface of the nets perpendicular, and any two sides should meet at right angles, so that every break of turnips should either be within a rectangle or a square: the strain will thus be equalised over the entire length of the cords and the stakes of each side, no undue pressure being exerted on any one stake. A shepherd who pays attention to these particulars, will preserve the nets and stakes much longer in a serviceable state than one ignorant or careless of them.

The shepherd should be provided with net-twine to mend any holes that may break out in the nets.

Begin on High Ground.—The method in which the nets and hurdles are set has now been made clear. A commencement is generally made on the upper corner of the field. The turnips have been stripped in the proportion, say, of taking eight and leaving four drills, as the greater the space for the first break, the better for the sheep. The first net is set parallel to the drills enclosing four stripes, and this net may be extended to any length, at any time. Another net is set at right angles to the preceding one, cutting off a portion of about 25 yards in length.

Extent of Roots given at a time.—We have, then, an enclosure ready for the reception of from 200 to 250 sheep. Next day about 12 yards is given, and a like amount the following day, after which the sheep will begin to eat the bulbs, and fall back on the partially consumed breaks. Where sheep are fully learned, breaks which will serve a couple of days, or three at most, are given, but this will altogether depend on the weather.

In frosty weather or snow, turnips sufficient for the day only should be given, otherwise the shells will become hard frozen in a very short time, and the sheep are unable to eat them, so that when a fresh sets in these rot. A good plan is to allow the sheep to work on the ground given during the forenoon, and set pickers on in the afternoon, and pick up all the shells for the sheep, no more ground being given than will serve the sheep for the day.

Carting Turnips to Lea Land in Wet Weather.—When the weather becomes wet, and the sheep cannot comfortably consume the roots upon the black earth, then carts are sent to work, and the turnips, after being tailed, are taken from the field and spread or sparted on old lea or pasture, and the sheep taken from the turnip-breaks until better weather sets in.

Another plan has been adopted by Mr George Brown, Watten Mains, Caithness, with a lot of 700 hogs. After the sheep are properly learned to eat the turnips, they are driven off the break every afternoon at 3 o'clock to a lea field, in which are placed boxes containing a mixture of chaffed hay and light oats. The sheep are left there until next morning, when they are returned to the turnip-break, to come off again at the same time. This plan not only saves turnips, but is also more conducive to the good health and rapid progress of the sheep than the system of keeping the sheep day and night on the turnip-break.

Still another plan—that of pulping turnips for sheep—is pursued by some with great success, and is described on p. 198 by Mr D. Buttar, Corston.

Begin Turnip-feeding Early.—The turnip-break should be made ready for the sheep before the grass fails, so that the feeding sheep may not lose any of the condition they have acquired on grass; for it should be borne in mind that it is easier and better for animals to progress in improvement than to regain lost condition. Much rather leave pastures in a rough state than lose condition in sheep for want of turnips. Rough pasture will never be wasted, but will be serviceable in winter to ewes in lamb and to aged tups. Feeding sheep, therefore, should be put on turnips as early as will maintain the condition they have acquired on grass; and this can be the more certainly attained, that cattle requiring turnips before sheep, the land will be the earlier cleared for the sheep.

Begin cautiously with Turnips.—It is considered advisable to avoid putting sheep on turnips for the first time in the early part of the day when they are hungry. Danger may be apprehended from luxuriant tops at all times, but when they are wetted by rain, snow, or half-melted rime, they are sure to do harm. The afternoon, when the sheep are full of grass, should be chosen to put them first on turnips; and although they will immediately commence eating the tops, they will not have time to hurt themselves.

Turnips risky for Ewes.—Sheep for turnips are selected for the purpose. Ewes being at this season with young, are seldom, in Scotland, put on turnips in the early part of the winter, but continue to occupy the pastures, part of which should be left on purpose for them in a good state, to support them as long as the ground is free of snow. As the lambing-time approaches, and the pastures begin to get bare, a few turnips are often given daily to in-lamb ewes, generally on a pasture-field, and along with a little hay and cake. But care should be taken never to give frozen roots to in-lamb ewes, as this has often been blamed for causing abortion. Many farmers also avoid giving turnips to in-lamb ewes, in the belief that they are liable to cause inflammation at lambing.

Tups on Turnips.—Aged tups are frequently put on turnips, and young tups always, but not in the same part of the field as the feeding sheep, having a snug corner to themselves, or the turnips led to them in a sheltered part of a grass field.

Draft Ewes on Turnips. — Every year a certain number of old ewes, unfit for further breeding, from want of teeth or a supply of milk, are drafted out of the flock to make room for the same number of young females, and are fattened upon turnips.

Young Sheep on Turnips.—It sometimes happens that the hoggs—the castrated male lambs of last year—instead of being sold, have been grazed during the summer, and are fattened the second season on turnips. "The usual plan of feeding turnips out of doors is to give them whole until the hoggets begin to lose their teeth; after that the cutter must be employed. In feeding sheep on turnips, whether hoggets or old sheep, it is important to begin early, say about the middle of September, or at all events before the first of October. Sheep will feed faster netted on the turnip-land than when the turnips are laid on the grass. The turnips may, however, be given on fresh pasture the first fortnight or three weeks, after which the sheep should be folded. When this is done, it is a great point not to give too large a break at once, but shift the nets or hurdles often."

Turnip-tops for Sheep. — "Care should be taken, however, not to shift the sheep or give them a fresh break when the turnip-tops are covered with white or hoar frost, as numbers of deaths happen from this cause. In fact, farmers put too much value on turnip-tops; if hoggs, fat sheep, or other feeding animals were never to taste them, they would fatten much faster. If the tops are cut off a day or two before the fold is shifted, and scattered over the ground, they wither before the hoggs get at them, and much loss is avoided.

"A supply of stored turnips should always be at hand to give the sheep in case of hard frost." [1]

Lambs on Turnips.—In this age of precocity, a great proportion of the wedder and part of the ewe lambs are fed and sent to the butcher before they are twelve months old. Even with the mountain breeds, such as Blackfaces and Cheviots, this practice is now pursued extensively, and in these cases the lambs are freely fed on turnips.

Mixed Sheep on Turnips.—With the exception of the tups, all these classes of sheep, of different ages, may together occupy the same break of turnips. It is seldom that the lambs of last year are kept on to the second year, but draft ewes are fed along with young sheep, and prove useful in breaking the turnips and eating the picked shells. A mixture of old and young sheep is less useful when turnips are cut by machines.

Nomenclature of Sheep.—In thus speaking of all the classes of sheep, here is a favourable opportunity of recognising those classes by acquiring their technical names in accordance with age and sex. A new-born sheep is a *lamb*, and retains the name until weaned from its mother. The generic name is altered according to the sex and state of the animal: when a female, it is a *ewe-lamb;* when a male, a *tup-lamb;* and this last is changed to *hogg-lamb* after it has undergone castration.

[1] *Farming World*, 1887, 317.

After a lamb has been weaned, until the first fleece is shorn, it is a *hogg*, which is modified according to sex and state, a female being a *ewe-hogg*, a male a *tup-hogg*, and a castrated male a *wether-hogg*. Hogg is said to be derived from the Celtic *og*, young, whence *ogan*, a young man, and *oigie*, a virgin.[1]

After the first fleece has been shorn, another change is made in the nomenclature: a ewe-hogg then becomes a *gimmer* or *shearling-ewe*, a tup-hogg a *shearling-tup*, and the wether-hogg a *dinmont*.

After the second shearing another change is effected in all the names: a gimmer is then a *ewe*, if *in lamb;* if not in lamb, a *barren gimmer* or *yeld ewe*, and if never put to the ram, a *yeld gimmer*. A shearling-tup is then a *2-shear tup*, and a dinmont a *wether*, but more correctly a *2-shear wether*.

A ewe three times shorn is a *twinter ewe* (two-winter ewe); a tup, a *3-shear tup;* and a wether still a *wether*, or more correctly a *3-shear wether*.

A ewe four times shorn is a *three-winter ewe* or *aged ewe;* a tup, an *aged tup*, a name he retains ever after; and the wether is now a *wether* properly so called.

A *tup* and *ram* are synonymous terms, applied to entire males.

A ewe that has borne a lamb and fails to be with lamb again is a *tup yeld* or *barren ewe*. After a ewe has ceased to give milk she is a *yeld ewe*.

A ewe when removed from the breeding flock is a *draft ewe;* gimmers unfit for breeding from are *draft gimmers;* and lambs, dinmonts, or wethers, when drafted, are *sheddings*, *tails*, or *drafts*.

In many parts of England a somewhat different nomenclature prevails. Sheep bear the name of *lamb* until 8 months old, after which they are *ewe* and *wether teggs* until once clipped. Gimmers are *theaves* or "two tooths" until they bear the first lamb, when they are *ewes of 4-teeth*, next year *ewes of 6-teeth*, and the year after *full-mouthed ewes*. Dinmonts are *shear hoggets* until shorn of the fleece, when they are *2-shear wethers*, and ever after are *wethers*.

Dry Food with Turnips.—When sheep are on turnips, they should always be supplied with dry fodder, hay or straw; that is, where they cannot have a daily run of some rough dry pasture. Clover-hay is the best and most nutritious, but fresh oat-straw answers the purpose very well. The best way of supplying dry food is to chaff the hay or straw and place it in the boxes which are required for the cut turnips later in the season. About ¼ lb. oats per sheep per day, mixed along with the chaff, gives excellent results; many of the sheep will be ready for the butcher without further feeding. The fodder may also be given in racks, which are of various forms: some are so elevated that sheep can with difficulty

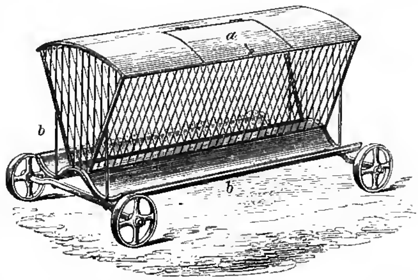


Fig. 76.—*Kirkwood's wire sheep-fodder rack.*

Rack of wirework 6 feet long, 2 feet 9 inches wide at top, 8 inches wide at bottom, and 2 feet 3½ inches deep.
a Curved cover of sheet-iron with a hatch.
b b Sheet-iron troughs to contain corn, &c.

reach the fodder; and others are mounted on too high wheels. An elegant, strong, and useful fodder-rack for sheep, fit for grass or tares in summer, or turnips in winter, is shown in fig. 76. It was invented by Mr Kirkwood of Tranent. The troughs are provided with a hole at each end to allow the rain to drain off, and might be used in dry weather for holding salt or oilcake for the day. The rack is mounted on axles and 4 wheels, to be moved anywhere.

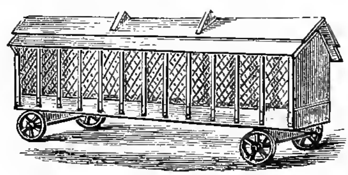


Fig. 77.—*Elder's sheep-fodder rack.*

Another very useful rack, made by Mr W. Elder, Berwick-on-Tweed, is shown

[1] *Notes and Quer.*, 1st ser., ii. 461.

in fig. 77. It is made chiefly of wood and wire, and is useful also as affording shelter.

Substitutes for Racks.—Another plan often adopted by farmers is to hang a net on a double row of stakes, the middle of the net forming a receptacle for the hay. Wire-netting with mesh of about 1¾ inch, hung on stakes, has also been found a very cheap and durable means of giving hay to sheep.

Supplying Fodder.—Two racks or more are required, according to the number of sheep. It is the shepherd's duty to fill them with fodder, and is easily done by carrying a small bundle of fodder every time he visits the sheep. When carts are removing turnips from the field, carry out the bundles, the shepherd having prepared them in the straw-barn or hay-house. Though only for shelter, the racks should be kept full of fodder. Fodder is consumed more at one time than another; in keen sharp weather the sheep eat it greedily, and when turnips are frozen they have recourse to it. In rainy or soft muggy weather it is eaten with little relish; but it has been observed that sheep eat it steadily and late, and seek shelter near the racks, prior to a storm; while in fine weather they select a lair in the open part of the break.

A combined rack and trough, specially designed to prevent waste in fodder, has been patented by Mr James A. Gordon of Arabella. It is brought out in various forms for holding cake and grain as well as fodder, and is sometimes made so that by its being turned upside down, the food is protected from damage by snow or rain. Fig. 78 shows Mr Gordon's "economiser," as applied to an ordinary wooden trough. The trough, or box, is 12 feet long, 9 inches broad at bottom and 11 inches at top, and 9 inches deep. The ends are made of wood 1¼ inch thick, the sides and bottom being ¾ inch, the top rail 1½ inch by 2½. The cut turnips, as well as cake, grain, or hay or straw, may in turn be given in this combined rack and trough.

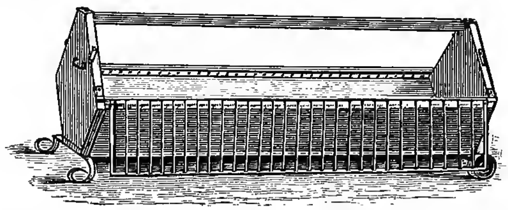


Fig. 78.—*Gordon's "Economiser."*

Fig. 79 is a simple and convenient form of trough for oats or other feeding-stuffs. A convenient length is 8 feet, its form acute at the bottom.

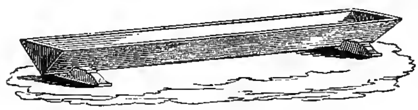


Fig. 79.—*Trough for turnip sheep-feeding.*

Picking out Turnips-shells.—Until of late years, sheep helped themselves to turnips, and when the bulbs were scooped out to the ground, their *shells* were raised with a *picker*, the mode of using which is seen in fig. 80. By this mode of action, the tap-root of the turnip is cut through and the shell separated from the ground at one stroke. The tap-root contains an acrid juice detrimental to the stomach of sheep, and should be left in the ground.

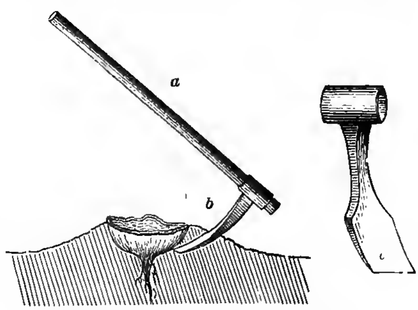


Fig. 80.—*Best form of turnip-picker.*

a Handle 4 feet long.
b Blade 10 inches long, including eye for handle.
c Breadth of blade 2 inches.

Only half the ground occupied by shells should be picked up at once, so that the sheep may take up a larger space of ground while consuming them. When the ground is dry, the shells should, on the score of economy, be nearly eaten up before a new break of turnips is given; and if any shells are left, the sheep will come over the ground again and eat them.

Cutting Turnips for Sheep.—The feeding of sheep on uncut turnips can be satisfactorily carried out until their teeth becomes defective: this occurs from the constant eating of hard roots, often in a semi-frozen state, which loosens the front teeth. The farmer can readily judge when other measures become necessary by the appearance of the bulbs, which have their outer skin peeled off by the sheep, and so left.

To meet this difficulty, the turnip-cutter comes into requisition. A most efficient machine is Samuelson's improved Gardner's cylinder turnip-cutter, fig. 81,

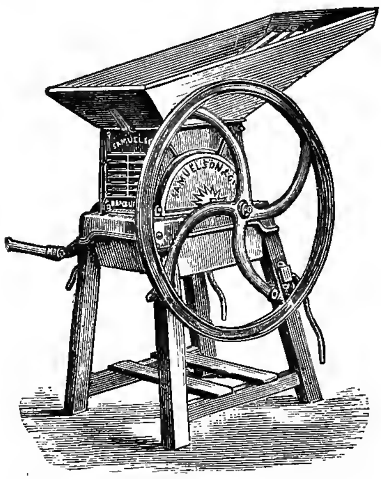


Fig. 81.—*Samuelson's Gardner's cylindrical turnip-cutter.*

which cuts the turnips into finger-pieces. In this form they are readily eaten by the sheep. The plan adopted, if the turnips are to be eaten on the land where grown, is to cast them into heaps alongside the net, a sufficient quantity for one or two days in each heap. The turnip-cutter is sometimes fitted up with boards, which enclose the framing beneath on three sides and bottom, the open side being opposite the driving-wheel; and a box 4½ feet long, 2½ feet deep, and of sufficient breadth to fit the open side of the cutter, is provided, and put on to catch the cut turnips. This arrangement prevents the cut turnips falling to the ground, and allows the work to be done in a satisfactory manner. The cut turnips are then given to the sheep in the troughs or boxes (fig. 82), 7 boxes being sufficient for 100 sheep.

The heaps being laid down at intervals allows the troughs or boxes to be changed to fresh ground daily, so that the land is equally manured all over the field. One worker can in this manner feed 300 sheep.

Feeding Cut Turnips on Lea.—In very wet weather, or late in the season, the sheep may require to be changed to lea or pasture, when the same plan can be adopted, or the sheep allowed their liberty over the whole field. In such a case the boxes or troughs are placed in line along the top of the ridge at one side of the field, and daily changed from ridge to ridge across the field until the other side is reached.

Force required.—All that is requisite to feed 500 to 1000 sheep is pony-gearing to drive the cutter, and a small cart with scoop to carry the cut turnips. The boy or man first attaches the pony to the arm of the driving-gearing, cuts the boxful of turnips, then yokes the pony in the cart and loads up, going from box to box down the ridge. The scoop takes sufficient turnips from the cart at each turn to make expeditious work.

A good method of placing the boxes is described on p. 199 by Mr D. Buttar.

Ploughing Land manured by Sheep.—A large field, that contains sheep for a considerable part of the season, is ploughed as each stretch of breaks is cleared, to preserve the manure. In ploughing, however, with this intent, the sheep should not be deprived of any natural shelter, which should be secured to them as long as practicable, by arranging the breaks so as to make the first at the most sheltered part of the field, that the sheep might resort to the bottom of the break they are occupying, after the first breadth of breaks had been given up and ploughed from the bottom to the top of the field. Such an arrangement requires some consideration at first, as its oversight may create much inconvenience to sheep in want of shelter, or delay in ploughing. Shelter to sheep on turnips does not merely imply protection from a blast for a night or two, but also preservation of the fleece, and comfort to the flock through the winter.

The Cutter Cart.—The old-fashioned method of cutting turnips by means of the lever slicer has now been superseded by the cutter cart, or cylinder cutter. The cutter cart is preferable for a small lot of ewes or tup hoggs. This implement may be briefly described as follows: A cart 7 feet long by 3½ feet broad, and 18 inches deep, is provided; 1½ foot of the hind part of the cart is boarded off from the main portion. In this division is a slip-door leading into a miniature cutter or slicer head, which is fitted up in the portion cut off behind. Under this head is placed an ordinary cutter barrel, with tooth gearing and clutch. The power is taken from the wheel of the cart by means of a chain which revolves upon a couple of pulleys attached to the nave and axle of barrel respectively. A lever being connected with the clutch, the machine can readily be thrown in or out of gearing. The slip-door being shut, the fore part of the cart is loaded up with turnips, and the cart taken to the field where the sheep are being fed. The machine is then thrown into gearing, the slip-door drawn, and the horse started down the centre of the ridge. The finger-pieces fall regularly to the ground, and the sheep eat them cleanly and thrive well.

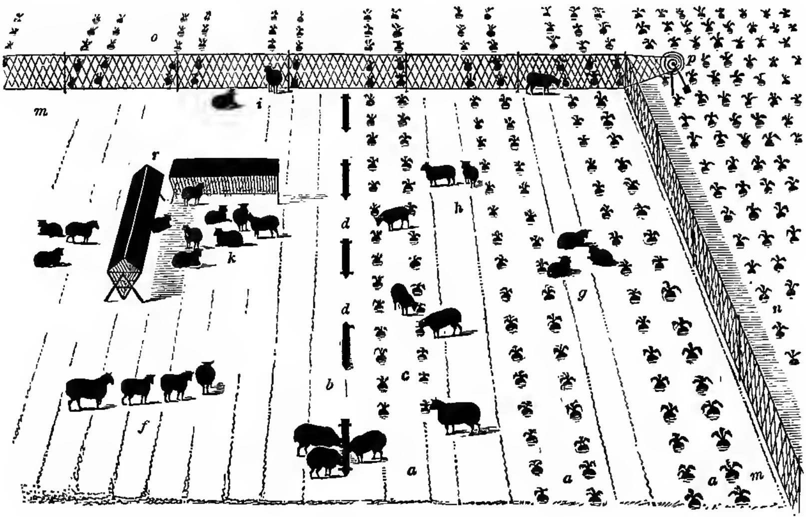


Fig. 82.—*Mode of occupying turnips with feeding sheep.*

This plan has been pursued for years with very satisfactory results by Mr George Brown, Watten, Caithness, in feeding a flock of 50 Border Leicester rams.

Cake or Corn for Sheep on Turnips.—Sheep while on turnips may receive either oilcake or corn, or a mixture of both. These concentrated foods are best served in a covered trough, to protect them from the weather. Mr James A. Gordon's patent combined rack and trough is shown in fig. 83, as it is used for holding cake or corn for sheep.

In fig. 84 is represented a very useful combined feeding-trough and corn-bin made by E. Thomas & Co., Oswestry. A supply of corn may be locked into the corn-bin and withdrawn and placed in the trough by the shepherd as desired.

Oilcake or corn, or both, may be served in these troughs to sheep on grass in winter as their entire food. Oilcake renders the dung of sheep moist. It is given them in a bruised form, partly in powder and partly in pieces, as it falls from the oilcake-breaker. There is no use measuring the quantity of oilcake to sheep when on turnips, as they will eat it when inclined, and some sheep eat it more heartily than others, but 1 lb. to each sheep a-day is the usual allowance, as is also of corn.

Oats and Hay for Hoggs.—Referring to the wintering of hoggs, a writer in the *Farming World* says: "Some prefer to put them wholly on turnips. My plan is to give them not more than two or three hours daily on the turnips, giving them the remainder of the time the run of a dry pasture-field, where they get ½ lb. of oats per head daily, and a handful of hay when the weather is hard. After the New Year the turnips must be cut for them; so from that date any turnips that are going are given in boxes *on the pasture.*"

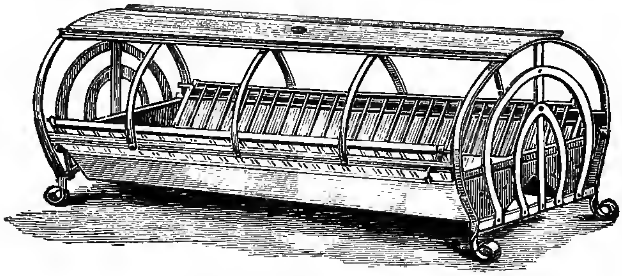


Fig. 83.—*Gordon's combined rack and trough.*

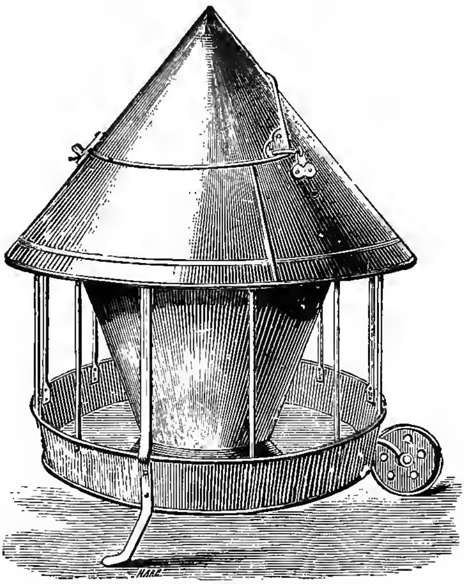


Fig. 84.—*Combined trough and corn-bin.*

Some useful information was brought out by the following query in the same journal from an East Lothian farmer: "I have still a lot of hoggets to finish off, and have no roots and no hay to spare for them, but plenty of oats and oat-straw. How shall I feed them?" One correspondent advised him to "chop fine the oat-straw and mix with rolled or ground oats, and say ½ lb. best oilcake per day for each sheep. Add a little salt to the mixture, or have some rock-salt convenient to the feeding-troughs, and plenty of pure water." A little bran would improve this mixture. Another said: "East Lothian had better take turnips for his hoggs in his own neighbourhood; for oat-straw and oats would be very unsuitable food for them without turnips, or their equivalent in green soft food."[1]

Ensilage for Tup Hoggs.—Mr W. Oliver, Howpasley, Hawick, says: "My tup hoggs were wintered on silage instead of roots, with the same quantity of Indian corn as they usually get, ½ lb. each per day. They did as well as on turnips, and certainly they never came out better as regards both health and condition; they preferred the silage to turnips."

Cake-breaker.—In fig. 85 is a representation of a first-class oilcake-

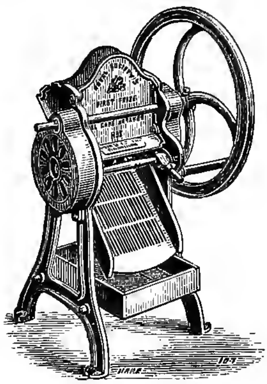


Fig. 85.—*Oilcake-breaker.*

breaker made by Barford & Perkins, Peterborough. The oilcake is put into the hopper, the mouth of which is open upwards. The two rollers bruise it to any degree of smallness, by means of pinching-screws. The bruised cake falls down the spout into any vessel below.

Salt for Sheep.—*Salt* is frequently given to sheep on turnips, and conveniently in a covered box, or in fig. 83, in the form of rock. The eagerness with which sheep at first follow the shepherd when he lays down a small quantity, here and there, upon flat stones, and the relish they manifest, are very remarkable; but the relish lasts a very short time, and by-and-by they will be found to eat very little of it. Sheep should have access to water when using salt. Perhaps the cultivator who advocated the use of salt to animals most perseveringly was Mr Curwen, of Workington Hall, Cumberland, who gave from 2 to 4 ounces per week to each sheep when on dry pastures, and on turnips or rape it was supplied without stint. Salt is said to prevent rot in sheep, and some have even gone the length of averring that it will cure rot, which is certainly erroneous.

Removing Sheep from Turnip Land in Heavy Rains.—There are certain inconveniences attending sheep on turnips *in winter*. A heavy rain falling for days will render the ground soft and poachy, though thorough-drained, or even naturally dry. Until the rain disappears, the removal of the sheep for a day or two to an old grass field where turnips can be carted to them will give the land sufficient time to resume its firmness.

A heavy rain may fall in a day, and inundate the lower end of the field with water, which may take some days to subside. The best way of keeping the sheep from any wet part of a field is to fence it off with a net.

Sheep on Turnips during Snow.—A fall of snow, driven by the wind, may cover the sheltered part of the field, and leave the turnips bare only in the most exposed places. In this case the sheep must feed in the exposed parts, and the racks should be so placed there as to afford shelter.

But the snow may fall heavily, and lie deep over the whole field, and cover every turnip out of reach. Two expedients only present themselves in such a case; one is to cast the snow from the drills containing the turnips, and pile it upon those which have been stripped. This cannot be done by the shepherd himself, or by female field-workers. The ploughmen must clear away the snow; and in doing so in severe frost, as many turnips only should be exposed as will serve the sheep for the day. When the

[1] *Farming World*, 1888.

snow does not lie to a great depth on the ground, the simpler plan is for the workers to start along the rows with ordinary pickers, and pull out a sufficiency of roots for the day. This plan is frequently adopted to provide turnips for both cattle and sheep.

The best plan to pursue at first, when a heavy snowfall takes place, is the other expedient,—to give the sheep oilcake and hay in their troughs and racks, in a sheltered place of the field for a time, until it is seen whether the snow is likely soon to disappear; and should it remain long, the snow may be cleared away, and its disadvantages submitted to. Yet it should always be borne in mind that sudden changes in food are undesirable for all kinds of stock, and have therefore to be avoided as much as possible.

Unripe Turnips dangerous.—In the winter of 1887 great mortality occurred in Perthshire, Dumfriesshire, and other parts of Scotland, amongst young sheep and ewes being fed on turnips. The death-rate in several cases was as high as 25 per cent, in one or two cases still higher. A form of "braxy" was generally believed to be the fatal ailment, and there seemed to be good reason to suspect that the cause of the disease was too exclusive feeding upon unripe unusually watery turnips. A *post-mortem* examination of some of the sheep which thus died, showed that their kidneys had been completely over-taxed in endeavouring to discharge the excessive amount of water consumed in the ill-balanced unripe food.

Commenting upon these fatalities, the *Farming World* (Dec. 16, 1887, p. 437) says: "It is more than likely that the unripe condition of the turnips is the primary cause of the present mischief; but any ill effects from unripe roots, it is well to know, may be completely counteracted by pulling the roots two or three days before the sheep are allowed to feed upon them. The present experience recalls the old saying that 'a good turnip year is never a good sheep year.'

"The fact is, that the Scotch method of turnip-feeding sheep is faulty to a degree and wasteful in the extreme. Were all the turnips pulled and cut before feeding them, one-half the present acreage grown would suffice, and as many animals would be fed, while they would thrive better."

Avoid sudden Changes in Feeding.—Writing in the *Farming World* as to the injurious influence of sudden changes in methods of feeding sheep, an experienced sheep-farmer says: "The plan which I would recommend, and have practised with great success, is to make inquiry when the sheep are bought as to their previous bill of fare, and feed accordingly. For instance, if the sheep had been on a good pasture, and getting just a bite of hand-feeding in the form of cake, I should not hesitate to commence cake-feeding at once, with a small allowance, of course. On the other hand, if the sheep came off a bleak exposed pasture, and had never been hand-fed, it would be madness to start them on cake. Better, far better, wait a little till they become acclimatised and accustomed to the place and richer pasture. Then commence with good hay, and after a bit give a small allowance of cake and corn when on the turnip-break.

"If the feed is gradually increased in this way, the sheep will be healthier and pay better than if the excessive forcing process were pursued. I have known hoggs bought off a poor place, and when brought home immediately given cake, and within a week were getting above 1 lb. per day. Small wonder, I say, that many died, and were lost altogether, because in a case of this kind the dead ones are usually found cold in the morning. That flock did not pay. A very few deaths take all the profit out of a lot of sheep nowadays. Yet feeding sheep does pay if properly done.

"I have been writing more especially of young half and three-quarter bred hoggs, but my remarks apply with equal if not more force to blackfaced stock. 'Hasten slowly,' and 'More hurry the less speed,' are very good mottoes to keep in mind."[1]

Fattening Wethers.—Mr S. Robinson, Lynhales, Hereford, states that the wethers which he fattens for slaughter are treated as follows: "They are weaned the last week in June, when they are put on a fresh pasture, and are drawn in two lots. They are allowed ¼

[1] *Farming World*, 1887.

lb. of linseed-cake, mixed with a few uncrushed oats and cut hay. In November they are put on common turnips, and the allowance then is ¼ lb. of linseed-cake, ¼ lb. decorticated cotton-cake, and a pint of crushed oats per sheep. This allowance is continued until after Christmas, when the sheep are put on to swedes, when ½ pint of peas is added to the above." [1]

Feeding Ewes in Lamb in Winter.—Whilst young sheep and tups are provided with turnips in winter, the *ewes in lamb* find food on the older grass, which, for their sakes, should not be eaten too bare in autumn. When pastures are bare, or snow covers the ground, they should have cut turnips in troughs, or, what is better, clover-hay in a sheltered spot. The best hay for sheep is the red clover, and next, meadow-hay; but much rather give them turnips than hay in a wet or moulded state, as such hay has an injurious influence on the health of the sheep; and as regards ewes in lamb, in particular, it is apt to produce abortion.

If turnips cannot be had, and the hay bad, give them sheaves of oats, or oats in troughs, or oilcake; but whatever extraneous food is given, do not supply it in such quantity as to fatten the ewes, but only to keep them in fair condition.

Ration for Breeding Ewes.—"A daily ration for each ewe of 1 lb. bran and ¾ lb. crushed oats, mixed with 2½ lb. of straw-chaff, has been found very useful in the case of a large flock when given from the 1st of January, where no roots, &c., could be given. Pulped roots mixed with straw-chaff also make a very good feed for ewes, where straw has to be substituted for hay." [2]

As to substitutes for hay and roots, in wintering ewes, Professor Wrightson says: "Rough cotton-cake given at the rate of about ½ to 1 lb. per head, according to the state of the weather, together with oat-straw or pea-haulm, would answer very well. It costs very little over ½d. per lb., and would cost from 2d. to 4d. per week. I find a good many farmers now rely a good deal upon pea-chaff, or the outer husk of peas. Also malt-combs mixed with chopped straw is a good substitute for hay, say ¼ to ½ lb. each per day, well turned over, and mixed with the chopped straw. There must be some bulky material, such as straw, together with a concentrated food, to keep sheep healthy."

Blackfaced Sheep in Winter.—"It is always safe policy in stormy weather to supplement the natural food with hay. Blackfaces being naturally very hardy, they require less artificial feeding in winter than almost any other breed of mountain-sheep; yet in excessively severe winters the prudent manager does not leave his sheep to forage for themselves until it is too late to help them. So long as the snow does not get too deep, or is not frozen hard, they take little harm. Blackfaced sheep are excellent workers in the snow, and will toil bravely for a sustenance under the most trying circumstances. Hand-feeding is only resorted to when it cannot be longer avoided; and in that case the sheep are either removed to a lower district or fed on hay at home." [3]

Hay-silage and Corn for Hill Sheep.—"Hay is still considered the best of winter foods for hill sheep; but silage is likely to take its place very largely in the damp regions of the Western Highlands, where hay-making is frequently seriously interrupted by wet or misty weather. Corn is only fed to blackfaced sheep in winter, when hay would be ineffectual in maintaining ewes in a condition fit to rear their lambs. Those so treated, however, are usually drafted the following autumn." [4]

When to begin Hand-feeding.—The proper time to begin the hand-feeding of hill sheep in a storm is a point of vital importance, and not easy to determine. "When to commence to feed, is a question that has created more discussion, more disagreement, and more loss of sheep than any other in the whole range of the subject of wintering sheep. . . . When the sheep once acquire a taste for hay or other food, they never settle afterwards so well to their natural fare; and even in fresh weather they continue to languish for food they don't re-

[1] *Live Stock Jour.*, 1886, p. 549.
[2] *Farming World*, 1887.
[3] *Blackfaced Sheep*, by J. and C. Scott, 109.
[4] *Ibid.*

quire, and which it will not pay to allow them. Rather than disturb their equanimity in this way, it is maintained, and rightly, by many good stockmen, that it is better for the sheep not to commence feeding them until it can be no longer avoided. Where the evil arises, however, is in putting off the inevitable for too long. The point which the stock-owner has to decide is whether the loss of condition [in the sheep], or the harm done by feeding in the event of a storm of short duration, is the greater evil. When the storm ultimately proves to be protracted, and lasts for perhaps a month or six weeks, then the earlier the feeding is commenced the better; but on the other hand, when a thaw shortly ensues, much damage may be the result. To rightly decide what to do, is not at all times an easy matter. . . . There is one rule, however, which may be given as nearly correct as it is possible to make it under the circumstances, and it is this: when feeding becomes necessary, it should be begun early, and not discontinued until there is plenty of grass."[1]

Dangers of putting Sheep in a Wood in a Snowstorm.—During a severe snowstorm we put ewes into an old Scots-fir plantation, into which only a small quantity of snow had penetrated, and supplied them there with hay upon the snow round the roots of the trees. A precaution is requisite in using a Scots-fir plantation in snow for sheep: its evergreen branches intercepting the snow are apt to be broken by its weight, and fall upon the sheep and kill them; and in this case, a ewe was killed on the spot by this cause the first night. Heavily loaded branches should therefore be cleared partly of their snow where the sheep are to lodge.

In driving ewes heavy with lamb through deep snow to a place of shelter, ample time should be given them to wade through it, in case they overreach themselves and bring on abortion.

Rape for Sheep.—In the south of Scotland, and more generally in England, rape is grown for sheep. The rape (*Brassica rapa oleifera* of De Candolle) cultivated in this country is distinguished from the colsat of the Continent by the smoothness of its leaves. It has been cultivated for feeding sheep in winter from time immemorial. The green leaves, as food for sheep, are scarcely surpassed by any other vegetable, in so far as respects their nutritious properties; but as a crop it cannot cope with turnips or cabbages. Its haulm may be used as hay as readily as cut straw.[2] The consumption of rape by sheep is conducted by breaks in exactly the same manner as that of turnips; but rape is never stripped or pulled, the entire crop being consumed on the ground.

In England, the rape intended for sheep is sown broadcast and very thick, in which state it grows very suitable for them. In Scotland, it is often raised in drills like turnips; and although not so conveniently placed for sheep as the broadcast, the top leaves being somewhat beyond their reach from the bottom of the drill, yet the drills permit the land being well cleaned in summer, which renders the rape an ameliorating crop for the land. It is acknowledged on all hands that, for oil, the drill form of culture is far the best.

Standing and Floating Flocks.—Every kind of sheep kept in the low country should be treated in winter in the way described above, though the remarks are meant to apply chiefly where a *standing flock* is kept. But on Lowland farms, in certain districts, no flock of ewes is kept for breeding, and sheep to be fattened on turnips are bought in, and are thus known as *floating* or *flying* flocks. For this purpose some farmers purchase wethers, others old ewes, dinmonts, or lambs. Sheep are thus easily obtained for turnips at fairs in autumn; but where certain mountain stocks have acquired a good name, purchasers go to the spot and buy them direct from the breeders.

Shelter for Sheep on Turnips.—Sheep on turnips have little shelter but what the fences of the field afford, or plantations. In some cases this is quite sufficient, but in others it is inadequate. Of late years the subject of shelter has attracted much attention, and artificial

[1] *Blackfaced Sheep*, by J. and C. Scott, p. 109.

[2] Don's *Dict. Bot.*, i. 245.

means have been suggested, consisting of various devices, involving different degrees of cost, to afford shelter not merely against sudden outbreaks of weather, but with the view of gradually improving the condition of sheep, both in carcass and wool. It is a natural expectation that a fat carcass should produce the most wool, and constant shelter preserve its quality.

An excellent temporary shelter for sheep on turnips may be made by the erection of a double line of hurdles or nets, the space between the lines being filled up with straw. A curve or angle can be introduced, and thus shelter can be provided for every quarter from which storms may come.

Ewes in lamb are very apt to catch cold, and when exposed to wet and cold weather, or kept in a wet lair, are liable to abort.

Littering the Turnip-break for Sheep.—Mr Hunter of Tynefield, in East Lothian, tried littering of the break occupied by sheep with straw, and supplied them with turnips upon it. He littered 300 sheep upon 17 acres of turnips with wheat-straw, at 26 cwt. per acre. The sheep thus treated for 5 months fetched 2s. a-head more than those treated in the usual manner. This increase of price is small, and not commensurate to the trouble of carting, at intervals, 22 tons of straw to the field—of carting the same, as manure, from that field to another.

When turnips are laid upon straw, sheep cannot bite them easily, from their rolling away; and this is an objection to laying whole turnips on grass, instead of cutting them with a turnip-cutter. Amongst damp litter sheep invariably contract foot-rot; and of Mr Hunter's flock many became lame, and some died.[1]

Feeding Sheep in Sheds.—In former times the feeding of sheep in sheds was strongly commended by a few who had experimented upon it with satisfactory results. Others, however, were less successful, and while it may be useful for small flocks, it is not likely to come into extensive practice where large flocks are kept. Shed-feeding has been tried by one or two enthusiasts in modern times, but has rarely been successful, as if attempted for any lengthened period, the sheep were almost invariably foundered, or attacked with foot-rot. The practice, if it could be called such, has indeed been entirely discontinued.

There can be no doubt that the better plan to adopt with our domestic animals, especially sheep, is to keep them as nearly as possible in their natural condition. The only improvement which can safely be introduced is to increase their comfort, but not at the expense of exercise, fresh air, and the health-giving influences of temperature; otherwise we must weaken the constitution, deteriorate the quality of the mutton, and diminish growth.

In the most northern county of Scotland, which has been famed for its breed of sheep, shed-feeding, when thoroughly tried, proved an utter failure, and is now never attempted, except where Leicester rams are early clipped, and even then it has been modified, as the rams have the run of a field during the day.

Feeding sheep in boxes, and tied up in stalls like cattle, has also been tried by enthusiasts, but neither system can be said to come within the range of practical stock-rearing.

"Shed and Yard" Feeding.—A much better method than attempting to feed in sheds is what is known as "shed and yard" feeding. In reference to this system the *Farming World* (October 28, 1887, p. 317) says: "Shed or yard feeding is now much practised, and with considerable advantage when extra feeding is to be given; for a sheep put up to fatten does not require exercise any more than a steer or a pig; but the system requires a great deal of attention. For the accommodation of 100 sheep, a shed 60 feet long and 8 feet wide, with a yard at least twice that size, must be provided. The yard and sheds should be divided by a railing 4 feet high, into five compartments, so as to separate the sheep into lots of twenty. Troughs for turnips should be placed in the yards, and boxes and racks for corn, cake, and hay should be fitted up around the inside of the sheds, and the floors of the sheds should be kept well

[1] Sinclair's *Husb. Scot.*, ii. App., 47.

bedded with dry peat-litter or cut straw.

"A flock of 100 feeding sheep in the yard will nearly occupy a lad's whole time, as the turnips must be all cut and carried to the troughs. The sheep should only get as many turnips as they will eat up clean, and no more. As soon as they have done feeding, the troughs should be swept out and kept fresh for the next feeding-time. The food should always be given at stated hours. The allowance of grain or oilcake may vary from ¾ to 1½ lb. per head per day—half the quantity to be given in the morning; and while they are eating it, the keeper should be filling the troughs with cut turnips, and during the time they are eating these, he should clean out the sheds. When the turnips are eaten the troughs should be cleaned and a little hay put into the racks, after which the yard should be immediately shut up, and the animals left in quietness till next feeding-time, which should be about twelve o'clock. The second allowance of cake or corn should now be given, and turnips to follow—adopting the same process as in the morning. They should be again fed at four o'clock with turnips, and a little good hay given them in the racks; after this last meal of turnips, the yard should be closed for the night. Each yard should have a close-boarded door, in order that the sheep may not at any time be disturbed from the outside; in fact, no person should be allowed to go near them, except the keeper and master. The keeper on no account to have a dog. Quiet and rest are the two grand requisites in yard-feeding, with regularity and cleanliness."

Shed for Sheep.—A very good shed for sheep can be made with a tight roof, and west, north, and east parts covered up tight, leaving the south side open. Let the roof slope to the north and extend far enough over the sides, so that a good gutter will carry off the water. If the dirt taken out of the gutter is banked up against the side, it will assist in keeping it dry. Having a dry place to stand is fully as important as a good roof, and in planning the sheep-yard take some pains to build the shed where good drainage can be readily secured.

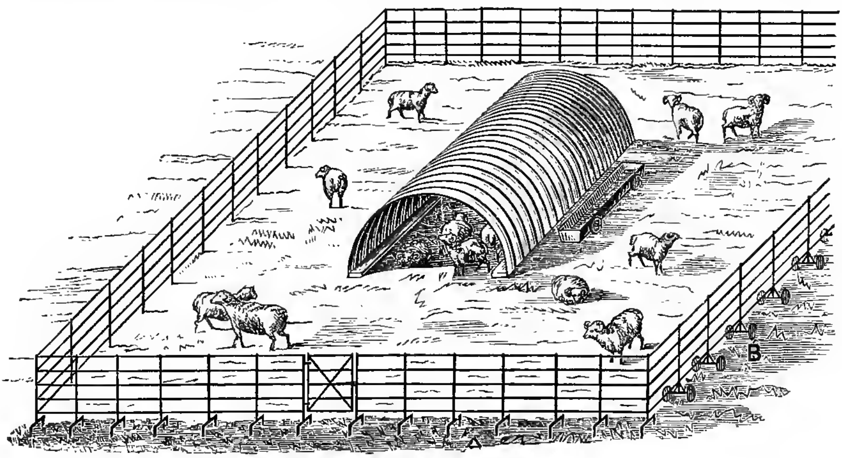


Fig. 86.—*Sheep-yard and shelter.*

Fig. 86 represents a very useful form of yard and shed for sheep, made by T. Pearson & Co., Midland Iron Works, Wolverhampton. The important feature here is the simple, durable, and efficient form of the "shed," which is constructed of galvanised iron, corrugated and covered, and resting upon a wooden bearer. In exposed situations, a close fence for the yard would be preferable.

White Turnips *v.* Swedes for Sheep.—Some curious and interesting results were brought out by experiments made by Mr Pawlett in feeding sheep on *different kinds of turnips*, and in *washing* these. A lot of lambs were put on white turnips in October, and another lot on swedes, and in the course of the month the lot on white turnips had gained each 10¾ lb., while that on swedes only gained 4¾ lb. each, showing a gain of 6 lb. in the month. Other experiments for the same purpose produced similar results. "Since these experiments," observes Mr Pawlett, "I have invariably used white turnips for lambs in the autumn, and find they are excellent food if not sown too early in the season, and are not too old at the time, and preferable to swedes during the months of September and October, equal to them in November or until the latter part of that month, and very inferior to them in December, or when the weather becomes cold and frosty. Lambs are not naturally fond of white turnips, and will take to swedes much sooner."

A turnip-cutter will bring sheep to like any turnip sooner than any other expedient.

Washing Roots for Sheep.—"Being aware," writes Mr Pawlett, "that it was the custom of some sheep-breeders to *wash* the food—such as turnips, carrots, and other roots—for their sheep, I was induced also to try the system; and as I usually act cautiously in adopting any new scheme, generally bringing it down to the true standard of experience, I selected for the trial two lots of lambs. One lot was fed, in the usual manner, on carrots and swedes *unwashed;* the other lot was fed exactly on the same kinds of food, but the carrots and swedes were *washed* very clean every day: they were weighed before trial, on the 2d December, and again on the 30th December, 1835. The lambs fed with the unwashed food gained each 7½ lb., and those on the washed gained 4¾ lb. each; which shows that those lambs which were fed in the usual way, without having their food washed, gained the most weight in a month by 2¾ lb. each lamb. There appears to me no advantage in this method of management—indeed animals are fond of licking the earth, particularly if fresh turned up; and a little of it taken into the stomach with the food must be conducive to their health, or nature would not lead them to take it."[1] The earth would act as an alkaline tonic.

Linseed-cake for Sheep.—To test the value of *linseed-cake* as food for sheep, Mr James Bruce, Waughton, East Lothian, took two lots of sheep of 60 each from two flocks. A part of two fields of swedes, which had a uniform soil and crop, was carefully divided into equal portions, each of which was occupied by 20 sheep.

One lot of 60 consisted of half-bred dinmonts of good quality, 20 of which *a* were put on turnips alone, 20 *b* on home cake, and 20 *c* on foreign cake. On the 1st January *a* weighed 2803 lb., *b* 2768 lb., and *c* 2739 lb. On the 7th February, *a* having consumed its portion of turnips, was reweighed, and found to be 2880 lb.; on the 1st of March, having also consumed theirs, *b* weighed 3054 lb., and *c* 2966 lb. The quantity of cake consumed by each division was 1182 lb., being nearly 16 oz. each day per sheep.

The other lot of 60 consisted of Cheviot dinmonts of inferior quality, 20 of which *d* were put on turnips alone, 20 *e* on home cake, and 20 *f* on foreign cake. On the 9th January, the weight of *d* was 2031 lb., of *e* 2082 lb., and of *f* 2001 lb. On the 15th of February, *d*, having finished their turnips, were reweighed and gave 2097 lb.; and on the 2d of March, having also finished theirs, *e* weighed 2315 lb., and *f* 2274 lb.; *e* and *f* on the cake consuming the same quantity of turnips. The management of this lot was exactly similar to that of the other, described above; but the sheep would take no more than 13 oz. each of cake each day.

The results of both these experiments are given in the following table:—

Lots of Sheep.		Live weight at first.	Live weight at last.	Incr.	Incr. from cake.	Cake eaten.	Of cake to produce 1 lb. mutton.	
		lb.	lb.	lb.	lb.	lb.	lb.	oz.
60	20 *a*	2803	2880	77	..	..	..	..
	20 *b*	2768	3054	286	209	1182	5	3
	20 *c*	2739	2966	227	150	1182	7	14
60	20 *d*	2031	2097	66	..	..	..	..
	20 *e*	2082	2315	233	167	880	5	4
	20 *f*	2001	2274	273	207	880	4	4

The remarks which the perusal of this table suggests are—that as regards in-

[1] *Jour. Royal Agric. Soc. Eng.*, vi. 368-370.

crease of live weight, the offal of sheep remaining comparatively the same, whatever weight is gained is of intrinsic value; that the improvement on turnips alone is below the average; that the improvement experienced by *b* and *e* on the home cake, in the one field, was reversed by *c* and *f* on the foreign in the other field—a circumstance quite unaccountable. The average quantity of cake to produce 1 lb. of mutton was 5 lb. 10 oz.

Linseed, Beans, and Turnips for Sheep. — In another experiment, Mr Bruce put 15 sheep *a* upon linseed, 20 *b* upon linseed-cake, 20 *c* upon a mixture of beans and linseed for three weeks, and afterwards upon poppy-cake, 20 *d* upon beans, and 20 *e* upon a mixture of beans and linseed. The results will be understood by the contents of the next table. An explanation is given for the use of beans with linseed to the sheep in *a*; the linseed, lying in a ground state, had acquired a musty smell, and the beans were added to induce the sheep to eat it.

Lots of sheep of 20 each.	Weighed at first.	Weighed at last.	Incr.	Eaten by each sheep per week.	Incr. of each sheep per week.	Quantity of ingredients to produce 1 lb. mutton.	Total consumption.
	lb.	lb.	lb.	lb. oz.	lb. oz.	lb. oz.	lb.
a	1839	2008	169	3 8½ Beans & linseed 4¼ Beans	1 4	2 14½ Linseed	477 Linseed 36 Beans
b	2401	2603	202	7 1¼ Linseed-cake	1 2	6 5 Linseed-cake	1275 Linseed-cake
c	2382	2479	97	5 15½ Beans & linseed	1 9¾	4 11 Beans & linseed	310 Beans 48 Linseed
...	2479	2657	178	9 13¾ Poppy-cake	1 7¾	6 10 Poppy-cake	1180 Poppy-cake
d	2404	2557	153	7 1¼ Beans	0 13½	8 5¼ Beans	1275 Beans
e	2417	2736	319	6 4 Beans & linseed	1 12¼	3 8¼ Beans & linseed	702 Beans 422 Linseed

Linseed-cake saving Roots. — In order to ascertain whether those substances would economise the consumption of turnips, Mr Bruce put all the sheep on a full allowance of white turnips, with abundance of the materials enumerated above, and the results were—that the saving of turnips effected by linseed-cake is very great, and secures a larger proportion than the cake used in the former experiment realised; but much of these results must depend on the size and condition of the sheep, as the lower the condition the greater quantity of food will be consumed. It may be safely held, says Mr Bruce, that an allowance of 1 lb. of good linseed-cake to a sheep of 9 stones weight imperial, every day, will effect a saving in the consumption of turnips of 33 per cent, and at the same time improve its health so as to diminish the chances of death by upwards of 50 per cent. This last result is well worth remembering.

Increase in Tallow.—Whether or not the use of these extraneous ingredients increases the tallow in sheep, is a reasonable inquiry; and Mr Bruce made experiments to ascertain this point also, by taking 5 average ewes from each division of the experiment, first weighing them, and in two days afterwards killing them after being driven 23 miles. The results are detailed in the following table:—

Lots of Sheep of 5 each.	Fed upon.	Live weight, Dec. 23.	Weight of carcass, Dec. 25.	Weight of tallow.	Weight of skin.
		lb.	lb.	lb.	lb.
a	Linseed and beans	666	344	55	52
b	Linseed-cake .	647	335	57	57
c	Beans and linseed and poppy-cake	654	338	57	57
d	Beans	641	327	49	52
e	Beans and linseed	688	347	61	50

Advantageous to use Rich Foods with Turnips. — The conclusion Mr Bruce draws from these experiments is, that "they clearly establish the fact, that mutton can be produced at a lower rate per lb. upon a liberal use of such ingredients along with turnips than upon turnips alone, taking, of course, the increased value of the manure into account; and that of the articles used, linseed is the most valuable, and beans the least so, but that a mixture of the two forms the most nutritious food."[1] This last result is also worth remembering.

In the section on Foods, information is given as to feeding sheep with malt, barley, wheat, peas, &c.

Wheat-meal *v.* Linseed-cake.—In a comparative trial between the nutritive property of wheat-meal and linseed-cake, Mr P. H. Frere obtained the following results from December 26 to February 20:—

	lb.
Linseed-cake.	
5 Down shearlings gain .	99
5 East-down hoggets gain . . .	108
Wheat-meal.	
5 Down shearlings gain . .	100½
5 East-down hoggets gain .	106½

All four lots are put on swedes; the shearlings eat 6 stone per pen per day; the hoggets 4 stone.

Cabbages *v.* Swedes. — Mr John M'Laren, farm-manager to Lord Kinnaird, Rossie Priory, Perthshire, made an experiment to ascertain the comparative values of cabbage and swedes in feeding sheep. He selected 10 Leicester wethers bred on the farm for each kind of food, and placed them in a well-sheltered lea field with a division between them, and supplied the food in troughs, with abundance of hay. The particulars of the following table will at once show the results:—

No. of Sheep.	Kind of food.	Weight of 10 sheep, 1st Dec. 1855.		Weight of 10 sheep, 1st Mar. 1856.		Gain of weight.		Value of gain at 6d. per lb.			Weight of food consumed.			Weight of crop per acre.		Value of crop per acre.		
		st.	lb.	st.	lb.	st.	lb.	L.	S.	D.	tons	cwt.	lb.	tons	cwt.	L.	S.	D.
10	Cabbage	90	10	101	5	10	9	3	14	6	8	13	47	42	14	18	6	6
10	Swedes	89	3	100	7	11	4	3	19	0	8	10	7	26	12	12	6	7¼

Mr M'Laren offers these remarks: That both lots were sold in Edinburgh at the same price, 52s. 6d.; that each lot consumed about the same quantity of food, 21$^1/_5$ lb. cabbage per day each sheep, and 20$\frac{9}{10}$ lb. swedes; that swedes gave a return of 11 st. 4 lb. of weight, and cabbage 10 st. 9 lb.; that 3 cwt. 40 lb. less of swedes were consumed; that taking mutton at 6d. per lb., swedes were worth 9s. 3¼d. per ton, and cabbage 8s. 7d. per ton; that the extra cost of raising cabbage was £4, 10s. 11d. per acre, and of swedes 7s. per acre; but that the great additional weight of crop gave a balance in favour of cabbage, at the above prices, of £1, 15s. 11¾d. per acre.[2]

Mangels for Lambs and Sheep.—It is feared by some that mangel-wurzel is dangerous food for lambs, and not without reason, at an early period of winter, because it is well known that unmatured roots of all kinds act powerfully upon the bowels. Even swedes may produce black scour on hoggs before November. But Mr Thomas Stagg, Grafton Manor Farm, Wilts, believes in no such accusation against mangel. He has had 600 or 700 sheep and lambs on it for 15 years. His treatment of lambs with mangel is this: "The quantity I commence with giving lambs is about 10 bushels of cut roots to a hundred lambs per day; this quantity I increase gradually as the season advances, and as the lambs grow, and require more food. Of course, large animals would require more than small."

No doubt, when hoggets are first placed on roots, we must be careful not to overfeed, especially if the animals' condition is low. In such cases black scour sets in, and mortality is great. Hence a little artificial food given at this time will keep lambs in thriving condition. When first put on turnips, ½ lb. of oilcake, with chopped hay or fresh oat-straw, will be sufficient.

Reluctance to give Hay to Hill Sheep.—In his prize report on wintering a flock of sheep, Mr Thomas Carruthers refers to the prejudice which he says exists among some stock farmers against feeding hill sheep in winter, and adds: "That such should be the case at this time of day, and that any rational being can expect sheep or any other animal to

[1] *Trans. High. Soc.*, July 1849, 376-381.
[2] *Ibid.*, October 1858.

live without food, surpasses my comprehension. I hold that whenever winter sets in with severity the sheep should be foddered, and when hay fails they should be fed with locust-beans or something else. Were this more attended to, thousands of sheep might be saved which now perish from hunger."[1]

Consumption of Food and Increase of Weight.

Sir John Bennett Lawes states that "fatting sheep, fed liberally upon good food, composed of a moderate proportion of cake or corn, some hay or straw-chaff, with roots or other succulent food, and well managed, will on the average consume about 15 lb. per week, and should yield over a considerable period of time one part of increase in live weight for about nine parts of the dry substance of their food. If the food be of good quality, sheep may give a maximum amount of increase for a given amount of total dry substance of food, even provided the latter contains as much as five parts of total non-nitrogenous to one of nitrogenous compounds."

Canadian Experiments on Sheep-feeding.—Many important experiments on the feeding of live stock have been carried out by Professor Brown at the Ontario College of Agriculture and Experimental Farm, Guelph, Ontario, Canada. The following summarised results of a series of experiments conducted by him on the feeding of sheep may be perused with interest and advantage:—

Oats and Hay with Turnips.

Results per head per day with four head for fifteen weeks, beginning 10th November: The sheep in this test and all the others hereto noted are Oxford Downs and Shrops grade wether lambs, dropped on an average in March, and with the exception of the high and low feeding, were alternated to the different foods in pens, as described.

The average wether lamb receiving 1¾ lb. oats, 2⅔ lb. of clover-hay, and 1⅓ lb. of turnips, gave a daily increase of fully ⅓ lb., at a cost of 9 cents (4½d.) per lb. to the added weight of the animal.

Peas and Hay with Turnips.

In this experiment the average wether lamb consumed fully 1½ lb. of peas, nearly 2½ lb. of hay, 2$\frac{11}{16}$ lb. turnips per day, and increased in live weight at the rate of ¼ lb. per day—cost, 12 cents (6d.) per lb. of added weight.

Beans ana Hay with Turnips.

The daily consumption of this ration was 1⅛ lb. beans, 2$\frac{7}{10}$ lb. hay, and 1¼ lb. turnips, and the increase to live weight scarcely 1 lb. per week, which makes a cost of 19 cents (9½d.) to produce every pound added to the live weight of the average wether lamb.

Low Feeding of Sheep.

Upon a daily ration of 2½ lb. of clover-hay, 1 lb. pea-straw, and 4 lb. of turnips, the average wether lamb increased in weight at the rate of nearly ⅔ lb. per week, and the cost of producing 1 lb. to live weight amounted in this case to 22 cents (11d.)

High Feeding of Sheep.

Results per day with four wether lambs for 15 weeks:—

Food Consumed.								Daily increase.	Weekly increase.	Weight of average animal at finish.
Oats.	Peas.	Beans.	Bran.	Hay.	Roots.	Oilcake.	Thorley.			
lb.	lb.	lb.	lb	lb.	lb.	lb.	lb.	lb.	lb.	lb.
.507	.354	.101	.601	1.992	1.269	.27	.2	.2	1.4	125

The food above enumerated is the daily ration as consumed by the average wether lamb, upon which it increased in weight at the rate of $^1/_5$ lb. per day; cost of production 12½ cents (6¼d.) per lb.

[1] *Farming World*, 1888, 507.

Comparative results in Feeding Wether Lambs.

	Weekly increase per head.	Weight at finish.	Cost of increase per lb.
	lb.	lb.	cents.
Oats and hay with turnips	2.60	143	9
Peas and hay with turnips	1.75	124	12
Beans and hay with turnips	.95	117	19
Low feeding	.63	112	22
High feeding	1.40	125	12½

Analysis.

The rapid and cheap production of mutton in winter has here been attained best by the use of oats and hay; and second, by peas and hay. This places six wether lambs as equivalent to one two-year-old steer. The average of these two only distinct ordinary forms of feeding sheep in this test equals ⅓ lb. per head per day, and 10½ cents for the added 10 lb. in weight.

Beans do not seem to be as profitable food for sheep as peas, as the rate of growth of the average wether lamb is little over half, and the cost of production is double that of peas.

That poor feeding is expensive feeding is well illustrated here: not one-third the ordinary rate of progress, and twice the cost of production, must be very much the position of those who practise such economy as this.

Cross-bred *v.* Pure-bred Sheep.—It accords with experience that cross-bred sheep return a larger quantity of mutton in the same food and time than pure-bred sheep. Half-breds somehow consume more food than pure-breds. Perhaps an analogy might be found in the human race. A raw-boned middle-class consumes more food than a high-bred upper-class, and acquires a heavier weight in a given time than the more refined individual, who will maintain his condition on a smaller allowance of food.

This is an interesting proposition in the comparative economy of the farm.

Mr Bird has endeavoured to solve it. He selected 4 lots of 5 matured wethers in each, consisting of Leicesters Twice-crossed, pure-bred Cheviots, and Half-breds. The Half-breds were a cross between Leicester and Cheviots, and the Twice-crossed were between the Half-breds and Leicester tups. The enclosures within which they were confined were hurdles and straw, open above, in the same fold against a stone wall, and were 15 yards in length and 9 broad. Their food consisted of swedes cut with a Gardner's slicer in troughs, and oats for the last 5 weeks of the experiment, which lasted from 13th November to 16th March. This table furnishes the particulars of the experiment:—

Kind of Sheep.	Weight, 13th Nov. 1858.	Weight, 16th March 1859.	Gain on weight.	Turnips consumed.	Oats consumed.
	st. lb.	st. lb.	st. lb.	sq. yds.	lb.
Leicesters	51 9½	55 10½	4 1½	1220	128
Twice-crossed	50 6½	57 3½	6 11	1295	128
Cheviots	50 1½	56 9½	6 8	1300	128
Half-breds	50 0½	60 10½	10 10	1417	128

The Half-breds having thus gained 4 stones more weight than any of the others, in return for little more than 100 square yards more turnips consumed, undoubtedly must be awarded to them the superiority of acquiring an increase of weight. It must be observed that the Leicesters did not eat so plentifully as the others, and were for several weeks before the close getting discontented both with food and confinement, two of them having literally lost weight of 1 st. 1 lb. This experiment corroborates the common idea that half-breds pay better for food than pure-breds—that is, where the latter are, like the former, kept for direct mutton production, and where they have no special value in the raising of young stock to be sold for breeding purposes.

Sheep on Carse-farms.—Sheep are not fed on turnips on every kind of farm. Carse-farms are unsuited to this kind of stock, and where turnips are raised on them, cattle would be more conveniently fed on them. And even where there are no turnips, it would be better on carse-farms where straw is plentiful to keep cattle than sheep, and feed the former upon the straw, cake, and grain.

Sheep near Towns.—On farms in the neighbourhood of *large* towns, whence a supply of manure is obtained at all times, turnips are not eaten off with sheep. The turnips in this case will usually bring more money by being sold to cow-feeders. Near small towns sheep are fed on turnips to manure the land. They are bought in for the purpose, and consist of wethers, hoggs, or draft ewes: the ewes, if young, feed more quickly than wethers of the same age.

Sheep on Dairy-farms.—On dairy-farms there is as little use for sheep as near towns, except a few to eat off any surplus turnips.

Attention to Details. — Mr John Coleman well observes: "Fatting sheep should be kept in rather close quarters, and placed in small lots about 40 in each pen; fresh ground given each day if practicable, and great regularity in feeding observed. During the short days of winter, the routine of operations should consist in supplying corn and cut straw the first thing in the morning; and whilst this is being consumed, the troughs should be filled with roots—the swedes having been carefully cleaned, and also the troughs: success depends upon attention to details. The sheep feed until replete, and at about ten to eleven lie down to ruminate. The fresh fold may now be pitched, and the animals left undisturbed until about two; feeding then recommences. More corn and cut straw (either then, or, which is better, the last thing at night), and the root-troughs filled. A teg (or hogg) will consume from 18 to 20 lb. of roots, and ¾ to 1 lb. of cut straw, with corn, daily. As the spring advances, the sheep must be attended to betimes in the morning and late at night, and the roots supplied three times a-day. Water should be given, and boxes with rock-salt should never be absent."

DETAILS OF MANAGEMENT IN TYPICAL FLOCKS.

Although it is with the winter management that we are in the meantime chiefly concerned, it may be convenient to present here in a connected form the outstanding features in the systems pursued throughout the year in a few leading flocks.

Mr T. H. Hutchinson's Leicesters.

Mr T. H. Hutchinson, Manor House, Catterick, Yorkshire, has long maintained a very celebrated flock of the genuine old English Leicesters. In response to a request for information as to his system of management, he writes:—

"I keep a flock of pure-bred Leicesters, which I find to answer my purpose better than any other breed. My aim is to produce as much wool and mutton as possible from the produce of my farm, and to keep the land in a very high state of cultivation.

"I annually put 100 ewes to the ram, and generally average about 1½ lambs to a ewe. The ewes are put to the ram last week in September.

"Besides the lambs I breed, I buy from 150 to 250 to 'turnip' during the winter. As I cannot buy pure Leicesters, I generally buy 'north' lambs—that is, lambs bred from Cheviot ewes with three crosses of the Border Leicester. These do remarkably well on turnips, and go off fat in February and March, weighing from 16 lb. to 22 lb. per quarter.

Feeding of Ewes.—"The ewes run on the grass in autumn, and have roots with cut oat-sheaves given in addition before lambing, also hay if I can spare it. After lambing, the ewes get roots with a mixture of malt-combs, linseed-cake, bran, oats, and cut hay, until the pastures are good enough to keep them going.

Feeding Lambs.—"The lambs are weaned in July either on to some after-grass or good old pastures, until cabbages or thousand-headed kale are ready. After that they go on to Fosterton Hybrid turnips, then finish on the swedes. As soon as the lambs go upon cabbage, &c., they are allowed a mixture of crushed tail corn, linseed-cake, malt-combs, bran, &c., made into a kind of lamb food. I prefer a mixture to cake alone. When put upon turnips the roots are all cut, the turnips all being stored in October and early part of November in small pieces. Hay and straw are also given. I find nothing like plenty of dry food for sheep on turnips.

"A piece of rock-salt should always

be kept in a trough, for the sheep to go to when they like.

"The lambs and ewes are all dipped after clipping, and again in autumn.

"The rams for show purposes are kept as well as possible, and get the best of everything likely to do them good.

"You ask me what quantity of turnips or other food should be consumed per day. I am sorry to say I cannot tell you. I always let the sheep have plenty to go to, and fancy they are better judges than I am as to the quantity they require; at any rate, I leave it to them to decide."

Glenbuck Blackfaces.

Age of Draft Ewes.—The valuable flock of highly improved Blackfaced sheep belonging to Mr Charles Howatson of Glenbuck is managed in a very systematic and skilful manner. Mr Howatson takes only four crops of lambs from his ewes before parting with them, as he finds that better and stronger lambs are bred from robust young ewes than from exhausted old ewes, and that, as a matter of course, five-year-old draft ewes sell better than ewes a year older. The draft ewes are sold early in October, and the whole remaining flock is then dipped, the dipping being repeated in January if the weather permits.

Early Lambs.—Mr Howatson lets out his rams about the first week of November, which is about a week earlier than the general custom. The best lot of rams go first, and then in about three weeks the remainder of the rams are put amongst the ewes, so as to pick up those not already served.

Ram Lambs.—Mr Howatson has so much improved his flock, that he finds a ready demand for all his ram lambs for breeding purposes, so that none of them are castrated. He retains a few of the choicest of the ram lambs for his own flock, and the remainder, with the spare ewe lambs, are sold at the Glenbuck ram sale in September, which is now one of the principal events of the year in blackfaced circles. The system of selling ram lambs, so successfully inaugurated by Mr Howatson about 1870, is growing in favour, as thereby the purchaser gets possession of the young sire before he can be spoiled by over-feeding, as is sometimes the case with rams sold as shearlings in September.

Ewe Lambs.—The Glenbuck ewe lambs are weaned in August. The selection of ewe lambs to be retained in the flock are dipped and sent back to the hill till the second week in October, when they are despatched to the low country, where they are wintered at a cost of from 7s. to 8s. per head.

Clipping.—Clipping begins in the second week of June with the ewe hoggs. At this time care is taken to mark for sale any of the ewe hoggs which may not in every respect be satisfactory for breeding purposes, special attention being given to the fleece, in the improvement of which Mr Howatson has been very successful. Mr Howatson thinks it advantageous to delay clipping ewes until the new wool is well raised, and the clipping of them is therefore postponed till the latter part of July.

Cheviot Flocks.

Mr John Robson, Newton, Bellingham, whose valuable and old-established flock of Cheviots has for several years taken the leading position in showyards, has favoured us with some notes relating to the management of his own and other similar flocks. His flock is entirely home bred. He casts ewes at 5 or 6 years old, according to the ground they go on. Almost all West-country ewes are sold at 6; further east or on the Cheviot range, at 5 years old.

Selling Young.—Wether lambs used to be hogged on the farm, and kept till 3 or 4 years old, then sold fat—or in plentiful turnip years, for turniping. Now, on account of bad seasons, increase of sickness, and low price of wool, they are mostly sold as lambs, to go to better land to be fed off as shearlings; or if kept on hill farms, they are sold at 2 years old.

Weights.—Ewes weigh when sold probably 60 lb., Wethers, 72 lb.; but, of course, when very fat they greatly exceed these weights.

Hirsels.—On the Cheviot Hills a farm is generally divided into two hirsels. On large farms the number of hirsels is of course multiplied indefinitely. But take a sixty-score farm—the ewe hirsel will contain three ages of ten scores of ewes each, 3, 4, and 5 years old; the hogg hirsels, two ages of fourteen or fifteen scores each of 1 and 2 years old sheep. At clipping time the 2 years old ewes or "young ewes" are brought from their "hogging" and put amongst the ewes, their ground being hained till the end of July, when the ewe lambs are weaned and taken to it.

Land "tired of Hogging."—Thus lambs never follow lambs, the ground always getting a year's rest from lambs, as they are allowed to remain till 2 years old. If lambs follow lambs too often, the land is apt to get "tired of hogging," which, if continued, means that the hoggs either die freely of sickness or of poverty.

Age for Breeding.—When farms are managed on this system, the gimmers are not, except on the very best low-lying farms, expected to bring lambs; only a few of the strongest are put to the tup, to provide lambs for setting on.

West-country System.—The other or West-country system is to allow the ewe lambs to follow their mothers—none but those on the draft ewes being weaned, and those only for ten days, when they are put back to their mothers. Here the gimmers in good seasons are expected to bring lambs, all but a few of the worst get the chance of the tup, and the ewes are generally sold at 6 years old.

On land addicted to louping-ill this is much the best way, as there is less change; but on the healthy and stormy Cheviot Hills the former plan has this advantage, that it provides a stock for the harder and higher ground which would not keep ewes, and also allows of the hoggs being better looked after in a storm.

Feeding in a Snowstorm.—The only difference between winter feeding and summer is, that if a snowstorm comes which blocks up the ground so thoroughly that little or no natural food can be got, the sheep are given hay. About one pound each is the usual quantity once a-day, as early in the morning as possible. Great care should be taken to keep sheep in as small "cuts" as possible—100 is about the best number, and every farm should have a stell for every cut of sheep.

Hand-feed judiciously.—Hay should only be given to prevent hunger, as on some land sheep which have been heavily hayed do not thrive next summer so satisfactorily as those which have not been so much pampered. Corn or cake has also the same tendency, and ewes which have been hand-fed one winter always look for the same indulgence afterwards.

Wethers on Turnips.—Wethers are mostly kept on turnips about 20 weeks the first winter, and 6 or 8 weeks the next.

Extra Food with Turnips.—As a rule, no additional food is given to sheep on turnips, but sometimes when turnips are taken by the week they get hay or straw; feeding-stuff is rarely given. If a hill-farmer has turnips of his own, he is generally a generous feeder, giving cake or corn and hay to fatting sheep, and hay or straw to hoggs. In a storm all sheep get hay, but seldom corn or cake.

Dressing.—The sheep are dipped either in October after the surplus stock is cleared off, or in the spring. The latter is the best time for killing vermin, but in bad springs it is often difficult to get suitable weather for dipping. Usually some of the well-advertised sheep-dips are used; but since money became scarcer many farmers have begun to use preparations of their own, which are often quite as efficacious and cost much less.

Rams.—The rams are usually kept amongst the other sheep during summer. In winter they get turnips, and when being prepared for sale a little cotton-cake.

Price and Quantity of Turnips.—Turnips for wethers cost this year (1887) 5d. or 6d. per week; for hoggs, 3d. And as an acre of fair turnips is said to winter a score of hoggs, it may be supposed that the same quantity will keep 20 wethers 10 weeks. Probably an acre and a half will be required to feed 20 wethers.

Winchendon Oxford Downs.

Mr John Treadwell, Upper Winchendon, Aylesbury, Bucks, favours us with the following notes as to the management of his famous prize flock of Oxford Downs: "This flock being entirely devoted to ram-breeding, is in many respects managed differently from an ordinary flock kept for mutton producing.

Management of Ewes.—"About the middle of August the ewes are separated into lots, according to their suitability to the different rams to be used; and as many of the sires used are home-bred ones, care has to be taken as to the different pedigrees, as well as to size, wool, and symmetry. This adapting the rams to the different ewes is considered the most important factor in the whole matter of breeding.

"This farm containing a large proportion of grass-land—two-thirds—enables the ewes to be placed in lots as they are drawn in the different pastures, excepting what are served by *the show sheep*. These latter ewes are generally put on to a piece of old seeds or stubbles, and probably come on to a piece of cabbage or some other green food at night, having a 'teazer' with them; and the ewes as they come into use are taken up and served by these heavy sheep on a stage, or what we term *hand-tupping*.

"About the beginning of November when the ewes are all served they are put together, and clear up mangel-tops, stubbles, seeds, or anything there is for them. When this is done they are again drafted into smaller lots about the pastures, until they come up to the lambing-pen for lambing. They are sometimes dipped in November at the veterinary surgeon's dipping-yard, but not always.

"Rather a large number of rams are used, as some have only a very few ewes and others have a fair number, varying from 10 to 70 to a ram.

"When the ewes come up to the lambing-pen they get a little hay or straw, according to the weather and their condition; and they run on pastures by day. As soon as they have lambed they return to the pastures, and have about 2 pints of oats each, and hay if they require it. The oats are continued until April, when they are gradually taken off, as the grass comes on.

"They are shorn about the end of May, and the lambs are generally weaned in June—the ewes being put to vetches or clover, or a rough pasture, or anywhere where they can be kept cheaper until tupping-time.

"The draft ewes get better treatment at this time. They are fed on the pastures, sometimes getting some cake and corn until they are sold off fat or put to roots or cabbage to finish. These get to very heavy weights if put on roots and brought out in January. They will average about 16 to 18 stone when well finished. Sometimes some of the best of them are sold to breeders to keep on another year or two.

Treatment of Lambs and Rams.—"The lambs when weaned are separated, the ram lambs getting a little cake and corn at once. The ewe lambs do not get anything with the grass, as a rule.

"The ram lambs have their cake and corn increased slightly as the season advances, but do not get much attention until after the shearling rams are sold in August, when they are got on to the arable land as soon as some rape or turnips or something can be got for them. They then follow on to swedes and mangels until about the beginning of April, when, if the weather permits, they are shorn, kept in for a few nights, and out in the day, but kept out entirely as soon as possible. They get on to kale, then to rye, and then to vetches, with which they get some mangels until the cabbages come, when these take the place of mangels.

"These rams grow very fast and get big by the 1st Wednesday in August, when about 60 of the best of them are annually sold by auction at home, when buyers from almost every county in England and from many distant countries attend, and every sheep offered is always sold—the rest of the rams having been generally sold previously by private bargain to foreign buyers, chiefly Germans.

"The show rams are managed differently, being selected from the rest in October, shorn, and fed in the sheds—of course getting more fare.

"The ewe lambs generally go off the pastures on to rape in October, and then on to turnips, with which they get a little cotton-cake. In the spring about half are selected for the flock, and they are fed on vetches or seeds or pasture until turned into the ewe flock, when the rams are put amongst them. The draft ones are put into the pastures, and sold during the summer for stock or to the butchers, the majority now going to the United States for breeding purposes.

"The stock rams, except those for showing, are not highly fed."

Nocton Heath Lincolns.

Mr Wright, Nocton Heath, Lincoln, keeps his well-known flock of well-bred Lincoln sheep in a liberal but natural and rent-paying condition.

Ewes.—The ewes are wintered on turnips and grass. A short time before lambing commences, they get cut straw or wheat-chaff, with a little linseed and cotton-cake and oats. No extra food on the grass in summer.

Lambs.—Lambs are wintered on turnips, with a liberal supply of cake and mixed corn, and cut straw and fodder. On the grass in summer they generally have a little cake and oats.

Rams.—The young rams have a liberal supply of cake and corn on the pasture in summer, as well as with the roots in winter. Stock rams have cabbage taken to them on the pasture, and receive cake and corn night and morning.

Littlecott Hampshires.

Mr F. R. Moore, Littlecott, Upavon, Wilts, has, like several other leading breeders of Hampshire Downs, given great attention to the breeding and rearing of ram lambs for sale in the autumn of the year in which they are dropped. He breeds about 200 ram lambs every year, and sells them in August and September for use as sires that same year. The stock ewes are kept on the Downs during summer. Before lambing, they get roots sparingly; after lambing, plenty of roots—that is, if any are grown—with cake, hay, and perhaps a little malt-dust. All the hay is cut into chaff, and if it is not plentiful, a quantity of cut straw is mixed with it.

The bulk of the ram lambs get corn and cake moderately when young, with rye, barley, mangels, and vetches, with rape, cabbage, &c., to follow in course. Show animals are fed more liberally.

Biddenham Oxford Downs.

Mr Charles Howard's valuable flock of Oxford Downs at Biddenham, Bedford, usually consists of about 400 ewes, from which he rears about 450 lambs.

Management of Ewes.—The ewes are generally put to the rams about the second week in August, and are from that time, with the run of the stubbles, the scavengers of the farm. Some white peas are grown for the use of the rams; immediately these are harvested, the stubble is either ploughed or dragged, and mustard sown, which is ready at the latter end of September, upon which the ewes are folded at night. After this is disposed of, they run the grasses, and are folded at night upon the land where the mangels have been drawn. A few kohl-rabi are generally sown with the mangels, which are left for consumption by the ewes. After this they generally consume the cabbage-sprouts, and are then supplied with some dry food. Approaching lambing-time, they are placed in comfortable yards at night, and have a supply of chaff and straw, with some bran, oats, and mixed cake. Previous to lambing, they get as few roots as possible.

Treatment of Lambs.—The ewes, after lambing, run upon grass adjoining the yards, and when the lambs are strong enough, they are placed upon the roots, with lamb hurdles for the lambs to run forward on the tops, and have a supply of bran, oats, and cake crushed very small. Mr Howard thinks it desirable to get them out of the yards as soon as possible, which of course depends upon the weather and the strength of the lambs. After the turnips are consumed they are placed upon winter oats and tares or the grasses, until the clovers are ready, the ewes being plentifully supplied with mangels. The lambs are weaned in June, and are placed as soon as possible on the aftermaths of clovers and grasses, when a supply of cabbages is drawn to them, which generally lasts until September, when a few white turnips of an early variety are ready for them, upon which they are folded at night.

Feeding "Tegs."—The feeding tegs get permanently settled about the middle or latter end of October upon roots, which are sliced for them, and have a supply of clover chaff and ½ to ¾ lb. mixed cake and split-peas, which is increased as the season advances to 1 lb., being then composed of mixed cake, split-peas, beans, peas, maize, and a little malt. The ram tegs are somewhat more generously treated.

The breeding ewe tegs get a good supply of clover-chaff and about ½ lb. of mixed corn and cake. The feeding tegs are ready for market between February and April, being between twelve and fourteen months old. Those sold in the former month are in the wool; those in April are shorn, and weigh from 10 to 12 stone, and as they are of excellent quality they command a good sale for the London market.

Feeding Flocks in Norfolk.

Mr Hubert V. Sheringham, South Creake, Fakenham, Norfolk, gives the following account of the Norfolk system: "I both breed and buy sheep for fattening, and that is the case with most Norfolk farmers, as few of them keep a large enough flock to breed as many sheep as they require to feed off their roots in the winter.

"As to feeding. The breeding ewes during lambing-time have a pen of turnips every day, and a mixture of cut hay and either malt-dust or bran, and some of the weaker ones get a little linseed-cake in addition to the other food. As soon as the lambs are able to eat they have a small allowance of Mackinder's lamb food, in troughs placed outside the fold (so that the ewes are not able to get it), and the quantity is increased as they are able to stand it. I usually take the lambs off the ewes about the end of May or beginning of June, and run them on trefoil and rye-grass until after the hays are off, when they are put on clover and sainfoin eddish, and I like, if possible, to have mangel to throw them until I have some turnips fit for use, about the middle or end of August. At this time the lamb food has been increased to about ½ lb. each.

"About the 20th of September the lambs begin feeding off the early turnips, having a fresh fold every day, and cut hay and a small quantity of linseed-cake added to the lamb food. This method of feeding continues until the beginning of November, when the sheep go on to swedes, which are put through a turnip-cutter, and given them in troughs, they (the swedes) having been previously thrown up into heaps; and the allowance of artificial food is increased to about ¾ lb. each until the last two months, when they get 1 lb. each of cake and corn. These sheep—cross-breds from Hampshire Down ewes and Cotswold rams—are fit for the butcher at a year old, and the best of them at that age will weigh from 84 lb. to 90 lb. each dead weight, and will clip a fleece of from 9 lb. to 10 lb. of wool."[1]

Mr H. Dudding's Lincolns.

Mr H. Dudding, Riby Grange, Great Grimsby, has a large and valuable flock of pure-bred Lincoln sheep—350 ewes on a 650-acre farm. In reference to his system of management he says: "The greatest attention is paid to the lambs after taking them from the ewes in July. As a rule, they have all got to eat well from the troughs a mixture of linseed-cake, crushed oats, and locust-beans, a little bran, malt-combs, and a little cut clover, which make a most healthy mixture, at a cost of under £5 a ton. The most critical time is before getting them on turnips in October without a loss, especially the cough which is caused by the throat-worm, and in many cases shrinks them 10s. a-head. After the hoggs, as they are now termed, have got well hold of turnips, they improve rapidly without much loss."[2]

Montford Shropshires.

Mr T. S. Minton, Montford, Shrewsbury, whose well-known flock of Shropshire sheep has taken a high position, both in the show-yard and sale-ring, says: "The breed of sheep kept almost exclusively in this neighbourhood is the Shropshire. They are very hardy, prolific, and produce high-class mutton and wool. My custom is to breed my own, having the lambs February and March. During March, April, and May, the ewes and lambs are on seeds one and two years old, the ewes receiving mangels at first, and the lambs a few split-peas (in a pen made on purpose in centre of field) during the latter part.

Care of Lambs.—"In June the lambs are weaned and put on a sweet pasture,

[1] *Live Stock Jour.*, 1886, 549.
[2] *Ibid.*, 573.

receiving a small allowance (two or three ounces) of corn, where they remain until the clover aftermath is ready, which generally lasts them July and August. The last few years the custom has been to shear the lambs in June, as we consider they grow better, are not troubled much with the fly, and keep much cleaner when on the turnip land in winter.

"In September lambs go on to the young seeds on the cleared barley stubbles, still receiving their corn, and where they remain until the middle of October, when they are gradually moved on to white turnips, where in the course of a week they remain altogether, and now receive ¼ lb. of corn and some clover-hay in racks. The hurdles are moved daily, and they bite their own turnips for the first month, when the roots are then cut into fingers. White turnips generally last till Christmas, and we then commence swedes. The allowance of corn is then gradually increased to ½ lb.

"The last few years I have sold mine in the wool, at from eleven to twelve months old, weighing about 80 lb. per sheep, and having from 8 to 8½ lb. of wool to cut. When on turnips they receive their corn the first thing in the morning, then a feed of turnips. During the morning the clover is put in racks, and another feed of turnips in the afternoon." [1]

Mr David Buttar's Flock.

Upon his arable farms of Corston and Baldinny, Coupar-Angus, Mr David Buttar maintains a large stock of sheep, and in response to our request he gives the following interesting notes as to his system of management: "The class of sheep principally kept by me are pure-bred Shropshires, but I also buy in a considerable number of other kinds of sheep for feeding during winter.

Shropshire Flock.—"My Shropshire flock consists of from 120 to 130 ewes, with 3 or 4 stock rams. The produce of these—numbering generally from 90 to 100 ram lambs, and the same number of ewe lambs—are all reared and sold in August and September of the year following for breeding purposes, with the exception of a few shotts or culls which go to the fat market.

Feeding of Stock Ewes.—"The stock ewes during winter are fed principally on the foggage of the farm, with no extra keep whatever, except perhaps a little hay and a few turnips during the time of a snowstorm. About the beginning of February—a month or so before the lambing season—I commence to give them a few fresh yellow turnips (swedes strictly withheld at this time) twice a-day, with a little hay; and as there is a considerable drain on their constitution at this time—the most of the ewes having two lambs, and sometimes three, to support—I increase their daily allowance of turnips by degrees till they get about 20 lb. each.

"After the ewes have lambed, I give them, in addition, a little linseed-cake and oats (crushed), and some bran, twice a-day, increasing the feed by degrees till they have a daily allowance of from 1 to 1½ lb. of this mixed food for each ewe with their lambs. I continue this till there is plenty of grass, when I stop giving the ewes any extraneous feeding, as they are apt to get too fat. But I continue to give the lambs about ¼ lb. each daily, which they get access to through hurdles made for the purpose.

"After weaning the lambs, which takes place about the middle of June or beginning of July, I put the ewes to the barest and worst pasture I have till September, when I again give them better keep to bring them into proper condition for the rams, which are generally put to the ewes about the first of October.

Feeding of Lambs.—"The lambs, on the other hand, after being weaned, are put on the very best pasture I have, with a continuance of their daily allowance of cake, bran, &c., which keeps them growing: once stint a lamb, and it will never do so well again, give it what you like. And when the pastures are getting bare towards the autumn, I supplement their feeding with an allowance of vetches, rape, cabbages, and suchlike, which I have always growing for them, and which, I think, is better for them than an extra allowance of cake, &c.

"During winter, the ram and ewe

[1] *Live Stock Jour.*, 1886, 573.

lambs being drawn, are folded on separate fields, and both fed very much in the same way,—their principal food being a mixture of cut hay and pulped turnips, with a few blades of thousand-headed cabbage, which stand the winter better than any other variety, and which the sheep are very fond of. They have also at all times a quantity of rock-salt beside them.

Young Rams.—"In April month the young rams are generally shorn, and for a week or two at that time are taken under cover on account of the cold. They are let out to the fields again in May when the weather gets a little warmer, and there they are fed on early grass, winter vetches, &c., with a little cake and corn if thought necessary.

Dipping.—"For the prevention of scab and other skin-diseases, and the killing of ticks, &c., the lambs are generally dipped twice a-year—first, shortly after they are weaned, and again about the New Year. The ewes are dipped only once a-year, shortly before the rams are put amongst them.

Prevention of Foot-rot.—"With the object of preventing attacks of this destructive ailment, we pass the whole flock *twice* during the year through a solution of arsenic, prepared and carried out in the following manner:—

Solution for Foot-rot.

"Boil 2 lb. of arsenic with 2 lb. of potash (pearl-ash) in 1 gallon of water over a *slow* fire for half an hour; keep stirring, and when like to boil over, pour in a little cold water; then add 5 gallons of cold water.

"Put this solution to the depth of 1 to 1¼ inch, just sufficient to cover the hoofs of the sheep, in a trough 12 feet long, by 18 inches wide, and about 6 inches deep—the trough to be set *perfectly level* along the side of a wall or other fence in some place out of the way, with a good waterproof lid on it, and secured by a padlock to prevent danger from the poison which might be left in it. There should also be a wooden fence on the other side of the trough, carried out a little at one end to conduct the sheep into the trough, as indicated in fig. 87.

"Before the sheep are passed through the trough their feet should be well pared; then walk them quietly through, and let them remain in the second pen twenty minutes or so before taking them back to their pastures.

"Before adopting this plan my sheep were scarcely ever free of foot-rot. Now they have not a single case of it, and

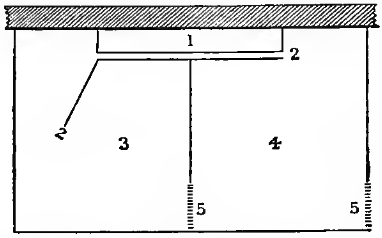


Fig. 87.—*Trough and pens for foot-rot dressing.*

1 Trough. 2 Fence. 3 First pen. 4 Second pen. 5 Gates.

have had none since I adopted the practice four years ago.

Feeding Sheep.—"The sheep I generally buy in for feeding purposes are two-year-old Blackfaced wethers.

Pulped Food for Sheep.—"They are all fed with pulped food, none ever seeing a turnip in the shape of a turnip. They are generally bought in about October or November; and as all the foggage on the farm is required for the breeding flock, the wethers are at once folded on a field of stubble on which I intend to have potatoes, or on any other suitable field, and commence to give them prepared food. At first I am very careful to feed them sparingly, till their stomachs are accustomed with such feeding; but after a few weeks the food is increased slightly from week to week till they get their full allowance, which is about 1 lb. cut hay and straw, 10 lb. pulped turnips, 1 lb. of cake and crushed grain, with a little salt. The cost of this full feeding per day is 1½d. for each sheep, or 10½d. per week; but from this must be deducted the value of the droppings on the land, which I value at not less than *one-third* of the whole cost, leaving a net cost for feeding of 7d. a-week, or say in round figures, 2s. 6d. a-month.

"In the autumn of 1877 I bought 400 two-years-old Blackfaced wethers, and on 9th November put them in two lots of 200 each on the pulped food.

On that day I drew out 10 average sheep of nearly equal size from each lot, and on weighing them, found they averaged 110 lb. each. I then weighed them regularly every month during the time I had them, and at the end of three months, when sold, they averaged 155 lb., being an average gain of 15 lb. each month, or about 8¾ lb. of mutton (allowing 58 per cent of the live weight for mutton). This, at 7½d. per lb., gave 5s. 6d. a-month for feeding, which cost only 2s. or so, as they did not get more than half the allowance of food for the first month."

Advantages of Pulped Food for Sheep.—"This system of feeding sheep, besides being much more profitable, has many advantages over the ordinary way of feeding in the fold. One very important advantage gained is that the sheep always get a clean warm feed instead of a bellyful of dirty cold frozen turnips, which is generally the case in the ordinary way. Besides this, the percentage of deaths is much less. Iu 1887, out of 800 sheep, I lost only one during the whole winter-feeding. Then, with me, the cost of labour in carrying out this system was no greater, as two men did the whole work of pulping and feeding, &c., for the 800 sheep; and they could have done no more had they been fed in the usual way. Without water-power for pulping, however (which I have), the cost would necessarily be a little more.

"By this system there is also a great economising of a costly and valuable root-crop, which is a very great advantage. In the usual way of feeding on the fold, an ordinary Blackfaced wether will consume not less than 20 lb. of turnips per day; whereas by this pulping system not more than 10 lb., the one-half, is required.

"The droppings of the sheep are also richer by this mode of feeding; and by careful attention to the shifting of the feeding-troughs, which should be done at least *once* every day, the whole field can be gone over and manured as equally as by the ordinary way of feeding off sheep.

Shifting Feeding-boxes.—"The following is the method I adopt in placing the feeding-boxes: Suppose there is a lot of 200 sheep to be fed; they require 20 feeding-troughs, of about 10 or 12 feet long, 6 inches wide at the bottom, 12 inches wide at the top, and 6 inches deep. These are put down in two rows, 5 yards or so apart, in the order below—

"A clear space of 12 feet or so (the supposed length of the troughs) is left between the ends of the troughs. By this means the sheep, and also the horse and waggon drawing out the pulped food, can freely pass round them in any way; and by removing the troughs forward about 5 or 6 yards every day, the whole field is thereby thoroughly and regularly gone over."

Sussex Flocks.

The first of three prizes offered (1888) by the *Farming World* for reports on the wintering of a flock of sheep was won by Mr H. Sessions, Truleigh Farm, Beeding, Sussex, from whose report we take the following extracts:—

"The farm lies on the north side of the South Downs, and has 300 acres below the hill, and 200 acres of down and hill arable.

Cropping.—"The hill arable is farmed almost exclusively for the sheep on a five years' system—corn, fallow crop, corn, and seeds for two years. Rape is almost invariably grown as the green crop, though cabbage sometimes is sown on a part of the fallow. Besides this rape on the hill we had eight acres just below, and ought to have had ten acres of swedes and turnips on the lower greensand for the ewes to eat during lambing, but the dry autumn prevented a plant being got, though the land was repeatedly worked and drilled, and had at last to be planted with winter oats, hoping they would come away in time for the ewes and lambs to run over in the spring. This, with five acres of rye and five of winter barley, constituted the available green food for the winter.

Stocking.—"The flock whose wintering I am describing is a well-bred South Down one, and consisted at the beginning of the winter of 262 ewes. There are 172 full-mouthed ones, the remainder being six-toothed. We put three rams with this flock on the 7th October, and kept them in until December 2d.

Winter Feeding.—"The ewes came

first into the rape under the hill, having a 'bait' twelve hurdles square in the middle of the day, running on the downs the remainder, and folding on a wheat stubble (where our mangels are now) during the night. The reason they did not go back to fold on the rape ground was the danger of having the present wheat crop too big and down, and also to help the mangel crop, a very important one on a heavily stocked farm.

"Just after Christmas the flock, having eaten their rape below, had to be sent on to the hill. To make a deadfold, protected from the winds, which come unchecked for miles, is very necessary. Fortunately we have a shed and walled yard, which, though not large enough to hold the flock, make a very useful base. To make it larger, straw stacks are put on the north and south sides, joining the east wall, in which is the gate. This leaves only the east side of the outer part unprotected, and we cut a number of furzes and built a wall against the hurdles to make that side also as snug as possible. The ewes lay here very comfortably; and even when the snow was three feet deep in their rapefold, and the cutting wind and frozen particles made it hard work to get to them, yet once there you were out of snow and wind.

"The ewes started the day with some mixed cotton and linseed cake, a bushel of each *per diem*, then on to the grattons till mid-day, back to a pitch of rape, then on the down until folding-time, when they went back to the fold from which they had eaten their rape, as long as the weather permitted. When it got colder and rougher they went to the deadfold at nights, following the same course during the days as long as they could. When the snow prevented their going out at all, they had three, and, as they got near lambing, five trusses of clover hay *per diem*, and unlimited oat-straw. This, with three bushels of linseed-cake, only just kept them in the same order—in fact, if either way, they rather lost flesh for a week or two.

"The end of February the ewes came down to the sheds and yards on the lower greensand. The feeding course now was —pea-haulm to start with, then three bushels of cake and five trusses of hay, out into the meadows, and back to a liberal allowance of oat-straw.

Lambing-yard.—"While the ewes were out, the time was utilised in getting the yard ready for lambing. It was divided into three main parts by thatched and furzed hurdles, which could easily be repitched as the numbers in the divisions altered. The largest part was at first for the 'full ewes,' the next division, about thirty pens, being reserved for the single lambs, and the last part being occupied by the twins. The bay of a barn was reserved as a hospital, and the occupants of that and the twins had rather a larger allowance of cake and the pick of the hay.

"As soon as a ewe lambed she was put into one of the pens, and drafted into one of the larger lots—twins or singles—when another ewe wanted her pen. After lambing, and while in the yard, they had a mangel each *per diem*.

Scour in Lambs.—"Several of the lambs died of scour; and in the case of singles we parted the weakliest twins, and put one to the mother of the dead lamb, using the dead lamb's skin as a coat for the stranger until the new mother took to it.

"There is no infallible remedy for scour; prevention is the great thing—keeping the ewes on proper food, and getting the lambs away from the crowded yards to the fields as soon as it can possibly be managed. When we saw a case of scour, the lamb had a dose of salts or oil, and sometimes the lamb died and sometimes it lived, whether through the salts and oil, or in spite of them, is hard to say.

Help in Lambing.—"When we had to help a ewe that was lambing, we used carbolic oil to dress the hands, and also as a salve for sore places, except on the udder, which, when inclined to garget, was dressed with fresh lard.

Late Spring.—"The late spring made it necessary for the ewes to stay round the yards much longer than was profitable or good for the sheep, but until the rye began to grow there was nothing for them elsewhere. They had their first fold of rye the second week in April, and ran the different meadows the rest of the day. When the meadows were eaten down they ran over the winter oats, and after that the winter barley, which just lasted them until the grass on the downs began to grow, where they are now coming into a fold of trefoil at night. The lambs run into a fold that is pitched forward, and have a bushel and half of linseed-cake in their troughs, which they eat greedily. The ewes have two bushels before they go to the downs in the morning.

"Of the 262 ewes with which we commenced the winter 1 died, 7 were barren, and we have 254 running with 281 lambs."

A Roxburgh Flock.

In his prize report on the wintering of Mr David Pringle's flock on the farm of Hyndlee, Bonchester Bridge, Hawick, Thomas Carruthers says:—

"There are five hirsels upon the farm, which is from 1200 to 1800 feet above sea-level. Pretnest and Nedslaw are mostly bog-lea, and have little heather; and Jedhead and Ravenburn, the farthest out and highest hirsels, are mixed with lea, moss, and heather, there being little bog.

Shelter.—"There are on the farm 16 stone stells of the cipher shape, that hold from 160 to 200 sheep each; and 5 old fir plantations, into which the sheep are admitted. We greatly prefer the plantations for shelter, the sheep lying much warmer than in the stells, as the drift goes through the stone walls. It is to be regretted that generally there are so few plantations on hill-farms, the want of which is the cause of great loss in severe winters. They afford the best of shelter, and improve the climate, and this is a department of estate management which should be more attended to.

Stocking.—"The stocking of the farm on the 1st November 1887 consisted of 1841 Cheviot ewes (three, four, and five years old), 366 Cheviot gimmers, and 455 Cheviot ewe hoggs; and 273 Blackfaced ewes (three, four, and five years old), 36 Blackfaced gimmers, and 125 Blackfaced hoggs,—in all, 3096 head.

Losses.—"We have lost by death, or otherwise, 11 Cheviot ewes (5 from inflammation of the lungs, 2 drowned, 1 disease in the head, 1 hanged in the hay-heck, 1 pined, 1 sturdy); 2 Cheviot gimmers (from sickness and sturdy); 9 Cheviot ewe hoggs (5 from sickness, 2 drowned, and 2 sturdies); 1 Blackfaced gimmer (from pining); and 2 Blackfaced hoggs (from sickness)—25 head in all.

Dipping.—"We bath with an oily dip, which we consider to be the best for sheeting the wool and keeping the sheep through winter.

Winter Feeding.—"Upon the hirsels where there is no heather, the Cheviot hoggs are taken to where heather and moss abound, which is hained for ten days or so previous. Whenever snow covers the ground, it is the practice at once to fill the hecks with hay, by this means keeping the sheep in good condition; and all this winter and spring till now hay has been given during snow or frost.

"The cuts of sheep mostly remain on their own hefts, there being either plantations or stells for every cut, and the hay is carried to them by sleds or on horses' backs.

"We try to fodder the sheep in the morning with hay; for, as a cup of good tea is cheering to man, so is a lock of good hay to sheep. And it is a fact that sheep spread themselves over the ground for grass far better after a good morning's bite of hay than when they get none. After getting the hay the shepherds go round and put them quietly away to the hill.

"When the weather is fine we hain the low ground; and during cold and wet we turn them down for shelter.

"Though it is rather expensive to make so much hay, still, from long experience, it is found to pay well. Besides a meadow of 50 acres, we make as much hay as we can get among the sheep's feet. We use the latter first, and reserve the meadow-hay till the spring. Ewes nurse lambs fairly well on good hay. Cows give abundance of milk on hay alone, and so will a ewe."[1]

Sheep on Pastoral Farms.

On pastoral farms, sheep are not fattened on turnips; but the treatment of sheep on them in winter possesses exciting interest. There are *two sorts of pastoral* farms for sheep, and a few re-

[1] *Farming World*, 1888, 507.

marks on their constitution and fitness for rearing sheep will be useful.

Want of Shelter.—The first thing that strikes any one on examining a pastoral country is the *entire want of artificial shelter.* After being accustomed to see the enclosed and protected fields of arable land, the winding valleys and round-backed hills of a pastoral country appear naked and bleak. One is not surprised to find bare mountain-tops and exposed slopes in an alpine country, because it is scarcely practicable for man to enclose and shelter elevated and peaked mountains with trees; but amongst green hills and narrow glens, where no natural obstacles to the formation of plantations seem to exist, but whose beautiful outlines rather indicate them as sites for clumps and belts of trees that would delight the eye, one would expect to see at least an attempt made to rear trees for the express purpose of procuring shelter and comfort to sheep; and should these be deemed too expensive for a whole farm, the farm-buildings might surely be protected by trees.

Fencing Plantations.—The chief difficulty of forming shelter on a large scale is the dreaded expense of enclosing plantations—for it is wisely concluded there is no use of planting trees unless they are protected from injury, and few animals injure young trees so much as sheep, by nibbling them with their teeth as well as rubbing against them with their fleece; and yet in a mountainous country there is no want of rock for building rough but substantial stone fences; labour is but required to remove and put them together, and it is surprising what a quantity of stones a couple of men will quarry from a hill-face, and a couple of single-horse carts convey, in the course of a summer. Carriage might always be sent down-hill, fresh rock being attainable at higher elevations as the fences proceed. Or, failing rock, turf, even peaty turf, makes a very good wall.

Suppose a hill-farm containing 4 square miles, or 2560 acres, were enclosed with a ring-fence of plantation of at least 60 yards in width, the ground occupied by it would amount to 174 acres. A 6-feet stone wall round the inside of the planting will extend to 13,600 yards, which, at 1s. 6d. per running yard, will cost £1020. But the sheltered 2386 acres will be worth more to the tenant than the interest of the cost, and of course also to the landlord, than the entire 2560 acres unsheltered would ever be; and the fence will accelerate the growth of the trees by 10 years at least, whilst the proprietor will have the value of the thinnings of the wood to meet the cost of fencing, over and above the value of the standing timber. Planting one farm with a ring-fence shelters at the same time one side of 4 adjoining farms of the same size. Were neighbouring proprietors to undertake simultaneously sheltering of their farms by large plantations, on a systematic plan, not only would warmth be imparted over a wide extent of country, but planting and fencing would be accomplished along march-fences at a comparatively small cost to each proprietor.

A Low Sheep-farm.—A low sheep-farm contains from 500 to 2000 sheep—one that maintains from 500 to 1000 is perhaps the highest rented, being within the capital of many farmers; and one of 1000 to 2000, if it have arable land attached to it, is perhaps the most pleasant to possess, as affording employment to the farmer, while he could easily manage 6000 sheep without arable land, with good shepherds. A shepherd to every 600 sheep is considered a fair allowance, where the ground is not difficult to traverse, and it may be a fair stent to put 1000 sheep on every 1200 acres imperial.[1]

Arable Land on Sheep-farms.—Every sheep-farm should have as much arable land as to supply turnips and hay to the stock, and provisions to the people who are on it. It is true, necessaries and luxuries of life may be purchased; but every dweller in the country would prefer to raise his own necessaries to purchasing them in town or village. It is not easy to determine the proportion which arable land should bear to pastoral, to supply every necessary; but perhaps 2 acres to every 20 breeding ewes may suffice. Taking this ratio, a pastoral farm with 1000 ewes should have 100 acres arable, which would em-

[1] Little *On Mount. Sheep,* 10.

ploy 2 pairs of horses to labour a 4-course shift, the pasture supplying the second year of the grass rotation. The rotation would be divided into 25 acres of turnips and potatoes, 25 of corn after them, 25 of sown grasses, and 25 of oats after the grasses. Manure will be required for 25 acres of green crop, which would partly be supplied by the 50 acres of straw, by phosphate or guano, and by sheep on the turnips. To make the straw into manure there are 4 horses, the cows of the farmer, of the shepherd, and of ploughmen; with a young heifer or two, the offspring of the cows. The arable land should be enclosed within a ring-fence of thorn, if the situation admit of its growth, or of stone.

Lands best suited for Hoggs and Ewes.—The pasture division of the farm should be subdivided into different lots. Hoggs are best adapted for soft rough grass, springing from a damp deep soil; and ewes for the short and bare, upon a dry soil and subsoil. Hoggs attain large bone on soft rough pasture, where ewes would not thrive, and these thrive better on dry soil where hoggs would be stinted. That farm is best which contains both kinds of pasture, and maintains both breeding and rearing stock.

Subdividing Pastoral Farms.—In subdividing a farm into lots, each should contain within itself the same quality of pasture, whether rough or short; for if fine and coarse grass be within the same lot, the stock will remain almost constantly upon the fine. The extent of one-fifth of coarse to fine may be permitted within the same lot. Should a large space of upper and inferior soil lie contiguous to what is much better, it should be divided by a fence, and a suitable breed of sheep reared upon it. By such arrangements, not only a greater number of sheep might be maintained upon a farm, but the larger number would always be in better condition.

Steading for Sheep-farm.—A steading suitable for the arable portion of such a sheep-farm should have similar accommodation to that included in plan, fig. 88, where the north range of building, standing E. and W., as well as all the other ranges, is 18 feet in width.[1] Of course, where water-power is available, the water-wheel should take the place of the horse-course, *p*, fig. 88.

Drainage of Pastoral Farms.—The drainage of pastoral farms should never be neglected. The best mode of doing it will be fully explained when treating of draining. One means of keeping part, at least, of the surface dry, is to clear the channel of every rivulet, however tiny,

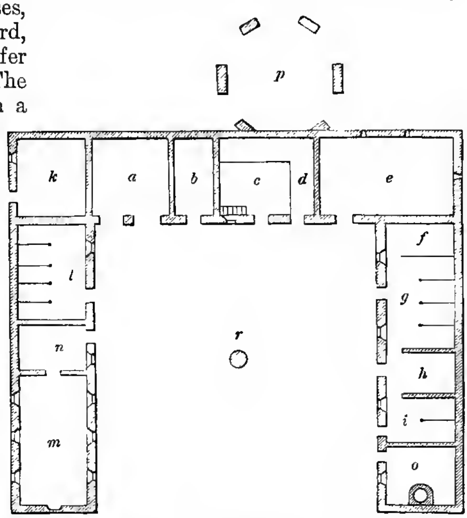


Fig. 88.—*Steading for the arable part of a sheep-farm.*

a Cart-shed, 2 ports.	*k* Implement-house.
b Gig-house.	*l* Byre, 5 stalls.
c Corn-barn, 32 ft. long.	*m* Wool-room, 34 ft. long.
d Chaff-house.	*n* Outhouse.
e Straw-barn, 40 ft. long.	*o* Boiler-house.
f Loose-box.	*p* Horse-course.
g Cart-stable, 4 stalls.	*r* Pump-well.
h Hay-house.	Upper barn above *c d*.
i Riding-stable, 2 stalls.	Granary above *b a k*.

that runs through the farm, every three years — especially in those parts where accumulated gravel causes a burn to overflow its banks in rainy weather, or at the breaking-up of a snowstorm. Overflowing water, acting as irrigation, sets up fresh vegetation, which becomes a habitat for the liver-fluke, and being readily devoured by sheep, is regarded as one of the main causes of rot. Confinement of water within its channels also prevents it wetting to

[1] See Plate II., fig. 2, *Book of Farm Buildings*, plan of steading for sheep-farm, with arable culture, by H. Stephens and R. S. Burn.

excess and souring the hollow parts of the land.

Securing Winter Food for Sheep.—In recommending a connection of arable with pasture farm, the object is simply to secure an abundant supply of food for sheep in winter. Were our winters as mild as to allow sheep to range over our hills in plenty, there would be little use for arable land, for domestic provisions could easily be obtained from a market. But when storms overwhelm a whole flock, and protracted snow and frost debar the use of grass for weeks together, it is absolutely necessary to provide food upon the farm. The arable land might not itself be capable of yielding rent or profit, but it may add greatly to the value of the adjoining pasture-land. Let it be always kept in view that the *more food and shelter provided in winter for stock*, the less loss will be incurred during the most inclement season. Let one instance, out of many, suffice to show the comparative immunity from loss in providing food and shelter for sheep in winter. In the wet and cold winters of 1816 and 1818, the *extra* loss of sheep and lambs on the farm of Crosscleuch, Selkirkshire, was as follows:—

In 1816.		
200 lambs, at 8s. each .	£80 0 0	
40 old sheep, at 20s. each	40 0 0	
		£120 0 0
In 1818.		
200 lambs, at 8s. each .	£80 0 0	
30 old sheep, at 20s. each	30 0 0	
		£110 0 0
Value of total *extra* loss .		£230 0 0

Whereas, on the sheltered farm of Bowerhope, belonging to the same farmer, and on which one-third more sheep are kept, the *extra* loss in those severe years was as follows:—

In 1816.		
70 lambs, at 8s. each .	£28 0 0	
10 old sheep, at 20s. each	10 0 0	
		£38 0 0
In 1818.		
50 lambs, at 8s. each .	£20 0 0	
8 old sheep, at 20s. each	8 0 0	
		£28 0 0
Value of total *extra* loss .		£66 0 0
Deduct from loss on Crosscleuch		230 0 0
Value saved on farm of Bowerhope		£164 0 0[1]

Food and shelter being thus both necessary for the proper treatment of sheep in winter, the means of supplying them demand the most serious attention of the store-farmer. In winter, sheep occupy the lower part of the farm. Hoggs are netted on turnips in the early part of the season for a part of each day, and are afterwards turned out during the afternoon and night to a bit of rough pasture. Many farmers prefer carting the turnips daily to the hoggs on the rough pasture. Ewes and other sheep subsist on the grass as long as it is green.

Turnips on Sheep-farms.—The division allotted to green crop in the arable part of the farm contains 25 acres, and allowing 3 acres for potatoes for the use of the farmer and his people, there remain 22 acres for turnips; and as land among the hills is generally dry, turnips grow well there, so that 30 double-horse cart-loads to the acre, of 15 cwt. each, may be calculated on as a return from the crop. It is thus judiciously recommended by Mr Fairbairn to strip and carry off, about the end of October or beginning of November, if the weather is fresh before the grass fails, $^{4}/_{5}$ of the turnips and store them in heaps; and allow the *ewe hoggs* to eat the remaining $^{1}/_{5}$ on the ground, with the small turnips left when the others were pulled.[2] In stripping the land in this proportion, 1 drill should be left and 4 carried off, fig. 59.

This is an excellent suggestion for adoption on every hill-farm, as it secures turnips from frost, and gives the entire command of them whenever required in a storm.

Turnips for Hoggs.—It is found that *hoggs* fall off in condition on turnips in spring, in a high district, if confined upon turnip-land—not for want of food, but want of shelter and teeth. In some cases they are removed from the turnips in the afternoon to pasture, where they remain all night, and are brought back to the turnips on the following morning. In other cases, as already indicated—and this is a capital plan,—the turnips are carted daily to the hoggs on a piece of rough pasture. One fair cart-

[1] Napier's *Store-Farm*, 126.

[2] Lammermuir Farmer. *On Sheep in High Districts*, 51.

load is allowed to every 100 hoggs, and at this rate an acre of turnips, weighing about 15 tons, will keep 100 hoggs about 45 days. Mr George Brown, Watten Mains, Caithness, says that the best lot of Cheviot hoggs he ever saw were treated in this way.

This treatment, it is obvious, deprives the land of much of the manure derivable from turnips; and hence, before the grain is sown, farm-dung should instead be put on the land, where turnips were raised with phosphate or guano.

Feeding of the older Sheep in a Storm.—As to the older sheep, they must partly depend, in storm, upon the turnips yet in store, and hay. Hay is obtained from the 20 acres of new grass, and allowing 5 acres for cutting-grass for suppers to horses and cows, 15 acres, at 120 stones (of 22 lb.) per acre, give 2400 hay stones, or 3771 imperial. The 1000 ewes will eat 1½ lb. each every day, besides the two cart-loads of turnips amongst them, and the hoggs ½ lb. At this rate the hay will last 31 days, a shorter time than many storms endure.

The ground would yield more hay were the young grass top-dressed with a special manure; and besides this, the rule should be to begin with a full hand of hay at the commencement of hill-farming, and preserve what may be left over in a favourable season, to mix with the new of the following, with a little salt, and thus prepare for any unusual continuance of storm. If the supply of home-grown hay is insufficient, it must be made up by purchased hay. It is bad management to run short of hay in a storm.

STELLS FOR SHEEP.

But in a storm provender cannot be given to sheep upon snow safely and conveniently, as ground-drift may blow and cover up both; so no place is so suitable for protecting sheep and provender from drift as *stells*. There are still many store-farmers sceptical of the utility of stells, if we may judge from their practice; but many repetitions of storm are not required to convince any reasonable man that stock are more comfortably lodged within a high enclosure than upon an open heath. A stell may be formed of plantation or high stone wall—either will afford shelter; but a plantation requires to be fenced by a stone wall.

Outside Stell.—Fig. 89 is a good *outside stell*, formed of plantation. Such has been erected by Dr Howison, of Crossburn House, Lanarkshire, and has

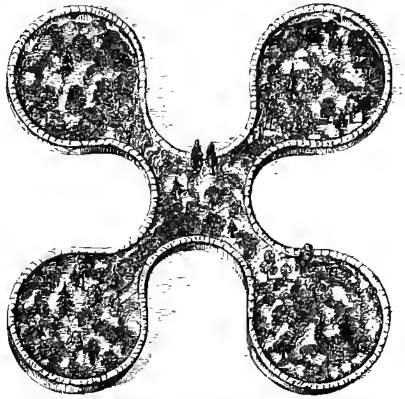


Fig. 89.—*Outside stell sheltered by plantation on every quarter.*

proved good for many years. The circumscribing stone wall is 6 feet high, the ground within it is planted with trees. Its 4 rounded projections shelter a corresponding number of recesses embraced between them; so let the wind blow from whatever quarter, two of the recesses will always afford shelter. The size of this stell is regulated by the number of sheep kept; but this rule is offered in regard to its power of accommodating stock—that each recess occupies about ⅛ part of the space comprehended within the extremities of the 4 projections; so that, in a stell covering four acres—which is perhaps as small as it should be—each recess will contain ½ an acre. "But, indeed," as Dr Howison observes, "were it not from motives of economy, I know no other circumstance that should set bounds to the size of the stells, as a small addition of walls adds so greatly to the number of the trees, that they become the more valuable as a plantation; and the droppings of the sheep or cattle increase the value of the pasture to a considerable distance around in a tenfold degree."[1]

[1] *Trans. High. Soc.*, xii. 334.

Forming Plantation Stells.—In making stells of plantation, it is desirable to plant the outside row of trees as far in as their branches shall not drop water upon sheep in their lair, such dropping never failing to chill them with cold, or entangle their wool with icicles. The spruce, by its pyramidal form, has no projecting branches at top, and affords excellent shelter by its evergreen leaves and closeness of sprays, descending to the very ground. The Scots pine would fill up the space behind the spruce; but every soil does not suit the spruce, so it may be inexpedient to plant it everywhere. Larches being deciduous, their branches are bare in winter. Larches grow best amongst the *dêbris* of rocks and on the sides of ravines; Scots fir on thin dry soils, however near the rock; and the spruce in deep moist soils. Of the Scots pine (*Pinus sylvestris*) Mr James Brown says: "This is the only one of the pine tribe which can be said to be a native of Britain, and in so far as regards the quality and usefulness of its timber, it is at least inferior to no other species which has yet been introduced, while it becomes a tree of first-rate magnitude in favourable situations. It is one of the most hardy of our forest-trees, being found in Scotland growing fully two thousand feet above the level of the sea. At one period this tree must have been very plentiful in the Highlands of Scotland."[1]

Size of Stells.—Stells should be as large as to contain 200 or perhaps as many as 300 sheep on an emergency; and even in the bustle necessarily occasioned by the dread of a coming storm, so large a number as 200 could be shed from the rest, and accommodated in a sheltered recess accessible from all quarters. Thus 5 such stells as fig. 89 would accommodate a whole hirsel of 1000 sheep.

Suppose, then, that 5 such stells were erected at convenient places—not near any natural shelter, such as a crag, ravine, or deep hollow, but on an open rising plain, over which drift sweeps unobstructed, and remains in less quantity than on any other place—with a stack of hay inside and a store of turnips outside, food would be provided for an emergency. On a sudden blast arriving, the whole hirsel might be safely lodged for the night in the two leeward recesses of one or two of these stells, and, should prognostics threaten a storm, next day all the stells could be inhabited in a short time. Lord Napier recommends a stack of hay to be placed close to the outside of every small circular stell; but so placed, it would arrest the drift which would otherwise pass on.

Concave Stells.—Instead of the small circular stell, Mr Fairbain recommends a form without plantation, having 4 concave sides, and a wall running out from each projecting angle as in fig. 90—each

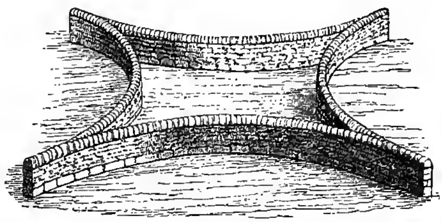


Fig. 90.—*Outside stell without plantation.*

stell to enclose ½ an acre of ground, to be fenced with a stone wall 6 feet high, if done by the landlord: and if by the tenant, 3 feet of stone and 3 feet of turf; which last construction, if done by contract, would not cost more than 2s. per rood of 6 yards. In this form of stell, without a plantation, the wind would strike against a perpendicular face of the wall in either recess, and being reflected upwards, would throw the snow down immediately beyond the wall, into the inside of the stell; and hence it is that Mr Fairbairn objects to sheep being lodged in the inside of a stell.[2]

This form, affording more shelter, is not open to the objections to ancient stells, as *a*, *b*, or *c*, fig. 91, the remains of which may yet be seen amongst the hills. The wind, rebounding from the walls of any of these ancient forms of stell, would inevitably throw the snow down upon the sheep within or outside them.

Inside Stells.—Opinion is not agreed

[1] Brown's *Forester*, 237.

[2] Lammermuir Farmer *On Sheep in High Districts.*

as to the best form of stell for high pastures, where wood is seldom found. At such a height the spruce will not thrive; and the larch, being deciduous, affords but little shelter with its spear-pointed top. There is nothing left but the ever-

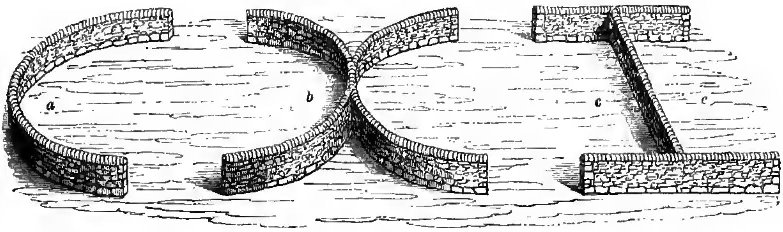


Fig. 91.—*Ancient stells.*

green Scots fir for the purpose, and when surrounding a circular stell *a*, fig. 92, it would afford acceptable shelter to a large number of sheep. This stell consists of 2 parallel circles of wall, enclosing a plantation of Scots pine, having a circular space, *a*, in the centre for sheep, as large

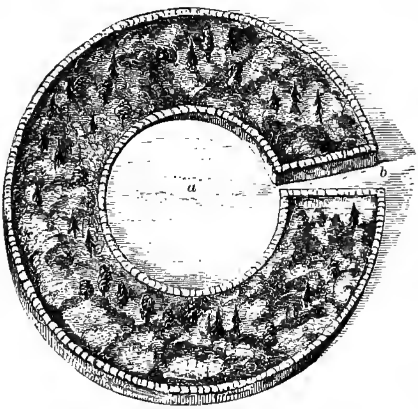


Fig. 92.—*Inside stell sheltered by plantation.*

as to contain any number. This may be denominated an *inside* stell, in contradistinction to the outside one in fig. 89, and has been proved efficient by the experience of Dr Howison. Its entrance, however, is erroneously made wider at the mouth than at the end next the interior circle, *a*, which produces the double injury of increasing the velocity of the wind into the circle, and of squeezing the sheep the more the nearer they reach the inner end of the passage. The walls of the passage should be parallel, and curved to break the force of the wind.

Circular Stells.—But where trees cannot be planted with a prospect of success, stells may be formed without them, and indeed usually are; and of all forms that have been tried, the *circular* has obtained the preference on hill-farms, but determining the best size is still a matter of dispute amongst hill-farmers. Some think 8 to 10 yards inside measurement best; others prefer a larger size, perhaps 18 yards. The circular form of any size is better than a square, a parallelogram, or a cross; because the wind striking against a curved surface, on coming from any quarter, is divided into two columns, each weaker than the undivided blast; whereas, on striking against a straight surface, though its velocity is somewhat checked, it is still undivided, and its force still great, when it springs upwards, curling over the top of the wall, and throwing down the snow a few yards within the stell. Any one who has noticed drifts of snow on each side of a straight stone wall, will remember that the leeward side of the wall is completely drifted up, while on the windward side a hollow is left, often clear to the ground, between the drift and the wall. Every stell, therefore, that presents a straight face to the drift, will have that fence drifted up and be no protection to sheep. Of two curves, that which has the larger diameter will divide the drift further asunder. A stell of small diameter, as 7 yards, divides a current of air which, on reuniting above, immediately lets the snow it carries fall into the stell. A stell of large diameter, of 18 yards, on dividing a column of air, deflects it so much on each side that it has passed beyond the stell before it reunites and deposits its snow; and hence the snow is found to fall in a triangular shape, with its apex away to leeward of the stell, and leaves the interior free.

Fig. 93 is a stell of 18 yards diameter inside, surrounded by a wall 6 feet high, the first 3 feet of stone, the other 3 feet of turf; costs 2s. 4d. per rood of 6 yards if erected by the tenant, and if wholly of stone, with a cope, by the landlord, 7s. per rood; will embrace 9⅓ roods, at a cost of £3, 5s. 4d., including quarrying and carriage of stones—a trifling outlay compared to the permanent advantage derived from it on a hill-farm. The opening into the stell should be from the side towards the rising ground, and its width 3 feet. Such a structure as this will easily contain 10 score of sheep for weeks, and even 15 or 16 score may be put into it for a night without being too much crowded.

A great improvement is effected on round stells by building dykes the same height as the wall of the stell out from the stell at the four opposite points, *a*, *b*, *c*, and *d*, fig. 93. The spaces enclosed afford excellent shelter for sheep from any quarter, and the longer the dykes

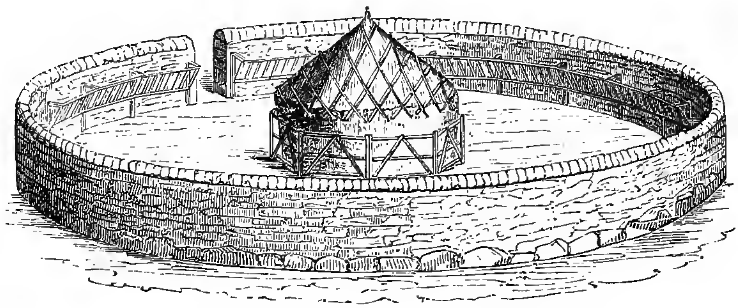


Fig. 93.—*Circular stell, with hay-racks and hay-stack.*

the greater the amount of shelter provided.

Giving Hay at Stells.—Circular stells should be fitted up with *hay-racks* round the inside, not in the expensive form of circular woodwork, but of a many-sided regular polygon. It is a bad plan to make sheep eat hay by rotation, as some recommend, because the timid and weak will be kept constantly back, and suffer much privation for days at a time. Let all have room and liberty to eat at one time, and as often as they choose. The hay-stack should be built in the centre of the stell, on a basement of stone, raised 6 inches above the ground to keep the hay dry. A small stack, 5 yards in diameter at base, 6 feet high in stem, with a top 6 feet in height, will contain about 450 hay-stones of hay, which will last 200 sheep 33 days; but upon that base a much greater quantity of hay might be built. The hay-stack requires strong thatching. The circumference of the stell measures 160 feet round the hay-racks; and were 8 or 9 six-feet hurdles put round the stack, at once to protect the hay and serve as additional hay-racks, they would afford 47 feet more—which would give 1 foot of standing-room at the racks to each of 200 sheep at one time.

It is well to have some turnips stored near the stells for use in a protracted snowstorm.

Natural Shelter.—As long as the ground continues green, natural shelter is as requisite as stells: this consists of rocks, crags, braes, bushes, heather, and such like. To render this as available to sheep as practicable, the ground should be cleared of all rubbish around them, and bushes planted in places most suited to their growth, such as the whin (*Ulex europæa*), in poor thin clay, and it is a favourite food of sheep in winter; the broom (*Genista scoparia*), on rich light soil; the juniper (*Juniperus communis*), in sandy soil; the common elder (*Sambucus nigra*), in any soil, and it grows well in exposed windy situations; the mountain-ash (*Pyrus aucuparia*), a hardy grower in any soil; and the birch, when bushy (*Betula alba*), grows in any soil, and forms excellent clumps or hedges for shelter, as well as the hazel (*Corylus avellana*) and the common heaths (*Erica vulgaris* and *tetralix*), when they get leave to grow in patches to their natural height in peaty earth.

Whins and Broom.— Many sheep-farmers, who are alive to their business, fill their pockets every spring morning with the seeds of the whin and broom, and in their walks over the sheep-farm, scatter these seeds on any likely spot. These eventually provide food for sheep in a stormy winter, besides—especially if a favourable winter occurs after they are sown—growing into strong bushes which afford excellent shelter.

Benefits of Planting.—It is allowed by all who have given their attention to the improvement of waste lands in our country, that the rearing up of healthy plantations improves the general climate of the neighbourhood; and not only is the climate improved to a great degree, but the very soil upon which forest-trees grow is much improved by the gradual accumulation of vegetable matter from them. I would ask the plain question, What is the natural cause of so much waste land being found in the north of Scotland, and in many parts of England? Can it be denied that it is the want of trees to give shelter? Why is it that the proprietors of land complain so much of great tracts of it being worthless, growing nothing but the inferior grasses, mosses, rushes, and heaths, upon which even one sheep cannot find food upon two acres? Is it not for the want of plantations to give shelter?[1]

Sheep Cots or Sheds.—Much diversity of opinion exists regarding the utility of *sheep-cots* on a store-farm. These are rudely formed houses, in which sheep are put under cover in wet weather, especially at lambing - time. Lord Napier recommended one to be erected beside every stell, to contain the hay in winter if necessary; and Mr Little advises them to be built to contain the whole hirsel of sheep in wet weather. It seems a chimerical project to house a large flock of sheep for days, and perhaps weeks; and, if practicable, could not be done but at great cost. Others object to sheep-cots on high farms, because, when inhabited in winter, even for one night, by as many sheep as would fill them, an unnatural height of temperature is thereby generated. Cots may be serviceable at night when a ewe or two become sick at lambing, or when a lamb has to be mothered upon a ewe that has lost her own lamb; and such cases being few at a time, the cot never becomes overheated.

Paddocks for Sheep.—In an unsheltered store-farm it is requisite to have two paddocks, which are sufficient to contain all the invalid sheep, tups, and twin lambs, until strong enough to join the hirsel.

Penning Rams in Autumn.—Tups may graze with the hirsel in the early part of summer; but as no ordinary wall will confine them in autumn, they should be penned in one of the stells, or in some enclosure near the steading, on hay or turnips, until put to the ewes.

Bridging Rivulets for Sheep.—Where a rivulet passes through an important part of a farm, it will be advisable to throw *bridges* across it at convenient places for sheep to pass along to better pasture, or better shelter on the opposite bank. Bridges are best constructed of stone, and though rough, if put together on correct principles, will be strong; but if stone cannot be found fit for arches, they may do for buttresses, and trees laid close together across the stream, held firm by transverse pieces, and then covered with tough turf, form a safe roadway.

Altitude of Sheep - farms. — The highest hill-farms for sheep in Scotland occupy an altitude ranging from 1500 to 3000 feet and upwards above the sea, and indeed some of them extend to the highest points of our mountain-ranges.

At such elevations pasture must necessarily be coarse and scanty, consisting entirely of alpine plants. A considerable extent of such herbage is required to support a single sheep during the year, and consequently the farms are of great

[1] Brown's *Forester*, 8, 9.

extent, many of them extending miles in length, and embracing many thousand acres.

Blackfaced Sheep for High Altitudes.—The Blackfaced breed is admirably suited for occupying the highest range of farms, having not only a bold and daring disposition, capable of enduring much fatigue in search of food, but a hardy constitution, and yielding most delicious mutton.

Little Breeding on High Farms.—The circumstance of elevation and seclusion from roads imposes in the treatment of this breed a difference from that pursued in the lower country. Many sheep-farmers in the lower country who breed Blackfaced sheep sell what lambs they can spare after retaining as many as will keep their ewe-stock fresh. They thus dispose of all their wether hoggs, the smaller ewe hoggs, and draft ewes. Suppose 1000 ewes wean 1000 lambs, 500 of these will be wether and 500 ewe hoggs, of which latter 17 score, or 340, will be retained, to replace one-sixth of the ewes drafted every year, and the remaining 160, together with the 500 wether lambs, will be disposed of. The high hill-farmer purchases those lambs, rears them until fit, as wethers, to go to the low country to be fed fat on turnips; and, in acting thus, he never keeps breeding ewes. Many farmers hold both high and low farms, breeding and wintering on the latter, and sending the yeld sheep to the high farm during summer and the greater part of autumn.

Young Sheep best for Hill-farms.—The state of hill-pastures modifies the management on hill-farms. The hill-pasture does not rise quickly in spring, nor until early summer; and when it does begin to vegetate it grows rapidly, affording a full bite. It is found that this young and succulent herbage is not congenial to the ewe—it is apt in the autumn to superinduce in her the liver-rot; but it is well adapted for forwarding the condition and increasing the size and bone of young sheep. It is therefore safer for hill-farmers to purchase lambs from south-country pastoral farmers, who breed Blackfaced sheep largely, as well as Cheviot, than to keep standing flocks of ewes of their own. The winter half-year, too, on the hills, is a long period to sustain a flock of ewes on extraneous food.

Turnips on Hill-farms.—Many hill-farmers are adverse to giving turnips to their sheep in winter, although this objection is not nearly so strong as in former times. Whatever may prompt hill-farmers to object to arable culture, reasons would require to be very strong to prove that Blackfaced sheep would not thrive on turnips on the hills. Doubtless on many farms, far removed from great roads, it would be difficult to bring even a favoured piece of ground into culture, and to raise green crops with even light manures; but there are many glens among the hills not far removed from tolerable roads, which might be cultivated to advantage, and the green crop and hay from which might maintain the flock well through a stormy period.

Hay for Hill-sheep.—Hill-sheep, however, getting hay in spring when the ground is covered with snow, will be some days before they will eat it, and will fall fast off in condition. Sheep so treated on their own ground will scrape the snow to get at the grass rather than eat the hay. When off their own ground they will eat it more readily. Hill-sheep getting turnips, hay, or other extra food in winter, fall fast off in condition when the snow falls again on their ground after having this artificial feeding; and this is perhaps one of the considerations which have weighed with hill-farmers in their reluctance to adopt turnip-feeding.

Utility of Arable Land on Hill-farms.—As a corroborative proof of the utility of cultivated land on hill-farms, is the practice of taking turnips or rough grazings for stock in the lower part of the country, as near their own homes as food can be procured; and of Lowland farmers, who possess hill-farms, bringing their sheep to the low country in winter, and putting them on turnips. If turnips and rough hay so taken will repay, much more would they repay if raised at home; and when sheep are thus brought safe through the dreary part of winter, they would have the additional advantage of the conveniences of home when snow covered the ground for weeks together. Stores of turnips and stacks of hay would thus be as useful at home as abroad; and when these failed, whins and bushes would afford as good food at home as at a distance.

Scots-fir Leaves for Sheep.—Where a Scots-fir plantation is near a haunt of sheep, these need not starve, even in a snowstorm; for a daily supply of sprays, fresh cut from the trees, will support them as heartily as hay alone; and if hay is given along with the fir-leaves, they will thrive better than on either alone.[1]

Losses from want of Shelter on Hill-farms.—The want of adequate shelter at home may induce some hill-farmers to send their stock to the low country in winter. The hills are bare of wood, the few trees being confined to the glens, and the sheep can find no shelter in their usual grounds; and it is surprising how susceptible of cold even Blackfaced sheep are when the atmosphere is becoming moist. They will cower down, creep into corners and beside the smallest bushes for shelter, or stand hanging their heads and grinding their teeth, having no appetite for food. If a piercing blast of wind follows such a cold day, the chances are that not a few of them perish in the night; and if thick snow-drift comes on, they drive before it, apparently regardless of consequences, and descend into the first hollow, where they are overwhelmed. Thus the utility of stells becomes manifest, and many hearty wishes are no doubt expressed for them by the farmer and his shepherds when they have them not in the hour of peril.

Such regrets, however, are no substitute for the necessity, the utility, the humanity of cultivating such an extent of ground, in favoured spots, as would raise food to support the whole flock through the protracted period of the longest storm. The bad effects of storms should be the strongest incentives to make extensive plantations for shelter on all mountain-ranges. Though some trees might fail to grow, it does not follow that others would not grow well enough to afford invaluable shelter in the bleakest period of the year. At least, the catastrophes of winter should urge hill-farmers to construct commodious stells in the most exposed situations.

[1] Little *On Mount. Sheep*, 44.

Bratting Sheep.—There are other modes of protecting hill-sheep from the severities of weather besides stells, and which may be regarded as more personally comfortable to them. One of these is *bratting*, which is covering the sheep with a cloth.

But this method is impracticable except in a very small flock, as the expense is great, and it is now seldom if ever attempted.

A brat may be made in five minutes, and fitted on in other five. The method

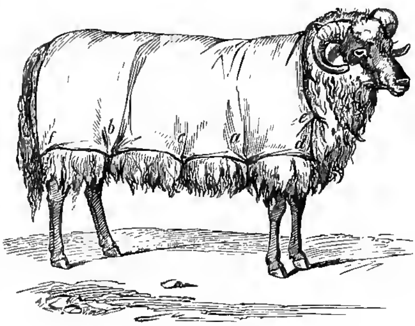


Fig. 94.—*Bratted sheep.*

a A tie below the belly behind the shoulder.
b One before hind legs.
c Under the middle of the belly.
d e Across the breast.
f Behind the hind legs.

of bratting a sheep is seen in fig. 94, representing a bratted sheep.

Irrigation on Hill-farms.—Since *hay* is the principal food for mountain sheep in snow or black frost, it is of importance to procure this valuable provender in the best state, and of the best description. It has long been known that irrigation promotes, in an extraordinary degree, the growth of natural grasses; and perhaps there are few localities which possess greater facilities for irrigation, though on a limited scale, than the Highland glens of Scotland. Rivulets meander down those glens through haughs of richest alluvium, which bear the finest description of natural pasture plants. Were those rivulets subdivided into irrigating rills, the herbage of the haughs might be multiplied many fold, and hill-farmers are earnestly urged to convert them into irrigated meadows. Although each meadow may be of limited extent, the grass they afford is greatly increased in quantity and value when converted into hay.

One obstruction alone existing to the formation of meadows is, the fencing required to keep stock off while the grass is growing for hay. But the fencing should be made for the sake of the crop protected by it. Hurdles make an excellent fence. This difficulty is now greatly lessened by the introduction of cheap wire-fences. Besides places for regular irrigation, there are rough patches of pasture, probably stimulated by latent water performing a sort of under-irrigation to the roots of the plants, which should be mown for hay; and to save further trouble, *this* hay should be ricked on the spot, fenced with hurdles, around which the sheep would assemble at times to feed through them in frosty weather from the rick, and wander again over the pasture for the remainder of the day; and when snow came, the stells would be the places of refuge and support. As the hay in the stack is eaten, the hurdles are drawn closer to the stack, to allow the sheep again to reach the hay.

The practice now generally adopted, however, is to lay out the hay in handfuls on the snow, keeping plenty of room between the lines of hay.

Construction of Hurdles.—Hurdles are constructed in different forms. Fig. 69 is the strongest and most durable, but also the most expensive in the first cost. Each hurdle, with its fixtures, consists of 14 pieces—viz., 2 side-posts *a*, 4 rails *b*, and 3 braces *c*, *d*, *d*, which form the single hurdle; and 1 stay *f*, 1 stob *g*, and 4 pins *g*, *h*, and *i*, are required for fixing each hurdle. The scantling of the parts are the side-posts *a*, 4½ feet long, 4 inches by 2 inches. The rails *b*, 9 feet long, 3½ inches broad by 1 inch thick. The braces, 2 diagonals *d*, 5 feet 2 inches long, 2¼ inches broad, by ¾ inch thick; and 1 upright *c*, 4 feet long, and of like breadth and thickness. The stay *f* is 4½ feet long, 4 inches broad, and 2 inches thick, and bored at both ends for the pins; the stob *g*, 1½ foot long, pointed and bored. The pins *h i*, 1 foot 1¼ inch diameter.

The preparation of the parts consists in mortising the side-posts, the mortises being usually left round in the ends, and they are bored at equal distances from the joining and stay pins. The ends of the rails are roughly rounded on the edges, which completes the preparation of the parts; and when the flake is completed, its dimensions are 9 feet in length, and 3 feet 4 inches in breadth over the rails; the bottom rail being 9 inches from the foot of the post, and the upper rail 5 inches from the head.

Another form of flake, more extensively employed, has 5 rails, which are 1¾ inch square. The ends of the rails are turned round by machinery, and the side-posts bored for their reception, as well as the pins, also by machinery. The bottom rail is 9 inches from the foot of the posts; the spaces *between* the first and second, and the second and third rails, are each 7 inches, and the two upper spaces are respectively 8 and 9 inches, leaving 5 inches of the post above the upper rail.

Growing Willows for Hurdles.—Where the common crack-willow (*Salix fragilis*) will grow, every farmer may have poles enough every year for making 2 or 3 dozen hurdles to keep up his stock. To establish a plantation, large cuttings 9 or 10 feet long should be pushed, not driven, into moist soil, and on being fenced from cattle, will soon shoot both in the roots and head, the latter being fit to be cut every seventh year.

A larger kind of hurdle, called *park hurdles*, worth 2s. each, is made for subdividing meadows or pastures, and are a sufficient fence for cattle. The small hurdles are used for sheep, the larger to fence cattle, whereas the Scotch flakes answer both purposes at once, and are therefore more economical.

Sheep-nets.—*Nets*, which confine sheep on turnips in winter, are made of good hempen twine, and the finer the quality of hemp, and superior the workmanship bestowed on it, the longer will nets last. Being necessarily much exposed to the weather, they soon decay, unless properly prepared and cared for. Now, it is the custom to dip sheep-nets in a preparation of tar and oil, which has a most beneficial effect, increasing their durability considerably. A net properly treated should last 4 or 5 years.

Nets are wrought by hand and by machinery. By hand they are simply made of *dead netting*, which consists of plain work in regular rows. A shepherd ought to know how to make nets as well as mend them, and cannot mend them well unless he understand how to make them. Net-making is a very suitable occupation for women. Nets made by hand will last longer than those made by machinery.

All the instruments required in this sort of net-making are a *needle* and *spool*. "Needles are of two kinds,—those made alike at each end with open forks, and those made with an eye and tongue at one end and a fork at the other. In both needles the twine is wound on them nearly in the same manner—namely, by passing it alternately between the fork at each end, in the first case, or between the fork at the lower end and round the tongue at the upper end, in the second case; so that the turns of the string may lie parallel to the length of the needle, and be kept on by the tongue and fork. The tongue-and-eye needle is preferable both for making and mending nets, inasmuch as it is not so liable to be hitched into the adjoining meshes in working; but some netters prefer the other kind, as being capable of holding more twine in proportion to their size." An 8-inch needle does for making nets, but a 4-inch one is more convenient for mending them.

Spools, being made as broad as the length of the side of the mesh, are of different breadths. They "consist of a flat piece of wood of any given width, of *stout* wood, so as not to warp, with a portion cut away at one end, to admit the finger and thumb of the left hand to grasp it conveniently. The twine in netting embraces the spool across the width; and each time that a loop is pulled *taught*, half a mesh is completed. Large meshes may be made on small spools, by giving the twine two or more turns round them, as occasion may require."

"In charging your needle, take the twine from the *inside* of the ball. This prevents tangling, which is at once recommendation enough. When you charge the needle with *double* twine, draw from two separate balls."[1]

In joining the ends of *twine* together, in mending, the *bend* or *weaver's* knot is used; and in joining top and bottom ropes in setting nets, the *reef*-knot is best, as the tighter it is drawn the firmer it holds.

Sheep-nets run about 50 yards in length when set, and weigh about 14 lb. Hogg-nets stand 3 feet in height, and wethers 3 feet 3 inches, and both are set 3 inches above the ground. The mesh of the hogg-net is 3½ inches in the side, and 9½ meshes are required; and of the wether 4½ inches, and 8½ meshes are required.

It is imagined that nets will not confine Blackfaced sheep on turnips, because they would be broken by being entangled in the sheep's horns; but the objection is unfounded, as horned sheep soon learn to keep clear of the net.

The *diseases of sheep* will be treated of in a subsequent section.

CATTLE IN WINTER.

HOUSING OF CATTLE.

The construction of farm-buildings does not come within the ordinary routine of farm-work. It is a matter of the utmost importance for the successful management of a farm, and may be most conveniently considered by itself, with other outstanding subjects.

Before the advent of the winter season cattle of all kinds have been assigned to their winter quarters, in which we find them when we set out upon the round of the agricultural year. Assuming, then, that houses of a suitable kind have been provided, we shall here notice only some

[1] Bathurst's *Notes on Nets*, 15, 17, and 138.

points, connected with buildings, which have a direct and specially important bearing upon the winter rearing and feeding of stock.

Accommodation in Steadings.—As a farm of mixed husbandry comprises every variety of culture, so its steading should be constructed to *afford accommodation for every variety of produce.* The grain and straw, being useful and bulky articles, should be accommodated with room as well after as before they are separated by threshing, which process is executed with horse, water, or steam power. Room should also be provided for every kind of food for animals, such as hay and turnips.

Of the animals themselves, the horses being constantly in hand at work, and receiving their food daily at regular intervals of time, should have a stable which will not only afford them lodging, but also facilities for consuming their food. Similar accommodation is required for cows, the breeding portion of cattle. Calves have cribs as long as very young, and a court with shed afterwards. Young cattle are usually reared in partially or entirely roofed spaces, called courts, with troughs for food and water. Cattle feeding for sale are either put into courts, or into small sheds called hammels, or fastened to stakes in byres or loose in boxes. Young horses are reared either by themselves in courts with sheds and mangers, or kept with the young cattle. Young pigs often roam about everywhere, and lodge amongst the litter of young cattle; whilst sows with sucking-pigs are provided with small enclosures, fitted up with a littered apartment at one end, and troughs for food at the other. It is considered useful to have a few young pigs running through cattle courts, to pick up refuse, but, as a rule, even young pigs will be found worthy of apartments for themselves. In any case, pigs should not be allowed to roam all over the steading, making things untidy, which, by the way, they much delight in doing.

The smaller implements of husbandry, when not in use, are put into a suitable apartment; whilst the carts are provided with a shed, into which also some of the larger implements which are only occasionally used are stored by. Wool is stored in a cool clean room. An apartment containing a furnace and boiler, to heat water and prepare food when required for any of the animals, is most useful in a steading.

These are the principal accommodations required in a steading where live stock are housed; and in the most convenient arrangement of the apartments, the entire building will cover a considerable space of ground.

Arrangement of the Steading.—The leading *principle* on which these arrangements are determined is very simple. Straw being the bulkiest article on the farm, heavy and unwieldy, in daily use by every kind of live stock, and having to be carried and distributed in small quantities by bodily labour, its receptacle, the *straw-barn*, occupies the central part of the steading, and the several apartments for live stock are easily accessible from it.

That so bulky and heavy an article as straw should in all circumstances be moved to short distances, and not at all, if possible, from any other apartment but the straw-barn, the *threshing-machine*, which supplies the straw from the grain, is placed so as to throw the straw into the straw-barn.

The *stack-yard*, containing the unthreshed straw with its corn, is contiguous to the threshing-machine.

The passage of straw from the stack-yard to the straw-barn through the threshing-machine being directly progressive, the stack-yard, threshing-mill, and straw-barn are most convenient when placed in a line, and in the order mentioned.

Different classes of stock require different quantities of straw to maintain them in the same degree of cleanliness and condition. *Those* requiring the *most* are therefore placed *nearest* the *straw-barn.*

Attention to Littering.—When cattle are put into their winter quarters, it is specially important that careful attention should be given at the outset to littering. Their apartment, be it close houses or courts, should be liberally littered with straw, for a thin layer at first is uncomfortable, and will soon be compressed down. A thick layer of straw is not only comfortable in itself, but acts as a drain for a long time, whether to urine or rain, in whatever size of courts.

Sometimes a deficiency of straw is experienced in the early part of winter, from various causes, amongst which may be mentioned a dislike in farmers to begin to thresh the new crop in early winter, even when no old straw or old stack of corn is left from the former crop; and a ready excuse is found in the want of water or wind, or disinclination to put on steam to move the threshing-machine: but however recently built the stacks may be, or inconvenient to thresh their produce at the time potato-lifting or wheat-sowing is going on, it should be done rather than stint cattle of bedding; for should bad weather ensue—an event not unlikely to happen—cattle become chilled at once in ill-littered quarters, especially at first, and a great part of the winter may be gone ere they recover from its effects; and hence arise diseases and serious suppression of condition.

With even plenty of old stacks, a want of water to drive the threshing-machine may really be experienced, and this is no uncommon occurrence in the beginning of winter on farms which depend upon surface-water only for their supply; and a windmill is in no better condition at that season from want of wind. In case such contingencies *may* happen, it is the duty of the farmer to provide a sufficient quantity of litter in good time; and there are various ways of doing it. Those who still use the flail may employ it at any season; and those having horse threshing-mills are equally independent of water and wind.

Substitutes for Straw as Litter.—Bog-land supplies coarse herbage, which, being made into hay in summer, makes excellent litter; but precaution is requisite in using fresh or even old grassy turf as a bottoming for the litter of courts, as it absorbs water like a sponge on the first fall of rain, when scarcely any quantity of straw will prevent the cattle trampling the bedding into a poached mass.

"Peat-moss litter"—dry compressed peat—is now extensively used with excellent results, especially for horses. Ferns cut and dried, as also dried rushes, grass, and fallen leaves from woods, form an excellent foundation for litter.

By one or all of these means a comfortable bed may be provided for cattle at the commencement of winter, independently of straw.

Rones.—Another point which should have immediate attention, if it has not already been looked to, is the condition of the rones around the eaves of farm-buildings. If *rones* (rain-water spouts) were put up along the eaves of all the roofs of the sheds and hammels connected with any court, they would render every court comfortably dry. This safeguard against wet is much neglected in the steadings of this country.

Cattle-troughs.—All cattle-courts and hammels should be provided with *troughs for turnips*, and they are placed conveniently against the walls, as in fig. 95. Some board the bottom with wood;

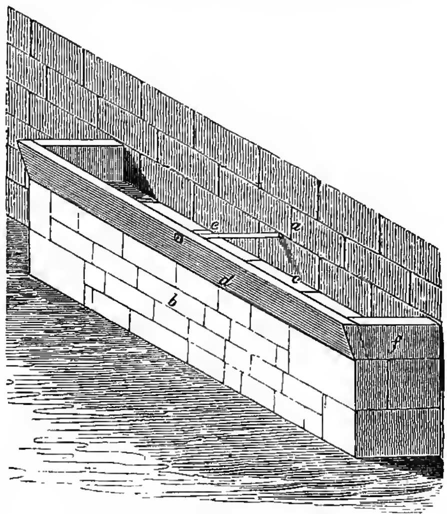


Fig. 95.—*Turnip-trough for courts.*

a The wall.
b Building to support bottom of trough.
c Pavement bottom of trough.
d f Planking of front and end of trough.
e Iron bar to strengthen the planking.

and, where that is plentiful, it is cheap, and answers the purpose, and is pleasanter for cattle in wet and frosty weather; but where pavement can be easily procured, it is more durable. A plank 3 inches thick and 9 inches in depth keeps in the turnips. Old planking from wrecks, and old spruce-trees, however knotty, have been found a cheap and durable front planking for turnip-troughs. The planks are spliced together at their ends to any length, and held on edge by rods of iron batted with lead into the wall, and fixed with nut and screw. The height in front should be 2 feet 9 inches for calves, and 3 feet for older beasts, and it will become less as the straw daily accumulates. This form of trough is also used in the hammels. Turnip-troughs for boxes are made of wood. Those short in length for byres are made of pavement or stone.

In fig. 96 is represented a very convenient movable cattle-trough, made by E. Thomas & Co., Oswestry. It is constructed of extra strong galvanised iron, fitted to an angle-iron frame.

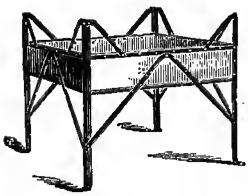


Fig. 96.—*Iron cattle-trough.*

Concrete Troughs.—Troughs are now frequently made of concrete, and when made of good material—good Portland cement and sand and gravel, free from earthy matter—are very durable.

"In making troughs of concrete, it is first of all necessary to have the sides framed with smooth planks, leaving sufficient space between the double rows for the desired thickness of concrete. In making the concrete, 1 part of Portland cement goes to 6 or 7 of broken stone, burnt ballast, gravel, or slag. These last must be free from loam, mud, fine sand, or dirt of any kind. This mixture is used for the bottom and the side, and allowed to stand for 12 or 18 hours to harden, when a thin coating of cement and good water-sand in about equal proportions is put on for a finish. The mould-boards should always be well soaped before the concrete is poured in. If Roman cement is used, it must be remembered that it is only one-third the strength of the above."[1]

Troughs made of fire-clay are clean, durable, and convenient. Asphalt is not suited for turnip-troughs, as it becomes soft in the sun and heat under cover, and is easily fractured at any time.

Straw-racks.—*Straw-racks for courts* are made of various forms. A common kind is in fig. 97, of a square form,

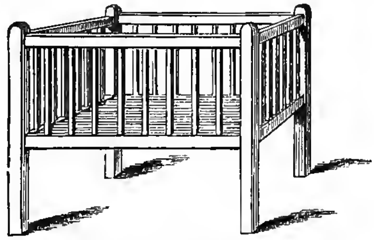


Fig. 97.—*Wooden straw-rack for courts.*

sparred round the sides and bottom to keep in the straw. It stands upon the litter. The cattle draw the straw through the spars as long as its top is too high for them to reach over it, but after the dung accumulates, and the rack thereby becomes low, they get at the straw over the top. It may be pulled up as the dung accumulates. It is made of wood, 5 feet square and 4 feet in height.

Fig. 98 is a rack of malleable iron to supply the straw always over its top, and

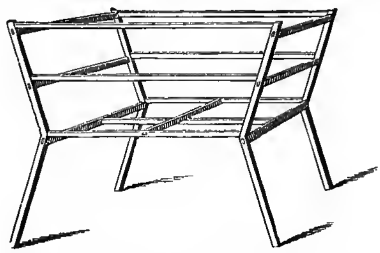


Fig. 98.—*Malleable-iron straw-rack for courts.*

is rodded in the sides to keep in the straw. It remains constantly on the ground, and is not drawn up as the dung accumulates. It is 5½ feet in length, 4½ in breadth, and 4½ in height; the upper rails and legs are of 1 inch square iron, and the other rails ¾ inch. This is a durable straw-rack.

A very useful combined rack and feeding-trough, specially suited for calves, made by E. Thomas & Co., Oswestry, is shown in fig. 99.

Turnip-stores.—Few things indicate

[1] *Farming World*, June 1888, 485.

greater care for cattle than providing stored turnips for their use—being not only convenient, but the best mode of keeping them clean and fresh. The turnip-stores should be placed as near as possible to the cattle, and be easy of access to carts.

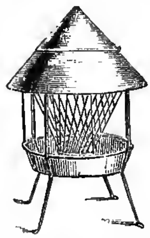


Fig. 99. — *Combined rack and trough.*

Water-supply in Buildings.—Supply of *water* to courts is of paramount consideration. Water-troughs may be supplied with water either directly from pump-wells, or by pipes from a fountain at a distance. As a pump cannot conveniently be placed at each trough, we have found a plan of supplying any number of troughs from one pump to answer well, provided the surface of the ground will allow the troughs being placed *nearly* on the same level. One plan is to connect the bottoms of two or more troughs on the same level with lead pipes placed under ground; and on the first trough being supplied direct from the pump, the water will flow to the same level in all the other troughs. This arrangement is so far objectionable, that when one of the troughs is emptying by drinking, the water is drawn from the other troughs at the same time, but then the quantity drawn from any single trough is small.

Position of Water-troughs.—Were a receiving-trough placed a few inches *below* the top of the supplying one, and were a lead pipe to come from the bottom of the supply-trough over the edge of the receiving, the water might be entirely emptied by drinking in one, without affecting the quantity in the other. Let *a*, fig. 100, be the supply-trough immediately beside the pump in one court, and let *b* be the trough in another court, 3 inches below the level of *a*. Let a lead pipe *d* be fastened to the bottom of *a*, the orifice raised up, and protected by the hemispherical drainer *c*. Let this lead pipe *d* be passed under ground to the trough *b*, and emerge by its side over the top at *e*. When *a* is filling with water from the pump, the moment the water rises in *a* to the level of *e*, it will flow into *b*, and continue to do so until *b* is filled, if the pumping be continued. The water in *a*, *below* the level of *e*, may be used in *a* without affecting that in *b*, and the water in *b* may be used at all times without affecting that in *a*.

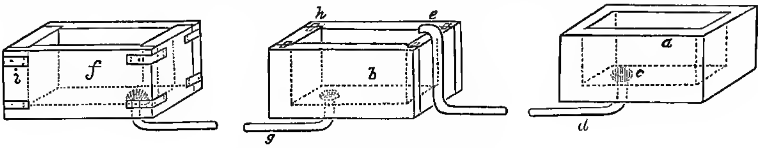


Fig. 100.—*Water-troughs for courts.*

Water-troughs.—Water-troughs may be made of various materials: *a* is hewn out of a solid block of freestone, which makes the closest, most durable, and best trough. If of flagstones, as *b*, the sides are sunk into the edges of the bottom in grooves luted with white-lead, and held together with iron clasps *h* at the corners. This makes a good trough, but is apt to leak at the joints. Trough *f* is made of wood dovetailed at the corners, luted with white-lead, and held together by clamps of iron *i*. When made of good timber and painted, they last many years. They are frequently made of cast-iron.

Water-cistern.—Water-troughs are sometimes supplied from a large cistern, somewhat elevated above their level, and filled from a well with a common or force pump. In this case a cock, or ball-and-cock, is required at each trough: if a cock, the supply must depend on the cock being turned in due time; and if a ball-and-cock, the supply depends on the cistern having water in it: but this method is expensive, and liable to go out of order when cattle have access to it.

In an abundant supply of water from natural springs, accessible without a pump, a lead pipe would emit a constant stream of water into each trough, the surplus being conveyed by drains to the horse-pond.

Still another mode may be adopted where water is plentiful, and it flows constantly into a supply-cistern. Let the supply-cistern be 2 feet in length, 1 foot wide, and 18 inches in depth, provided with a ball-and-cock, and let a pipe proceed from its bottom, as *g* in trough *b*, fig. 100, to a trough *f*, into which let the pipe enter by the end or side a little way, say 3 inches, below its mouth. Let a pipe proceed from the end of trough *f* into the end of another trough, and so on, into the ends of as many succeeding troughs, on the same level, as are required, and when the water is withdrawn by drinking from one trough, the ball-and-cock will replenish it direct from the supply-cistern. The objection to the ball-and-cock does not apply in this as in the other case, as they are out of the reach of cattle.

Hydraulic Ram.—Where no water can be found at the steading by a well, should a rivulet pass it at a lower level, a good supply of water might be obtained by means of a hydraulic ram (p. 26), fig. 101, where *a a* is the supply-pipe, which leads the running stream down to the chamber *b b*, bolted to the bed-plate *c c*. A valve *d d* is provided to the

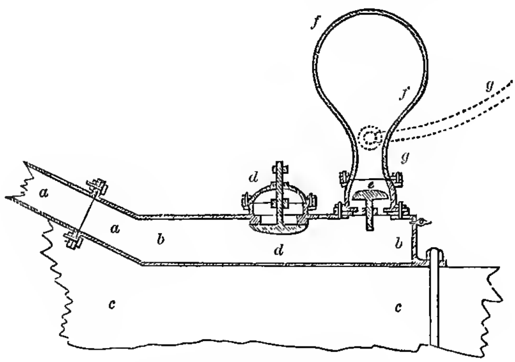


Fig. 101.—*Section of hydraulic ram.*

chamber *b b*, which has a tendency to fall from its seat so as to keep the water-way open, till the stream flowing from the pipe *a a* acquires sufficient momentum to close it. The velocity of the stream being thus checked, the water raises the valve *e*, which moves the reverse way of the valve *d d*, and enters the air-vessel *f f*, from which it is finally passed by the pipe *g g*, which can be raised to any required elevation to a supply-cistern above the level of the ram. On the water passing into the air-chamber *f f*, it is pressed upon by the air in the upper part of the vessel, which closes the valve *e*. The momentum of the flowing stream in the pipe *a a* and chamber *b b* being thus exhausted, the valve *d d* falls, and allows the water to escape from *b b* through the valve-opening, till the flowing stream acquires such momentum as again to close the valve *d d*. When this happens the valve *e* is again opened, and a second quantity of water discharged into the air-vessel *f f*. The action thus described goes on continually, night and day, resulting in a regular beating or pulsation of the valves *e*, *d d*, each rising and falling alternately.[1]

Protection to Timid Animals.—The sheds of large cattle-courts are usually provided with more than one arched port, with the view of allowing a timid animal to escape by one of the openings while chased by an unruly companion. But both the safety and comfort of cattle are more secure with only one port *at one end* of the shed, because then there will be no corner at the outlet to pin the timid one into, and draughts of air will thereby be prevented through the shed — the laudable object of escape to the ill-used one being thus ensured, while the comfort of all will not be sacrificed for the safety of one; and it is doubtful, after all, if the danger can be avoided until a general

[1] See *Book of Farm Imple.*, 543.

agreement ensues among the cattle after a common use of the same apartment for a time. Cattle bought from different quarters are much less likely to agree in the same court than those brought up together from calf-hood.

The risk of loss by animals injuring each other is lessened by carefully assorting the lots, so that, as near as possible, cattle of one age and size may be together. It is desirable not to have too many in one apartment—not more than 20, and as few as 8 or 10 if convenient.

Hammels.—A hammel consists of a shed and an open court, communicating by a large opening. A convenient hammel for two oxen is one 12 feet by 10, with a court 14 feet by 10. A straw-rack should be fastened against the inner wall of the shed. A water-trough at a corner of the court is a requisite. To give permanency to hammels, sheds should be roofed like the other buildings. Temporary erections are constantly requiring repairs, and in the end cost as much as substantial work. There should be rones. The opening of the shed, 5 feet in width, should be at one side, and not in the middle of the hammel, to afford more room and warmth to the interior. The corners of the scuncheon should be chamfered, to save the cattle being injured against sharp angles. The division-walls betwixt the courts should be of stone and lime, 1 foot in thickness and 6 feet in height. Those within the sheds should be carried up close to the roof, but frequently they are only so to the first baulk of the couples, over which a draught of air is generated from shed to shed, much to the discomfort of the animals.

Hammels are preferred by many to large courts, even for young beasts, as it is advisable to have heifers separated from steers, and each class subdivided to suit strength, age, and temper. It is surprising how much better the same animals look and thrive when well assorted. The dung is seldom removed from hammels until the end of the season, when it is generally used for turnips. The temperature in the courts of hammels facing the S. is generally agreeable, and that in the sheds is always decidedly temperate.

Cattle-boxes.—Some prefer boxes to hammels, especially for fattening cattle. These boxes are just small compartments or subdivisions of a larger building, usually about 8 feet square, each animal having a box to itself. Cattle fatten more rapidly in boxes than in any other way; but they entail more labour as well as more litter, and of course are relatively more costly than larger compartments. The dung is removed from boxes at intervals, when it is thought to have too much accumulated. Boxes are fitted up of wood, the rails to separate the oxen, the troughs to contain turnips, and the racks for straw or hay. Being under cover, the temperature of boxes should be high for winter.

Stalls for Cows.— Cows stand in stalls, and stalls, to be easy for them to lie down and rise up and be milked in, should never be less than 5 feet in width. Four feet is a more common width, but is too narrow for a large cow, and even 7 feet is considered in dairy districts a good double stall for two cows. Many farmers contend that every cow should have a stall for her own use in lying, standing, eating her food, and being milked, and of such length and breadth as she may lie at ease betwixt the manger and the gutter. A width of 18 feet makes a handsome byre, apportioned thus: manger 2 feet, length of a large cow 8 feet, the gutter 1 foot broad, leaving 7 feet behind the gutter for a passage. If a passage of 3 feet for food is given at the head of cows, the passage for milk-work will be curtailed from 7 to 4 feet, which may be inconvenient for dairy purposes, but may do for feeding cattle.

Stalls for Feeding Cattle.—Fattening cattle are very often tied in stalls, and this economises both space and litter. A stall of 4 feet in width will suffice for a feeding ox, or even, for the sake of economy, a double stall of 8 feet for two oxen. In every other respect feeding cattle should have the same accommodation as cows.

The ceiling in byres should be open to the slates, and for every four cows there should be a ventilator in the roof for regulating the temperature and admitting fresh air. A door, divided into upper and lower halves, should open outwards to the court on a giblet-check, for the easy passage of cows to and from the court, and each half-door fastened on the inside with a hand-bar. This half-door and windows with glass panes, with the lower part furnished with shutters to open, will give sufficient light, as also air. The plastering of the walls adds greatly to the comfort and cleanliness of byres.

Fig. 102 is a section of *travis and manger of a byre*. The opening through the wall is not necessary, and the shed behind it may be dispensed with; but where it is, it forms a convenient turnip-store, to which access might be obtained from the byre by a back-door. The earth

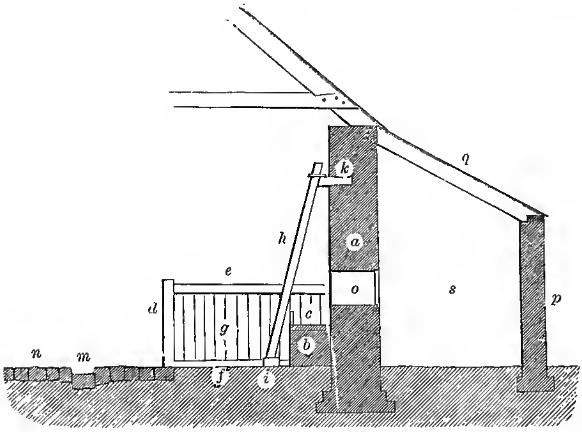


Fig. 102.—*Byre travis, manger, and stake.*

a Wall of byre.
b Building supporting manger.
c Manger with a front of wood.
d Hardwood hind post.
e Hardwood top rail.
f Curb-stone.
g Travis of wood, 6 feet long.
h Hardwood stake for the binder.
i Stone base for stake.
k Block of wood for top of stake.
m Dung-gutter of pavement.
n Paved floor.
o Opening through wall for turnips.
p Wall of shed.
q Roof of shed.
s Shed for food.

on the space upon which the cows kneel is beaten smooth and firm.

The *stalls* are most comfortably made of wood, though some recommend stone, which always feels hard, and even seems cold.

Single and Double Stalls.—A wide single stall is not only useful in supplying food from within the byre, but admits of cows being more easily and conveniently milked. A double stall for cows is objectionable on many accounts: a cow is often a capricious creature, and not always friendly with her neighbour, and one of them in a double stall must be bound to the stake on the same side she is milked from; and, to avoid this inconvenience, the dairymaid puts the cow aside nearer her neighbour in the same stall, which must prove unpleasant to both. Neither is it a matter of indifference to the cow from which side she is milked, for many will not let down their milk if the milkmaid sits down at the unaccustomed side. The best plan is for each cow to have a roomy stall to herself—although this, of course, entails more space and greater outlay in building.

Mangers.—The *mangers* of byres are usually placed on a level with the floor, with a curb-stone in front to keep in the food, and paved in the bottom. Such a position is highly objectionable, as, on breaking turnips, whether sliced or whole, the head of the animal is depressed so low, that an undue weight is put upon the fore-legs, and an injurious strain imposed on the muscles of the lower jaw. The manger should rest on a building raised from 15 to 20 inches from the ground, and a plank set on edge in front to keep in the food. Out of such a manger a cow or ox will eat with ease any kind of food, whether whole or cut. Mangers are generally made too narrow for cattle with long horns, and the consequence is the rubbing away of their points against the wall, to the injury of both. Mangers are now often formed of concrete or fire-clay.

Flooring of Byres.—The *floor* of byres is usually paved with rectangular stones; but now concrete floors, indented on the surface, in causeway form, to prevent slipping, are often met with. The gutter should be broader than an ordinary square-mouthed shovel, and flagged at the bottom, and having right-angled curb-stones. Such a gutter is quickly cleaned out. A gutter should run from this one through the wall to a liquid-manure tank. The causewaying of the stalls should extend no farther than the hind-posts, because cattle, in lying down and rising up, first kneel upon their fore-knees, which would be injured if pressed against stones, even when covered with litter. A pressure on the knees may produce a permanent swelling in them. The earth beaten firm will make a good flooring there. We have seen this part of cow-stalls covered with india-rubber pavement.

Various forms of flooring for stalls with the view of saving litter have been tried, such as flooring with wood, and causewaying with bricks made with a hollow centre through which the urine is enabled to pass directly into the gutter.

Binding Cattle.—Cows and oxen are bound to a stake in stalls by means of a ligature which goes round the neck behind the back of the head. One method of binding is with the *baikie*, made of a piece of hardwood, *e*, fig. 103, standing upright, and flat to the neck of the cow. A rope *g* fastens the lower end of it to the stake, upon which it slides up and down in a perpendicular direction, by means of a loop which the rope forms round the stake. This rope passes *under* the neck of the animal, and is never loosened. Another rope *k* is fastened at the upper end of the piece of wood *e*, and, passing *over* the neck of the animal and round the stake, is made fast to itself by a knot and eye, which serves the purpose of fastening and loosening the animal. The neck, being embraced between the two ropes, moves up and down, carrying the baikie along with it. This method of binding, though quite easy to the animals themselves, is objectionable in preventing them turning their heads round to lick their bodies; and the stake being perpendicular, the animals can move their heads only up and down, and are obliged to hold them always over the mangers.

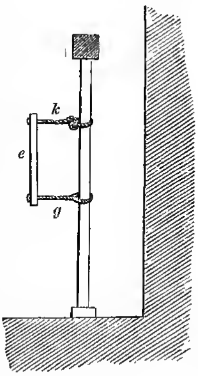


Fig. 103.—*Baikie.*

A much better method of binding cattle is with the *seal*, which consists of an iron chain, fig. 104, where *a* is the large ring of the binder, which slides up and down the inclined stake *h*. The iron chain, being put round the neck of the cow or ox, is fastened to itself by a broad-tongued hook at *c*, which is put into any link of the chain that gauges the neck, and it cannot come out until turned on purpose edgeways to the link of which it has a hold. This sort of binder is in general use in the midland and northern counties of Scotland. It is most durable, and gives the animal liberty not only to lick itself, but to turn its head in any direction it pleases; and the inclination of the stake *h* gives the animal further liberty of lying down or standing back free of the manger.

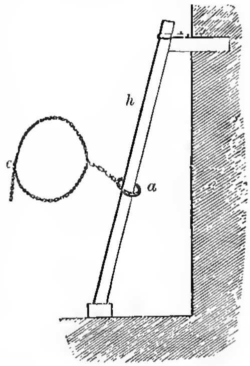


Fig. 104.—*Cattle seal or binder.*

A chain binder, swivelled and sliding on an upright bar, fixed to the travis, makes a good and safe form of fastening.

Windows in Byres.—A light and airy *window* is essential to the comfort of a byre. It consists of two shutters, *a a*, fig. 105, 2 feet in height, which open by cross-tailed hinges, and are kept shut with thumb-latches. The window-

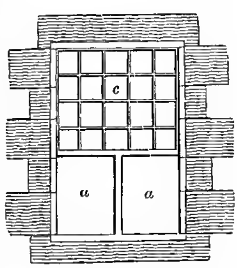


Fig. 105.—*Byre window.*

frame is made of wood or cast-iron, $2\frac{1}{2}$ feet in height and 3 in width. The frame is glazed with 4 rows of panes in the height and 5 rows of panes in the breadth.

Ventilation of Byres.—It greatly promotes the comfort and health of animals confined for many hours every day in one apartment to have fresh air admitted to them without the creation of draughts, and no means of obtaining this object is so much in our own power as placing *ventilators* in the roof of the part of the steading occupied by animals.

Fig. 106 is a *ventilator*, in which the Venetian blinds *a* are fixed, and answer the double purpose of permitting the escape of heated air and effluvia, and of preventing the entrance of rain or snow. The blinds are covered and protected by a roof *b* of slates and zinc; *c* is an apron of zinc upon the slates of the roof.

Such a ventilator would be more ornamental and protective to the blinds if its roof projected 12 inches over them.

One ventilator, 6 feet in length, 3 feet in height in front, and 2 feet above the ridging of the roof, for every 6 horses, cows, or oxen, might suffice to maintain a complete ventilation.

But such openings in the roof will not of themselves constitute ventilation, unless an adequate supply of fresh air is admitted below; and the supply might be obtained from small openings in the walls, including chinks of doors and windows when shut, whose gross areas are nearly equal to those of the ventilators. The openings should be in such situations and numbers as to cause no draught of air upon the animals, and might be conveniently placed, protected by iron or zinc gratings on the outside to prevent the entrance of insects, in the wall behind the animals, and of such form as to disperse and spread the air upwards as it enters.

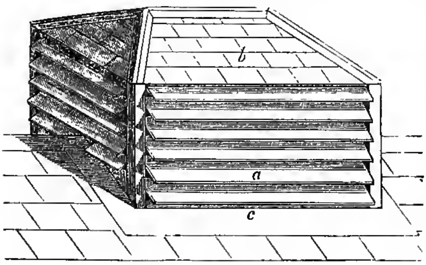


Fig. 106.—*Ventilator.*

Other forms of ventilators are in use, consisting of a large zinc pipe projected through the roof and bent downwards; or simply a few of the slates or tiles of the roof raised up a little, either of which is better than no ventilator at all. But for simplicity, cheapness, and efficiency, the ventilator represented in fig. 107 is very satisfactory. It consists of a *square* box of 2 or 3 feet above the ridging of the roof. The box is equally divided in its length by a partition of wood, extending from a couple of inches from the upper edge of the box to a few inches below its lower edge under the roof. The effect of this simple partition is to cause a current of warm or vitiated air to pass upwards from the apartment to the atmosphere through one of the divisions of the box; while an opposite current of pure cool air from the atmosphere passes downward into the apartment through the other division—both currents being equal and above the reach of the animals, and never cease to pass day and night. The ventilation is complete, as well as the diffusion of cool air through the apartment. Rain or snow would be prevented falling through the ventilator by a square prismatic cover, as in the figure.

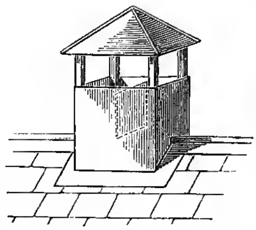


Fig 107.—*Watson's ventilator.*

Ventilators so ingeniously arranged as to revolve rapidly with the slightest current of air are now frequently used. See Ventilation of Stables.

Byres for Feeding Cattle.—The construction of byres for *feeding oxen* and *milk cows* is very similar, but feeding-byres are usually made much too small for the number of oxen confined in them. When stalls are put up, they seldom exceed 4 feet in width; more frequently two oxen are put into a double stall of 7 feet, and not unfrequently travises are dispensed with altogether, and simply a triangular piece of boarding placed across the manger against the wall, to divide the food betwixt each pair of oxen. In double stalls, and where there are no stalls, even small oxen, as they increase in size, cannot all lie down at one time to chew their cud and rest; and thus hampered for room, and the chewing of the cud interfered with, they cannot thrive as they should do. In such confined byres the gutter is placed too near the heels of the oxen, and prevents them standing back when they desire; and if any do stand back, it must be in the gutter, at a level lower than the stall. Short stalls, it is true, save litter being dirtied, by the dung dropping from the cattle directly into the gutter, and this saves the cattleman some trouble; but the saving of both trouble and litter is at the sacrifice of comfort to the animals.

Economy overdone. — In the construction of byres, economy of space and expense may easily be overdone. Cowkeepers in towns may be justified in pushing economy to an extreme point; but no landowner or farmer should sanction such a plan. In fitting up a byre for milk cows or feeding oxen, it should be borne in mind that a small sum withheld at its construction may cause a yearly loss of much greater amount, if it prevent feeding cattle attaining perfection, or cows bearing strong and healthy calves.

Drainage of Byres and Courts.— Neither courts, hammels, boxes, nor byres are competently furnished for comfort unless provided with good drains to carry away rapidly surplus liquid manure. A *drain* should enter into each of the large courts, across the middle of the court of each hammel, and into the byres and boxes. The ground of every court should be so formed as to have the lowest part where the drain should have its mouth. The mouth should be furnished with a strong block of hewn freestone, into which is sunk flush an iron grating, having the bars only an inch asunder, to prevent straw getting into the drain. Fig. 108 is a grating, made of malleable iron, to bear rough usage, such as the wheel of a cart passing over it; the bars being placed across with a curve *downwards*, to keep them free from pressure when the water passes through the straw. We have seen gratings in steadings with the ribs bent *upwards*, in the idea they are not so liable to be choked up. The idea is quite correct in regard to the open

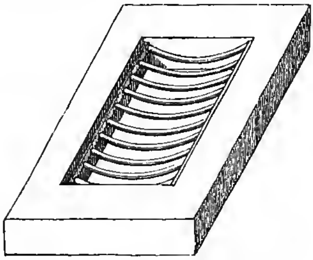


Fig. 108.—*Drain grating for courts.*

gratings of sewers in towns, as with ribs bent *downwards* there, the accumulated stuff brought upon them by the gutters would soon prevent water getting into the drains; but the case is different in courts where the straw, covering the gratings, lies loosely over the ribs bent downwards, and acts *as a permanent drainer;* whereas were the straw to be pressed constantly against the ribs bent upwards, the water could not percolate through it. Any one who has seen the straw of dunghills pressed hard against a raised stone in the ground below it, will easily understand this effect.

Liquid-manure drains may be built with stone-and-lime walls, 9 inches high and 6 inches asunder, flagged smoothly in the bottom, and covered with single stones, as shown in fig. 109. They are

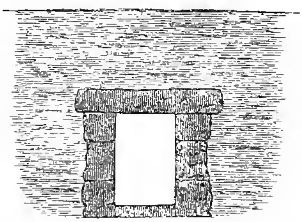


Fig. 109.—*Liquid-manure drain.*

better of cylindrical glazed stoneware tubes, fig. 110, of a diameter suited to the quantity of liquid to be conveyed. The spigot and faucet drain-tube consists of *a a* the spigot tube, and *c c* the faucet of the tube *b b*. In laying these tubes, it is necessary to observe that they have a full bearing given them, and not to allow the plain ends to rest entirely on the socket, as by doing so the pipes are exceedingly apt to be broken. Another precaution is, that the clay or cement used to make good the joint is not pushed into the interior of the pipe, to make a ridge there, and cause a permanent obstruction to the liquid manure.[1]

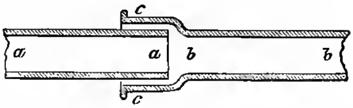


Fig. 110.—*Section of a spigot and faucet drain-tube.*

As liquid-manure is sluggish in its motions, the drains for it require a greater fall than rain-water drains. They should run in direct lines, and have few turnings on their way to the tank, which should be in the lowest ground, not far from the steading, and out of the way. The advantages of these drains being made straight is, that should they choke up, water would soon clear the obstruction, and this will be the more easily effected in stoneware tubes.

Liquid-manure Tank.—One *tank* would suffice for even a large steading. Were the practice adopted here, as in Flanders, of applying liquid manure in the field direct from the animals, a small tank at every court and feeding apartment would be convenient.

The *liquid-manure tank* should be built of masonry, or of brick and lime, or formed of concrete. Its form may either be round, rectangular, or irregular, and it may be arched, covered with wood, left open, or under a slated or thatched roof; the arched forming the completest roof, the rectangular form may be chosen. We have found a tank of an area of only 100 square feet, and a depth of 4 feet below the bottom of the drains, contain a large proportion of the whole liquid manure collected during the winter, from courts and hammels well littered with straw, in a steading for 300 acres, well provided with rain-water spouts.

Liquid-manure Pump.—A *cast-iron* pump should be affixed to one end of the tank, the spout of which should be elevated so as to allow the liquid to run

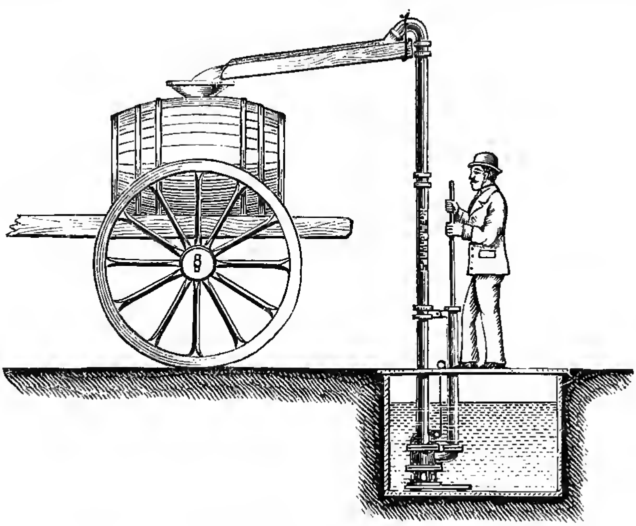


Fig. 111.—*Simplex pump.*

into the trough in the bung-hole of a large barrel placed upon the framing of a cart, or over a series of compost dunghills. A very useful pump for this purpose, made by Ben. Reid & Co., Aberdeen, is represented in fig. 111.

Rain-water Spouts.—It is clear that

[1] See *Book of Farm Buildings*, 239-241, for drain-tubes.

if all the rain that falls upon the roof of the steading makes its way into the courts and hammels occupied by cattle, it will pass through the manure rapidly, and dissolve a large proportion of its soluble parts, and so far deteriorate the quality of the dunghill. The liquid manure thus conveyed to the tank will, therefore, largely consist of rain-water; and when it is carried from the tank to the fields, or spread over the compost-heaps, much labour will thereby be imposed in carrying simply rain-water. Of what utility would so much rain - water be to the compost-heap? Would it not be better to prevent the rain-water entering the courts at all, and only to carry the pure liquid manure which has flowed from the dunghills, when the straw in them was unable to absorb and retain any more of it? No doubt it would. There should, therefore, not be much liquid manure at a steading of feeding beasts. The largest proportion of pure liquid manure is found on dairy-farms, where cows are supplied largely with succulent food in the byre, and with very little litter.

The only way of preventing rain-water getting into courts is to have them entirely roofed, or the eaves of the roofs of the houses which surround the courts provided with *rain-water spouts*, to carry the rain in drains from the farmstead.

As to the rain from other parts of the roofs, *drains* should be made along the bottom of every wall. They should be 6 inches below the foundation-stones of the walls, having drain pipe-tiles, and the drain filled to the surface of the ground with broken stones. The broken stones will receive the rain dropping from the roofs, and the pipe-tile conduit will carry it away; and should the stones ever become hardened on the surface, or grown over with grass, they can be loosened by a hand-pick. Strong pipes are now made on purpose for drains of all dimensions.

Rain-water spouts are made of wood, cast-iron, lead, or zinc, the last being durable, very light, and cheapest in the end, and are fastened to the wall by iron holdfasts. Wooden spouts, subject to alternate drought and wet, soon decay. Lead is far too expensive for a steading. Cast-iron is clumsy, and rusts.

NOMENCLATURE OF CATTLE.

The *names* given to cattle at their various ages are these: A new-born animal of the ox tribe is called a *calf*, a male being a *bull-calf*, a female a *quey-calf*, *heifer-calf*, or *cow-calf;* and a castrated male calf is a *stot-calf*, *ox-calf*, or simply a *calf*. Calf is applied to all young cattle until they attain one year old, when they are *year-olds* or *yearlings* —*year-old bull*, *year-old quey* or *heifer*, *year-old stot*. *Stot* in some places is a bull of any age.

In another year they are *2-year-old bull*, *2-year-old quey* or *heifer*, *2-year-old stot* or *steer*. In England, females are *stirks* from calves to 2-year-old, and males are *steers;* in Scotland, both young male and female are *stirks*.

The next year they are *3-year-old bull*, in England 3-year-old female a *heifer*, in Scotland *3-year-old* female a *quey*, and a male is a *2-year-old stot* or *steer*. In some parts of England *bullock* is a general term for all adult cattle.

When a quey bears a calf, it is a *cow*, both in Scotland and England. Next year the *bulls* are *aged;* the *cows* retain the name ever after, and the *stots* or *steers* are *oxen*, which they continue to any age. A cow or quey that has received the bull is *served* or *bulled*, and are then *in calf*, and in that state are in England *in-calvers*. A cow that suffers abortion *slips* her calf. A cow that has either *missed* being in calf or has *slipped* calf is *eill;* and one that has gone dry of milk is a *yeld-cow*. A cow giving milk is a *milk* or *milch cow*. When 2 calves are born at one birth, they are *twins;* if three, *triplets*. A quey-calf of twins of bull and quey calves is a *free martin*, and seldom produces young, but exhibits no marks of a hybrid or mule. The male twin can be trusted to procreate.

Cattle, *black cattle*, *horned cattle*, and *neat cattle*, are all generic names for the ox tribe, and the term *beast* is a synonym.

An ox without horns is *dodded*, *humbled*, *hummle*, or *polled*.

A castrated bull is a *segg*. A quey-calf whose ovaries have been extracted to prevent breeding is a *spayed heifer* or a *spayed quey*.

CATTLE-COURTS, COVERED AND UNCOVERED.

The covering of cattle-courts has a very close and important bearing upon the winter rearing and feeding of cattle; and as it might be possible, even after the winter season has set in, to throw a roof over the whole or part of a court hitherto open, it may be useful at this point to consider fully the question of covered courts.

There has been much discussion from time to time as to the relative merits of open, wholly, or partially covered courts for cattle. The greater convenience of having cattle loose in courts instead of tied up in byres, or shut up singly or in couples in boxes or in small lots in hammels, is generally acknowledged. That some portion of the court should be roofed is also undisputed; but even yet, after much experience and careful consideration of the particular point, farmers as a body are still divided as to whether the whole or only a portion of the court should be roofed.

Pros and Cons.—The *pros* and *cons* of the question are soon stated. It is urged in favour of the covered court, that it economises litter by keeping out the rain; and against the partially open court, that it wastes litter by admitting rain. It is claimed for the covered court that the dung made in it is more valuable than the dung made in the exposed court, on account of the greater conservation in the former of the fertilising properties in the dung. The general soundness of these arguments in favour of the covered court is not seriously denied; but there is considerable disagreement as to the *degree* of difference between the two systems in these particular points.

It is acknowledged, of course, that the covered court is more costly than the partially covered one, but the advocates of the former contended that the advantages indicated far outweigh the excess in first cost.

As to the influence of the two kinds of courts upon the progress of the cattle there is great divergence of opinion. Some say animals fatten more quickly in the wholly covered court than in the other; while many experienced stock-owners argue that if the greater part of the court is roofed so as to ensure a dry, comfortable bed to the cattle, they will thrive better with a portion, perhaps a third or a fourth, or less, of the court without any covering.

It may be interesting to consider in detail the chief points which have been put forward both in support of and against covered courts.

ADVANTAGES OF COVERED COURTS.

The late Mr John Coleman, York, one of the most practical and trustworthy agricultural writers of this century, was from experience and observation a confirmed believer in the benefits claimed for covered courts. In a paper read before the London Farmers' Club in November 1885, he discussed the subject exhaustively, dealing with it under these five heads: 1. The increased value of the manure made in covered courts; 2. The saving of litter; 3. Economy of food; 4. Details of construction; and 5. Cost and return.

Increased Value of Manure.

On this branch of the subject Mr Coleman said recent discoveries all tended to demonstrate the importance of using farmyard manure in a fresh and not rotten condition. Weight for weight, he believed manure made in covered yards was worth on an average double that in open yards, but owing to the smaller quantity of straw used, the weight of manure yielded per beast would be reduced about one-third.

Quantity of Manure per Head.—What weight of manure may be calculated on under the two conditions is a point on which authorities differ.

Taking one beast with another, he estimated the average consumption of litter in open yards at about 20 lb. a-day, and that in covered yards at 10 lb. a-day; and he believed that the production of manure made under cover could not exceed one ton per month, as against one and a half ton in an open yard.

Professor Stockhart calculated the weight of a cow's excreta daily at 22 lb. of urine and 55 lb. of solid, and if they added 10 lb. of straw, this would give 87 lb. a-day, equal to 22 cwt. per month. But our mixed cattle would not evacuate nearly so much, and 75 lb. would probably fully represent the average weight of straw and excreta, which give close upon a ton a month. If these figures were correct, and assuming a period of eight months' feeding, they had—

8 tons of covered-yard manure at 7s.	£2	16	0
12 tons of open-yard manure at 3s. 6d.	2	2	0
Total gain in manure per head	0	14	0
Add savings of carting, heaping, and turning	0	4	0
Savings in manure per head .	£0	18	0

Covered - court *v.* **Open - court Dung.**—As bearing out the above estimate, Mr Coleman stated that he had grown better crops of potatoes with 10 cart-loads of covered-yard manure than with fifteen cart-loads of equal weight of open-yard manure from animals receiving similar food; and Lord Kinnaird's experiments, reported in the *Transactions of the Highland Society*, proved the superior efficacy of covered-yard manure, weight for weight, to that from open yards, made under similar conditions as to food and age of animals.

	OPEN YARD.	COVERED YARD.
1st year potatoes	£7, 12s.	£11, 5s.
2d year wheat	42 bushels	54 bushels.
Straw	150 stones	215 stones.

Of course these experiments were defective, inasmuch as we had no facts as to the comparative quantity of manure produced, but they are conclusive as to value. It would be of great practical interest if this question were made the subject of accurate experiments, and with this might be combined the comparative and actual value of artificial foods consumed under these different conditions, and thus actual facts as to the unexhausted value of food would be obtained, in place of the theoretical estimates, which are of such doubtful accuracy.

Saving of Litter.

Assuming that the calculation as to the relative quantity of straw used were correct, it followed that the saving of straw per head during a period of eight months' feeding would average about a ton per beast.

Value of Straw.—Now, this at only its consuming value would add £1 a-head to the savings; but often in these days straw was worth much more. Surely there were few landlords or agents who would interfere with the sale of spare straw, provided that the land was well farmed. The manuring value of straw ranged from 10s. to 15s., according to sort, and that might be easily and beneficially replaced by purchased cake. If only the tenant would keep his yards full of growing and feeding cattle during the winter, the agent need not distress himself about the sale of straw or anything else. There was every prospect of straw becoming dearer, because the area under arable farming steadily decreases. It could not be imported to a large extent, being too bulky even in a compressed state to bear long carriage, and it was one of the merits of the covered-yard system that it allowed of such a large saving of litter, available for sale when there is excess, and allowing of greater economy in use when it was scarce.

Some years since it was an argument against covered yards that in certain outlying districts, such as the wolds and limestone districts, where arable lands prevailed, the straw could not thus be consumed, and would have to be rotted down, because there was no market—a difficulty which hardly exists now.

As a practical illustration of the saving of straw, Mr Coleman stated that on a farm of which he had the management for many years—650 acres in extent, about one-third arable—the annual outlays for straw, in the old open-yard days, ranged from £70 to £100, which was almost entirely saved by covering over the yards. In his calculations he estimated the gain at £1 a beast.

So great was the demand for straw in the large manufacturing centres of the north, that during summer it was largely imported from France and Germany to Hull, and carried by railway to the north of Lancashire.

Economy of Food.

Mr Coleman contended that, given well-constructed—*i.e.*, well-ventilated—yards, there must be economy of food. In early days the mistake was sometimes made of having the place too hot and close. Then, to correct this, the opposite and greater mistake was made of draughts over the animals' backs. They could not have too perfect ventilation, and it should be from every part of the roof, and not by leaving any of the sides open.

They were sometimes told that the south side of the yards should be left open in order that the cattle may feel the sun. This he believed to be a mistake, for with the small amount of sun in the winter time they would get a great deal of searching wind, and it was just this that they wanted to avoid.

The chemist and animal physiologist told them that warmth — that is, the absence of cold—is equivalent to food. The great waste of the system occurred when the animals were exposed to a keen, bitter blast, or a drenching driving rain from the east. It stood to reason that there must be a saving of fuel when the fire burned in an equable temperature; but what this amounted to, though the advantage was quite apparent to their observation, had never yet been determined with scientific accuracy.

Mr Moscrop stated that he proved in an experimental trial that under-cover animals, each of which had a separate box, gained as much weight with something under one-eighth less food as others kept in the common form of court and shed, when the open part bore to the shedding the proportion of four to one. The gain was nearly 1s. per head per week, which was entirely attributable to the superior warmth, comfort, and repose enjoyed by the cattle under cover.

Dealing with a breeding farm, where they had animals of all ages—at any rate, from a year old and upwards—Mr Coleman thought it would be within the mark to assume that the saving of food for a given result would average 6d. a-head per week, and this over a period of eight months was equal to 16s. a-head.

Total Saving.

Thus Mr Coleman made out the following as the gain by the adoption of covered yards on each head of stock wintered:—

Increased value of manure and saving of labour	£0	18	0
Saving of one ton straw, consuming value	1	0	0
Saving of food at 6d. a-head per week, over 32 weeks . . .	0	16	0
Total saving per beast .	£2	14	0

It would be seen later on what was the cost to be incurred in order to gain these advantages; enough had been advanced to prove that the use of covered yards was one of the greatest and most important of modern economies; and in these days, when every branch of farm practice is undergoing a searching criticism, it was well that public opinion should be turned in this direction.

Construction of Covered Courts.

Mr Coleman then entered into the question of construction of covered courts.

Drainage of Courts.—As to drainage Mr Coleman advocated surface-channels, and disapproved of covered drains with cesspools and tanks.

Roofing. — As to covering, many recommended galvanised iron, and with present low prices it was possible that this might be as cheap as any other substantial roof. But there were some objections to iron roofing, one of which is, inferior ventilation. The air must be collected to certain points, generally to openings on either side of the ridge, and under the eaves, which must have a tendency to create draughts, which should be avoided. The other objection is that the galvanised coating is subject to injury from the presence of certain gaseous products in the air, which might arise from the animals themselves, and must exist whenever the manure is being removed. The risk of such injury might be prevented by keeping the surface well painted, but this entailed extra cost. A third objection was that iron roofs were cold in winter and hot in summer.

Numerous forms of roof had been designed with a view to reducing expenses. Ordinary framed roofs, with principals, purlins, and rafters, might be used for small spans, and are probably necessary when a heavy covering like pantiles, or Bridgwater tiles, are used; but there is a limit which is soon reached as to the spans of such roofs, hence they had to introduce supporters in the form of pillars, which were objectionable as taking up room, and as being liable to be run against by careless carters when the manure was being removed. Mr Coleman gave a detailed description of a roof, the cost of which would range from

5s. to 6s. 6d. a-yard of ground covered. He pointed out that wood equalised temperature better than either tiles or slates.

A still cheaper form of roof was described by Mr Coleman—a roof which, he said, could be made at a cost of from 2s. 6d. to 3s. per superficial yard of covered ground, or half to one-third of the cost of more durable structures. This cheap form of roof was illustrated in the *Field* of December 5, 1885, and through the courtesy of the publisher we are enabled to present these drawings here (fig. 112).

The roof consists of light principals 7 inches by 2½ inches, placed at intervals of 14 feet from centre to centre, carrying purlins varying in number according to the span of the roof, but placed about 4 feet 6 inches apart. The covering consists of rough ½-inch white-wood boards, any width not exceeding 9 inches, which are securely nailed to the purlins, but are not actually in contact with them, this being prevented by first driving *three clout nails* into the face of the purlins for each board, which thus ensures a clear space of about ¼ inch. The object of this arrangement is that any moisture which may run down the inner face of the boards should not rot the purlin.

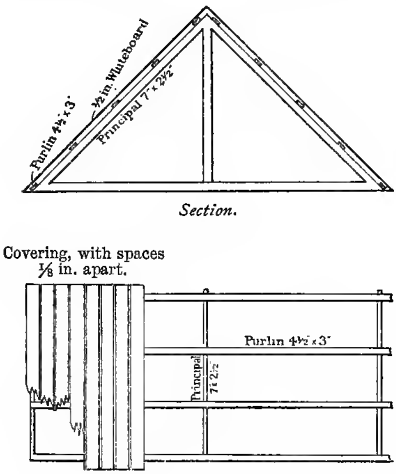


Fig. 112.—*Roof for court: Elevation, showing boards, purlins, and principals.*

It will be seen by the elevation that a space is left between each board of about ⅛ inch. This is one of the special features of this roof, it having been proved by experience that boards actually in contact keep out rain better than when just laid close. As a further protection (though whether absolutely necessary or not is a question to be decided by further trials), about ¼ inch from the edge of each board a small groove is hollowed out, which could not be shown in the drawing. It may be doubted if this is essential, and if not, it is objectionable, as weakening the boards.

The history of this simple and ingenious form of roof is interesting. About 1875, a brickmaker, working for Mr Edward York, of Marston, near York, found that shelter-boards not absolutely touching kept his bricks drier than when in contact, and he adopted the principle for a shed roof. Mr Cundy, of Wetherby, agent to Mr Montagu, an adjoining landowner, having seen the roof, covered a yard by way of experiment. Having been satisfied with the results, he had several yards so covered, and his experience of eight or nine years is thus far satisfactory.

The cost, as has been stated, need not exceed 2s. 6d. to 3s. per superficial yard of ground covered. Ordinary red-wood is recommended for the purlins and principals, and white-wood for the covering. Any intelligent carpenter might construct such a roof from the drawings: a gauge should be used to secure uniform space between the boards. The explanation of this rather curious fact as to the weather-proof condition is, that the globules of rain run down unbroken between the edges of the boards. It is quite certain that, even with a driving rain, the amount of moisture which penetrates is quite immaterial, that cattle so protected thrive well, that manure is not wasted, and that litter is economised.

Mr Coleman remarked that when it was remembered that the great object in these bad times was to make money go as far as possible, a cheap and yet efficient roof, such as he had described, was most desirable; and there was no reason why the boards should not be renewed after 25 or 30 years. The yard he saw was 30 ft. wide by 54 ft. long.

A roof of this description he considered well adapted for a tenant to invest in, when the landlord was unable or unwilling to do the work, but was yet open to an agreement as to tenant right; and in case of old buildings, when it was not worth while to do expensive work, it frequently happened they found large exposed yards surrounded by old buildings, which were much too useful to be swept away, although in process of time they might become untenantable. In such cases the ability to cover the yards at a small cost was a matter of great economy.

Whenever it was determined to erect new buildings, Mr Coleman said he could state from his own experience that, according to the accommodation provided, the principle of covering over the fold-yards was actually economical, because they required so much less ground-space per head of stock. In the case of open yards and shelter-sheds, the accommodation was determined by the number of animals that could be sheltered, and they had in addition all the open spaces, which necessarily increased the area of walling; but where all was covered, a very much smaller area was required per head of cattle. Averaging the size of the animals on a breeding farm, his experience was that 120 square feet was ample for each beast; and this brought him to the last section of his subject, viz. :—

Comparative Cost and Return.

Mr Coleman, in considering the question of comparative cost and return, said he had shown them that roofs might be constructed at from 2s. 6d. to 6s. 6d. a yard superficial, and if they preferred tiles, they could make an ordinary framed roof at about 7s. 6d. a yard. Assuming the highest cost, and that 120 square feet of ground were required for each beast, they had 13⅓ yards at 7s. 6d., which came to £5 per head. To repay this amount in 30 years, interest and principal, at 6½ per cent, would involve an annual charge of 6s. 6d. a-year per head—surely not a heavy outlay for the advantages of a well-constructed covered court.

Advantages of Covered Courts.

According to the figures submitted by Mr Coleman, it would appear that the saving per animal in covered courts, during a period of eight months, amounted to a sum of £2, 14s. Hence, he continued, there could be no doubt as to the economy and advantages of the system, and all that remained was to urge upon all who had not already covered yards for the winter feeding of their animals, to lose no chance, to relax no effort, to get this work carried out, which ranked next in importance in farm economy to drainage. He was quite certain that the increased return from having covered buildings for the winter accommodation of live stock would be many times the sum required to repay principal and interest on the sinking fund principle.

Subsidiary Uses of Covered Courts. — There were some additional advantages, such as the summering of calves on the soiling system. The opportunity for exercise and protection from sun and flies were often very advantageous. The yards might be of great service in harvest if the doorways were made high enough to take in a load of corn and hay.

As negative evidence, he might add, none of those who enjoyed the experience of properly covered yards had ever wished them away; on the contrary, every year's experience increased the estimation in which they were held.

Value of Covered Courts in Wet Weather.—The advantage of having a roof over the cattle-court is never greater or more obvious than in times of heavy rainfall. Mr John Chalmers Morton mentions this particular point as one of the lessons gathered from the experience of farmers in the disastrously cold and wet year of 1879.[1] Mr Clare Sewell Read, M.P., the celebrated Norfolk farmer, stated that the benefit of a covered court had on his farm been strikingly exemplified in wet weather. The owner of his farm had covered and fitted up to him a cattle-yard 80 feet square, at a cost of £100 for the roof, and £160 for boxes, mangers, &c., for

[1] *Jour. R.A.S.E.*, vol. xvi. p. 249.

which he had to pay £8 a-year. He considered that his stock in this covered yard, by their greater progress and saving of litter, had in a few months of exceptionally wet weather paid for the whole year's rent of the yard.

Covered-court Manure for Potatoes.—It has been found in practice, as shown above by Mr Coleman, that manure made in covered courts is specially valuable for potatoes. Mr George Hope, Fenton Barns, grew 4 tons of potatoes more per acre from manure made under cover than from manure made in the open yard. It has also been observed that for this crop the manure is most efficacious when driven directly from the court, and at once covered in the potato-drills.

Preventing "Fire-fang" in Manure.—It has often been mentioned as one of the objections to having cattle-courts entirely covered, that it is difficult, without the assistance of dew and rain, to get sufficient moisture into the litter to prevent the dung from becoming hot, and dry, and damaged, from what is commonly known as "fire-fang." In reference to this, Mr H. Howman, Balloughton, Coleshill, in a paper read before the Midland Farmers' Club, says: "I have met the difficulty by not allowing one bit of straw to be placed in the yards for litter without first being put through the litter-cutter and cut into about 6 inches in length; and this, I am convinced, is an absolute necessity for the proper working of manure. After two years' experience of the plan, against the cost of cutting up the straw, which is done by hand, I gain these advantages—the yards are littered more evenly and regularly, and not so much straw is used; while in emptying the yards, a great saving of labour is gained, because the manure is forked out so much more easily, and it is ready to be carted on to the land direct from the yards, and all the wasteful and laborious carting it into a heap to be rotted and wasted by the rain is saved."

Fermentation in the Dung doing no Injury.—Dr John Voelcker states that the fermentation which usually takes place in dung really does no injury. In the centre of the heap there is no doubt a considerable amount of fermentation, but as the gases rise towards the surface they get cool and fixed.

Loss in Manure by Washing.—With dung lying in an open court, the greatest risk is loss through the best ingredients being washed out by rainfall. The late Dr A. Voelcker found that sometimes the loss from this cause amounted to as much as two-thirds of the whole manurial value of the heap.

Indeed the risk of loss from washing in this way is considered so great by some careful farmers, that they have roofs put over their dung-pits for the sole purpose of guarding against it.

PARTIALLY OPEN COURTS.

A few men of high standing as agricultural authorities have from time to time "put in a word" for the open or partially open court.

Tillyfour's Opinion.—The late Mr William M'Combie of Tillyfour, M.P., who was one of the most successful breeders and feeders of cattle in his day, was no advocate for covered courts. His practice upon his own farms was to keep all the store-cattle which he intended to graze next season "in open straw-yards, with a sufficient covering for bad weather, and as dry a bed as the quantity of straw will permit;" and he tells us that in buying cattle for grazing, he carefully avoided those which he knew to have been wintered upon forcing food "in hot byres or close straw-yards," remarking that such cattle "will soon make a poor man of you." He says that cattle which have been highly fed in close houses with cake and corn, as well as turnips and straw, are very liable to suffer damage from inclement weather at the beginning of the grazing season; and that, although he did not mean that a few weeks of a little cake and corn would ruin a beast for grazing, yet he was strongly opposed to store-cattle being pampered or forced with high feeding during winter.

But Mr M'Combie did not go the length of recommending open courts for the fattening of cattle. His fattening cattle were usually tied up in close but fairly well ventilated byres. And it is important to note that even for store-cattle he was careful to provide "a sufficient covering for bad weather." So that it may safely enough be concluded that, in the light of more recent experience, Mr M'Combie would have become a believer in the *partially covered court.*

Store-cattle Thriving best in partially Open Courts.—Mr M'Combie's objection to "close" houses or courts for store-cattle is shared by many leading farmers. A very large number of practical farmers in all parts of the country, who acknowledge the benefits of entirely covered courts for fattening cattle, still prefer the partially roofed courts for store-cattle, believing that by the admission of a greater amount of fresh air the animals become more robust, and thrive better than if they were housed more closely. But there is seldom more than a third, more frequently not nearly so much, of the court uncovered. This open space should always be at the best sheltered part of the court, usually facing south.

Even by the strongest advocate of covered courts, the desirability of securing the free admission of fresh air, especially where young growing cattle are kept, is recognised and acted upon. Very often there is a good deal of open space at one end or side of the court. Mr Clare Sewell Read states that he is in favour of having the south end of roofed courts partially open.

No Fire-fang in Open-court Dung.—Some practical men have contended that it is easier to keep dung in good condition in open than in close courts. The manure in the open court becomes more moist than in the covered court, and is therefore not so liable to damage by fire-fang. On the other hand, it is argued that in the open court the plant-food in the dung gets washed away by rain; but the advocates of the open or partially open courts point out that loss in that way may be averted by having the bottom of the court rendered water-tight by a layer of concrete or pounded clay, and the overflow of liquid manure conducted either into a compost-heap or into specially prepared tanks, from which it may at convenient times be taken for irrigation, or for pouring over dry manure or heaps of compost.

It was at one time thought that dung sustained serious loss by evaporation; but it has been shown, notably by Dr A. Voelcker, that while the loss by washing may be very great, that by evaporation is usually trifling.

RECAPITULATION.

Upon the whole, therefore, with all in view that has been said for and against covered courts, there need be no hesitation in deciding that for fattening cattle the wholly covered, judiciously ventilated court is the best. For store-cattle the full roof is not so essential or advantageous. Even for these the greater part of the court should certainly be roofed; and if they have a dry bed and ample protection from wet and cold, the young growing animals will be little the worse—many affirm they will be the better—of access to an uncovered space, where they can breathe pure air, and enjoy any gleam of sunshine that may gladden the winter's day.

REARING AND FEEDING CATTLE IN WINTER.

This has come to possess a far greater relative importance, and to bulk more largely in farm management than in former times, when corn-growing was the mainstay of British agriculture. At the present time much greater dependence is placed upon live stock than has ever before been the case in this country, and on this account increased interest and significance are attached to all matters of practical importance relating to the animals of the farm. At this season, therefore, it becomes necessary to consider fully and in detail the indoor or house management and feeding of cattle. First, then, let us notice the

Duties of the Cattle-man.

Conveniently placed Straw-barns.—A laborious part of the duty of a cattle-man in winter is carrying straw in large bundles on his back to every part of the steading. It may easily be imagined, from this statement, that when the straw-barn is inconveniently placed, or at a considerable distance from the byres and hammels, the labour of the cattle-man must be very much increased; indeed from that circumstance alone he may require assistance to fulfil the duties he has to perform. An inconvenient straw-barn may thus be the cause of incurring the expense of another man's wages for the winter.

The straw-barn should be placed in a central position as regards all the apartments occupied by the live stock, and which are so arranged that the stock which requires most straw are placed nearest the straw-barn. This principle of arrangement in all steadings is fully illustrated in the *Book of Farm Buildings*, pp. 1 to 38.

A hard and fast rule as to the exact position of the straw-barn, or indeed of any one of the different apartments into which a farm-steading has to be divided, cannot be safely laid down. Still, in the arranging of a steading, the economising of daily labour should have careful consideration.

Method of Carrying Straw.—A convenient means of carrying straw is with a soft rope about the thickness of a finger, and 3 yards in length, furnished at one end with a small light iron ring, through which the other end slips easily along until it is tight enough to retain the bundle, when a simple loop-knot keeps good what it has got. Provided with 3 or 4 such ropes, the cattle-man can bundle the straw at his leisure in the barn, and have the bundles ready to remove when required. The iron ring permits the rope to free itself readily from the straw when the bundle is loosened.

Cattle-man's Dress.—The *dress* of a cattle-man is worth attending to, as regards its appropriateness for his business. Having so much straw to carry on his back, a bonnet or round-crowned hat is the most convenient head-dress; but what is of more importance, when he has charge of a bull, is to have his clothes of a sober hue, free of gaudy or strongly contrasted colours, especially *red*, as that colour is peculiarly offensive to bulls. It is with red cloth and red flags that the bulls in Spain are irritated to action at their celebrated bull-fights. There have been many cases of bulls turning upon their keepers who were partially habited in red, or some strongly contrasted bright colours. Indeed, like "a red rag to a bull" has become quite a common simile, when speaking of a certain cause of irritation. Be the cause of the disquietude in a bull what it may, it is prudential in a *cattle*-man to be habited in a sober suit of clothes. A short strong apron will save his clothes materially in carrying scullfuls of turnips to the cows, or oil-cake to other cattle.

Regularity in Hours of Feeding and Cleaning.—*Regularity of time* in everything done for them, is one of the chief secrets in the successful treatment of cattle. Dumb creatures as they are, they soon understand any plan that affects themselves—and the part of it to which they will reconcile themselves most quickly is regularity in the time of feeding; and any deviation from it will soon cause them to show discontent. Regularity consists in giving the same sort of cattle their food at the same periods of the day, and each day in succession. The cattle-man cannot follow this regular course without a watch; and no one should be selected for that charge who does not possess one.

The Cattle-man's Hours.—The cattle-man's day's work commences at break of day and ends at nightfall in winter, expanding the day with that of the season, until daybreak appears at 5 in the morning, and nightfall occurs at 6 in the evening. Beyond those hours he is not expected to work, excepting at 8 at night, when he examines in winter, with a light, every court and byre, to see that the cattle are in health and comfort before he goes to bed. Every hour of daylight in winter has its stated work; and it is only in the morning and evening, as the day lengthens, that any change in the time is allowable. As the same amount of work must be done every day, he has most to do in the least time in the shortest days in winter, and as the days lengthen he has more leisure.

The Cattle-man's "Time-table."—Let us accompany the cattle-man through a whole day's work. In some cases he breakfasts before he begins his labours; in others, not till he has gone his first "round." At daybreak, or not earlier than 5 in the morning should the day dawn before that hour, he goes to the cow-byre, and removes the dung in the stalls into the gutter with a graip, to make the stalls clean for the dairymaid when she comes to milk the cows. This business may occupy about 10 minutes.

On farms on which calves are bred, the cows are heavy with calf in winter; so most of them will be dry in that season, and those still yielding milk, being the latest to calve, will give but a scanty supply. It is not as *milk*-cows that breeding-cows are treated in winter, receiving but little succulent food.

The *graip*, fig. 113, with which he clears the dung into the gutter, consists simply of 4 long prongs, and a helve of wood set in a socket, having a slight bend near the prongs. This bend gives a leverage power to the handle, when the graip is used to lift rank wet litter; and it serves also to keep the hands clean from the dung. The stalls are thus cleared of dung for the dairymaid to proceed with the milking. Farm graips and forks are now, as a rule, made of steel, and they are vastly superior to the clumsy iron tools of former times. The graip here represented is made by Spear & Jackson, Sheffield.

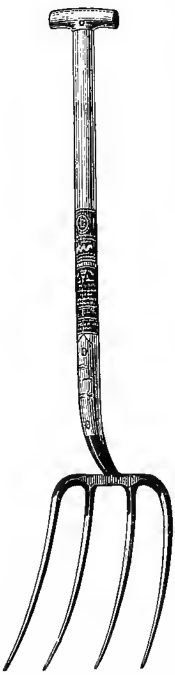


Fig. 113.—*Graip.*

He then goes to the servants' cow-byre, and does the same piece of work there for the servants' wives, who also milk their cows at this time. It may occupy him 5 minutes.

He shuts the doors of both byres, leaving the half-doors open for the admission of fresh air. The cows are now milked.

He then goes to the feeding beasts in the hammels, and cleans out with a *shovel* the refuse of the turnips of the former meal from the troughs, always beginning at the same hammel; and as soon as one hammel is cleared out, he replenishes its trough with turnips from the store at hand, the turnips having been broken with one of the implements in use. This may occupy him 40 minutes.

The byre and stable *shovel* is fig. 114. It has a broad square mouth, to stretch across the bottom and enter the corners of the gutters of the byre, or turnip-troughs of hammels and courts. Its helve is of wood, having a slight curve in it, to clear the hands from the dung. Another kind of shovel is often used, and it is specially adapted to clear the gutters of byres of dung in a quick and efficient manner. It is square in the mouth, and of a breadth to fit into the gutter, having the sides raised up 2 inches, and the back 3 inches, with socket for the handle. It has a wooden handle, with a cross head. This shovel is worked by simply pushing it forward along the gutter, at the end of which the dung is accumulated and removed. Such an implement hastens work in a large dairy, or where there are few hands.

Fig. 114.—*Square-mouthed shovel.*

From the hammels the cattle-man proceeds to the cattle-courts, where the young heifers and bullocks are, and cleans the turnip-troughs of the refuse, supplying them with turnips from the store. He may be occupied with them for 25 minutes.

The bulls in the hammels next receive his care. Their turnip-troughs are cleaned out, and a few fresh turnips given them, sliced in baskets from the store. The two hammels may engage him 10 minutes.

The extra beasts also in the adjoining hammels should next be attended to, by cleaning out their turnip-troughs and giving them a fresh supply of sliced turnips from the same store. These may take 10 minutes to be attended to.

The heifers in calf in the same row of hammels should have no turnips in the morning, only some fresh oat-straw. It may take 8 or 10 minutes to go for this to the straw-barn hard by, and put it into the racks.

Having thus given all the cattle at liberty their morning's ration, the cattle-man takes a bundle of fresh oat-straw from the straw-barn, returns with it to the cow-byre, and gives a little to each of the cows, and then removes all the dung and dirtied litter from the stalls and gutter with the graip, shovel, and wheelbarrow into the dung-house, sweeping the gutter and causeway of the byre clean with a broom. This work may engage him 30 minutes.

In like manner he gives the servants' cows a little fresh oat-straw, and cleans out their byre of dung and litter. In doing this he may be engaged 25 minutes.

The wheelbarrow, fig. 115, is of the common form, with close-boarded bottom,

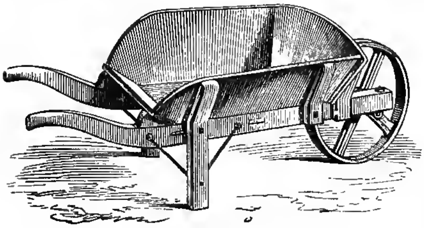


Fig. 115.—*Wheelbarrow.*

sides, and back, and of a capacity sufficient to carry a good load of litter, but of such breadth as will easily pass, with a load, through the byre-door.

When the byres have thus been cleaned, the cattle-man takes a bundle of litter from the straw-barn, and returns with it to the byre; and on clearing the troughs of the refuse fodder of the previous night, and sprinkling it over the stalls for litter, the cows are ready for straw or hay and turnips.

Turnips for Cows.—After milking is finished by the dairymaid in the morning, a common practice is to give the cows, though heavy in calf, a feed of cold turnips into their empty stomachs, which we consider a very injudicious practice. That it is so is evidenced by the fact of the fœtus indicating unequivocal symptoms of its existence in the womb after this or a drink of cold water in the morning. It is more prudent to give cows some fresh straw or hay, to prepare their stomach for the cold watery turnips. Cows in calf should never get as many turnips as they can eat. They should be fed moderately, the object being not to fatten, but support them in a fair condition for calving; for were they fed fat, they would run the risk of losing their life at calving by inflammation, and their calves would be small. On the other hand, it is bad management to let cows get low in condition.

It is not easy to specify the weight of turnips that should be given to cows; for some may advantageously get more than others. Fuller information on this point will be given subsequently, when dealing specially with the feeding of cows.

After the racks and troughs have been supplied with the fodder and turnips respectively, in the same order of distribution, from stall to stall, daily observed, the stalls are littered with the straw the cattle-man brought with him; and on shutting the principal door, and leaving the other half-door open for air, he leaves them for a time to rest and chew their cud—for nothing irritates cows more than to go about them, or remain in the byre and make a noise, while they are eating their principal meal. This work may require about 30 minutes.

Turnips are supplied to cows, either from a passage running along the heads of the stalls, as in feeding-byres, or from the causeway by the stalls themselves, in whichever way the byre has been constructed. Small doors opening through the wall, at the head of stalls in byres, are objectionable, as they are a means of superinducing catarrh or other head complaint in cattle.

A common practice is carrying turnips by the stalls in baskets called *sculls*, which are hollow hemispherical-shaped baskets of willow or wire, having either an opening on each side to take hold of the stout

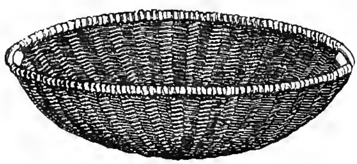


Fig. 116.—*Willow scull or basket.*

rim for handles, or handles attached to the rim at the ends. A willow basket, fig. 116, being in perspective, requires no description.

Turnips for Servants' Cows.—The servants' cows are then littered to lie down and rest, the turnips being given to them by the servants themselves, in such quantities, and at such time, as they think proper. The littering may occupy about 10 minutes.

The supply of turnips to servants' cows depends on the terms of agreement made with the servants. When a specified number of cart-loads are given, the servant may not choose to give them to his cow during the earlier part of the winter, if she is dry; but if in milk, the servant's family give what quantity they choose from their own store. If the farmer has agreed to treat his servants' cows in the same manner as his own, the cattle-man takes charge of them in every respect as he does those of his master.

The heifers in calf now get a few turnips sliced. This may occupy 10 minutes.

The extra beasts feeding in the hammels should now receive some fresh oat-straw as fodder. The time engaged in this may be about 10 minutes.

Foddering and Littering.—All the cattle having now had their morning meal, the next step the cattle-man takes is to supply them in the hammels and courts with fodder and litter where fodder has not already been given. He first pulls the old fodder out of the racks and scatters it about as litter, and then supplies them with fresh oat-straw from the straw-barn. The litter straw is then taken from the straw-barn, and used to litter the courts and hammels in such quantity as is requisite at the time, dry, fresh, or frosty weather saving the usual quantity, and rainy weather requiring more to render the courts comfortable. This distribution of the straw may occupy about 30 minutes.

"Airing" Cows in Winter.—In fair weather the cows should be turned into the court, or into a paddock of grass near at hand, to enjoy the fresh air, lick themselves and one another, drink water, or bask in the sun. They should go out every day until they calve, except in a storm and wet. One hour at least, and longer if fine, they should remain out.

Order in Letting out Cows.—In loosening cows from the stalls, a method is required to prevent confusion. Every cow, in the beginning of the season, should be put in the stall she has occupied since she first became an inmate of the byre; and she will go direct to *it*, and no other, avoiding collision with the rest. They should be loosened from the stalls one by one, always beginning at the same end of the byre, and finishing at the other, and not indiscriminately. This prevents impatience in any cow until it is released, as also collision on the floor and jamming in the doorway on going out, thereby escaping accidents injurious to animals with young.

The servants' cows are let out into their court, or into another field near at hand, from the other cows. The two byres may in this way occupy 15 minutes.

It is now time to give the feeding beasts in the hammels their mid-day ration of turnips; and it is as necessary to clear the turnip-troughs of refuse as in the morning. The turnips should be sliced. This may occupy 20 minutes.

Completion of Forenoon Duties.—In enumerating the portions of time thus occupied by the cattle-man, it will be found to be 5 hours 5 minutes; and if he began his work at dawn, say at 7 o'clock, the time now will be 5 minutes past 12 at noon. The cattle-man is then ready for his dinner, both as regards time and the state of his work. Should he find he has little enough time to accomplish his work, he has the consolation that, as the days lengthen after the 22d of December, he will have longer time to do the same work, and cannot possibly have more to do at any time. The cattle-man is entitled to rest one hour at dinner, like the other work-people.

Bundling Straw.—Immediately after his dinner-hour is spent, the cattle-man goes to the straw-barn, and bundles as many *windlings* of straw for supper as there are cows or cattle in byres under his charge. This is more safely done now than at night in candle-light. A windling is a small bundle twisted and fastened upon itself, and is about 10 lb. in weight. He also makes up a few large bundles of fodder. Taking one of these last to the cow-byre, he places fodder into every stall. Straw is often carried by cattle-men without being put into windlings, called "wisps" in some parts, but greater carefulness is then required to avoid losing straw by the way.

A Bit of Discipline for Cows.—The cows are then returned from the court or paddock into the byre; and to remove every temptation from even a greedy cow running up into another one's stall for the sake of snatching a little of her food, no green food should be lying in the troughs when they return to their stalls; and none should be given them immediately after returning to the byre, as the desire to receive it will render them impatient in the paddock, and again in the stall until they receive it. This is contrary to usual practice, but it suppresses inordinate desire, prevents violation of discipline, and necessity for correction. When subjected to regular discipline, cows soon obey it, and make no confusion, and conduct themselves peaceably. They should be bound to the stake in the same regular order they were loosened from it, from one end of the byre to the other, and the regularity provides against any cow being forgotten to be bound up.

The servants' cows are returned into their byre in the same manner.

Afternoon Foddering.—The cattle-man then replenishes the racks in the courts and hammels with fresh straw, strewing about the old fodder as litter; and he litters both with as much fresh straw from the barn as is requisite to render the courts comfortable to the cattle to lie down in the open air if they choose. In moonlight, many of the cattle will remain out in the open air all night, even though rime should be deposited on their backs.

He places the windlings in the byres, in the proportion required by the cows, for their evening foddering; and he does it in daylight to avoid the danger of going into the straw-barn for them at night with a light.

Second Ration of Turnips.—When foddering and littering with straw has been gone through, it is time to give the *cows* their second ration of turnips, to have them eaten up by the time the dairy-maid returns to the byre, at dusk, to milk them. Some people do not give cows when dry a second ration, but it is better to give them the same quantity of turnips at two separate times than all at once.

The *feeding oxen* in the hammels then receive their evening ration of turnips, having the troughs cleaned out and turnips sliced, and the quantity given will depend on the state of the night; for if the moon shine through the greater part of the night, a larger allowance of turnips should be given, cattle eating busily during moonlight. It is the same with sheep on turnips.

The *young cattle* in the large courts receive their second ration of sliced turnips immediately after the feeding beasts have been served.

The *extra beasts* fattening in the hammels should be treated in the same manner as the young beasts.

The *young heifers* and *bulls* in the hammels next receive their turnips; and as they both get limited quantities of roots, their proportion is divided into two small meals, sliced—one served after all the rest in the morning, and the other after the rest in the evening. Both classes depending much upon fodder for food, it should be of the sweetest and freshest straw, and supplied at least 3 times a-day—morning, noon, and evening; and having water at command, and liberty to move about, they will maintain sufficient condition. The heifers and bulls are supplied from the turnip-store.

The cattle-man then litters the *servants' cows* for the night, by which time the cows in the other byre will be milked; immediately after which they are also littered for the night, and the doors closed upon them. This last act finishes the labours of the day of the cattle-man.

Eight-o'clock Inspection.—At eight o'clock in the evening the cattle-man inspects every court, byre, and hammel, and sees that all the cattle are well and comfortable. Until twilight permit him to see the cattle, he takes a lantern to assist him. In courts and hammels, and in most modern byres, cattle have access to the fodder at all times, the fodder being held in racks specially provided for itself. Many byres, however, are still without this great advantage, and in these, in his round at 8 P.M., the cattle-man gives the cows the windlings of straw he had made up in the straw-barn during the day, and piled up in each byre at nightfall.

Lantern.—It is very important to have the cattle-man supplied with a handy form of *lantern* that will distribute a sufficient intensity of light around, and yet be safe to carry to any part of a steading, amongst straw or other highly inflammable material. Such a lantern (fig. 117, made by Rowatt & Sons) is now obtainable at a very low price.

Treatment of Feeding Oxen.—The treatment of *oxen* feeding in a byre is somewhat different from that of cows. As it is unusual to feed oxen in byres

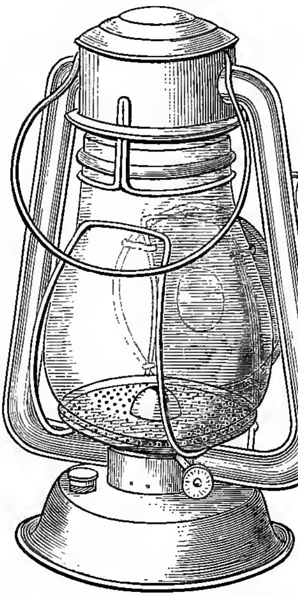


Fig. 117.—*Stable lantern.*

and hammels on the same farm, what has been said of feeding cattle in hammels should be considered applicable to those in byres. After the stalls of the cow-byres have been cleared into the gutter of any dung that might annoy the dairy-maid, the cattleman goes to the feeding-byre, and, first removing any refuse fodder from the stalls, and refuse of turnips from the troughs into the gutter, gives the cattle a feed of sliced turnips at once. The quantity at this time should be more than the third if fed three times, and more than the half if fed twice, of what they eat during the day, for they have wanted a long time.

Method in Feeding.—In distributing the food, the same regularity should be observed as with cows, the same ox receiving the first supply, and the same ox the last. When thus fed in regular order, cattle do not become impatient for their turn when the cattle-man enters the byre. The best plan is to begin serving at the farthest end of the byre, as the cattle-man will then have no occasion to pass and disturb those already served; and so in the case of *double-headed* byres, in which the cattle's heads are on both sides of the passage, both sides should be served simultaneously, one beast alternately on each side, working backwards, and thus leaving the served ones undisturbed. With the half-door left open for admission of fresh and the emission of heated air through the ventilators, the cattle-man leaves them to enjoy their meal in quietness.

Whenever the cattle have eaten their turnips, and not before, the byre should be cleared of the dung and dirty litter with the graip, shovel, and besom, and wheeled into the dunghill with the barrow. A fresh foddering and a fresh littering are then given, and they are left to themselves to rest and chew the cud until the next time of feeding, which should be at mid-day. After or along with this feed, more fodder is put into the racks, and the dung drawn from the stall into the gutter. In the afternoon, before daylight goes, the dung should again be carried away to the dunghill, and then the last supply of turnips given. Fresh fodder is again supplied, and the litter shaken up and augmented where requisite. After eating a little of this fodder, the cattle will lie down and rest until visited at night.

Oxen in Boxes.—When *boxes* are occupied by feeding oxen, the cattle-man comes to them when he has left the cow-byre. His first act is to remove the refuse fodder from the racks, which is strewn about for litter, and any refuse turnips from the trough, which have fallen upon the litter. An allowance of sliced turnips is then given, and the animals are left in quiet to enjoy their meal. The farthest end of the boxes are first served, and as the boxes are arranged on both sides of the passage, each ox on alternate sides is served in succession, thus avoiding disturbance to the oxen that have been served. With half-doors and ventilators left open, fresh air will find easy access to the cattle. After the turnips have been eaten up, or nearly so, fresh fodder and litter are served, and the cattle left to lie down and chew their cud. At mid-day another ration of sliced turnips or of cake or other mixed food is served, and after it is finished fresh fodder is supplied. In the afternoon, before daylight is gone, the last feed of sliced turnips is served; and after they are eaten, some more fodder should be given. In boxes the refuse fodder will generally serve for litter, the animals being under cover and the litter in a comparatively dry state from what it would be in hammels. After partaking of some of the fodder, the cattle will lie down to rest until visited at night.

A "Golden Rule" for Cattle-men.—In thus detailing the duties of the cattle-man, the object has been to show how the various meals should be minutely distributed to cattle. Whatever hour and minute the cattle-man devotes, from experience, to each portion of his work, he does *the same operation at the same time every day*. By strict attention to time, cattle will be ready for and expect their wonted meals, and will not complain. Complaints from stock should be distressing to every farmer's ears, for he may be assured they will not complain until they feel hunger; and if allowed to hunger, they will not only lose condition, but become less capable of acquiring it when the food is even fully given. Wherever lowings are heard from cattle, one may safely conclude that matters are conducted irregularly. Cattle are no hypocrites, and concoct no design for making a fool of their attendant. Their outcry may therefore be believed to be sincere. The cattle-man's rule is simple, and easily remembered: *Give food and fodder to cattle at fixed times, and dispense them in a fixed order.*

Method essential both for Cattle-men and Cattle.—These minute details, in the treatment of cattle, may be regarded as frivolous. They are not so; and where a number of minutiæ have to be gone into, unless they are taken in order, are apt to be forgotten, or hastily performed. Consider the number of things a cattle-man has to attend to. He has various classes of cattle under his charge—cows, feeding beasts, young steers, calves, heifers, bulls, and extra beasts; and he has to keep them clean in their various places, and supply them with food and fodder three times in a short winter's day of 7 or 8 hours. Is it possible to attend to all these particulars as they should be, without a matured plan? A cattle-man requires a plan for his own sake; for were he to do anything only when the idea struck him, he would be as prone to forget as to remember what he had to do. The injurious effects upon the condition of cattle by irregular attendance render a plan as necessary for their sakes.

Before the full force of this observation can be seen, it must be remembered how injurious it is to have food, fodder, and litter, given to cattle too much at one time, too little at another; frequently one day, seldom another; surfeiting them one time, hungering them another; having them clean one day, and dirty another. It stands to reason that such erratic treatment cannot fail to irritate their temper and prevent them acquiring the fine condition which good management never fails to secure.

Loss by Bad Management.—Let us reduce the loss by bad management to figures. Suppose three sets of beasts, of different ages, each containing 20 beasts, 60 in all, and they get as much food as they can eat. Suppose that each beast acquires half a pound less live weight every day than it would by the best management, this would incur a loss of 30 lb. a-day of live weight, which, over 180 days of the fattening season, will make the loss amount to 5400 lb.; and according to a common rule of computation, that amount of live weight is equal to 3240 lb., or 231 stones (14 lb.) of dead weight, which, at 8s. the stone, gives a loss of £92, a sum equal to much more than twice the yearly wages and board of the cattle-man. And the loss might easily be double that amount.

Treatment of Show Cattle.—What has been said applies to feeding ordinary cattle, but selected cattle may be desired to be fattened to attain a particular object, such as a pair of very fine oxen to be exhibited at a show. They should have a hammel or box—a byre does not seem a suitable place for such—comfortably fitted up for them, and ingenuity should be exercised to render it also convenient every way, after determining the sorts of food to be given. A trough for sliced Swedish turnips—a box for cake and meal—a rack for hay—cut hay and straw—and a trough for water. There should be abundance of straw for litter and warmth, and daily dressing of the skin to keep it clean, as *fat* oxen can reach but few parts of their body with their tongue. But all these appliances will avail nothing if regularity in time is neglected by the cattle-man.

Farmers have not yet acquired the art of administering food to stock on physiological principles, in accordance with the functions of the animal economy. Great advance has in recent years been made in acquiring knowledge on this point, but as yet the general body of farmers are to a large extent groping in the dark.

Grooming and Cleaning Cattle.—Much has been said on the propriety of wisping and currying cows and feeding oxen in the byre, and much may be said in commendation of the practice where cattle are always confined to the byre. When so confined, it seems indispensable for good health to groom them daily, perhaps with the curry-comb and brush, or "wisp" of straw or mat. Currying should be exercised on cattle only when not eating their food and not chewing their cud; and this rule should be strictly enjoined, for there is a strong propensity to dress and fondle animals when at food—from no desire to tease, far less to torment, but it seems a good opportunity for attendants to employ themselves without regarding the feelings of the animals. The untimely meddling, however, has a tendency to irritate some cattle, whilst it pleases others so much as to make them desist from eating. Many are jealous of being approached when eating their food, as is seen when a dog growls and a horse scowls.

In practice there is considerable variation in the hours as well as in the general system of feeding. It is not pretended that the hours mentioned are the best for all cases; still, these full details as to the daily routine of the cattle-man's duties are worthy of a place in this work, even if for no other reason than that they are calculated to enforce upon the mind of the farmer and the cattle-man the great importance of pursuing a well-thought-out system of cattle-feeding with unfailing precision and punctuality.

FOOD AND FEEDING.

Having traced in detail the duties of the cattle-man in regard to the hours of feeding, cleaning, and general treatment of cattle in houses, and having also in a preceding section noticed the arrangement of cattle in byres, courts, and boxes, we now proceed to consider the important subjects of "food and feeding"—that is, the food used for cattle, and the best methods and most suitable quantities, conditions, and proportions of administering it to them.

Here we at once enter into a broad field, in which there are many points—many hills and hollows, so to speak—which have never yet been fully explored and explained. To British farmers of the present day it is a subject of vast interest, and of great and still growing importance. In this work it demands, and shall receive, the fullest and most careful treatment.

It will be convenient to notice in the first place the functions of food and the various articles of food used in the rearing of farm live stock.

FOOD AND ITS FUNCTIONS.

Elements of Food.—The elements of which perfect food is composed are of three different classes: *firstly*, those containing nitrogen, which enter into the composition of bones, hair, horn, wool, skin, blood, and muscle or flesh; *secondly*, those in which nitrogen does not exist, and which mainly fulfil the office of supporting respiration and animal heat, of producing mechanical force and forming fat; *thirdly*, mineral and saline matters, such as build up the main substance of bones, and take an important part in the constitution of the blood and other juices.

Functions of different Elements.—The first are generally classed as the nitrogenised or "flesh-forming" constituents of food; the second as the non-nitrogenised constituents, or the elements of respiration and fat.

The sharp distinction thus formerly made between the nitrogenous and non-nitrogenous constituents of food has, however, by later investigation, been found to have been too arbitrary. For example, it is now known that nitrogenous matters may become, to a certain extent, transformed into fat, which was at one time doubted or denied by physiologists; while it is now conceded that the non-nitrogenous matters play a highly important part in the production of mechanical force, formerly supposed to be due to the actual using up of muscular tissue.

Affinity of Elements of Plants and of Animals.—The elements which produce the flesh and fat of animals are supplied in their food, ready to be converted to their several uses without undergoing any great or material change. In vegetable bodies there are vegetable albumen, gluten, and casein, which are, in chemical constitution, very closely allied to the muscular and vascular tissues of the body, the curd of milk, and the fibrin and albumen of blood. The phosphates, common salt, &c., which exist largely in the bones, muscles, blood, and milk of animals, exist also in plants; whilst fat exists to some extent, ready formed, in vegetables, in which, moreover, are found in abundance such materials as sugar, starch, gum, and digestible cellular tissue, which are readily convertible into fat, or utilisable for the production of mechanical force and heat.

The proportions, however, in which these various classes of substances exist, vary in different classes of plants and parts of plants, and hence the different results experienced from the use of different kinds of food.

Different Foods for Growing and Fattening Stock.—Young growing animals require different food from those which are being fattened for the butcher. In the former, the object is to build up the bony structure, and to ensure full muscular development; whilst in the case of the animal preparing for the butcher, although we still draw on the nitrogenous or so-called flesh-producing elements of food, yet the chief demands are on the non-nitrogenous or fat-forming constituents.

Proper Mixture of Foods.—There must, however, at all times be a proper mixture of the elements. If an animal is fed exclusively on one description of food—food, for example, which contains merely nitrogenous matter — it would gradually sink and waste, in consequence of the absence of those elements which are required to maintain an efficient supply of animal heat and to keep up the existence of fat. Again, an animal cannot exist solely on non-nitrogenised food, such as starch or sugar, and if so fed it would rapidly die.

RESPIRATION AND MECHANICAL FORCE.

Stock-owners are earnestly commended, before entering upon a consideration of the various kinds of food, to peruse carefully the following observations as to the utilisation of food in maintaining *respiration* and producing *mechanical force—i.e.*, the various movements of the animals, voluntary and involuntary.

Even the casual reading of these notes will at once make clear to farmers the importance of keeping cattle in a comfortable condition—exposed neither to inclement weather nor to undue or unnecessary exercise. But do not let the reading be casual. Let it rather be painstaking and thoughtful, and the more fully and accurately the considerations submitted are borne in mind and acted upon, the more successful will be the feeding operations.

Study carefully also what is said as to *ventilation* and *exercise.*

Respiration.—In respiration, or the act of breathing, the animal inhales and exhales the atmospheric air. The air drawn in, or inhaled, if dry, consists nearly of—

Nitrogen	79.16
Oxygen	20.80
Carbonic acid	0.04
	100.00

After the air has passed through the lungs, it then consists of—

Nitrogen	79.16
Oxygen	16.84 to 12
Carbonic acid	4.00 to 8
	100.00

The amount of carbonic acid, therefore, is much greater after the air has passed through the lungs than it was when first inhaled. On an average, the natural proportion of carbonic acid in the air is found to be increased 100 times after it is expelled by breathing from the lungs.

Whence, then, is this excess of carbonic acid derived? It must evidently be from some other source than the atmospheric air. In fact, it must obviously be either derived from the body itself or produced within the body during the process of respiration. If we burn a piece of animal or vegetable substance in the air under circumstances which enable us to measure or examine the gases produced by the combustion, we shall find that the carbon, which forms an important integral part of all animal and vegetable matter, has combined with the oxygen in the air, forming carbonic acid gas; while the hydrogen of the substance has been converted into watery vapour by a like process. In fact, it is the chemical combination of the oxygen with the carbon and hydrogen of the substance that constitutes the phenomenon of combustion with its attendant heat.

Now when air is taken into the lungs it is brought, by a beautifully organised mechanism (which we cannot in this place describe), into very intimate contact with the blood, which takes up some of its oxygen, and conveys it through the circulatory system. Here the oxygen chemically acts on certain constituents of the blood, and combines with them, virtually burning them up. The main products of this combustion are the same as those produced by burning paper, or tallow, or other combustible matter in the air—viz., carbonic acid gas and water. The carbonic acid gas is eliminated in the breath, and so, to some extent, is the water, the remainder passing away in perspiration and through the kidneys, which also excrete the urea formed by the destruction or using up of the nitrogenous constituents of the blood.

Speaking practically, and not with any special regard to the niceties of physiological accuracy, we may say that the materials burnt up in the blood are the materials supplied in food,—that, except for the comparatively small proportion of food actually utilised for the formation of new tissues, all the digestible parts of the food furnish merely so much fuel to be burnt up in the blood. But is the quantity so burnt up, or oxidised, a vague or illimitable quantity? Certainly not. On what, then, does it depend? On the following considerations:—

Temperature of Animals.—An animal has to keep up a certain high temperature. This temperature is variable in different animals, but is in most cases somewhere near 100 degrees Fahrenheit. If the blood of the animal rises above its normal temperature it becomes feverish, and a few degrees further rise are fatal. An abnormally low temperature is no more compatible with health than an abnormally high one.

How, then, is this bodily temperature kept constant amid the variations of external temperature to which all animals are more or less subjected? In answer to this we need here give only the short reply that nature, while an animal is in health, provides that more or less food-material shall be burnt, according to whether the tendency is to lose or gain in temperature. In cold weather an animal radiates heat much faster than in hot; and if respiration ceases—and with it life—the heat of the animal is rapidly dissipated, and it soon becomes as cold as the surrounding air. The rapid loss of heat in such a case is easily apparent.

We are apt, however, not to reflect that in the same cold weather a living animal loses heat even faster. But as fast as heat is dispersed from its body into the cold air, fresh heat is produced by the combustion involved through the respiratory process. If the weather becomes warmer, or the animal is taken into a warmer place, less heat is given off into the surrounding air in a given time than in the colder condition just considered. In order, then, that the animal may not grow too hot, the combustion process in the blood becomes diminished, so that less heat is manufactured.

There are other controlling agencies, such as the action of the perspiratory glands; but essentially we may say that nature keeps the animal temperature constant, by regulating the quantity of food-material burnt in the blood.

Mechanical Force.—All the material burnt in the blood, however, does not produce heat. Much of it is spent in producing mechanical force. Just as coal burnt in an engine-furnace produces force which is ultimately used in driving wheels or cranks for raising weights, grinding corn, ploughing, threshing, or other mechanical work, so a portion of the food burnt in the blood is spent in the production of the various movements of the animal, voluntary and involuntary.

The minimum of food for this purpose is consumed by the animal in the stall where it does no work; the maximum by the horse or the ploughing ox.

Food regarded as Fuel.—The fat, the starch, the sugar, the gum, the digestible fibre, and, to a minor extent, the albuminoids or nitrogenous matters, are, then, to be regarded as so much fuel put into the animal engine, to be converted partly into heat, partly into mechanical force or movement, involving more or less work. But we have seen that the food or fuel consumed for keeping up temperature is limited by the surrounding temperature, and that consumed to produce movement or work is limited by the movement effected or the work done.

Forming Fat.—What, then, becomes of such food as is over and above what is thus required? *It accumulates in the body mainly in the form of fat.* It is, indeed, the judicious supply of this surplus food that constitutes the skill of the fattener of stock.

In feeding a horse, we give him just so much food as will enable him to do his work and keep him in "fit" condition. With the ox or the sheep or the cow, we have to make flesh or milk; and we have to bear carefully in mind that for the purposes of heat and movement—merely, that is to say, to keep the animal alive—there is a certain daily expenditure of food, the excess over which is alone available for making increase or profit.

We strive, therefore, to limit the profitless consumption of food which merely keeps the animal alive, by protecting it, when feasible, from cold, and by limiting its exercise.

Thick Hides in Cold Regions.—It is to economise food that animals in cold regions possess warmer coverings than those which inhabit hot regions. Those who have always been accustomed to the sleek fine coats of carefully tended cattle may think that the shaggy winter covering of the kyloe is grotesque, and perhaps more ornamental than useful; but they overlook the fact that the shaggy covering is an economiser of food, and that by means of the additional warmth which it affords, the scanty food which the kyloe procures during winter in its natural state, and which would be insufficient of itself to sustain the animal—that is, to evolve a sufficient amount of heat to enable the animal to undergo the rigour of the winter—becomes equal to the purpose, in consequence of this covering. There is a less demand on the combustible materials stored up in the food, and thus the shaggy covering becomes essential to the existence of the animal.

Shelter for Cattle.—It will now be easily seen that insufficient house-accommodation is a serious disadvantage to the owner of cattle, entailing as it does an extra expenditure of food without an equivalent return. And how much greater is the loss in the case of those whose cattle are exposed during the entire winter, without any shelter beyond that which is afforded by a hedge! As truly remarked by Mr R. O. Pringle,[1] when cattle on a cold winter day

> "Mourn in corners where the fence
> Screens them, and seem half petrified to sleep
> In unrecumbent sadness,"

there is a waste of material going on as surely as if the owner wilfully undertook the office of the incendiary, and set fire to his hay-ricks. On the approach of winter, all cattle ought to be put either into properly constructed houses or covered yards, where their food will be expended in promoting their growth and development, and not wasted in meeting the extra demand for animal-heat-producing material which exposure creates.

Ventilation. — But while shelter is essential, so also is *ventilation* in houses for cattle. Allusion has been made to the change which takes place after the air has passed through the lungs, by which carbonic acid is abundantly produced. If there is no means of escape provided, the carbonic acid will accumulate to such an extent as to be most prejudicial to the animals breathing an atmosphere which is saturated with it. It is, in fact, a deadly poison; and when we bear this in mind, we can have little difficulty in tracing to their true source many of those inflammatory diseases to which

[1] *Live Stock of the Farm*, 30.

cattle confined in ill-ventilated houses are subject, and the origin of which often at first appears so very mysterious.

A man consumes about a gallon of air per minute. "A horse," according to Boussingault, "throws off daily forty-five pounds of carbon in the form of carbonic acid gas; and in the case of the cow, four-ninths of the carbon contained in the daily food is consumed during the process of respiration." This shows how very soon the air in a closely shut-up stable or cow-house becomes vitiated, and rendered utterly unfit to support life in a healthy state.

If, therefore, it is necessary to prevent waste of food by providing proper shelter, it is no less requisite to the healthy condition of the animals that the air which they breathe shall always be kept in a state of purity.

Ample space should be secured over the heads of the animals, and hay-lofts and other obstructions to a free circulation of air ought never to be permitted. Ventilators should be inserted in the apex of the roof to permit the heated exhaled air to escape, and means taken to secure a constant supply of fresh air from beneath, without creating a thorough draught, the effect of which would be to check the perspiration, and thus lay the foundation of catarrh and other diseases.

Effects of Exercise on Feeding Stock.—The exercise which an animal takes, causes, as we have seen, a corresponding waste of food. By exercise the respirations are not only rendered more frequent, but are also increased in force; hence there is a greater consumption of carbon and hydrogen—consequently the animal requires a larger amount of food to enable it to fatten, or if this is withheld, it becomes wasted or leaner. It is well known that fattening animals become more rapidly fat when kept perfectly quiet, and free from everything which excites their attention and renders them restless.

Exercise necessary for growing Animals.—The growing animal, indeed, requires a certain amount of exercise in order to promote muscular development and strength of constitution. If sufficient exercise is prevented in this case, the young animal will, no doubt, accumulate fat freely, but its constitution will be enfeebled; and if the same treatment is pursued through several successive generations, although the animals will gradually acquire a greater aptitude to fatten at an early age, they will also become less to be relied upon for breeding purposes. Growing and breeding animals should therefore be always permitted a sufficient amount of exercise to secure a healthy system, whilst those which are fattening for the butcher must be kept quiet and undisturbed.

VARIETIES OF FOOD.

It has been thought desirable to present in this work a full description of the various commodities used as food for stock. Prices, and home supply or deficiency, and other circumstances which tend to regulate the choice of foods, are subject to such variation, that precise directions cannot safely be given as to the kinds and proportions of foods which would be best for all circumstances. Careful consideration of the information furnished as to the different varieties of foods will assist stock-owners in deciding from time to time as to which they should select for their stock. In Pringle's *Live Stock of the Farm* (third edition, William Blackwood & Sons) a great deal of useful matter relating to foods is given; and not a little of this, revised in the light of recent discoveries and experience, is produced here, largely supplemented by fresh information of practical value.

Milk.

Milk is the most perfect and most natural of all foods for young animals. As already observed, there must be a proper mixture of the nitrogenous elements or albuminoids along with the non-nitrogenous (carbo-hydrates and fat), to form perfect food. A perfect illustration of this mixture is found in milk, the first description of food upon which the young animal subsists. It contains, 1st, casein or curd, which is chiefly analogous to the *fibrin* or lean part of the flesh; 2d, fat in the shape of butter; 3d, sugar; and 4th, certain substances which are converted into the earthy part of the bones, and the saline matter of the blood. The saline or earthy portion of milk consists of the phosphates of lime, magnesia, and iron, chloride of potassium, and common salt.

In its ordinary state the milk of the cow consists on the average of about 3½ per cent of casein or flesh-forming matter, 3½ per cent of butter, oil, or fat; 4½ per cent of sugar; ¾ per cent of saline matter; and 87¾ per cent of water. Everything, therefore, which is required to promote the development of the growing animal is contained in the milk, blended together in proportions suited for the purpose.

Wheat.

The average composition of the grain of wheat is as follows:—

Water	12.5
Albuminoids	12.0
Fat	2.0
Starch, &c.	69.3
Woody fibre	2.5
Mineral matter (ash)	1.7
	100.0

Flour Unsuitable for Stock.—In the shape of flour, wheat is a very starchy food, and in that form not suitable for stock; but as it leaves the straw with the bran and other coats, it comes pretty near to the desired albuminoid ratio of 1 to 5.

Fall in Price of Wheat.—Formerly, when wheat was selling at from 45s. to 60s. per quarter, it was too expensive to be used in feeding stock. Unfortunately for owners and occupiers of wheat lands, it has, since the "eighties" set in, tumbled down headlong in price, till in 1887 its average market value was not more than 32s. per quarter. At this very low price wheat may in some cases be employed with advantage as food for stock.

Damaged Wheat for Stock.—Indeed several instances are recorded of wheat, even when the market price was as high as 50s. per quarter, having been used profitably in feeding stock—chiefly in cases in which the wheat had been damaged by wet weather or mildew. In 1872 much wheat was damaged by the wet harvest, and a great deal of the sprouted grain was turned to good account in feeding stock. It was first kiln-dried and then mixed with chaffed hay or straw.

Wheat for Cattle and Sheep.—Mr Badcock of Stogumber, writing to the *Chamber of Agriculture Journal* on the use of wheat for farm-stock, says: "I grind the wheat to fine meal. At present I am feeding ten beasts on grass, with half a peck per day, mixed with straw-chaff, and cart-horses receive one-third peck each per day, and chaff with grass. When I take my horses in house I shall give one peck of meal and two pecks of oats mixed with chaff, and a few cut mangels to every three horses per day. I do not give it to hack-horses. Fatting beasts in house receive it with roots and a plentiful supply of water, and if I feed them very high, I mix linseed-cake. I think there is nothing better for pigs. For sheep I have never used it except with cut roots; then I shake it over the roots in the troughs."

Mr Wilcox of Almondsbury, Gloucestershire, was in the habit of feeding stock with wheat before the decline in its price, and he considered it to be more nutritious than any other food he had ever used. His method with cattle was as follows: Cut straw and hay to fine chaff—the greater proportion being straw, thrown over a given quantity (4 lb. or 5 lb.) of meal, with as much pulped-root as you feel disposed to put, mixing all together. Give it twice a-day. To sheep he always gave it crushed or bruised—say a pint or a pint and a half each per day. He thought it the finest food for sheep he had ever used.

Feeding Value of Wheat.—Mr John Speir, Newton Farm, Newton, Glasgow, has used wheat with very satisfactory results in the feeding of dairy-cows. He points out, however, that to be a successful feeding-stuff by itself it would require much more oil than it possesses, and considers that the addition of one-fourth of linseed or one-third of linseed-cake, would much enhance its feeding value. He adds: "Even to cattle—mixed with an equal proportion of decorticated cotton-cake and peas or beans, all ground into rough meal (not flour)—the very best results have been obtained. It is better boiled and given whole than ground into flour, but as rough meal it is better than either, as it never then gets into the doughy state, and it mixes freely with chaff and pressed or sliced turnips."

Taking as his standard of value, the digestible carbo-hydrates at ½d. per lb., and the digestible fat and albuminoids at 2½d. per lb., Mr Speir places the feeding value of wheat at £6, 8s. 4d. per ton, with maize at £5, 18s. 2d., linseed at £13, 0s. 11d., and linseed-cake at £9, 9s. 6d. If linseed-cake fell in market price to, say, £7 per ton, then wheat would, according to this calculation, be worth only £4, 15s. 2d. per ton as food for stock. Mr Speir takes linseed-cake as the standard or most important food for meat-production, and so estimates the feeding worth of other foods by its market price.

For milk-production Mr Speir takes beans as the chief food, and according to the above method of calculation, when the market price of beans is £7 per ton, wheat would be worth £5, 12s. 3d., or 17s. per ton more than when compared with linseed-cake for meat production.

Even at the low price of 31s. per quarter to which it fell in 1887, wheat realises in the grain market over £7 per ton. On the basis of the calculations made by Mr Speir, it would seem that it would still be more profitable to sell wheat than consume it by stock, for linseed-cake can now (1888) be purchased at from £7 to £8 per ton.

Wheat for Sheep.—Experiments conducted by the Royal Agricultural Society of England at Woburn, place wheat in a more favourable light than Mr Speir's calculations — at any rate as food for sheep. During the winter 1885-86 a series of experiments with linseed-cake, wheat, and other cereals as food for sheep gave results which were unexpectedly favourable to wheat. Indeed, considered as food only—that is, omitting the question of manurial value—wheat gave the best monetary return, linseed-cake coming second. Reckoning manurial value according to Lawes's table, these two stood about equal.

With the view of correcting or verifying these results, another series of experiments were conducted at Woburn in the winter of 1886-87. The experiment continued for 95 days, and the sheep—40 crosses between the Hampshire and Oxford Down breeds, divided into 5 pens of 8 sheep each—were put on roots for a short time before the experiment began, to accustom them to the diet. Each pen received as much sliced swedes and chopped hay as the animals could eat, and had, in addition, for each animal ½ lb. for the first week, and thereafter ¾ lb. per day of the particular kind of food being tested. The foods on trial were—pen 1, linseed-cake; pen 2, wheat; pen 3, decorticated cotton-cake; pen 4, linseed-cake and barley in equal proportions; and pen 5, decorticated cotton-cake and barley-meal in equal proportions.

The following table shows the weights at the conclusion of the experiment, as well as the increase in the 95 days:—

WEIGHTS OF 5 PENS OF SHEEP AT THE END OF 95 DAYS, DEC. 23, 1886, TO MARCH 28, 1887.

	PEN I. Linseed-cake.	PEN II. Wheat.	PEN III. Decorticated cotton-cake.	PEN IV. Linseed-cake and grittled barley.	PEN V. Decorticated cotton-cake and grittled barley.
	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.
Total weight of 8 sheep on March 28, 1887	13 2 3	13 1 12	13 3 9	12 3 23	12 2 1
Total weight on Dec. 23, 1886	11 0 17	11 0 16	11 0 15	11 0 16	11 0 17
Total increase in weight of 8 sheep during 95 days	2 1 14	2 0 24	2 2 22	1 3 7	1 1 12
Equivalent in lb.	266 lb.	248 lb.	302 lb.	203 lb.	152 lb.
Increase per head during the whole 95 days	33 lb. 4 oz.	31 lb.	37 lb. 12 oz.	25 lb. 6 oz.	19 lb.
Daily increase per head . .	5.6 oz.	5.2 oz.	6.4 oz.	4.3 oz.	3.2 oz.

Reckoning linseed-cake at £8, 14s. 10d. per ton, decorticated cotton-cake at £7, 4s., wheat at £6, 8s. (30s. per quarter), barley at £5, 6s. (22s. per quarter) —which were the market prices at the time—Dr John Voelcker shows that the relative cost per lb. of the increase in live weight produced by the various foods was as follows:—

Pen		d.
I.	Linseed-cake	1.84
II.	Wheat	1.50
III.	Decorticated cotton-cake	1.33
IV.	Linseed-cake and barley	1.96
V.	Decorticated cotton-cake and barley	2.34

It is thus seen that decorticated cotton-cake not only produced the largest increase, but also did this at the lowest cost. In the first experiment it was undecorticated cotton-cake that was tried, but it did not come out so well. Wheat comes second, and is just about as far ahead of linseed-cake as it was in the experiments of the preceding winter.

The following table shows the manurial values of a ton of linseed-cake, wheat, and decorticated cotton-cake, as estimated by Lawes and Gilbert; and also the manurial value, according to this standard, of the 522 lb. of each of these foods consumed by each of the pens of 8 sheep during the 95 days of the experiment:—

	Manure Value. Per ton.	Per 522 lb. consumed.
Linseed-cake	£3 8 6	£0 18 3½
Wheat	1 8 7	0 6 8
Decorticated cotton-cake	5 13 0	1 6 4

Now, considering these foods in regard to their value both for feeding and manurial purposes, we arrive at the following table:—

	Linseed-cake.	Wheat.	Decorticated cotton-cake.
	d.	d.	d.
Cost of additional food for each lb. of live weight	1.84	1.50	1.33
Less manurial value	.82	.32	1.04
Net cost of additional food for each lb. of live weight	1.02	1.18	.29

It is seldom found in practice that the full relative manurial values here stated are realised; yet the great superiority of decorticated cotton-cake over both wheat and linseed-cake, in the feeding of sheep, stands out indisputably.

The wheat was given whole, as it had been found in the previous year that this form answered best. Dr J. Voelcker remarks that "the fact that all the sheep fed on wheat went through the experiment without any illness whatever, confirms the observation before made, that it can be quite safely used for sheep."

The quantity of roots, sliced swedes, consumed per head, began at about 23 lb. per day and rose gradually to about 30 lb. The pen on linseed-cake consumed most roots, averaging about 29 lb per day for the 95 days; pens 2 and 3 averaging 28 lb. per day per head; and the other two 26½ lb.

At first the sheep consumed about 4 oz. of hay-chaff per head daily, and increased in a week to about 8 oz.

There did not seem to be much difference in the growth of wool in the various pens; but it was observed that the quality of the wool of the cake-fed sheep was decidedly better than that of the wheat-fed ones.[1]

Bran.

In milling wheat for use as human food, the bran is usually separated from the flour. An average analysis of bran is as follows:—

Water	14.0
Albuminoids	14.5
Fat	4.0
Starch, &c.	51.5
Woody fibre	10.0
Mineral matter (ash)	6.0
	100.0

Bran is much used as food for live stock, sometimes in the form of mashes, and at other times mixed with other kinds of foods. When used by itself, or mixed with cold water, it has a slightly laxative effect, which renders it useful in preparing horses for physic, and in some cases may so act as to obviate the necessity of giving purgative medicine. The ash of bran contains a large proportion

[1] *Jour. Royal Agric. Soc. Eng.*, xxiii. 417.

of phosphates, or the earth of bones, much larger than the ash of barley or oats. Hence it is particularly useful as part of the food given to milch cows, when such are "in profit," or full milk —milk being rich in phosphatic constituents.

Bran acts beneficially in counteracting the heating properties of maize and other meals.

Bran for Stock-feeding.—Mr G. H. C. Wright, Sigglesthorne Hall, Hull, says that, given to cows in excess, bran deteriorates the butter by diminishing the size of the fat globule of the milk; and adds: "I consider that bran is more suitable for feeding stock than for dairy-cows; for the feeding beasts, a daily ration of 1 stone of bran, 1 stone hay, and 2 stone turnips, will give a much larger increase in the weight of the cattle than any corn-meal used in conjunction with the hay and the turnips, and will prove to be a cheaper artificial food. In the case of dairy-cows, this is reversed; grain-meal will give a much better result than bran, both as regards quality and quantity of milk."[1]

This, it should be mentioned, is not in accordance with the opinions hitherto most generally accepted. The value of bran for fattening stock deserves fuller investigation by actual experiment.

Barley.

The following is an average analysis of barley:—

Water	14.0
Albuminoids	10.5
Fat	4.5
Starch, &c.	62.0
Woody fibre	7.0
Mineral matter	2.0
	100.0

Barley is thus exceedingly rich in the fattening properties of food. It is seldom—and never should be—given in its dry whole state as food for stock; but in the form of rough meal, or malt, or cooked, it is employed very extensively in feeding stock. Like wheat, it has fallen greatly in price, and its home consumption, now very much larger than in former times, is steadily increasing.

[1] *Jour. Bri. Dairy Fr. Ass.*, 1888, 14.

Cooked Barley. — When barley is cooked, it must be allowed to simmer slowly at least twelve hours, until the whole forms a mass of rich pulpy matter, perfectly free from whole grains; and in cooking, the greatest care must be taken to prevent the barley from becoming burned, by adhering to the boiler in which it is prepared. When thoroughly cooked, it becomes a most valuable ingredient in the food of fattening animals, and horses thrive remarkably well upon it—so much so, that a course of boiled barley given at least once a-day will very soon renovate horses that have been worn out with hard work.

Boiled barley is used by some of the most successful exhibitors of shorthorns in the preparation of their cattle for the show-yards. Along with a little oilcake, it gives that finish—brings out that mellowness in handling—which is so much desired in such cases.

Barley-meal for Pigs.—For the fattening of pigs, barley-meal is the king of all foods. For pork-production, it is, on account of its exceptionally high percentage of starchy matter, the most perfect food yet discovered, and no other animal will yield a larger percentage of butcher-meat from a given quantity of barley than a pig of a good sort.

Steeping Barley. — Whole barley should be steeped in water at least twenty-four hours before being given to stock; but the more common practice now is to grind it or to crush it into rough meal. Some think it advisable to steep the ground barley in water.

Malt.

The Malt-tax Controversy.—Barley is converted into *malt* by being first steeped and then allowed to germinate; the original object of this process being to prepare the barley for distillers and brewers. As to the simple question of the relative feeding merits of *malted* and *unmalted* barley, there was a lively and long-continued controversy. Formerly the duty now levied directly upon manufactured spirits, ales, and porters, was imposed upon malt, so that the farmer could not malt barley for feeding his stock without paying the malt-duty. This was a momentous grievance to the farmer, on whose behalf it was urged that malt was much more valuable as food for stock than unmalted barley. Human nature is a little curious in some of its moods, and it is just possible that the barrier which formerly existed to the use of malt as food for stock may have had something to do with the high opinion then expressed as to its value for that purpose. Be that as it may, the duty was removed from the malt, and now that farmers can make malt for their stock as freely as they desire, less is heard of its alleged special feeding virtues than when they had no such liberty. Indeed, it is used as food only to a very limited extent.

That malt is a valuable and palatable food, there is no doubt whatever. The contention that it is superior food to unmalted barley has not been borne out by practical experience.

Rothamsted Experiments on Malt.—Sir John Bennett Lawes carried out an elaborate series of experiments upon the use of malt in feeding various kinds of stock, and it may be useful to produce here the following summary of a report which Sir John made upon the subject to the Government:—

The Loss and Chemical Changes which the Grain undergoes by Malting.

1. In malting barley of fair malting quality, in the usual way, there was a loss of nearly 19 per cent of its weight, about 12 of which was water, the remaining 7 being solid matter or food-material.

2. In malting barley of good feeding but inferior malting quality, there was a loss of about 22 per cent of its weight, of which 15 was water, and 7 solid matter or food-material.

3. The loss of solid matter consisted chiefly of starch or other non-nitrogenous substances, but comprised also a small amount of nitrogenous or "flesh-forming" and mineral matters.

4. The most characteristic change which the grain undergoes by malting is the conversion of a portion of its starch into dextrine, and the further conversion of a portion of the latter, amounting to from 8 to 10 per cent of the grain, into sugar.

5. By malting, the grain acquires properties by virtue of which, when the malt is digested with water, much of its own remaining starch gradually changes into dextrine and sugar; and if the digestion be aided by heat, not only the whole of the remaining starch of the malt itself, but the starch of a considerable quantity of unmalted grain or other starchy substances mixed with it, may become so converted.

6. Owing to the great loss of moisture and non-nitrogenous substances—in fact, of total weight—which grain undergoes by malting, a given weight of the malted grain contains a larger quantity of nitrogenous or flesh-forming substances than an equal weight of the unmalted grain; but as there is an actual loss of those substances by malting, a given weight of malt will, of course, contain less of them than the amount of barley from which it was produced.

Malting, and the use of Malt for Feeding.

7. It is probable that if grain were malted extensively for feeding purposes, the growth would not be carried so far as in the manufacture of malt for brewing, and the loss of solid matter or food-material would, of course, be less accordingly.

8. As the "malt-dust" contains a considerable amount of food-material, abstracted from the grain during growth, when malt is used for feeding, the "dust" should either not be separated, or, if separated, should be given to the animals along with the screened malt.

9. Owing to the loss of weight which grain undergoes by malting, equal weights of malted and unmalted grain should not be employed in comparative feeding experiments, but only so much malt (with the dust) as would be produced from the amount of raw grain given, or to be substituted, in the parallel experiment.

10. Malt given as food to animals may be supposed to act simply by supplying more or less of the starch of the grain from which it was produced in the more soluble, and, perhaps, therefore more easily digestible, conditions of dextrine and sugar, or also by aiding the conversion into dextrine and sugar of the starch of other foods given with it.

The Experiments with Milking Cows.

11. A comparative experiment was made in which, besides other appropriate

food, ten cows received, for a period of ten weeks, 3 lb. of fair malting barley per head per day, and other ten received the amount of malt (with its dust) produced from 3 lb. of barley from the same stock.

12. In the experiment in which the malt was given, it contributed about 7½ per cent of the solid matter of the total food.

13. The result was, that almost exactly the same amount of milk was yielded for a given amount of food with the unmalted and with the malted barley, but that the milk from the cows having the unmalted barley contained the higher proportion of cream.

The Experiments with Fattening Oxen.

14. A comparative feeding experiment was made for a period of twenty weeks, in which, with other appropriate food, ten oxen received 4 lb. of good feeding barley per head per day, and other ten the amount of malt (with its dust) produced from 4 lb. of barley from the same stock.

15. In the experiment with malt, it contributed about 13½ per cent of the dry or solid substance of the food.

16. Both lots of oxen gave more than an average amount of increase, whether reckoned in proportion to a given live weight within a given time, or to a given amount of food consumed; but the ten having the unmalted barley gave rather more than those having the malted.

17. The barley-fed oxen also gave rather the higher proportion of dead weight to live, and although neither lot was fully ripe, the barley-fed animals were more even in condition and quality than the others; but the beef of some of the malt-fed ones was decidedly superior in point of ripeness and quality, and that of others decidedly inferior, to that of any of the barley-fed oxen.

18. It would seem, therefore, that the effect of the malt as food was more dependent on the constitution and condition of the individual members than was that of the barley; and it should be remarked that the oxen which fattened the best upon the malt were not the most backward or weakly animals, but those which were the heaviest and in the best condition at the commencement.

The Experiments with Fattening Sheep.

19. Comparative experiments were made for a period of twenty weeks with five lots of sheep of twelve each. Besides other appropriate food given equally to all, the allowance per head per day was —to lot 1, from ¾ to 1 lb. of fair malting barley; to lot 2, the malt (with its dust) from an equal amount of the same barley; to lot 3, from ¾ to 1 lb. of good feeding barley; to lot 4, the malt (with its dust) from an equal amount of the same barley; and to lot 5, an equal amount of the same barley, two-thirds unmalted and one-third malted.

20. In experiments 2 and 4, the malt contributed about 22½ per cent, and in experiment 5 about 7½ per cent, of the dry or solid substance of the food.

21. All five lots of sheep gave about an average amount of increase; there was very little difference in the result obtained with the unmalted and the malted grain, but such as it was, it was rather in favour of the unmalted.

22. The mutton of all five lots was of very good quality—there was no appreciable difference between the lots in this respect; but the barley-fed animals gave slightly the higher proportion of dead weight to live weight.

The Experiments with Fattening Pigs.

23. The appropriate food of the fattening pig contains a larger proportion of starch than does that of either cows, oxen, or sheep. If, therefore, the starch of food be rendered more digestible and assimilable by its artificial conversion into the more soluble forms of dextrine and sugar, it might be supposed that it would be peculiarly advantageous to malt a part, or the whole, of the characteristically starchy food of the fattening pig.

24. Experiments were made for a period of ten weeks with six lots of pigs of eight each. Besides 1 lb. of pea-meal per head per day given to all—lot 1 had crushed malting barley; lot 2, the crushed malt (with its dust) from the same barley; and lot 3, the unmalted and the malted barley, each separately, *ad libitum;* lot 4 had crushed feeding barley; lot 5, the crushed malt (with its dust) from the same barley; lot 6, the same barley, four-fifths unmalted and one-fifth malted, *ad libitum.*

25. In experiment 2 the malt contributed 87½, in experiment 3 about 13, in experiment 5 about 89, and in experiment 6 about 16½ per cent of the dry or solid substance of the food.

26. The pigs having pea-meal and entirely unmalted barley (lots 1 and 4) gave a full average amount of increase, both in relation to a given live weight within a given time, and to a given amount of food consumed: those having only a small proportion of malted barley (lots 3 and 6) increased in both respects nearly, but not quite, as well; but those having the pea-meal and entirely malted barley (lots 2 and 5, more especially lot 2) gave less increase in relation to a given live weight within a given time, and required the expenditure of considerably more barley to produce a given amount of increase.

27. The pigs having the unmalted barley (lots 1 and 4) also gave the best average proportion of dead weight to live weight, and their pork was of very good quality; the pork of the other lots was also of very good quality, but the more evenly so where a small proportion of malt was given (lots 3 and 6).

Woburn Experiments on Malt.—In the winter 1882-83, the late Dr A. Voelcker carried out a series of experiments at Woburn, under the auspices of the Royal Agricultural Society, with the view of testing the relative merits of malted and unmalted barley and other foods for sheep, and the results from the barley in the two forms were so nearly equal, that he says the only legitimate conclusion that could be drawn is, "that barley-meal and linseed-cake given to young growing sheep in moderate proportions, together with roots and some hay and straw-chaff, is as good as the same feeding mixture in which the same amount of barley is used in a malted state." [1]

Fair Comparison of Malt and Barley.—In experimenting upon malted and unmalted barley, it, of course, should be borne in mind that it is not fair to compare the feeding value of a given weight of malt with that of the same weight of barley, and then to credit the malt with the full superiority that might be observed. We have to remember, bearing in mind the statement of Sir John Bennett Lawes already given, that the given weight of malt is derived from a considerably larger weight of barley, and that the malting process itself, represents a money cost. It is a fair comparison only when the malt is fed, as in the Rothamsted experiments, side by side with the quantity of raw barley which it represents: or we might go further and say, with a somewhat larger quantity, seeing that the cost of malting may be taken to represent the value of a little additional food. In trials made by practical farmers such niceties of calculation and experiment, though of vital consequence, are too often overlooked, which may account for the non-realisation of the evidently over-sanguine expectations originally formed as to the coming importance of malt as food for stock.

At any rate, the present negative attitude of the farmers towards malt, now that it is within their unrestricted reach, is with some justice claimed by the followers of Sir John Bennett Lawes, as a practical testimony to the soundness of his views.

Mr James Howard, M.P., on Malt.—Mr James Howard, of Clapham Park, Bedford, M.P., states that for many years he used malt for getting horses into condition, and that the results were very satisfactory. After the repeal of the malt-tax, malt became an article of regular diet upon his farms. Working horses, young horses, feeding cattle, store cattle, sheep on roots, sheep in houses, as well as lambs, all had malt along with other food, and Mr Howard expresses satisfaction with the results. Each working horse got per week 1½ bushel of oats, 1 peck of maize, 1 peck of malt, and 14 lb. of bran—the maize and malt being crushed together: he would not use malt without crushing it. Upon this feeding, at less cost, his horses did better than when fed upon 2 bushels of oats, ½ bushel of maize, and 14 lb. of bran per week. Young growing horses had 1½ lb. malt per day, along with 3 pecks of oats and 14 lb. of bran per week. Wether-sheep on roots had ½ lb. malt daily, along with 1 pint of tail barley. Feeding cattle had 2½ lb. (increased to 4 lb. as they approached maturity) of malt per day,

[1] *Jour. Royal Agric. Soc. Eng.*, xix. 430.

mixed with 1 gallon of meal and 1 gallon of linseed and cotton cake. Young store cattle got about ½ lb. malt and 1 lb. cotton-cake per day—all these being winter rations. Mr Howard found it desirable to begin with small quantities of malt, and increase by degrees.[1]

Cost of preparing Malt.—Mr F. Beard, Horton, near Canterbury, states that he found the cost of converting barley into malt was rather less than 2s. per quarter, and he considers that its value as a condiment, apart altogether from its feeding value in the ordinary sense, would quite pay for the cost of conversion.[2]

Special Properties of Malt.—It has, however, been proved that malt does possess certain useful properties in the feeding of stock which are not possessed to the same extent by unmalted barley. The late Mr Richard Booth, of Warlaby, considered that malt was superior to any other article for feeding cattle up to the very "tip-top" condition to which they require to be brought when they are intended for the show-yard. The late Mr Hudson, of Castle Acre, instituted an experiment between cattle fed on malt and a lot of similar cattle fed upon barley-meal. The result was decidedly in favour of the malt-fed animals. And the butcher who slaughtered Mr Hudson's cattle stated that the cattle which had been fed on malt "were of a much better quality than the others; the grain was finer, and altogether of a superior description."

Malt has been used with good results in rearing young pure-bred bulls. An experienced Northumberland breeder of shorthorns used regularly to sell his barley and buy malt, for the purpose of feeding his calves and young cattle, as he said he could not do without it.

All kinds of farm-stock thrive on malt, and it has the best effects when given to animals which are delicate, recovering from an illness, or "off their feeding." It has been found that the addition of malt to other food prevents "scour" in sheep.

Malt evidently assists digestion, and thus it is not only a useful article of food in itself, but, by the manner in which it acts, it tends to render other kinds of food, along with which it is given, more useful than they would be without it. The late Dr A. Voelcker stated, that "when an animal has got into fine condition, and has to be supplied with a large amount of food in order to its rapid development, the addition of malt is most useful. It seems to help the digestion remarkably—it might be said, wonderfully. Now we can easily understand this; for it is not only the sugar of malt which acts usefully, but it has also the peculiar power of changing the starch in barley-meal rapidly into sugar. This shows there is something in malt, over and above the ready-made sugar, which accounts for its efficiency in certain circumstances."

The truth probably is, that such special value as malt possesses is to a great extent a *condimentary* value. Just as cattle-spices are valuable for imparting a relish to diets in which straw-chaff or poor hay predominates, stimulating the salivary and gastric juices to do rather more work than they would otherwise be apt to perform under the circumstances, so malt, owing to its sweet and appetising flavour, may impart a relish to food that may be of value.

This would apply either in the case of coarse or poor food, or in the case of an animal a little out of health, and, no doubt, also in the case of an over-fed and therefore dainty animal being finished for the show-yard; and it is especially, it may be noted, with regard to such cases as the last-named that we have evidence of the value of malt.

It by no means follows that a food which best puts the finishing touches on an abnormally fat animal (which is rarely produced at a profit) is to be regarded as, on that account, an economical article of diet for profitable meat-production.

Bere and Rye.

These are very similar, but slightly inferior, to barley, in feeding value.

Rye is generally used in this country in a green state when given to cattle. The grain is useful for feeding purposes, although somewhat inferior to barley. Sir Charles Cameron gives the following as

[1] *Jour. Royal Agric. Soc. Eng.*, xvii. 88.
[2] *Ibid.*, xvii. 87.

an analysis of the grain of rye grown in Ireland:—

Water	16.0
Albuminoids	9.0
Fat-formers	66.0
Woody fibre	8.0
Mineral matter (ash)	1.0
	100.0

Rye-meal is given with advantage to milch cows.

Malt-combs.

When barley is converted into malt, the effect of the steeping process is to cause the grain to throw out young shoots, just as the seed does when put in the soil. These young shoots are afterwards separated from the malt, and are known as "*malt-combs*," or "*cummins*," or "*malt-dust*." The combs are used as feeding-stuff, and have been found useful, along with other articles, as food for milch cows. The following analysis of malt-combs was made by Sir Charles Cameron of Dublin:—

Water	8.42
Albuminoids	21.50
Digestible fat-forming substances	53.47
Woody fibre (indigestible)	8.57
Mineral matter (ash)	8.04
	100.00
Yielding nitrogen	3.44
Containing potash	1.35
" phosphoric acid	1.74[1]

Sir Charles Cameron says that "its composition indicates a high nutritive power, but it is probable that its nitrogenous matters are partly in a low degree of elaboration, which greatly detracts from its alimental value."

Malt-combs for Cows.—The late Dr A. Voelcker considered that malt-combs possessed high milk-producing qualities, and that the food might be given with great benefit to dairy-cows.[2]

Malt-combs as Manure.—Malt-combs are also used as manure, but the late Dr A. Voelcker considered it wasteful to apply them directly to the land; they should first be passed through the animal's body.

[1] *The Stock-Feeder's Manual*, 228.
[2] *Jour. Royal Agric. Soc. Eng.*, vol. xiv. 248.

Brewers' Grains.

Brewers' grains, or "draff," as the article is called in some parts, consists of the refuse malt after it has undergone fermentation. The grains left in the distillation of spirits are said to be richer than those left in brewing ale or porter. The following is an average analysis of brewers' grains:—

Water	75.5
Albuminoids	5.0
Fat	1.0
Soluble carbo-hydrates	12.5
Woody fibre	5.0
Mineral matter	1.0
	100.0

Desiccated Grains.—A process of preparing grains by drying and other modes of manipulation has been invented, and the article so prepared is sold under the name of "*Desiccated Grains.*" The grains in this state are more concentrated than they are in the ordinary state, and may be given to all kinds of live stock as follows: For horses, substitute at first 3 lb. of grains for 3 lb. of oats, and increase proportion until half the feed is composed of grains. Cattle—the grains may be mixed with other food, and should be damped where oilcake is used: the animals should be supplied with water when equal parts of grain and cake are used. Milch cows—damp with boiling water, and allow the grains to swell; 10 to 15 lb. per day may be given. Sheep—to be given alone, or with an equal weight of corn or cake. Pigs—damp well with boiling water as much as will be required for a day's use.

Desiccated *v.* Wet Grains.—A ton of desiccated grains would be equal to between three and four times its weight of wet grains. The drying chiefly effects economy in carriage. But when a brewery or distillery is within easy reach, it is, of course, more economical to use wet grains than the artificially dried, and therefore somewhat more costly article.

Grains for Dairy-cows.—Grains are a particularly favourite food with cowkeepers, as they produce a large flow of milk—more remarkable, however, for its abundance than its richness, that is, where grains are largely the preponderating food. When mixed with a fair proportion of other richer concentrated food, such as cake or grain, the grains form a most admirable article of diet for cows in milk. The judges of the Royal Agricultural Society prize farms in the "Derby District" in 1881 state that, from what they had learned on the competing farms, "there appears no food like them for the production of milk, and when mixed with more costly feeding-stuffs, the milk is not only abundant but exceedingly good."[1]

As to the quantities of grains given to cows, full information will be found under the heading of "Winter Feeding of Cows."

Storing Grains.—Grains are usually very much cheaper in summer than in winter, sometimes even as much as two-thirds less than in the height of winter. As would be expected, therefore, means have been found of storing grains. This is done successfully by burying them in pits in ensilage fashion. Great pits from 6 to 10 feet deep are dug in the dry ground, and 5000 or 6000 bushels of grains are trodden in. When the surface is reached the grains are well heaped up in the middle, beaten down, cased with chaff or road-scrapings, and then well covered with a thick coat of soil, so as to resemble a large mangel-hole. Sometimes these pits are lined with bricks, and more frequently a proper vault, either above or under the ground, is made. An old barn, with brick partitions run across it, makes a capital receptacle for storing grains. Some farmers use salt in packing the fresh grains, and are very particular in the covering that is applied to the surface; but it appears that if ordinary care is taken to exclude the air, grains may be kept in the roughest manner and be perfectly sweet and good at the end of six or even nine months.[2]

Very often the grains-pit is sunk in the end or in a corner of the cow-house. At any rate, it should be close at hand for ease of feeding. A pit lined with concrete is very suitable, and even where only a few weeks' supply is kept at a time, it is found convenient to have such a pit.

Distillery Wash.

"Dreg" or "wash" is a liquid residue from malt used in distilleries. It consists of a thick and a thin liquid. The thin part of the liquid is about half the nutritive value of its weight of common turnips, and the thicker or sedimentary portion about equal to its weight of the average composition of turnips. Dr Anderson considers that 15 gallons are equal in nutritive value to 100 lb. of turnips. This liquid is used chiefly by dairymen; but cattle fattened at or near distilleries get large quantities of it as well as of grains.

Oats.

The following is an average analysis of the whole grain of the oat:—

Water	14.0
Albuminoids	13.0
Fat	6.0
Fat-formers	54.0
Woody fibre	10.0
Mineral matter (ash)	3.0
	100.0

No other variety of grain is so extensively used in this country as food for live stock as are oats. And in the form of meal it is a very wholesome food for man, still used very largely—but we fear not so extensively as in former times—in Scotland. It was Dr Johnson who described oats as "the food of men in Scotland, and horses in England." It was probably a Scotchman who retorted,—"Ay; and where will you find such men and such horses?"

Oats are highly favourable to the formation of muscle. Their nutritive value, however, is by no means regular, some varieties being one-third more nutritive than other kinds.

Bruising Oats.—Oats ought generally to be bruised before being given to animals, as the food then becomes not only more thoroughly masticated, but also much less liable to produce inflammatory action, which sometimes arises from the over-liberal or inconsiderate use of the whole grain.

Nutriment in Oatmeal.—In the form of meal it is seldom used as cattle-food, except as nourishing drinks or gruel; but when ground into meal, the more thoroughly it is sifted the more nutritious it becomes. This is exactly the reverse of what takes place in the case of flour, because a large proportion of the flesh-forming and also of the fat-forming sub-

[1] *Jour. Royal Agric. Soc. Eng.*, xvii. 462.
[2] *Ibid.*

stances contained in wheat is removed in the bran. Fine oatmeal contains nearly double the amount of nitrogenised matter found in fine wheat-flour.

There is no need to enlarge here upon the merits of a food which is so generally esteemed for this purpose as oats are. Details as to the allowances of oats to animals are given in treating of the feeding of the various kinds of stock.

Indian Corn.

The prevailing cheapness and high nutritive properties of Indian corn or maize have brought it into extensive use as food for farm live stock. The following is an average analysis of Indian corn:—

Water	11.5
Albuminoids	10.0
Fat	5.0
Starch, &c.	70.0
Woody fibre	2.0
Mineral matter (ash)	1.5
	100.0

It will be seen that this food is very rich in starchy matters. Given by itself, or in large proportions, it has a heating and binding tendency; but it does well with other foods, such as linseed-cake, and is now one of the most extensively employed articles of food for all kinds of farm live stock, including poultry.

Buckwheat.

The following is an analysis of the grain of buckwheat:—

Water	14.0
Flesh-formers	9.0
Fat	0.5
Starch, &c.	59.5
Woody fibre	15.0
Mineral matter (ash)	2.0
	100.0

This plant is comparatively little grown, being easily susceptible of injury from frost if the seed is sown earlier than the middle of May. The crop is sometimes cut green, and used for soiling. The grain is used chiefly for feeding game or poultry.

In Ireland the term "buckwheat" is sometimes locally applied to some of the varieties of common wheat, with which the true buckwheat has no connection.

Rice.

The following is an analysis of rice:—

Water	14.0
Albuminoids	5.3
Fat	0.4
Starch, &c.	78.1
Woody fibre	1.5
Mineral matter	0.7
	100.0

Rice is used as food for poultry, and is of a very fattening nature, being exceptionally high in starchy matter.

Rice-meal.

Much more important than rice, as a feeding-stuff, is the so-called "*rice-meal*," which consists of the ground refuse left after dressing or trimming rice for human food. This rice-meal consists mainly of the coating of the reed (or bran), with more or less of the adherent starchy matter.

The following is an average analysis of good rice-meal:—

Water	9.6
Albuminoids	11.3
Oil	12.0
Starch, &c.	51.5
Woody fibre	6.0
Mineral matter	9.6
	100.0

This material, it will be seen, contains a fair quantity of albuminoids, and is rich in oil, and is in much request for pig-feeding. Rice-meal is now also being used as food for cattle, and the experience of it has, on the whole, been very satisfactory. Mr Garrett Taylor, Trowse House, Norwich, has used it largely both for dairy-cows and young store-cattle, and he speaks of it very favourably.

Care should be taken to obtain the genuine article, as this food is sometimes adulterated with ground rice shudes—the outer husks of the rice—which have very little nutritive value, but consist mainly of a siliceous woody fibre.

Dari or Durra.

This is the seed of the plant called Indian millet or Guinea corn, which is largely cultivated in India, China, Africa, Italy, the West Indies, &c., where it is used for feeding horses, pigs, and poultry. It weighs upwards of 60 lb. a bushel, is of the size of a large millet-seed, is covered with a husk or envelope, and gives, when crushed, a beautiful white flour. Dr A. Voelcker gives the following analysis of Dari grain:—

Water	11.31
Oil	4.02
Albuminoid compounds	10.06
Starch and digestible fibre	68.10
Woody fibre (cellulose)	3.65
Mineral matter (ash)	2.86
	100.00

Dari Grain for Cattle.—Ground into meal this grain is an excellent fattening food for cattle. As Dr Voelcker remarks: "It contains an appreciable amount of ready-made fat, and a large proportion of starch, which is with ease transformed into fat in the animal economy; but it is rather deficient in albuminoids, and for this reason Dari meal should be given to stock in conjunction with cake, beans, or peas, or, speaking generally, with food rich in albuminous compounds."[1]

Dari grain is also good food for poultry.

Beans, Peas, and Lentils.

These leguminous plants closely resemble each other in their composition. From their nature they are better suited to be used as a portion of the food of working or growing animals or milch cows, than of those which are being fattened for the butcher. At the same time, when used along with other kinds of food, particularly such as are of an oily nature, they may be given with much advantage to fattening stock. Lentils are chiefly imported, but they may be profitably grown in this country on light, dry, sandy, or calcareous soils. The following table gives the average composition of beans, peas, and lentils:—

	Beans.	Peas.	Lentils.
Water	13.5	14.0	14.0
Albuminoids	25.5	23.0	24.0
Fat	1.5	2.0	2.5
Starch, &c.	46.5	48.5	49.5
Woody fibre	10.0	10.0	7.0
Ash	3.0	2.5	3.0
	100.0	100.0	100.0

[1] *Jour. Royal Agric. Soc. Eng.*, xiv. 247.

Vegetable Casein.—It is worthy of note that the albuminoids in these three seeds (and also in other leguminous seeds) are in a form almost identical with the casein of milk, and hence termed "vegetable casein." It is on this account that meals made from these seeds form useful ingredients in mixtures for calves.

Beans for Dairy-cows.—Bean-meal is by many recognised authorities assigned the very highest position as an article of diet for dairy-cows. Mr John Speir, Newton Farm, Newton, Glasgow, says that "for the production of butter or cheese of the best quality, no feeding-stuff ever had or still keeps the reputation beans do;" and he adds, "they are also very palatable to all stock of the horse, sheep, and cow kind, although swine are not so fond of them." Beans, like the other leading leguminous foods, have an albuminoid ratio double what a proper food should exhibit; and, therefore, they are well suited for mixing with other foods rich in carbo-hydrates, such as turnips, potatoes, oats, rice, straw, and hay. Professor M'Connell says that "beans have made a name for themselves as food for dairy-cows, but prices and handiness make it more desirable to use something else." He adds that he gives his cows a mixture of crushed beans and oats and bran.

Preparing Beans as Food.—Beans should invariably be ground into rough meal before being given to stock, but should not, as is sometimes done, be steeped in water before being mixed with the other foods, as then, on account of its highly albuminous nature, the meal is apt to get into a doughy, indigestible mass. "Bean-meal holds the premier place as a milk-producer; but being so highly albuminous, it requires to be mixed with some more bulky food in order to keep its particles apart, and allow the juices of the stomach and intestines to dissolve them. Unless thus mechanically divided and kept apart, such a highly concentrated food becomes more a poison than a food. Mixed with cut hay or straw the meal becomes one homogeneous mass of such a porous nature, that each atom of its constituents can separately be attacked by the juices of the digestive organs; whereas if mixed in water alone, the bulk of it is voided undigested, if it does not also produce indigestion by the way."[1]

Peas for Sheep.—Peas are capital food for sheep—along with linseed-cake there is perhaps no better as a concentrated food. In a series of experiments conducted at Woburn in the winter of 1882-83, by Dr A. Voelcker, on behalf of the Royal Agricultural Society of England, pea-meal was contrasted with barley-meal and malt as food for sheep, each along with turnips, hay and straw, chaff and linseed-cake. In summing up the results, which were favourable to the pea-meal, Dr A. Voelcker says that "linseed-cake and pea-meal in equal proportions, and used at the rate of ¼ lb. each per head per day, in conjunction with some hay and straw, chaff and swedes, given *ad libitum*, is a better food for young sheep than either a mixture of linseed-cake and barley-meal, or linseed-cake and malt."[2]

Lupin.

The following is an approximate analysis of the seeds of lupin :—

Water	14.0
Albuminoids	33.0
Fat	5.0
Starch, &c.	33.0
Woody fibre	12.0
Mineral matter	3.0
	100.0

The seeds of the lupin contain, therefore, a larger proportion of flesh-forming substances than either beans, peas, or lentils.

The cultivation of the plant is quite simple, and it grows well on poor, sandy, and gravelly soils. It is cultivated extensively in the northern parts of Germany, and it has also been partially introduced into England. The stems make excellent hay, and the seeds are found to be very superior food for sheep, lambs, and fattening wethers. They are also given to horses and cattle, mixed with oats or beans; and lupin-meal is given with milk to calves.

Linseed.

Linseed has not inaptly been described as the sheet-anchor of the stock-feeder. He is now less dependent upon it than when he first began to use concentrated foods extensively. But although many other useful articles of food for farm live stock have been brought into notice in recent years — thanks in a large measure to the application of science to the question of economical stock-feeding—it is still true, as remarked by the late Mr R. O. Pringle, that "whether in the building up and development of the young growing animal, or the enriching of the produce of the dairy-cow, or the final preparation of the animal for the butcher, linseed is an article of the highest importance to the agriculturist."

The following analysis of linseed is by Dr Anderson :—

Water	7.50
Oil	34.00
Albuminoids	24.44
Gum, mucilage, sugar, &c., and woody fibre	30.73
Mineral matter (ash)	3.33
	100.00

There are, however, a great many varieties of linseed. The kinds grown in different parts of Russia, in India, and in America, differ among themselves in the percentages of oil and albuminoids they contain, as well as in shape and size. The proportion of oil in Indian linseed is often considerably more than 40 per cent.

Linseed of fine quality, weighing 52 lb. per bushel, readily yields from 11 to 12 gallons of oil per quarter (8 bushels), weighing 9 lb. per gallon, or about 25 per cent of its weight.

Preparing and using Linseed as Food.—It is thus seen that linseed is an exceedingly rich food. It is not advisable, however, to use it in its natural state, as, when so used, a considerable proportion of the seeds will be found to pass undigested. Being of a laxative nature, it requires to be used with caution, and in combination with other articles which have a counteracting effect.

The seed is sometimes boiled in order to prepare it for use as the food of animals, but a better mode of preparation is to grind it. When this is done, chaff, or the husks which are separated from oats in the process of milling, should be passed through along with the linseed, as either of these articles helps

[1] *Farming World*, June 1, 1888, 429.
[2] *Jour. Royal Agric. Soc. Eng.*, xix. 430.

to prevent the linseed from "clogging" the millstones; and besides, they absorb a portion of the oil which exudes from the seed in the grinding, and thus they become useful articles of food, although they are of little value in their natural state.

Boiling Linseed.—Meal made of pure linseed may be given in combination with other kinds of food, such as bean-meal, barley-meal, Indian meal, &c., but it is also frequently prepared for use by boiling. When the seed is prepared in this way, it is generally steeped for some hours in hot water and then boiled, but it is very apt to burn during the process of boiling unless it is carefully watched. In order to prevent burning, it has been found better to raise the water to the boiling-point before putting in the linseed, instead of putting the linseed into cold water and then boiling it. When the linseed is put into boiling water, add a little cold water, and then let it again come to the boil, and allow it to remain boiling for twenty minutes, stirring it occasionally. This mode of preparing linseed has the effect of splitting the seed, and thereby rendering the operation much more effectual than it is when the skin does not burst, as is usually the case when the linseed is put first into cold water which is afterwards brought to the boiling-point.

For calf-rearing no kind of food surpasses linseed, and in conjunction with cheaper commodities, it is very largely employed for this purpose.

Growing Flax for Fibre and Seed.—Flax is grown very extensively in the north of Ireland, but, as was pointed out by Mr R. O. Pringle, the chief object in growing flax there is—owing to the importance of the linen manufacture in Ireland—the production of a fine class of fibre, which is incompatible with a large crop of seed. If the value of the seed as a fattening material were inculcated more strongly than it has been by those who advocate the extension of flax-cultivation, it is probable that flax-growing would be more largely practised throughout the kingdom than it is at present. As it is, we have to depend upon foreign sources of supply for the linseed required for various purposes. Irish flax-growers in general are averse to separate the "bolls" or seed-capsules from the plants, alleging that when this is done the fibre is injured, and consequently they steep the flax without first removing the seed. The result is that the seed is lost; and the loss of feeding material from this cause alone which takes place in Ireland cannot be estimated at much less than £500,000 per annum.

The prevalent idea entertained in Ireland on this subject has been combated by Mr Charley, who is a grower of flax as well as a manufacturer. Mr Charley describes "the old-fashioned system of taking the flax to a watering-place with its valuable freight of seed unremoved," as being wanton waste of rich feeding material.[1]

When the "bolls" are saved, they are dried on a loft in a strong current of air, and then ground up with the outer husk or chaff. Even when the seed is extracted from the bolls, the residue, or chaff, makes excellent food for milch cows when prepared in the form of a hot mash. The bolls are also steamed along with other materials, and given as a mash to horses as well as to cattle.

Linseed-cake.

Linseed-cake is the refuse part of the seed left in the process of extracting linseed-oil. Formerly, although most part of the oil was extracted by crushers, there always remained from 10 to 12 or 14 per cent; but the machinery now employed in extracting the oil does its work so efficiently, that from a fourth to a third less oil is left.

The following is an average analysis of linseed-cake of the good old type—still sometimes met with; and side by side is given an analysis of good American cake, hard pressed, and therefore low in oil but rich in albuminoids:—

	High-class English.	American Western.
Water	10.05	9.00
Albuminoids	25.14	37.00
Mucilage	36.10	34.50
Oil	11.93	7.50
Woody fibre	9.53	7.00
Mineral matter (ash)	7.25	5.00
	100.00	100.00

It is thus apparent that linseed-cake is a highly concentrated description of food,

[1] *Flax and its Products.*

and is suited for the use of all kinds of farm live stock, with the exception of swine—the objection to its use in their case being that it imparts an oily flavour to the meat, and makes it soft or flabby. Horses become extremely fond of oilcake, and 3 lb. per day has been given to farm-horses with good effect.

Linseed-cake is crushed into small pieces before being given to stock.

The dung of cattle fed on oilcake is very rich, nearly half the weight of the ash of oilcake consisting of phosphate of lime; and one result of giving cake to cattle or sheep feeding on grass land during summer and autumn is to improve the pasture, besides hastening the fattening of the animals.

Storing Linseed-cake.—The late Dr A. Voelcker remarked—and this is a point of the very greatest importance —that "the nutritive value of feeding-cakes depends not merely upon their proximate composition, but likewise upon their physical condition. Like all other perishable articles of food, linseed-cake, when kept in a damp or badly ventilated place, rapidly turns mouldy, and after some time becomes unfit for feeding purposes."[1]

"Linseed-cakes should be stored in as dry a place as can be found. The floor should be a wooden one if possible. If it be of plaster or concrete it is advisable to lay some old timbers on the floor, forming a stool, and pile the cakes in stacks thereon, about 8 or 10 inches from the walls, so that a current of air could get round. The cakes, which generally measure 30 inches long and 12 inches broad and about 1 inch thick, should be packed in such a way that the air can get through the pile and come in contact with all the edges of the cake.

"The ventilating of the store should be good, and as much air as possible allowed to get inside when the atmosphere is dry, but the doors and windows should be closed when it is damp.

"The same remarks are applicable to cotton-cakes, but these do not keep well beyond a month or six weeks.

"When good linseed-cakes, manufactured without the use of water, are stored in the manner thus described, they have been known to keep for 12 months without any appreciable depreciation."[2]

Adulteration of Cakes.—Unfortunately, it has become so much the practice to adulterate cakes of all kinds in the process of manufacture, that the greatest caution is necessary in purchasing any article of the kind. Impurities also exist in the seed, varying from 1¾ per cent to 70 per cent; and these impurities are sometimes added artificially. Dr Voelcker states that "occasionally barges laden with siftings" (*i. e.*, impurities) "are sent out a little way to sea to meet ships having on board linseed, and coming from one of the ports in the north. An amalgamation of the siftings with the linseed is effected on the high sea, and the mixture, containing a greater or less quantity of siftings, is then imported, and sold as linseed 'genuine as imported.'

"A good deal of so-called genuine linseed-cake is made from such seed. It is well to bear in mind that a guarantee which describes a cake as made from linseed 'genuine as imported,' in point of fact is no guarantee at all; for it is well known that very dirty seed, not unfrequently containing more than half its weight of foreign weed-seeds, is freely imported into Hull and other ports."[3]

Cakes may now be purchased with a guarantee as to their purity which can be relied upon; and on this point the reader is referred to the remarks under the heading of "Purity of Cattle Foods."

Rape-cake.

Rape-cake, when pure, is a valuable food for cattle. The German green rape-cake is the best kind; and of a good sample of this sort, the late Dr A. Voelcker gave the following analysis:—

Water	10.82
Oil	8.72
Albuminoids	33.81
Mucilage, sugar, &c.	28.06
Woody fibre	11.49
Mineral matter	7.10
	100.00

In "flesh-formers"—albuminoids—rape-cake is thus richer than even the best of linseed-cakes.

[1] *Jour. Royal Agric. Soc. Eng.*, ix. 3.

[2] *Farming World*, 1888, p. 801.

[3] *Jour. Royal Agric. Soc. Eng.*, ix. 7.

It is not much relished by cattle at first, but if care is taken to prevent it from getting damp and mouldy they will take to it by degrees. If the animals refuse to eat it in its fresh state by itself, the difficulty may be got over by covering the cake for some time with sawdust, chaffed straw, or any substance that will prevent it from becoming damp or moulded.

Preparing Rape-cake for Cattle.—The cake is of course crushed, and it is of advantage to pour boiling water over the crushed cake, and allow the mixture to stand for a time before it is used. Steaming the cake along with chaffed straw is also a good mode of preparing it for cattle; and in so preparing it bean-meal or bran is added, in the proportion of 4 lb. of cake to 2 lb. of bran or 1 lb. of bean-meal. With these articles, 16 lb. of chaffed straw should be blended before steaming.

Impurity of Indian Rape-cake.—Dr A. Voelcker states that Indian rape-cake is generally "contaminated with so much wild mustard or charlock (*Sinapis arvensis*), that it is not safe to feed animals upon it. Several actions having been tried in our law courts, in which the plaintiffs obtained verdicts for damages caused by feeding cattle upon cake which turned out to be Indian rape-cake, it is now seldom sold for feeding purposes; but is either bought for manuring purposes, or employed for adulterating linseed-cake, or preparing mixed feeding-cakes."

From ¼ lb. of Indian rape-cake, Dr Voelcker obtained enough essential oil of mustard to convince him that half a cake of it, if not a smaller quantity, might kill a bullock.

Even the best rape, when mixed with linseed-cake, imparts a turnip-like flavour to the latter, which of course reduces its value.

Cotton-cake.

This cake is made from the seeds of the cotton-plant. There are two varieties of it in use—the decorticated, from which the husks have been completely removed, and the undecorticated, which contains a considerable proportion of the dark-brown husks of the seed.

The following is an average analysis of the two varieties by Dr A. Voelcker:—

	Decorticated.	Undecorticated.
Water	9.28	11.46
Oil	16.05	6.07
Albuminoids [1]	41.25	22.94
Mucilage, sugar, &c.	16.45	32.52
Woody fibre	8.92	20.99
Mineral matter	8.05	6.02
	100.00	100.00
[1] Containing nitrogen	6.58	3.67

As in the case of linseed-cake, the improvements in the crushing machinery have reduced the percentage of oil in cotton-cake, so that there is now rarely more than 12 or 13 per cent of oil, and often as little as 8 or 9, in decorticated cotton-cake.

The decorticated variety is of a uniform yellow colour, while the presence of the dark-brown husks in the undecorticated at once indicates its nature.

Caution in using Undecorticated Cotton-cake.—The undecorticated variety is not only less valuable than the other, but it is also apt to produce inflammatory symptons in the animals fed upon it, and death has frequently been the result. This arises from the quantity of cotton which adheres to the seed, and from the harsh nature of the husk. Although undecorticated cotton-cake may be employed as food for cattle when used cautiously, it is generally safer to use the decorticated variety, which, as will be gathered from the above analysis, is also superior as a feeding material.

It ought to be mentioned, however, that the undecorticated cake (often called "English," to distinguish it from the decorticated or American cake) has, in the eyes of graziers, a certain value beyond its mere intrinsical value as a food, owing to its astringent properties, which render it very useful to obviate any scouring tendency amongst cattle or sheep when on young or luxuriant pasture.

Uses of Decorticated Cotton-cake.—Decorticated cotton-cake is very rich in flesh-forming matters, as well as in phosphates, or "bone-formers," and is therefore specially adapted for growing stock and cows giving milk; but for calves and lambs it is not so suitable—indeed, for these young animals it is somewhat dangerous—on account of its being too indigestible for them; and should be given to them, if at all, only in very small quantities.

Preparing Cotton-cake for Feeding.—Some think it better to have the cake ground into meal than merely broken by the usual cake-crusher. If the cake is to be merely crushed, it would be useful to have this done some time, perhaps ten or fourteen days, before giving it to cattle, so that it might absorb moisture, and thereby get softened and more easily digested.

Manurial Value of Cotton-cake.—Cotton-cake imparts an exceptionally high value to the manure of the animals fed upon it. As will be shown presently, in dealing with the "Manurial Value of Foods," it stands above all other foods in this respect.

Palm-nut Meal.

The following is an analysis by Dr A. Voelcker of a good sample of palm-nut meal:—

Water	5.92
Oil and fatty matter	20.01
Albuminoids[1]	13.87
Mucilage, sugar, &c.	38.24
Woody fibre	18.56
Mineral matter	3.40
	100.00

[1] Containing nitrogen . 2.22

This meal is made from the cake which remains in pressing the oil out of the palm-nut. There are some very inferior kinds of palm-nut cake or meal in the market, and these have been used in adulterating linseed-cake—not so much lately, on account of the vigorous and commendable efforts that have been made to put down the adulteration of all feeding-stuffs as well as of manures.

Palm-nut meal of first-rate quality may now be had, and is extensively used in rearing and fattening stock, more particularly in calf-rearing. It has been found a most admirable food for calves, and for them it is prepared by being steeped in hot water for several hours, perhaps for a whole day. It is also well suited for cows in milk—increasing both the quantity and quality of the milk. It gives good results in feeding pigs, if used with such other foods as barley-meal, Indian meal, beans or peas. An equal mixture of palm-nut meal and decorticated cotton-cake is equivalent in feeding properties to linseed oilcake, and considerably less in cost.

Cocoa-cake.

Cocoa-cake is manufactured from the outer shell with fragments of the kernel of the cocoa-bean. It is a wholesome food, and cattle take to it readily. It is, however, inferior to pure linseed-cake, as the following analysis by Dr Voelcker will show:—

Water	14.95
Oil	8.02
Albuminoids[1]	19.87
Woody fibre	18.26
Mucilage, sugar, &c.	32.46
Mineral matter	6.44
	100.00

[1] Containing nitrogen . 3.18

The ordinary cocoa-nibs, as sold by grocers, are occasionally employed to supply a feeding material for young calves. This is done by boiling the nibs over a slow fire for two or three hours—6 or 8 quarts of water to 1 lb. of nibs. The nibs are then strained out, and the liquid is mixed with milk and given to calves when it is milk-warm.

Poppy-cake.

The following is Dr A. Voelcker's analysis of poppy-cake:—

Water	11.63
Oil	5.75
Albuminoids[1]	31.46
Mucilage, gum, and woody fibre	38.18
Mineral matter[2]	12.98
	100.00

[1] Containing nitrogen . 5.11
[2] Containing sand . 7.58

There are two varieties of poppy-cake,—one a light-coloured or whitish cake, made from white poppy; the other a dark or brownish cake, made from common poppy-seed.

Poppy-cake must be used when quite fresh, as the oil is apt to become soon rancid. When fresh, it is a useful feeding material.

Locust or Carob Beans.

These are the beans or pods of the locust-tree (*Ceratonia siliqua*). Dr A.

Voelcker has given the analysis of three samples of locust-meal as follows :—

	No. 1.	No. 2.	No. 3.
Water	17.11	12.61	14.22
Oil	1.19	1.08	0.96
Sugar	51.42	50.30	54.07
Mucilage and digestible fibre	13.75	20.13	14.41
Albuminoids[1]	7.50	5.87	7.72
Woody fibre	6.01	7.14	5.88
Mineral matter	3.02	2.87	2.74
	100.00	100.00	100.00
[1] Containing nitrogen	1.20	0.94	1.25

Locust-meal contains, therefore, fully half its weight of sugar, but it is deficient in albuminous compounds or flesh-formers; consequently it should be given to stock, in combination with peas or bean-meal, or with decorticated cotton-cake. The beans are either roughly crushed or ground into meal, and either way are much liked by cattle and sheep.

Molasses or Treacle.

Treacle risky for Breeding Stock.—It is pretty generally accepted as an established truth that food excessively rich in saccharine matter, while highly valuable in the fattening of stock, is unsuitable for breeding animals, in that it tends to impair their procreative powers. About three-fourths of the weight of molasses or treacle consist of sugar, so that it lies very specially under the above condemnation.

In his instructive paper on "The Reproductive Powers of Domesticated Animals" contributed to the Journal of the Royal Agricultural Society of England in 1865, Professor Tanner lays great stress upon the detrimental influence of "sugary" foods upon the reproductive powers, and considers it very doubtful if any stock which have been fed for a length of time upon food largely mixed with molasses ever regain their breeding powers.

These extreme views have not been universally accepted, but there is no doubt that the general drift of the contentions emphasised by Professor Tanner are well founded. The whole matter depends upon the skill and care—or the want of skill and care—with which the article is used.

Useful Properties of Treacle.—Treacle is a most useful, but, in the hands of the unskilled or careless breeder, a somewhat dangerous article of food. It possesses special properties of considerable value. Diluted with water, and sprinkled over a pulped mixture, it renders the food more palatable to the stock, and its laxative characteristic makes it a useful ingredient in many food-mixtures with an opposite tendency. Then its own intrinsic properties in laying on fat are very high; and therefore, properly and carefully employed, treacle is of considerable service to stock-owners.

Professor Tanner acknowledges the high fattening properties of treacle, and remarks that it has "the effect of suppressing these periodical returns of restlessness which prevent heifers feeding as well as steers;" and adds that, "whilst avoiding it for breeding animals, we may encourage its employment when cows or heifers have to be fattened."[1]

Treacle for Young Bulls.—There is no doubt that, in spite of all the warnings that have been given, treacle is still used extensively for breeding stock, notably in forcing young bulls and heifers into blooming condition for show or sale. We are aware that it is included in the feeding mixture for young bulls in several of the leading herds of the day; but in almost all these cases there is a skilful hand at the helm, and the tasty but dangerous treacle is given sparingly and judiciously, so as to benefit the animals without impairing their fecundity. We say "almost," because, unfortunately, as we are also aware, there is too good reason to believe that in some cases harm is really being done to the breeding properties of young animals, bulls more largely than heifers, by the too liberal and imprudent use of treacle.

How Treacle is used.—Treacle is often given to sickly animals mixed with bran or gruel, and it is sometimes put amongst milk for calves. Owing to its highly laxative nature, from 2 lb. to 3 lb. per day is the most that can be given with advantage even to full-grown beasts, and from ¼ lb. to 1 lb. to a calf, according to the age of the animal. The late Dr R. Thomson of

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., i. 267.

Glasgow found that about 3 lb. of molasses mixed with 9 lb. of barley-meal, and given along with 25 lb. to 30 lb. of hay, kept milch cows in full milk, and did nearly as well as 12 lb. of either linseed-cake or bean-meal. A few ounces per day, diluted with hot water, and sprinkled over the dry food of horses or of fattening sheep, will be found beneficial. As already indicated, treacle-water is a most useful addition to a pulped mixture for fattening cattle.

Turnips.

Roots form one of the principal elements of winter food for cattle, and are also consumed largely by sheep, and to a much smaller extent by horses and pigs.

Turnips, with the swede as the chief variety, supply the largest proportion of this description of food.

Variation in Nutritive Value of Roots.—The nutritive value of turnips varies with the variety, the climate, soil, and also the manures used in their cultivation, so that any description of their constituent elements can be regarded as only an approximation to the truth, even in the case of the same kind of turnips if grown under different circumstances. All the varieties of the turnip contain a large percentage of water—namely, from 86 to 94 per cent, and from 6 to 14 per cent of dry matter. Turnips grown in some parts of the kingdom, particularly in the north of Scotland, will, with the aid merely of fresh oat-straw, be found to fatten cattle without using much artificial food of any kind; whereas large quantities of cake and hay must be given along with the same kind of turnips to effect that object, when such turnips are grown in some other districts. This is more especially the case with turnips grown in the south and east of England.

Advantages of Storing Turnips.—Turnips become more nutritious after they have been stored for some time than they are when taken fresh from the field. By storing they lose a proportion of the water which they naturally contain; and there are also some chemical changes which take place in them tending to render them more nutritious.

When turnips are allowed to remain in the field until the leaves begin to put forth a fresh growth, as they will be found to do early in spring, a decided deterioration in their quality is the result, owing to certain of their elements becoming changed into indigestible woody fibre. Hence the necessity for storing turnips at the proper season, say in November and December.

The following table gives the average composition of five varieties of turnips, as deduced by Cameron from the results of the analyses of Anderson and Voelcker:—

	Swedes.	White Globe.	Aberdeen Yellow.	Purple-top Yellow.	Norfolk Turnip.
Water	89.460	90.430	90.578	91.200	92.280
Albuminoids	1.443	1.143	1.802	1.117	1.737
Sugar, &c.	5.932	5.457	4.622	4.436	2.962
Woody fibre	2.542	2.342	2.349	2.607	2.000
Ash	0.623	0.628	0.649	0.640	1.021
	100.000	100.000	100.000	100.000	100.000

The means of the analyses of 60 differently grown roots of Fosterton hybrid turnips gave Dr Aitken[1] the following results on soils at Pumpherston and Harelaw respectively:—

	Pumpherston.	Harelaw.
Water	91.3	92.6
Dry matter	8.7	7.4
	100.0	100.0

Composition of dry matter:—

Albumen	7.7	7.5
Woody fibre	10.8	11.7
Ash	5.8	6.4
Carbohydrates (sugar), &c.	75.7	74.4
	100.0	100.0

The mean results of 27 somewhat more detailed analyses of Aberdeen yellow turnips, grown with a great variety of manures at Carbeth, Stirlingshire, gave

[1] *Trans. High. Agric. Soc.*, xvi., 1884.

Mr David Wilson, jun., the following figures:[1]—

	In fresh roots.	In dry matter.
Water . . .	91.09	...
Sugar . . .	4.72	52.94
Woody fibre .	1.03	11.54
Albuminoids .	0.54	6.06
Non-albuminoid nitrogen × 6.25 .	0.60	6.76
Extractive matter free of nitrogen .	1.36	15.23
Ash . . .	0.66	7.47
	100.00	100.00

Variation in Composition of Turnips.—The quantity of nutritive matter in the same variety of the turnip varies —in white turnips from 8 to 13 per cent, and in the yellow turnip from 11½ to 17 per cent; so that 20 tons of yellow may be as valuable for feeding as 30 tons of white, which is an important fact, and may account for the discrepancies experienced by farmers in feeding stock.

Inasmuch as feeding-roots are essentially *sugar crops*, the sugar they contain is very valuable for meeting the respiratory requirements of sheep and cattle, also for fat-forming, and for milk-production. The following table, based on the experiments of Sir John Bennett Lawes and Dr Gilbert at Rothamsted, records estimates of the approximate average percentages of dry matter, and of sugar, in the kinds of roots mentioned:—

	Dry matter.	Sugar per cent.	
		In fresh roots.	In dry matter.
	per cent.	per cent.	per cent.
White turnips .	8.0	3.5 to 4.5	44 to 56
Yellow turnips .	9.0	4.0 to 5.0	44 to 56
Swedish turnips	11.0	6.0 to 7.0	55 to 64
Mangel . . .	12.5	7.5 to 8.5	60 to 68

A bushel of turnips weighs from 42 lb. to 45 lb.

Excess of Water in Roots.—In feeding with roots farmers are sometimes apt to forget or overlook with how much water the feeding matter in the roots is associated. Unless an animal gets some dry food as well as roots, it is forced, in order to obtain sufficient solid nutriment, to consume a very large quantity of water—very much more, in cold weather, than is necessary for it. This water when swallowed has to become warmed at the expense of the heat of the animal, which has simultaneously to be replaced by fresh heat—so that part of the sugar, &c., of the roots, instead of going to fatten the animal, is wasted in furnishing fuel to warm the superfluous water swallowed in the root-substance.

Desirability of Economising Turnips.—Over and over again, in various parts of this work, prominent reference is made to the great and avoidable waste which thus takes place in the old-fashioned and time-honoured system of turnip-and-straw feeding. It is needless here to reason out the point at great length. The above statement as to the deleterious influence of the excess of cold water the animal has to swallow in a full meal of roots will suffice here for that part of the subject. It is also unnecessary to enter into any lengthened arguments to show that other reasons exist which make it very desirable that the more economical use of roots in the rearing and feeding of stock should be practised. The root crop is a very costly one to grow, and unfortunately its cultivation is attended with great risks of loss from unfavourable weather, and fungoid and insect attacks. In dealing with the practical work of feeding the different kinds of stock, we have therefore given special attention to the question of how turnips may be most effectually and satisfactorily economised.

The avoidance of this waste is the great plea in favour of giving sheep in the turnip-fields a small daily allowance of cake or corn. They will then eat less of the roots, but will turn what they do eat to much better account.

Turnip-meal.—Swedes have been converted into meal, to be transported anywhere for the use of cattle. They are washed, and their juice squeezed out by means of rollers; and the squeezed fibre, being dried in a kiln and chopped, is easily ground into meal by millstones.

Professor Johnston found the composition of this meal to be as follows:—

[1] *Trans. High. Agric. Soc.*, xviii., 1886.

	Undried.	Dried at 212°.
Protein compounds	13.68	17.72
Gum . . .	4.14	5.36
Sugar . . .	48.72	59.23
Oil . . .	1.11	1.44
Fibre and pectin .	8.10	10.49
Water . . .	22.82	...
Ash . . .	4.27	5.53
	102.84	99.77

Turnip-tops.—As a rule, it is better to leave turnip-tops on the field, for they possess considerable manurial value, and, except when other food is scarce, will give a better return in that way than used as food. Still, they contain more nutritive matter than some would imagine, and are useful when scattered on a green field for the use of young cattle or sheep. They should, however, be given with caution, for when eaten too freely they are apt to produce scour. The ash of turnip-tops contains a large quantity of phosphate of lime and potash.

Mangel-wurzel.

This is a most valuable root, grown extensively and with great success in England and Ireland. It needs a warm climate, and is grown in Scotland only to a very limited extent. The orange globe and long yellow kinds have been found to contain a larger amount of the respiratory or fat-forming elements than the long red variety, which agrees with the practical results obtained by the use of those varieties in feeding cattle.

Advantages of Storing Mangels.—The tendency in fresh mangels to produce scour when these are given to cattle is well known to all who have used them, and so also is the fact that this property disappears after the roots have been stored for two or three months. Like good wine mangels improve by keeping, and it is desirable, as a rule, to delay the consumption of them till spring.

In comparison with turnips, it has been considered that 75 lb. of mangel are equivalent in feeding value to 100 lb. of turnips; but the two varieties vary so much in nutritive value that these proportions cannot be relied upon. The leaves of the mangel are also useful, especially for milch cows, but have a scouring tendency.

The late Dr A. Voelcker gives the following as the average composition of mangel-wurzel:—

Water	87.78
Albuminoids	1.54
Sugar	6.10
Gum, &c.	2.50
Woody fibre	1.12
Ash	0.96
	100.00

The solid matter here shown is 12.22 per cent. In some cases, however, the proportion of solid or dry matter falls below 10 per cent—while in dry seasons it sometimes is as high as 16 per cent.

Medium *v.* Large Roots.—It is to be borne in mind, with reference to both turnips and mangels, that moderate-sized roots are commonly more nutritious than very large ones. The huge over-sized roots often seen at root-shows are commonly watery, and such dry matter as they do contain is intrinsically less valuable than in normal roots.

Sugar-beet.

Sugar-beet has given excellent results in the feeding of dairy-cows; but as food for stock it is cultivated only to a very limited extent.

The following is the analysis of Irish-grown sugar-beet, which Dr A. Voelcker found contained a larger proportion of sugar than English-grown roots:—

Water	76.58
Albuminoids	2.10
Crystallisable sugar . . .	14.81
Pectin and extractive matters	0.66
Crude fibre (pulp) . . .	5.01
Ash	0.84
	100.00[1]

Considerable attention has been given to the cultivation of sugar-beet for the production of sugar, and the late Dr A. Voelcker published the results of some very elaborate investigations made by him as to the composition of sugar-beets grown under different circumstances.

Nutritive Value of Sugar-beet.—Dr A. Voelcker considered that the farmer "will run very little risk in trying the experiment to grow sugar-beets instead of common mangels; for although he may not get so heavy a crop as he does when he plants common mangels, it has

[1] *Jour. Royal Agric. Soc. Eng.*, vii., sec. ser.

to be borne in mind that 1 ton of sugar-beets is equivalent, in nutritive qualities as cattle-food, to at least 1½ ton of good common mangel."

Farmyard-dung should not be used in growing sugar-beet, as it renders the roots coarse and less nutritious. From 3 to 4 cwt. of superphosphate is sufficient to produce an average crop.

Beet-root Pulp.

Beet-root pulp is the refuse left in extracting the sugary juice from the beet-root. It is much esteemed on the Continent for its fattening properties. It is, however, deficient in flesh-forming compounds, and requires the addition of some cake or meal to supply this deficiency. Dr A. Voelcker recommends cotton-cake for this purpose. Milch cows fed on beet-root pulp and a fair allowance of bean-meal or cotton-cake produce abundance of milk of good quality. Pigs also thrive on the pulp if they get some barley-meal or pea-meal mixed with it. Dr A. Voelcker considers beet-root pulp at 12s. a ton a cheap and valuable food. The following analysis, as given by Voelcker, shows its average composition:—

Water	70.0
Sugar	1.5
Albuminoids	2.5
Crude fibre, &c.	24.0
Ash	2.0
	100.0

Carrots.

The following is the analysis of the white Belgian carrot by Dr A. Voelcker:—

Water	88.50
Albuminoids	0.60
Fat - formers (including woody fibre)	10.18
Ash	0.72
	100.00

The carrot does not contain any appreciable quantity of starch, but this deficiency is counterbalanced by its having about 6½ per cent of sugar. Carrots are esteemed for horses.

Carrot-tops are most admirable food for cows giving milk.

Parsnips.

The following is the average composition of the parsnip:—

Water	82.00
Albuminoids	1.30
Sugar, starch, &c.	7.75
Woody fibre	8.00
Ash	0.95
	100.00

Parsnips thus contain more starch, but less sugar, than carrots. The starch in parsnips exists only in the external layers of the root, none whatever being found in the heart. There is nearly double the quantity of solid matter in parsnips to that in turnips; so that 1 ton of parsnips ought to go as far, as a fattening material, as 2 tons of white turnips.

Kohl-rabi.

The following analysis of the bulbs and tops of kohl-rabi is given by Dr Anderson:—

	Bulb.	Top.
Water	86.74	86.68
Albuminoids	2.75	2.37
Sugar, &c.	8.62	8.29
Woody fibre	0.77	1.21
Ash	1.12	1.45
	100.00	100.00

Kohl-rabi is thus a valuable food, especially for milch cows, as it not only increases the milk, but does not impart to it any particular flavour of a disagreeable kind, such as is produced by turnips. The leaves of kohl-rabi form an excellent description of food for cattle and sheep.

Cabbages.

The following analysis of the cabbage was made by Fromberg:—

Water	93.40
Albuminoids	1.75
Sugar, digestible fibre, &c.	4.05
Ash	0.80
	100.00

Cabbages are not cultivated anything like so extensively as they deserve to be. Dr A. Voelcker stated that "weight for weight, cabbages and swedes possess nearly the same nutritive value." Cabbages are excellent food for sheep and other stock, and few other crops will give as good a return per acre.

Thousand-headed kale of the cabbage variety is most valuable as a green food for sheep or cows in autumn, early winter, or spring. Sprouting broccoli and winter greens are also cultivated for similar purposes.

Potatoes.

The demand which exists for potatoes as human food, generally renders them too expensive to be employed largely in feeding animals, although as food for most kinds of stock they are valuable.

Value of Potatoes for Cattle.—It has been stated that when potatoes can be purchased for £2 or £2, 10s. per ton, they will pay to be employed in feeding cattle; but this will always depend upon circumstances which are liable to variation, such as the market price of other foods, and the selling price of beef. Second and small-sized potatoes are equally useful for this purpose; and as the potato is a bulky and therefore an expensive article to send a long distance to market, those who grow potatoes to some extent in remote districts will be able to turn their crops to better account by converting the small tubers into meat than by selling the entire crop in its natural state. It is necessary to give potatoes to stock with caution, as the excess of starchy matter, unless counteracted by other foods, may injure the health of the animals.

There are many farmers who have an objection to potatoes as food for cattle. The late Mr M'Combie of Tillyfour said: "I would rather throw potatoes to the dunghill than give them to a store bullock, though I would give them to my fattening bullocks." He would never give them to animals intended to be afterwards grazed.[1]

Potatoes vary in composition, but the general results will be gathered from the following analyses given by Dr Anderson:—

	Regents.	Skerry Blues.	Flukes.
Water	76.32	76.60	74.41
Starch	12.21	11.79	12.55
Sugar, &c.	2.75	3.09	2.89
Albuminoids	2.37	2.06	2.18
Fibre	5.53	5.41	6.71
Ash	0.88	0.94	0.98
	100.06	99.89	99.72

[1] *Cattle and Cattle-Breeders*, p. 13.

The albuminoids, or flesh-forming matters, it will be seen, are deficient, but there is an exceptionally high percentage of the respiratory or fat-forming elements, which constitute the largest part of the dry matter. For cattle, therefore, potatoes should be used in combination with such other foods as cotton-cake, bean-meal, or pea-meal.

Utilising Diseased Potatoes.—When the potato is attacked with disease, it is the albuminoids, or flesh-forming constituents, that are destroyed; these are partially converted into ammonia and other volatile matters, and hence the offensive smell which is emitted from diseased potatoes. The starch, &c., remains intact, and advantage is taken of this by employing diseased potatoes in the manufacture of starch.

Diseased potatoes may, for the same reason, be turned to account for feeding animals, particularly swine. In order to do this, it is necessary to thoroughly cook the potatoes either by boiling or steaming—the latter, when practicable, being the better way—and then pack the cooked potatoes into flour-barrels or casks, ramming them well down, and sprinkling some salt occasionally through the mass. When the barrel or cask is filled to the top, it must be closed from the air, and the potatoes will keep for some time fit for use.

Potatoes for Horses.—Potatoes are often fed to horses, but when freely given in a raw condition, they are liable to produce colic.

Water with Potatoes.—Water should not be given to animals fed on either raw or cooked potatoes, for some time after the meal.

Green Rape.

Rape in a green or growing state is usually fed off with sheep, or cut and used as soiling food for house-fed cattle. It is a nutritious and valuable plant for these purposes, and for spring and autumn food it should be grown much more extensively than it is. Dr A. Voelcker gives the following as the composition of green rape, and it will be interesting to compare this analysis with that of turnips:—

Water	87.050
Albuminoid	3.133
Sugar, digestible fibre, &c.	4.649
Woody fibre	3.560
Ash	1.608
	100.000

Furze, Whins, or Gorse.

Like many other useful and beautiful plants indigenous to this country, furze —in some parts called whins, in others gorse—is not so highly esteemed as it ought to be, perhaps on account of its being so common, and of its tendency to grow where it has not been sown and is not wanted. Nevertheless, as food for cattle, sheep, and horses, it possesses very considerable value, and for this purpose it may be grown in any part of the country with success, financially and otherwise.

The sowing of furze comes into the spring work, and in the spring section of this volume information will be given as to the best means of cultivating the crop.

Furze as Winter Food.—The chief value of furze is as a green food for the winter months. It should be cut at least once every year, so that the plants may not be allowed to become too woody and hard. When sown thickly on fairly good land the shoots come up fine and juicy, growing to a length of from 2 to 2½ feet. The crop may be cut with the scythe, or with a strong mower past its best for regular harvest work —generally with the scythe.

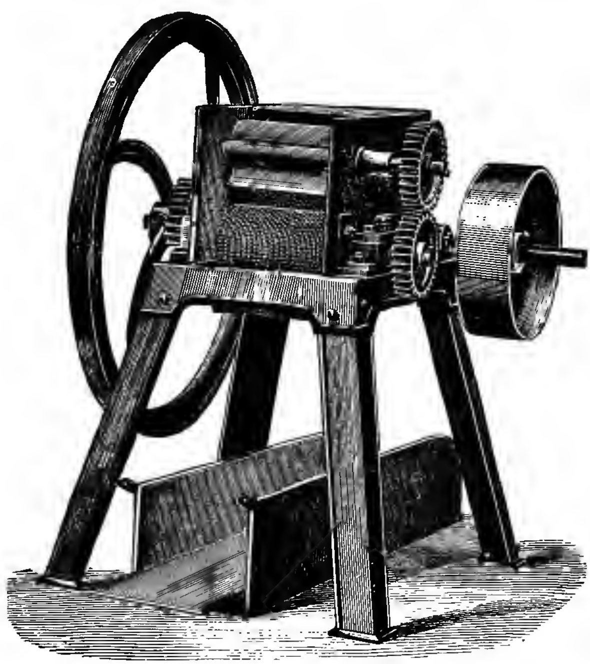


Fig. 118.—*Furze masticator.*

Preparing Furze as Food.—Before being given to stock the furze should be cut into short pieces by a strong chaff-cutter, or, better still, bruised and cut by a machine which has been specially designed for the purpose, aptly named the "Masticator," and made by Mackenzie & Sons, Cork. This useful machine, which may be driven by horse, water, or steam power, is shown in fig. 118.

Some think it desirable to chop or masticate the furze daily as required; but others perform this work twice a-week, and find that the chop keeps well enough.

How fed to Stock.—A correspondent, who has had thirty years' experience of furze as food for stock, writing to the *Agricultural Gazette* of May 7, 1888, says: "Cut up the furze with hay for milking cows, and you will make first-quality butter, but pale—with hay for horses, but do not feed too heavily; add 3 or 4 lb. mangels to counteract a resin the furze contains. Young stock thrive amazingly upon it. Furze-fed cattle are hard to be fattened on other food; oaten straw, with cut furze for them."

Mr R. O. Pringle stated that horses may be kept through the winter on furze without hay, and only a moderate allowance of oats; and the furze gives the horses a fine coat of hair. An acre of well-grown young furze, which is regularly cut, will keep four or five horses or cows during the winter and early spring months with very little assistance in the shape of hay or roots. For hard-working horses it should be accompanied by a liberal allowance of bruised oats or other concentrated food. Both horses and cattle take to it readily, but sheep do not eat it willingly except when there is snow on the ground. When grown as food for sheep, the crop is not cut, and in a snowstorm a few acres of young juicy furze are most valuable for sheep.

Composition of Furze.—That furze should, in practice, prove to be a useful food, will not surprise any one when its composition is considered and compared with that of roots, rye-grass, and clover. The following is the analysis by Cameron of the composition of fresh furze cut in August, perennial rye-grass and common red clover being shown alongside for comparison:—

	Furze.	Perennial Rye-grass.	Common Red Clover.
Water . .	72.00	71.43	81.01
Albuminoids .	3.21	3.37	4.27
Sugar, fibre, &c.	9.38	12.99	9.14
Woody fibre .	13.33	10.06	3.76
Ash . . .	2.08	2.15	1.82
	100.00	100.00	100.00

Grasses and Clovers.

It may seem strange, but it is nevertheless true, that farmers possess less reliable knowledge as to the relative cropping and feeding value of the various grasses which cover their pastures, than as to any of the other leading crops of the farm. A good deal of fresh knowledge as to the habits and characters of our grasses, has, no doubt, been gained in recent years, but investigations and experiments must be prosecuted much further before it can be said that we know our pastures and our hay crops as well as we do our crops of roots and grain.

There are special circumstances which render the investigation of this subject very difficult. Root and grain crops are usually matured, or almost so, before they are fed to stock, and thus it has been comparatively easy to obtain reliable information as to the average composition of food-mixtures consisting of these commodities. With grasses, however, especially those which are constantly grazed, the case is different. They are eaten at all stages of their growth, in extreme youth, full bloom, old age, and all the intervening stages. It is well known that the nutritive properties of plants vary at different stages of the development of the plants; and it does not follow that all grasses which show a useful composition when fully grown, are equally useful and suitable for grazing by stock in the earlier periods of their growth. Again, plants which would not stand well in an analysis of hay, may be extremely serviceable as an element in pastures to be regularly grazed.

The determining of the amount of nutrition—the grazing value—possessed by the different plants which compose our pastures, sown and natural, temporary and permanent, is thus at once a matter of the greatest difficulty and the utmost importance. No subject could more worthily engage the attention or employ the resources of the leading agricultural societies; and it is a matter, too, in which a great deal of good might be done by private experiment and investigation by farmers who have opportunities of studying their pastures, and watching the progress of the animals which feed upon them.

Composition of Rye-grass and Timothy.—As indicating the differences in the composition of grasses at the various stages of growth, the following tables, arranged by Mr John Speir, will be interesting:[1]—

[1] *Jour. Brit. Dairy Farm. Ass.*, iv. 34.

ANALYSIS OF RYE-GRASSES AND TIMOTHY CUT IN DIFFERENT STAGES OF GROWTH AND MADE INTO HAY.

	Stage when Mowed.			
	Head coming out.	Head well out.	In bloom.	After bloom.
Perennial Rye-grass Hay—				
Water	7.0	7.0	6.6	7.9
Ash	8.0	7.4	7.8	6.9
Fat	3.3	3.3	3.5	2.4
Carbohydrates	53.6	52.7	51.3	52.3
Albuminoids	10.8	10.3	8.4	7.0
Fibre	17.1	19.1	22.3	23.4
Albuminoid ratio	1 to 5.3	1 to 5.4	1 to 6.5	1 to 7.8
Italian Rye-grass Hay—				
Water	7.0	8.2	5.8	7.8
Ash	12.3	10.4	10.3	8.0
Fat	4.5	3.5	2.1	3.6
Carbohydrates	39.1	44.7	48.7	49.6
Albuminoids	20.1	13.1	13.6	10.6
Fibre	16.8	19.9	19.2	20.1
Albuminoid ratio	1 to 2.2	1 to 3.7	1 to 3.7	1 to 5.0

	Stage when Mowed.				
	Head invisible.	Head visible.	Early bloom.	Full bloom.	Early seed.
Timothy Hay—					
Water	7.8	8.8	5.6	6.3	5.95
Ash	8.0	5.8	5.7	5.3	9.9
Fat	4.2	3.10	3.63	3.35	3.2
Carbohydrates	50.0	52.2	54.0	55.0	47.0
Albuminoids	11.5	10.8	9.6	9.2	11.3
Fibre	18.3	19.1	21.4	20.5	22.4
Albuminoid ratio	1 to 4.7	1 to 5.1	1 to 6.0	1 to 6.3	1 to 4.4

Analyses of Pastures.—The following analyses indicate the nutritive value of poor, good, and rich pastures:—

	Upland pasture.	Good pasture grass.	Rich pasture grass.
Water	70.0	80.0	78.2
Ash	2.1	2.0	2.2
Albuminoids	3.4	3.5	4.5
Fibre	10.1	4.0	4.0
Carbohydrates	13.4	9.7	10.1
Fat	1.0	0.8	1.0
	100.0	100.0	100.0

Mr John Speir remarks that this *upland pasture*, with an albuminoid ratio of 1 to 8.1, must be considered poor; that the grass in the second column, with an albuminoid ratio of 1 to 4.4, gives a very fair feeding-power; while that in the last column, with the high albuminoid ratio of 1 to 3.6, gives a food capable of feeding rapidly.[1]

Thanks to the investigations of Dr Day, Dr Anderson, Dr Augustus Voelcker, Mr Martin John Sutton, Dr John A. Voelcker, Mr W. Carruthers, Mr Faunce de Laune, and others, we do possess a great deal of valuable information as to the composition and characteristics of the leading grasses in regular cultivation, when they have either become matured or attained a pretty full measure of growth.

Composition of Clovers.—As to the clovers, which occupy a prominent place in pastures as well as in hay, it will be seen from the following analyses, made of

[1] *Jour. Brit. Dairy Farm. Ass.*, iv. 23.

fresh plants cut in the third week of June, that they possess very high nutritive properties:—

	Common Red Clover.	Perennial Red Clover (Cow-grass).	White Clover.	Common Yellow Clover.
Water . . .	81.01	81.05	79.71	76.80
Albuminoids .	4.27	3.64	3.80	5.70
Sugar, digestible fibre, &c. . . .	9.14	8.82	9.03	8.67
Woody fibre .	3.76	4.91	5.38	6.32
Ash	1.82	1.38	2.08	2.51
	100.00	99.80	100.00	100.00

Alsyke clover, which is much esteemed for damp soils, and is specially suited for meadows, shows upon analysis a rather higher nutritive value than either of these varieties. In composition lucerne and sainfoin closely resemble the clovers.

Composition of Grasses.—Mr Martin John Sutton's valuable work, *Permanent and Temporary Pastures* (the first edition of which was issued in 1886, the third in 1888), contains a series of analyses of the principal agricultural grasses, made specially for the purpose by Dr John A. Voelcker. These analyses are the most exhaustive and most useful of the kind yet published; and in them, for the first time, the relative amounts of true albuminoids have been determined directly, and not, as in previously recorded results, merely given by calculation of the total nitrogen into albuminoids. A precise and clear description of each grass accompanies the analysis, and this, with the beautifully coloured illustrations of grasses, and Mr Sutton's practical directions as to the formation and treatment of temporary and permanent pastures, renders the work one of remarkable value.

Dr J. A. Voelcker explains that each variety thus analysed was grown separately and was perfectly pure; the sample being taken, in every instance, as nearly as possible at the time when it would have been cut for hay. And the analysis of each grass is shown in its natural state and dried at 212° Fahr.—that is, until nothing but the solid or dry matter remained.

The following analyses of four of the grasses, taken from this volume, will indicate the great value of the work to practical farmers:—

	Cocksfoot.		Meadow Foxtail.		Rye-grass.		Meadow Fescue.	
	Grass in natural state.	Dried at 212° Fahr.	Grass in natural state.	Dried at 212° Fahr.	Grass in natural state.	Dried at 212° Fahr.	Grass in natural state.	Dried at 212° Fahr.
Water	60.74	...	55.58	...	62.01	...	71.04	...
Soluble albuminoids[1] .	.25	.62	.50	1.13	.38	1.00	...	...
Insoluble albuminoids[2] .	1.50	3.81	2.56	5.75	2.06	5.38	1.13	3.88
Digestible fibre . .	11.30	28.78	14.22	32.01	7.98	21.01	8.91	30.77
Woody fibre . . .	16.24	41.36	16.42	36.96	17.71	46.62	12.51	43.19
Soluble mineral matter[3] .	2.04	5.19	2.58	5.81	2.90	7.64	1.05	3.62
Insoluble mineral matter[4]	.91	2.32	.94	2.11	.78	2.05	.64	2.21
Chlorophyll, soluble carbohydrates, &c. . .	7.02	17.92	7.20	16.23	6.18	16.30	4.72	16.33
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
[1] Containing nitrogen .	.04	.10	.08	.18	.06	.16	...	...
[2] Containing nitrogen .	.24	.61	.41	.92	.33	.86	.18	.62
Albuminoid nitrogen .	.28	.71	.49	1.10	.39	1.02	...	...
Non-albuminoid nitrogen	.18	.46	.30	.67	.38	1.00	.18	.62
Total nitrogen .	.46	1.17	.79	1.77	.77	2.02	.36	1.24
[3] Containing silica . .	.35	.89	.37	.83	.05	.13	...	...
[4] Containing silica . .	.51	1.29	.52	1.17	.32	.84	.39	1.35

Hay.

Loss in Hay-making.—In considering the feeding value of hay it must be borne in mind that the analyses of fresh grasses cannot be relied upon as a key to the nutritive properties and value of hay made from these grasses. If hay were simply *dried* grasses and clovers, then there would be no loss of nutriment and no deterioration in feeding value—water only would have passed away. But in farm practice it is impossible to secure this. In hay-making, even in the best of weather and under the most careful management, there always will be some loss of feeding material.

In dealing with the important subject of "hay-making" in its proper position in the work of the summer, full information will be given as to the risks incurred in hay-making, and as to how these may be most effectually avoided or minimised.

Damaged Hay.—Here it will suffice to state that in the process of making, hay may be so much spoiled as to be almost worthless as food for stock. In experiments at Rothamsted it was found that sheep would increase in weight on well-made hay alone; but in experiments conducted by Dr A. Voelcker, and lasting three months, it was shown that, fed wholly upon hay which had been damaged by wet weather in making, sheep actually lost in weight. This result proves at once the great importance of exercising skill and care in hay-making, and the imprudence of attempting to maintain stock solely on damaged hay.

It thus becomes apparent that, in giving hay to stock, the physical condition as well as the original quality of the hay must be carefully considered; and the quantities of it and accompanying other foods regulated accordingly.

Composition of Hay.—The following are average analyses of good clover and meadow hay, arranged by Professor Way:—

	Clover-hay.		Meadow-hay.	
		Dried at 212° Fahr.		Dried at 212° Fahr.
Moisture	16.60	...	14.61	...
Fatty matters	3.18	3.81	2.56	2.99
Albumen, and similar nitrogenous compounds (flesh-forming matters)[1]	15.81	18.96	8.44	9.88
Gum, sugar, mucilage, and carbohydrates, readily converted into sugar	34.42	41.27	41.07	48.09
Indigestible woody fibre (cellulose)	22.47	26.95	27.16	31.80
Mineral matter (ash)	7.52	9.01	6.16	7.24
	100.00	100.00	100.00	100.00
[1] Containing nitrogen	2.53	3.03	1.35	1.58

Hay *v.* Artificial Food.—Mr G. H. C. Wright, Sigglesthorne Hall, Hull, makes some interesting calculations as to the relative cost and value of hay and artificial foods in the feeding of stock. He says: "The analysis of good meadow-hay shows that it contains:—

Flesh-formers	8.44 × 2 =	16.88
Heat-producers		43.63
		60.51

The flesh-formers are considered to be worth twice as much as the heat-producers, therefore the value of hay may correctly be stated to be about 61 units. Hay is now selling at from £4 to £5 per ton on all farms having reasonable access to a market; it therefore costs per unit $\frac{90}{61}$ shillings, or 1s. 6d. a unit, taking £4, 10s. as the mean value of a ton of hay.

"A mixture of decorticated cotton-cake and rice-meal shows the following analysis:—

Flesh-formers	26.92 × 2 =	53.84
Heat-producers		49.24
		103.08

Multiplying the flesh-formers in the same way, we find the value of the food may be taken as 103 units. A ton of rice-meal and decorticated cotton-cake, in equal proportions, costs £5, 2s. 6d., therefore a unit of value of this food costs $\frac{102}{103}$, or rather less than 1s. per unit.

"The manurial value of hay is set down as £1, 9s. 10d. per ton consumed, while the manurial value of a ton of decorticated cotton-cake and rice-meal is estimated at about £3, 11s. 5d. It would be necessary in practice to deduct still further from both these estimates; but still it is clearly shown that on every side the artificial food is the cheaper of the two. There can be no doubt whatever that a certain quantity of hay, used in conjunction with artificial food, is necessary; but I maintain that the use of hay in large quantities is far more costly than a judicious mixture of artificial food used in conjunction with a smaller quantity of it. For dairy stock, green hay is superior to that which has heated in the stack sufficiently to turn it a dark colour."[1]

Straw.

The value of straw as food for stock has not yet been fully understood and appreciated by the general body of farmers. In recent years more prominent attention has been given to the subject, and much good will be done if farmers are induced to exercise greater care in the utilisation of straw. A large quantity of straw must no doubt be used as litter for cattle and horses; but in many cases, especially when hay is scarce and dear, it will be found advantageous to substitute, say, peat-moss as litter, and utilise the straw for feeding purposes. In any case there should be no waste—no more straw under the cattle than they can effectually convert into manure, and—what is still more unsightly—no loose bundles or handfuls of straw lying about the steading where no straw should be.

Feeding Value of Straw.—The value of straw as a feeding material depends not only on the kind of grain to which it belongs, but also on its condition as regards ripeness when it is harvested, and on the land and climate where it is grown. The straw of grain which is cut just as the grain is ripe, while there still remains a tinge of green in the straw, is much more nutritious than that which has been allowed to become over-ripe. Strong, coarse straw is, of course, not so much relished by cattle as that which is finer in the growth.

Composition of Straw.—The following analyses of different kinds of straw are by Voelcker:[2]—

No. 1.

	Wheat just ripe.	Wheat over-ripe.
Water	13.33	9.17
Albuminoids	2.93	2.12
Oil	1.74	0.65
Sugar, mucilage, &c.	4.26	3.46
Woody fibre (digestible)	19.40	82.26
" (indigestible)	54.13	
Mineral matter	4.21	2.34
	100.00	100.00

No. 2.

	Barley dead ripe.	Barley not too ripe.
Water	15.20	17.50
Albuminoids	4.43	5.37
Oil	1.36	1.17
Sugar, mucilage, &c.	2.24	71.44
Woody fibre (digestible)	5.97	
" (indigestible)	66.54	
Mineral matter	4.26	4.52
	100.00	100.00

No. 3.

	Oat-straw dried for stacking.		
	Cut green.	Fairly ripe.	Over-ripe.
Water	16.00	16.00	16.00
Albuminoids	8.49	4.08	3.65
Oil	1.57	1.05	1.25
Sugar, mucilage, &c.	16.04	10.57	3.19
Woody fibre (digestible)	26.34	30.17	27.75
Woody fibre (indigestible)	24.86	31.78	41.82
Mineral matter	6.70	6.35	6.34
	100.00	100.00	100.00

No. 4.

	Bean-straw.	Pea-straw.
Water	19.40	16.02
Albuminoids	3.36	8.86
Oil	1.02	2.34
Sugar, mucilage, &c.	4.18	8.32
Woody fibre (digestible)	2.75	16.74
" (indigestible)	65.58	42.79
Mineral matter	3.71	4.93
	100.00	100.00

[1] *Jour. Brit. Dairy Farm. Ass.*, iv. 17.

[2] *Jour. Roy. Agric. Soc. Eng.*, xxii. 1862.

The above analyses justify the preference which is given to oat-straw as food for stock. Fine oat-straw, cut before the crop has become quite ripe, is relished alike by cattle, sheep, and horses, and is given extensively to all, especially in the northern parts where the oat is the prevailing cereal. Indeed in many parts of Scotland good oat-straw (given with a small allowance of roots or perhaps a little cake) forms the main portion of the winter food of young store cattle and dry cows. In pea and bean straw it will be seen there are also high feeding properties; while wheat and barley straw, although less nutritive, likewise possess considerable value as food for stock.

Straw-chaff.—When straw is used as feeding material, it is given either in its natural state, as it comes from the threshing-machine, or it is cut into very short lengths by a machine constructed for the purpose, in which state it is known as straw-chaff or chaffed straw. The latter method is by far the more economical, as by it the amount of waste may be reduced to a minimum. In order to render straw-chaff more palatable to animals, it is either moistened with treacle mixed with water, or it is employed to absorb a quantity of linseed-meal gruel. The dry chaff is also mixed with the oats given to horses, as such admixture has the effect of causing the horses to masticate their oats more fully than they might otherwise do. Then in pulped mixtures straw-chaff is very extensively employed; and it has been clearly proved by experience that by the economical and careful use of cut straw and concentrated foods a greatly increased stock of cattle and sheep may be kept.

Preparing and Storing Straw-chaff.—There is perhaps no better way of turning straw to good account than by cutting it into chaff and storing it for a few months in large quantities with a slight admixture of chaffed green food, salt, and perhaps ground cake. By this system straw remaining over from the previous winter is cut into chaff in spring or summer and stored in barns till the following winter, when it is consumed; thus enabling the farmer to hold over a quantity of the fresh straw for similar treatment next spring or summer. The system is pursued with great success by many farmers, and particularly when roots are scarce the straw-chaff thus prepared will be found most valuable.

Mr Samuel Jonas, Chrishall, Saffron-Walden, carried out this plan for many years. The straw is cut into chaff as it leaves the threshing-machine by one of Maynard's chaff-cutters, which carries the chaff into the barn where it is to be stored. It is well trodden down and mixed, says Mr Jonas, with "about a bushel of salt to every ton, and also a certain quantity of green-stuff. Tares or rye cut green into chaff are sown by the hand as the chaff is brought in. This causes it to heat: and adding the amount of green-stuff required to give it a proper heat is the secret of the successful operation of storing chaff.

"Respecting the quantity of green chaff to be mixed with straw-chaff to cause a proper fermentation, I use about 1 cwt. to the ton of straw-chaff, and 1 bushel of salt (56 lb.) to the ton of chaff. But some judgment is required as to the state of the green-stuff. If it is green rye on the ear, a full cwt. is required; if very green tares, a rather less quantity will do, as the degree of fermentation depends upon the quantity of sap contained in it. This is done in spring and summer—the chaff is not used till October and the winter months. I can thus thresh and dress the corn crops, and cut the straw into chaff, in one process, the expense of cutting and storing the same being about 1s. per acre: the principal additional expense is for about 4 cwt. of coal per day, and we thresh and cut from 8 to 10 acres per day."[1] Some now use pulped mangels instead of vetches or rye for mixing with the dry straw-chaff as it is being stored, and get better results therefrom.

Advantages of Stored Straw-chaff.—Mr Jonas states that this mode of preparing and preserving straw-chaff "has in two seasons, with no turnips, enabled me to winter my sheep and fold the land, leaving sufficient folding to produce a good crop of barley, not from the chaff alone, but from its being the means by which I enabled my sheep to con-

[1] *Jour. Roy. Agric. Soc. Eng.*, vi., 1870.

sume with it large quantities of bran, malt-combs, and oilcake, sufficient to keep them in health and good condition, and to leave the land in a good state for the following crop of barley, which I could not have done by any other means. The turnips were such a failure that, the same two winters, all my fat cattle were fed without having a root to eat. I had two coppers hung in the mixing-house, ground my corn, and broke my cake with an American mill. These were mixed together with malt-combs and boiled, and, after a certain time, were emptied, boiling-hot, into a prepared bed of very old straw-chaff: these were stirred over and mixed well together, and used for the stock in a warm state. They did well so fed, and became good fat bullocks, and paid for the expense of food and attendance, which they very seldom do."

Mr Jonas prefers the chaff of wheat or oat straw, as "these may be cut without loss in a far greener state than is generally done; but barley, to be of good quality, cannot fairly be cut too ripe."

Fermentation of Straw.—Straw-chaff, as prepared by Mr Jonas, formed the subject of a paper read by Dr Augustus Voelcker, who ascertained by analysis[1]—1. That fermented straw-chaff (wheat) is one-fourth richer in flesh-forming compounds, or the materials which produce the lean fibre of meat, than ordinary wheat-straw; 2. That fermented straw-chaff contains nearly two and a half times the amount of sugar, gum, and similar compounds, which is found in common wheat-straw; 3. That nearly 51 per cent of the woody fibre in fermented straw-chaff was soluble, whilst the soluble portion of vegetable fibre in common wheat-straw does not amount to more than 26.48 per cent.

Effect of Fermentation in Straw.—Dr A. Voelcker further states that "the fermentation to which the straw is submitted in Mr Jonas's plan thus has the effect of rendering the hard and dry substance which constitutes the bulk of straw more soluble and digestible than it is in its natural condition." He also notices "the extremely delicate flavour and the palatable condition which is conferred upon the straw in the process of fermentation" as another recommendation. The prepared straw-chaff has "all the agreeable smell which characterises good green meadow-hay;" and the liquid produced by pouring hot water upon it "could hardly be distinguished from hay-tea."

Making Fermented Straw equal to Hay.—Dr A. Voelcker recommended that about 2 cwt. of decorticated cotton-cake, ground into meal, should be added to 1 ton of fermented straw-chaff, and stated that by means of this admixture the proportion of flesh-forming compounds in fermented straw-chaff could be brought up to what it is in good meadow-hay.

Condimental Foods.

Great ingenuity and enterprise have in late years been directed to the production of "condimental cattle foods," comprising composite cakes for cattle and sheep, mixed feeding-meal for young calves and grown-up cattle, milk substitutes for calves, compounded lamb food, poultry food, and appetising spices for all kinds of farm live stock. In the early days of this industry adulteration was rampant, and exorbitant prices were the rule. The wholesome craze for analysis, and excessive competition, have banished both these evils—not perhaps completely, but to a very large extent; and now the great bulk of the vast quantity of these condimental foods made and sold in this country is not only of high quality and well adapted to their various purposes, but also moderate in price. There is no doubt that farmers have derived much benefit by the enterprise and skill which have been employed in bringing out these prepared foods, more especially those which are designed as substitutes for milk in the rearing of calves.

We shall not attempt to describe the composition and individual characteristics of these condimental foods. It may be well, however, to advise farmers never on any account to purchase any of these foods without receiving therewith a warranty as to its freedom from adulteration, and a guaranteed analysis of its chemical composition. With this

[1] *Jour. Roy. Agric. Soc. Eng.*, vii., 1871.

analysis before him, and a reference to what is said in this work as to the elements of nutrition in cattle foods, the farmer will be able to form a tolerably correct idea as to the value of the food. A sample of the food may be analysed for a mere trifle, and if it should fall short of the guaranteed analysis, the vendor is fully responsible for the deficiency.

Vetches.

Of all green forage crops, the vetch is the most extensively grown in the United Kingdom. In almost all kinds of soils it can be grown easily, and at comparatively little expense. As will be seen from the following analyses of samples, cut at different periods of growth, it possesses high nutritive properties:[1]—

	Before bloom.	Full bloom.	Bloom and seed.
Water	6.0	7.8	7.8
Ash	12.0	10.6	11.4
Fat	3.9	4.0	3.6
Carbohydrates	31.9	35.7	35.4
Fibre	11.2	14.0	18.5
Albuminoids	34.8	27.6	23.1
Albuminoid ratio	1 to 1.0	1 to 4.0	1 to 1.9

Vetches cut when in full bloom, and before seeding, are much relished by all kinds of stock, and as will be again urged upon the farmers—in speaking of sowing vetches in spring—it is desirable that this crop should be grown much more extensively than it is.

How Vetches are Fed to Stock.—As is shown in the analyses, vetches contain an exceptionally high proportion of albuminoids, and they are thus very suitable for giving to stock along with starchy foods, such as rice-meal and Indian corn-meal. For this same reason it is not desirable to give highly nitrogenous foods, such as decorticated cotton-cake and beans, along with vetches, for then the food would be badly balanced—there would be an unprofitable, even a dangerous, excess of albuminoids. Vetches should be sown in successive patches, so as to afford a continuous supply of fresh food. When cut just before becoming fully ripe, vetches make excellent silage, and are much used for this purpose. Vetches are also consumed on the land by sheep.

Green Maize.

There is reason to hope that maize (Indian corn) may prove a valuable addition to our green forage crops. The subject of its cultivation in this country will be considered fully in later portions of this work. It will be a great gain to British farmers if it can be successfully acclimatised, for maize is capable of producing an enormous yield of succulent food, which is much relished by cattle, and which is well adapted for feeding in a fresh condition along with other foods, such as chopped hay or straw and decorticated cotton-cake, or for converting into silage for winter feeding.

Composition of Green Maize.—For use as a forage crop, maize is cut green, and before the cobs have formed. Its chemical composition in this form has been found to vary greatly. Green maize grown in France gave the following analysis:—

Albuminoids	1.22
Fat	0.25
Soluble carbohydrates	10.41
Sugar	0.58

Green maize is not a rich food. Its merit lies in the great quantity of palatable succulent food it will produce per acre. It is deficient in nitrogen, but along with highly nitrogenous foods such as decorticated cotton-cake it is most suitable and acceptable to all kinds of stock. Professor James Long found that 120 lb. of green maize and 2 lb. of decorticated cotton-cake made an excellent food for his dairy-cows. The nutritive ratio in this mixture he shows as follows:[2]—

	Albuminoids.	Fat.	Carbohydrates.
120 lb. of maize	1.45	0.60	12.00
2 lb. of cotton-cake	0.82	0.10	0.42
	2.27	0.70	12.42
		15.39	

A sample of green maize silage from M. Goffart's silo in France, was analysed by Dr A. Voelcker, and gave the following results:[3]—

[1] *Jour. Brit. Dairy Farm. Ass.*, iv. 43.

[2] *Jour. Royal Agric. Soc. Eng.*, xxiii. 132.

[3] *Ibid.*, xx. 489.

Water	78.80
Albuminous compounds[1]	1.12
Soluble carbohydrates	4.55
Crude fibre	13.64
Mineral matter (ash)	1.89
	100.00

[1] Containing nitrogen . . 0.18
Volatile acids, calculated as acetic acid 0.07
Non-volatile acids, calculated as lactic acid . . . 0.06

In a dry summer, when grass is scarce, green maize, chopped and mixed with chaffed straw or hay, will be found to be a valuable food for cows or young cattle. A sprinkling of crushed decorticated cotton-cake—1½ or 2 lb. per head—would make this a nutritive mixture for cows giving milk.

Sorghum.

Sorghum saccharatum is a tall-growing plant, similar in appearance to maize, but finer in the stem. In warm climates it grows with great luxuriance, and when cut green, forms excellent forage for stock. It is hoped that hardy varieties of it may be raised, so that it may be successfully cultivated in this country. As yet experiments have been confined to the south and centre of England, and so far the experience has been variable.

Professor James Long has grown it very successfully at Gravelly Manor, Stevenage, Herts, and he states, after two years' experience of it, that there is no succulent food which is more relished by cattle, or upon which they thrive better.

Green sorghum gives the following analysis :—

Water	77.0
Albuminoids	1.6
Carbohydrates	12.0
Fat	0.3

Sorghum is exceptionally rich in sugar, and therefore Professor Long found it specially suitable for feeding along with decorticated cotton-cake. Fed alone to cows it has a tendency to cause looseness; but 2 lb. of decorticated cotton-cake to 100 lb. of green sorghum corrected this, and made an excellent daily ration for cows in milk. The nutritive properties in this mixture Professor Long states as follows :[1]—

[1] *Jour. Royal Agric. Soc. Eng.*, xxiii. 137.

	Albuminoids.	Fat.	Carbohydrates.
100 lb. of sorghum	1.60	0.30	12.00
2 lb. of cotton-cake	0.82	0.28	0.42
	2.42	0.58	12.42
		15.42	

Lucerne.

Lucerne is exceptionally rich in albuminous matters, and is even more nutritious than red clover. Its analysis shows the following :—

Water	70.00
Fat	0.82
Albuminoids	3.82
Carbohydrates	13.60

It affords a large yield, under favourable circumstances sometimes close on 20 tons per acre; and is most useful when sown in a small patch near the steading, to be cut as required for consumption. Young lucerne given alone, or as the principal food, has a tendency to cause the animals to become blown; but this danger is avoided by giving it along with straw, the two being chaffed together—an excellent method of turning straw to good account as food.

Lucerne delights in a dry soil and dry weather, and will not give good results on wet soils or in rainy seasons. Sir John Bennett Lawes describes it as "the crop for a drought."

Sainfoin.

Sainfoin is a valuable plant, whether for cultivation by itself to be consumed as green food or made into hay, or as a leading ingredient in temporary pastures. For the latter purpose it is best adapted. It is peculiarly valuable in sheep-farming districts, and seems to sustain little or no injury by being grazed by sheep. Unlike lucerne, it has no tendency to cause blowing in cattle. As the following analysis will indicate, sainfoin is less nutritious than lucerne, and does not give nearly so large a yield per acre :—

Water	80.0
Fat	0.0
Albuminoids	2.1
Carbohydrates	8.0

Prickly Comfrey.

There is much difference of opinion as to the value of prickly comfrey as a forage crop. It is a hardy and prolific plant; and in good soil, well manured, will afford a large yield. There is probably no forage-plant that has made warmer friends or more bitter enemies than prickly comfrey. It is a somewhat coarse watery food, not much relished by cattle at the outset, but very useful as a green food for dairy-cows.

Dr Augustus Voelcker considered that prickly comfrey "has about the same feeding value as green mustard, or mangels, or turnip-tops, or Italian rye-grass grown on irrigated lands;" and gives its general composition as follows:[1]—

	Natural state.	Calculated dry.
Water	90.66	0.00
Nitrogenous organic compounds (flesh-formers)[1]	2.72	29.12
Non-nitrogenous compounds (heat and fat producers) . . .	4.78	51.28
Mineral matter (ash) .	1.84	19.60
	100.00	100.00
[1] Containing nitrogen .	0.434	4.66

Sugar.

The great reduction in the price of sugar naturally gave rise to the question, whether it might profitably be employed as food for stock. With the view of testing this point, Sir John Bennett Lawes, Bart., carried out some experiments with pigs; and the results reported in the *Journal of the Royal Agricultural Society of England* (vol. xxi., sec. ser., p. 81) are tantamount to an answer in the negative—that is, unless the price of sugar falls considerably lower still. It was then (1885) selling at from £10, 15s. to £11, 5s. per ton for feeding purposes.

Sugar *v.* Starch.—In animal economy, sugar and starch perform similar functions; and the experiments conducted by Sir John Bennett Lawes showed that, "whether for the purpose of supporting the functional actions of the body, or of ministering to the formation of increase, . . . starch and sugar have, weight for weight, values almost identical. . . . Starch and sugar, therefore, as foods, appear to be equivalent; or, in other words, a pound of one, properly used, can produce no more increase in our stock than a pound of the other."

Remarking upon the exaggerated value which had been placed upon sugar as a food for stock, Sir John Bennett Lawes states that it is nevertheless an excellent food; and that the only question is, what price is sugar worth (in comparison with other foods) for feeding purposes?

Sir John considers that it would not be advisable to use sugar with such foods as cereal grains, maize, rice, roots, or even meadow-hay, as all these are somewhat low in nitrogen; and to dilute the nitrogen that exists still more, by the use of sugar, would tend to waste it. On the other hand, foods containing a large amount of nitrogenous substance, such as leguminous seeds—especially lentils, tares, and beans—as well as linseed-cake, cotton-cake, and clover-hay, might be safely diluted with sugar.

But for this purpose, is sugar at £10 or £11 per ton cheaper than the other foods, those rich in starch, which are capable of performing the same functions as sugar? Sir John thinks not. "When ordinary barley can be purchased at £4, 10s. per ton, and Rangoon rice-meal at £3 to £4 per ton, it would appear that sugar is too dear to compete with starchy foods at their present extremely low prices."

Fish-meal.

Cod-fish Soup for Cattle.—For ages the frugal farmers of Norway have to some extent utilised fish-offal as food for cattle. Their custom has been to boil down the heads of cod-fish into a kind of soup, which they mix with straw or other fodder and give to cattle, and by the means of this cheap and nutritious food many Norwegian farmers have been able to maintain a much larger stock of cattle than would have been otherwise practicable.

Herring-meal for Cattle.—The successful results obtained from this "cod-fish soup" for cattle naturally led to further experiments of a similar kind, and from the refuse of herring a cattle-feeding meal of a very useful kind is being made in Christiania. Dr A. P. Aitken, chemist to the Highland and Agricultural Society, formed the opinion that this her-

[1] *Jour. Royal Agric. Soc. Eng.*, vii. 388.

ring-meal might prove a useful addition to our list of cattle foods; and in the spring of 1886 he procured a supply of it, and arranged with Mr John Speir, Newton Farm, Newton, Glasgow, to have the herring-meal tested as food for dairy-cows, compared with other feeding materials.

Mr Speir put the herring-meal to the test in two sets of experiments, the one conducted in the summer of 1886, and the other in the winter of 1887. The results are fully reported by him in the Transactions of the Highland and Agricultural Society.[1]

Composition of Herring-meal.—Upon analysis, this Norwegian herring-meal was found to contain about 40 per cent of albumen, and 20 per cent of oil; and being an animal product, there was of course, no starch. It smelt strongly of herring, and did not look as if it would be relished by cattle; while it was also feared that its fishy taste and smell might unpleasantly taint the milk and butter. After a day or two, however, the cows ate it readily enough, and no traces of injury to the flavour of the milk or butter were discovered.

Value as Food.—The results of both experiments were favourable to the herring-meal, and Mr Speir considers that it is proved (1) that herring-meal is a useful cattle food; (2) that it would be injudicious to use it largely alone; (3) that the best results are obtained when suitably mixed with very starchy food; (4) that it is fairly palatable, as cows take to it as readily as to most manufactured foods, linseed and condimental cakes excluded; (5) that it appears to be easily digested; and (6) that as far as this experience goes, it has not conveyed any fishy or other unpleasant taste to either the milk or the butter.

The price of this Norwegian herring-meal in bags at Glasgow was then (1887) £7, 12s. 6d. per ton, but Mr Speir considers that before it could come into extensive use in this country, its price would have to be very much reduced.

Utilising Fish-offal.—In view of the vast extent of the herring-fishing industry in this country, this experiment possesses peculiar interest. Not unfrequently, on account of excessive "catches" and a consequent glut in the herring-market, large quantities of herring have to be returned to the sea. Now, if it could be shown that these surplus boat-loads of fish—as well as the great quantities of fish-offal at the curing-yards—might be converted into a palatable and useful feeding-meal for cattle, a point of considerable national importance would be gained. Stock-owners would be benefited, and a helpful stimulus would be extended to the important industry of herring-fishing.

Fish-guano as Food.—Fish-guano has become a favourite manure with many farmers in this country; yet it is contended by some scientific men that the proper use of this fish product—meal or guano—is in the first instance as a food for stock, and that the manure made by the consumption of the fish-guano will be more readily available as plant-food than is the fish-guano itself, when applied directly to the land.

Fish-guanos contain from 2 to 12 per cent of oil, and this oil is not only valueless as manure, but acts injuriously in the soil by preventing the manure from rotting and yielding up its nitrogen to the crop. On the other hand, oil is a most valuable element in food, and Dr Aitken supports Weiske's suggestion that this fish meal or guano usually sold as a manure should be used in the first place as food, and that it should not be spread upon the land until it has been improved by passing through the digestive apparatus of farm-stock.

Fish meal or guano is rich in nitrogen, which usually ranges from 5 to 10 per cent, and the phosphates in it range from 15 to 50 per cent, so that it forms an excellent ingredient in the food of young stock. As to digestibility, the fish-guano would compare favourably with the majority of good feeding-cakes—recent experiments having shown that stock digest 90 per cent of its albuminoids.

In the process of fish-curing, there is considerable loss in disfigured fish rendered unfit for the market, and in the heads of the fish, which are chopped off in millions. Dr Aitken states that these two kinds of fish material, if properly dried and ground to powder, would make a food which, for cleanness and whole-

[1] Fourth ser., xx. 112.

someness, would leave nothing to be desired.[1]

Flesh-meal.

This is a by-product in the manufacture of Liebig's extract of beef, which is carried on upon an extensive scale in South America. The residue derived from that manufacture, consisting of the wholesome and nutritive fibrin of flesh, is dried and ground into a powder and sold as food for stock, under the name of Liebig's meat-meal.

Feeding Value.—Dr A. P. Aitken regards this meal as a useful kind of concentrated food for stock, and believes that it will be more appreciated as its nutritive qualities become better known. It contains no starch, and consists chiefly of albumen. It should therefore be given along with starchy food.

For Pigs.—Experiments upon pigs by Haubner and Hofmeister have shown that a pound of the flesh-meal is equal to about 3¾ lb. of barley-meal in the production of live weight in feeding pigs. Professor Lehman fed four pigs on a mixture of flesh-meal and potatoes, and one upon potatoes alone. The experiment lasted 44 days, and gave the following result:—

	Food consumed per head. Potatoes.	Flesh-meal.	Increase in live weight per head.
Lot 1,	422 lb.	20¾ lb.	52½ lb.
Lot 2,	415½ "	none	25 "

It is thus seen that all the pigs consumed about the same quantity of potatoes, and that every pound of flesh-meal eaten produced with the potatoes 1⅓ lb. increase in live weight.

The soluble salts being all dissolved in making the extract, the flesh-meal has very little flavour, which is rectified by the addition of chlorides and phosphates of soda, potash, and lime.

For Sheep.—Dr Hofmeister conducted experiments with flesh-meal as food for sheep at Dresden, but the results were not so favourable. He reckoned that 4 lb. of barley-meal produced the same result as 3 lb. of flesh-meal, and as the latter was very much dearer than the former, he did not consider the flesh-meal an economical food for sheep.

For Cattle.—It has been tried as food for cattle on several occasions on the Continent, and the results were on the whole satisfactory. They eat it readily enough, and it is given at the rate of from 1 to 3 lb. per day. Along with other food it produced favourable results both in increase of live weight and milk-production.[2]

ALBUMINOID RATIO.

The term "albuminoid ratio" has occasionally been used in the foregoing pages, and as it is a term which very often occurs in references to the composition of foods, it is desirable that it should be briefly explained. It means the ratio or proportion which the albuminoids in any given food bear to the non-nitrogenous food-constituents, of the nature of fat, starch, sugar, or digestible fibre.

But as fat or oil is a very much more concentrated food, regarded as a fat, heat, or force producer, than sugar or starch, we must, in order to institute any useful comparison between two articles of food, be able to translate, as it were, fat into its equivalent in sugar or starch. Sugar and starch, as already said, are practically equal in feeding value; so that starch, sugar, and other soluble carbohydrates—dextrine, digestible cellulose, &c. —can be set against one another, unit for unit. But oil or fat is equal in force-producing power, and therefore in feeding value, to 2½ times its weight of sugar or starch, so that to compare fat with sugar or starch we have to multiply it by 2½.

The following illustration will serve to show how, with the assistance of this factor, the albuminoid ratio of a food is calculated. Let us take analyses of linseed-cake and rice, and compare them:—

	Linseed-cake.	Rice.
Water	10.00	14.00
Albuminoids	25.00	5.30
Oil	12.00	0.40
Mucilage, starch, &c.	36.00	78.10
Woody fibre	10.00	1.50
Ash	7.00	0.70
	100.00	100.00

Taking the linseed-cake first, 12 of oil multiplied by 2½ gives 30, as the starch

[1] *Trans. High. Agric. Soc.*, xx., 1888.

[2] *Ibid.*, 4th ser., xx. 109.

equivalent of the oil. Adding this 30 to the 36.0 of digestible carbohydrates (mucilage, &c.), we get 66 as the starch equivalent in the linseed-cake. The "albuminoid ratio" is then as 25 to 66, or dividing 25 into 66, as 1 to 2.64, or, expressing it in the ordinary proportion form, 1 : 2.64. In the case of the rice we have only 0.4 of oil, which, multiplied by 2½, gives 1. This, added to 78, gives 79 as the starch equivalent of the rice. The albuminoid ratio of the rice then is as 5.3 to 78, or, dividing by 5.3, as 1 to 14.7, or 1 : 14.7.

The albuminoid ratio of average specimens of many of the foods in common use is as follows:—

	Albuminoid ratio.
Cotton-cake, decorticated	1 : 1.5
" " undecorticated	1 : 2.0
Linseed-cake	1 : 2.4
Rape-cake	1 : 1.6
Beans	1 : 2.5
Peas	1 : 3.1
Wheat-bran	1 : 5.2
Malt-dust	1 : 3.5
Brewers' grains	1 : 3.0
Oats	1 : 6.1
Barley	1 : 7.9
Maize	1 : 9.5
Pasture grass	1 : 5.9
Clover-hay (new)	1 : 7.4
Meadow-hay (medium)	1 : 9.4
Barley-straw	1 : 19.0
Oat-straw	1 : 22.3
Vetches	1 : 9.8
Swedes	1 : 9.8
Turnips	1 : 10.1
Mangels	1 : 17.0
Potatoes	1 : 17.2

Some difficulty is presented in this branch of the subject by the consideration that the various constituents of one and the same food are not equally digestible by all animals, and a given diet may *practically* have a different albuminoid ratio for oxen from that which it has for sheep or for horses.

Importance of properly balancing Food.—The proper balancing of the various elements of nutrition in the food given to animals is so essential to economical feeding, that its importance cannot be too strongly or too often impressed upon farmers. This balancing, indeed, is more important than mere bulk or quantity; for by giving a ration which is rich to excess in certain elements and poor in others, there will not only be loss of valuable feeding material, but the health and progress of the animal may also be seriously impaired. For instance, the injudicious use of too concentrated food may induce fever or other serious ailments, and thus by a turn of illness destroy all possibility of profit. Then as to the economy of the food itself, this can be fully ensured only by having the mixtures of it which are given to the animals prepared so that their various ingredients shall be present in the proper proportions.

Assuming that a certain food-mixture contains an unduly large proportion of carbohydrates, the animal feeding upon it, in order to obtain the amount of nitrogenous matter its system requires, will have to consume more carbohydrates than it can assimilate. To illustrate this still further, let it be supposed—(1) that the requirements of the animal for a certain time are 3 lb. of nitrogenous matter, to 15 of non-nitrogenous or carbohydrates; and (2) that the mixture of food given to it contains only 2 lb. of nitrogenous matter to 15 of carbohydrates.

Now, in order to obtain the necessary 3 lb. of nitrogenous matter, the animal has thus to consume 20 lb. of carbohydrates. What then becomes of the extra 5 lb. of carbohydrates? The animal's system cannot assimilate more than 15 lb., the other 5 passes away in the dung. And in the manure this non-nitrogenous matter is worthless, its ultimate products being carbonic acid and water. There is thus a complete loss of the 5 lb. of carbohydrates. Let the uneven proportions of the food be reversed, so as to have an excess of nitrogenous matter and a deficiency of carbohydrates, and the result is a similar loss of nitrogenous matter. In this case the excess of food—nitrogenous matter—which is excreted by the animal, increases the ammonia of the manure-heap; but it is a costly way of purchasing that valuable element of plant-food, and does not compensate for the loss by having the food unevenly balanced.

The strength of a chain depends upon the endurance of its weakest link—an often-used and serviceable illustration. It is a familiar representation of Liebig's law of minimum, which is quite as forcible in feeding as in manuring. Let there be no weak "links" in the "chain" of ingredients composing the feeding mixture. Consider and measure the demands which the wants and assimilating capacity of your animals are likely to make upon the nitrogenous and non-nitrogenous "links" (or elements) respectively, and have each made exactly, or as nearly as possible, equal to the strain upon it.

Ratio for Different Classes of Stock.—It is important that the ratio of albuminoids to non-albuminoids should be high in the case of the diet of young growing stock and of dairy cattle, as the former have to build up their muscle and bone, and the latter have to supply the albuminoids of the milk and to produce calves; while in the case of fattening animals, which assimilate comparatively little nitrogen, the ratio of albuminoids to non-albuminoids may be lower.

Probably the best average ratio, taking one class of animals with another, is about 1 of nitrogenous matter to 6 of non-nitrogenous—that is, an albuminoid ratio of 1 to 6. For young growing stock and milch cows it should, as a rule, be a little higher—perhaps 1 to 4 or 5, and for fattening stock a little lower—sometimes as low as 1 to 8.

A study of the foregoing table will show which foods, by their addition or introduction into an animal's diet, tend to raise, and which to lower, the albuminoid ratio. The desired elements of food should of course be drawn from whatever sources are for the time the cheapest.

For a fuller discussion of this subject, readers may be referred to the various manuals of agricultural chemistry.

HINTS ON THE PURCHASE OF FOOD.

It is desirable that farmers should exercise great care in the purchasing of artificial foods. In times past much deceit was practised by unscrupulous manufacturers and sellers of these foods, and farmers often sustained heavy losses by having adulterated and inferior material supplied to them, instead of the genuine article. Thanks mainly to the active efforts of agricultural and analytical associations, led by the courageous and commendable course of the Royal Agricultural Society of England in publishing the names of defaulters, these reprehensible practices have to a large extent disappeared. Still, in purchasing food as well as manure, the buyer should take every precaution to ensure the delivery of the genuine article.

With such foods as grain, peas, and beans, farmers can, by careful examination, satisfy themselves as to their purity, quality, and condition.

Chemical Analysis essential.—With cakes, meals, and other mixed foods, there is greater risk of deception, and more difficulty in detecting it. As to their general quality and soundness, experienced farmers can, as a rule, decide by sight, touch, taste, and smell; but without the aid of chemical analysis complete or sufficient certainty cannot be attained.

Guaranteed Analysis.—Farmers should be careful to buy all kinds of foods upon a guaranteed analysis, and with a written guarantee that each food is "pure" of its kind as described. The guaranteed analysis should state that the food contains not less than certain percentages of the various useful ingredients of foods, nor more than a certain percentage of "impurities," and a written statement should be added declaring that the food is in good, sound, wholesome condition, and free from ingredients of a poisonous or deleterious nature. Most of the leading firms now habitually sell their cakes and foods upon certain guarteed analyses.

Purity of Linseed-cake.—Linseed-cake has perhaps been more largely adulterated than any other variety of cake. Among the commodities most frequently used for adulterating linseed-cake are rape-seed, cockle-seed, buckwheat, and what is termed "mill-sweepings." Absolutely *pure* linseed-cake—that is, cake containing nothing but linseed—is not to be had, for the seed is certain to contain some small percentage of impurity. The question then arises, what should constitute a "*pure* linseed-cake"? There has been considerable discussion as to this, but there has been a pretty general agreement that the amount of impurity should not exceed 5 per cent. Accepting this limit, Dr John A. Voelcker has submitted the following as the essentials for a cake being considered a pure one, viz.:—

1. That it be made from sound seed of not less than 95 per cent purity, subsequently well screened.

2. That it contains no ingredients of a poisonous or deleterious nature.

3. That it be entirely free from sophistication of any kind.

4. That it contain not more than 2 per cent of sand.

5. That it be sold in good, merchantable condition.

Tests of Cake.—The late Dr Augustus Voelcker gave the following simple tests as to the quality and character of cake:—

1. Examine a bit of the cake as to its taste and smell; observe that it is fresh, and free from any mouldiness.

2. Examine another piece with a common pocket-lens. This examination will show whether the cake is a linseed or a rape cake, inasmuch as the form of the linseed and rape-seed is widely different. Much more difficult is it to distinguish by the lens mustard from rape cake.

3. Mix in a tumbler about 1 oz. of the cake, broken into small pieces, with 6 oz. of cold water. Good linseed-cake will form, under these circumstances, a stiff, agreeably tasting jelly, without separating any water. Rape-cake will become less gelatinous, and separate a yellowish or brown rather bitter tasting liquid. Mustard-cake, likewise, will become a little gelatinous, and separate a brown liquid which possesses the characteristic taste and smell of the essential oil of mustard. Rape-cake fraudulently or naturally mixed with mustard-seed under these circumstances, will exhibit a similar behaviour to that of mustard-seed, and by the degree of pungency of taste and smell, when compared with pure mustard-cake, will afford the means of estimating approximately the amount of mustard which the cake contains.

THE MANURIAL VALUE OF FOODS.

In the economical feeding of farm live stock, the manurial value of the foods used forms an important consideration. In some notes written specially for this edition, Mr Bernard Dyer, F.C.S., says: The value of animal excreta as a manure has been recognised perhaps as long as we have any records of agriculture.

Chemistry teaches us that—apart from mere mechanical effects on the texture of the soil—this value is due to the presence of nitrogenous and mineral compounds, of which latter the most important are the compounds of potash and of phosphoric acid. Seeing that, directly or indirectly, all the constituents of animal excreta are derived from the food it consumes, it is at once reasonable to suppose that the composition of the food must influence that of the excreta derived from it—that food, rich in nitrogen and in phosphates, for example, should produce manure rich in these materials; and that food, comparatively poor in these respects, should produce manure comparatively poor in them.

Urine.—The urine is the richest part of animal manure, for it is the means whereby is eliminated from the animal system the waste nitrogenous materials which have undergone digestion, and served their purpose physiologically. It is rich also in soluble salts of potash and phosphoric acid

Solid Excreta.—The solid excreta consist only of those materials which have passed through the animal undigested; and if an animal could be fed on theoretically perfect principles, they would possess hardly any manurial value. But practically, an animal always consumes more nitrogenous and phosphatic food than it really digests, and the excess thus consumed gives value to the solid excreta, although this value is generally small compared with that of the urine if the animal is properly fed.

Proportion of Food assimilated and voided.—An animal in order to gain a given increase in live weight has to consume an enormously greater quantity of food than would be required to produce that increase alone, for the mere sustenance of life involves a large daily assumption of food-material. What becomes of the carbon, hydrogen, and oxygen (see the article on "Food") that is consumed by the animal beyond what it stores up as increase, does not here concern us; but it is of essential consequence as a basis of knowledge of this branch of agricultural chemistry, that we should know what is the destination of the nitrogen and of the mineral matters in the food consumed.

Much attention has been devoted to this point at Rothamsted, and without going into the details of experiments too elaborate to be here quoted, it may be at once stated that careful experimental inquiry has shown that, of every 10 lb. of nitrogen consumed by an animal in its food, not more than about 1 lb. will be stored up as increase of live weight, the remaining 9 lb. or so being voided in the manure, partly as undigested matter, partly as soluble nitrogenous compounds, which readily become converted, first into ammonia, and then into nitrates, when applied to the soil. Similarly, only from about one-fifth to about one-tenth of the phosphates in food are stored up by the animal, and a still smaller proportion of potash salts, the great bulk of both going to enrich the manure.

The actual proportion of any of these fertilising ingredients retained in any given case will depend upon how liberally the animal is fed, and also upon whether it is a growing animal, having to build up its bony frame and muscles, or whether it is an already adult animal adding little but fat to its carcass-weight; or whether again it may be a cow having to produce its calf, and yield a flow of milk, which will make a heavier demand on the food than will the mere fat-forming processes going on in the case of a stall-fed ox.

Lawes's Manurial Tables.—Taking one case with another, however, it is possible to arrive at an average which shall in no case err very widely; and the careful experiments and calculations made at Rothamsted have furnished us with classical tables, indicative both of the original proportions of the chief fertilising ingredients contained in the various foods, and the proportions of these which will, on the average, be voided by animals consuming, say, a ton of any of them.

The latest edition of these tables was that published by Sir John Bennett Lawes and Dr Gilbert in the *Journal of the Royal Agricultural Society of England* in 1885, and their importance justifies their quotation here in full.

[TABLES.

SIR J. B. LAWES'S REVISED TABLES OF COMPOSITION AND MANURIAL VALUE OF FOODS.

TABLE I.—Average Composition, Per Cent and per Ton, of Cattle Foods.

No.	Foods.	Per Cent.					Per Ton.		
		Dry Matter.	Nitrogen.	Mineral Matter (Ash).	Phosphoric Acid.	Potash.	Nitrogen.	Phosphoric Acid.	Potash.
		per cent.	per cent.	per cent.	per cent.	per cent.	lb.	lb.	lb.
1	Linseed	90.00	3.60	4.00	1.54	1.37	80.64	34.50	30.69
2	Linseed-cake	88.50	4.75	6.50	2.00	1.40	106.40	44.80	31.36
3	Decorticated cotton-cake	90.00	6.60	7.00	3.10	2.00	147.84	69.44	44.80
4	Palm-nut-cake	91.00	2.50	3.60	1.20	0.50	56.00	26.88	11.20
5	Undecorticated cotton-cake	87.00	3.75	6.00	2.00	2.00	84.00	44.80	44.80
6	Cocoa-nut-cake	90.00	3.40	6.00	1.40	2.00	76.16	31.36	44.80
7	Rape-cake	89.00	4.90	7.50	2.50	1.50	109.76	56.00	33.60
8	Peas	85.00	3.60	2.50	0.85	0.96	80.64	19.04	21.50
9	Beans	85.00	4.00	3.00	1.10	1.30	89.60	24.64	29.12
10	Lentils	88.00	4.20	4.00	0.75	0.70	94.08	16.80	15.68
11	Tares (seed)	84.00	4.20	2.50	0.80	0.80	94.08	17.92	17.92
12	Indian corn	88.00	1.70	1.40	0.60	0.37	38.08	13.44	8.29
13	Wheat	85.00	1.80	1.70	0.85	0.53	40.32	19.04	11.87
14	Malt	94.00	1.70	2.50	0.80	0.50	38.08	17.92	11.20
15	Barley	84.00	1.65	2.20	0.75	0.55	36.96	16.80	12.32
16	Oats	86.00	2.00	2.80	0.60	0.50	44.80	13.44	11.20
17	Rice-meal [1]	90.00	1.90	7.50	(0.60)	(0.37)	42.56	(13.44)	(8.29)
18	Locust-beans [1]	85.00	1.20	2.50	...	...	26.88	...	...
19	Malt-combs	90.00	3.90	8.00	2.00	2.00	87.36	44.80	44.80
20	Fine pollard	86.00	2.45	5.50	2.90	1.46	54.88	64.96	32.70
21	Coarse pollard	86.00	2.50	6.40	3.50	1.50	56.00	78.40	33.60
22	Bran	86.00	2.50	6.50	3.60	1.45	56.00	80.64	32.48
23	Clover-hay	83.00	2.40	7.00	0.57	1.50	53.76	12.77	33.60
24	Meadow-hay	84.00	1.50	6.50	0.40	1.60	33.60	8.96	35.84
25	Pea-straw	82.50	1.00	5.50	0.35	1.00	22.40	7.84	22.40
26	Oat-straw	83.00	0.50	5.50	0.24	1.00	11.20	5.38	22.40
27	Wheat-straw	84.00	0.45	5.00	0.24	0.80	10.08	5.38	17.92
28	Barley-straw	85.00	0.40	4.50	0.18	1.00	8.96	4.03	22.40
29	Bean-straw	82.50	0.90	5.00	0.30	1.00	20.16	6.72	22.40
30	Potatoes	25.00	0.25	1.00	0.15	0.55	5.60	3.36	12.32
31	Carrots	14.00	0.20	0.90	0.09	0.28	4.48	2.02	6.27
32	Parsnips	16.00	0.22	1.00	0.19	0.36	4.93	4.26	8.06
33	Swedish turnips	11.00	0.25	0.60	0.06	0.22	5.60	1.34	4.93
34	Mangel-wurzels	12.50	0.22	1.00	0.07	0.40	4.93	1.57	8.96
35	Yellow turnips [1]	9.00	0.20	0.65	(0.06)	(0.22)	4.48	(1.34)	(4.93)
36	White turnips	8.00	0.18	0.68	0.05	0.30	4.03	1.12	6.72

[1] In the case of neither rice-meal, locust-beans, nor yellow turnips, have records of ash analyses been found. For rice-meal the same percentages of phosphoric acid and potash as in Indian corn, and for yellow turnips the same as in swedes, are provisionally adopted; but in all the Tables the assumed results are given in parentheses. For locust-beans no figure has been assumed, and the columns are left blank.

TABLE II.—SHOWING THE DATA, THE METHOD, AND THE RE-
OF CATTLE FOODS

No.	DESCRIPTION OF FOOD.	Fattening Increase in Live weight (Oxen or Sheep).		NITROGEN.						
				In Food.		In Fattening Increase (at 1.27 per cent).		In Manure.		
	—	Food to 1 Increase.	Increase per ton of food.	Per cent.	Per ton.	From 1 ton of Food.	Per cent of total consumed.	Total remaining for Manure.	Nitrogen equal Ammonia.	Value of Ammonia at 6d. per lb.
			lb.	%	lb.	lb.	%	lb.	lb.	£ s. d.
1	Linseed	5.0	448.0	3.60	80.64	5.69	7.06	74.95	91.0	2 5 6
2	Linseed-cake	6.0	373.3	4.75	106.40	4.74	4.45	101.66	123.4	3 1 8
3	Decorticated cotton-cake	6.5	344.6	6.60	147.84	4.38	2.96	143.46	174.2	4 7 1
4	Palm-nut-cake	7.0	320.0	2.50	56.00	4.06	7.25	51.94	63.1	1 11 7
5	Undecorticated cotton-cake	8.0	280.0	3.75	84.00	3.56	4.24	80.44	97.7	2 8 10
6	Cocoa-nut-cake	8.0	280.0	3.40	76.16	3.56	4.67	72.60	88.2	2 4 1
7	Rape-cake	(10)	(224)	4.90	109.76	2.84	2.59	106.92	129.8	3 4 11
8	Peas	7.0	320.0	3.60	80.64	4.06	5.03	76.58	93.0	2 6 6
9	Beans	7.0	320.0	4.00	89.60	4.06	4.53	85.54	103.9	2 11 11
10	Lentils	7.0	320.0	4.20	94.08	4.06	4.32	90.02	109.3	2 14 8
11	Tares (seed)	7.0	320.0	4.20	94.08	4.06	4.32	90.02	109.3	2 14 8
12	Indian corn	7.2	311.1	1.70	38.08	3.95	10.37	34.13	41.4	1 0 9
13	Wheat	7.2	311.1	1.80	40.32	3.95	9.80	36.37	44.2	1 2 1
14	Malt	7.0	320.0	1.70	38.08	4.06	10.66	34.02	41.3	1 0 8
15	Barley	7.2	311.1	1.65	36.96	3.95	10.69	33.01	40.1	1 0 1
16	Oats	7.5	298.7	2.00	44.80	3.79	8.46	41.01	49.8	1 4 11
17	Rice-meal	7.5	298.7	1.90	42.56	3.79	8.91	38.77	47.1	1 3 6
18	Locust-beans	9.0	248.9	1.20	26.88	3.16	11.76	23.72	28.8	0 14 5
19	Malt-combs	8.0	280.0	3.90	87.36	3.56	4.08	83.80	101.8	2 10 11
20	Fine pollard	7.5	298.7	2.45	54.88	3.79	6.91	51.09	62.0	1 11 0
21	Coarse pollard	8.0	280.0	2.50	56.00	3.56	6.35	52.44	63.7	1 11 10
22	Bran	9.0	248.9	2.50	56.00	3.16	5.64	52.84	64.2	1 12 1
23	Clover-hay	14.0	160.0	2.40	53.76	2.03	3.78	51.73	62.8	1 11 5
24	Meadow-hay	15.0	149.3	1.50	33.60	1.90	5.65	31.70	38.5	0 19 3
25	Pea-straw	16.0	140.0	1.00	22.40	1.78	7.95	20.62	25.0	0 12 6
26	Oat-straw	18.0	124.4	0.50	11.20	1.58	14.11	9.62	11.7	0 5 10
27	Wheat-straw	21.0	106.7	0.45	10.08	1.36	13.49	8.72	10.6	0 5 4
28	Barley-straw	23.0	97.4	0.40	8.96	1.24	13.84	7.72	9.4	0 4 8
29	Bean-straw	22.0	101.8	0.90	20.16	1.29	6.39	18.87	22.9	0 11 6
30	Potatoes	60.0	37.3	0.25	5.60	0.47	8.39	5.13	6.2	0 3 1
31	Carrots	85.7	26.1	0.20	4.48	0.33	7.37	4.15	5.0	0 2 6
32	Parsnips	75.0	29.9	0.22	4.93	0.38	7.71	4.55	5.5	0 2 9
33	Swedish turnips	109.1	20.5	0.25	5.60	0.26	4.64	5.34	6.5	0 3 3
34	Mangel-wurzels	96.0	23.3	0.22	4.93	0.30	6.09	4.63	5.6	0 2 10
35	Yellow turnips	133.3	16.8	0.20	4.48	0.21	4.69	4.27	5.2	0 2 7
36	White turnips	150.0	14.9	0.18	4.03	0.19	4.71	3.84	4.7	0 2 4

SULTS OF THE ESTIMATION OF THE ORIGINAL MANURE VALUE AFTER CONSUMPTION.

Phosphoric Acid.						Potash.						Total original Manure value per ton of Food consumed.
In Food.		In Fattening Increase at (0.86 per cent).		In Manure.		In Food.		In Fattening Increase at (0.11 per cent).		In Manure.		
Per cent.	Per ton.	From 1 ton of Food.	Per cent of total consumed.	Total remaining for Manure.	Value at 3d. per lb.	Per cent.	Per ton.	From 1 ton of Food.	Per cent of total consumed.	Total remaining for Manure.	Value at 2½d. per lb.	
%	lb.	lb.	%	lb.	s. d.	%	lb.	lb.	%	lb.	s. d.	£ s. d.
1.54	34.50	3.85	11.16	30.65	7 8	1.37	30.69	0.49	1.60	30.20	6 3	2 19 5
2.00	44.80	3.21	7.17	41.59	10 5	1.40	31.36	0.41	1.31	30.95	6 5	3 18 6
3.10	69.44	2.96	4.26	66.48	16 8	2.00	44.80	0.38	0.85	44.42	9 3	5 13 0
1.20	26.88	2.75	10.23	24.13	6 0	0.50	11.20	0.35	3.13	10.85	2 3	1 19 10
2.00	44.80	2.41	5.38	42.39	10 7	2.00	44.80	0.31	0.69	44.49	5 11	3 5 4
1.40	31.36	2.41	7.68	28.95	7 3	2.00	44.80	0.31	0.69	44.49	9 3	3 0 7
2.50	56.00	1.93	3.45	54.07	13 6	1.50	33.60	0.25	0.74	33.35	6 11	4 5 4
0.85	19.04	2.75	14.44	16.29	4 1	0.96	21.50	0.35	1.63	21.15	4 5	2 15 0
1.10	24.64	2.75	11.16	21.89	5 6	1.30	29.12	0.35	1.20	28.77	6 0	3 3 5
0.75	16.80	2.75	16.37	14.05	3 6	0.70	15.68	0.35	2.23	15.33	3 2	3 1 4
0.80	17.92	2.75	15.35	15.17	3 9	0.80	17.92	0.35	1.95	17.57	3 8	3 2 1
0.60	13.44	2.68	19.94	10.76	2 8	0.37	8.29	0.34	4.10	7.95	1 8	1 5 1
9.85	19.04	2.68	14.08	16.36	4 1	0.53	11.87	0.34	2.86	11.53	2 5	1 8 7
0.80	17.92	2.75	15.35	15.17	3 9	0.50	11.20	0.35	3.13	10.85	2 3	1 6 8
0.75	16.80	2.68	15.95	14.12	3 6	0.55	12.32	0.34	2.76	11.98	2 6	1 6 1
0.60	13.44	2.57	(19.12)	10.87	2 8	0.50	11.20	0.33	2.94	10.87	2 3	1 9 10
(0.60)	(13.44)	2.57	(19.12)	(10.87)	(2 8)	(0.37)	(8.29)	0.33	(4.00)	(7.96)	(1 8)	(1 7 10)
...	...	2.14	...	...	...	...	...	0.27	...	...	...	...
2.00	44.80	2.41	5.38	42.39	10 7	2.00	44.80	0.31	0.69	44.49	9 3	3 10 9
2.90	64.96	2.57	3.96	62.39	15 7	1.46	32.70	0.33	1.01	32.37	6 9	2 13 4
3.50	78.40	2.41	3.07	75.99	19 0	1.50	33.60	0.31	0.92	33.29	6 11	2 17 9
3.60	80.64	2.14	2.65	78.50	19 8	1.45	32.48	0.27	0.83	32.21	6 8	2 18 5
0.57	12.77	1.38	10.81	11.39	2 10	1.50	33.60	0.18	0.54	33.42	7 0	2 1 3
0.40	8.96	1.28	14.28	7.68	1 11	1.60	35.84	0.16	0.45	35.68	7 5	1 8 7
0.35	7.84	1.20	15.31	6.64	1 8	1.00	22.40	0.15	0.67	22.25	4 8	0 18 10
0.24	5.38	1.07	19.89	4.31	1 1	1.00	22.40	0.14	0.63	22.26	4 8	0 11 7
0.24	5.38	0.92	17.10	4.46	1 1	0.80	17.92	0.12	0.67	17.80	3 8	0 10 1
0.18	4.03	0.84	20.84	3.19	0 9	1.00	22.40	0.11	0.49	22.29	4 8	0 10 1
0.30	6.72	0.88	13.10	5.84	1 5	1.00	22.40	0.11	0.49	22.29	4 8	0 17 7
0.15	3.36	0.32	9.52	3.04	0 9	0.55	12.32	0.04	0.32	12.28	2 7	0 6 5
0.09	2.02	0.22	10.89	1.80	0 5	0.28	6.27	0.03	0.48	6.24	1 4	0 4 3
0.19	4.26	0.26	6.10	4.00	1 0	0.36	8.06	0.03	0.37	8.03	1 8	0 5 5
0.06	1.34	0.18	13.43	1.16	0 4	0.22	4.93	0.02	0.41	4.91	1 0	0 4 7
0.07	1.57	0.20	12.74	1.37	0 4	0.40	8.96	0.03	0.34	8.93	1 10	0 5 0
(0.06)	(1.34)	0.14	(10.78)	(1.20)	(0 4)	(0.22)	(4.93)	0.02	(0.34)	(4.91)	(1 0)	(0 3 11)
0.05	1.12	0.13	11.61	0.99	0 3	0.30	6.72	0.02	0.30	6.70	1 5	0 4 0

In the first of these tables we have the total quantities of ingredients capable of contributing to the fertility of the land contained in the principal varieties of foods in use on the farm, stated both as percentages and as pounds per ton. These figures represent the manurial matter that would reach the land, supposing that the foods were simply ground up and applied directly to the soil, without the intervention of the stock that consumes them.

In Table II. we have indicated to us the average destination of this fertilising matter—how much of it, that is to say, may be assumed to be retained by the animal increasing its weight, and how much will find its way into the manure. Then we have the theoretical money value of this latter portion calculated for each fertilising constituent; and finally, we have stated what would be the total value of the manure from a ton of the food, supposing its value to be completely realised.

To make the matter clearer, we will select an instance—say that of linseed-cake. From Table I., we learn that linseed-cake contains 88.5 per cent of dry matter, which includes 4.75 per cent of nitrogen, 2.00 of phosphoric acid, and 1.40 per cent of potash; or otherwise stated, one ton of linseed-cake contains 106.40 lb. of nitrogen, 44.80 lb. of phosphoric acid, and 31.36 lb. of potash. From Table II., we learn that 6 lb. of linseed-cake go to make 1 lb. of increase in live weight, so that 1 ton of cake yields 373.3 lb. of increase in live weight. We also learn that of the 106.40 lb. of nitrogen in the ton of cake, 4.74 lb. are retained by the animal, while 101.66 lb. pass into the manure. This quantity of nitrogen is equal to 123.4 lb. of ammonia, which, at 6d. per lb., is equal to £3, 1s. 8d. per ton. In like manner we find that of 44.8 lb. of phosphoric acid in the ton of cake, 3.21 lb. are retained by the animal, while 41.59 lb. pass into the manure, which, at 3d. per lb., would be worth 10s. 5d. Of 31.36 lb. of potash in the ton of cake, 0.41 lb. is retained, 30.95 lb. passing into the manure, giving at 2½d. per lb., 6s. 5d. The three money figures added together give £3, 18s. 6d. as the "total original manure value" of one ton of linseed-cake. This value in the case of decorticated cotton-cake is as high as £5, 13s., while for maize it is but £1, 5s. 1d., or for barley, £1, 6s. 1d., and for turnips it is less than 5s.

There can be no doubt that the proportions which these "original manure values" bear to one another, correctly represent the proportions borne to one another by the actual manurial values realisable in the field, provided that the circumstances are favourable for their comparative realisation; though it has happened, as in the Woburn experiments, that practical trial has occasionally shown that manure made by the use of a food like decorticated cotton-cake has done no more immediate good than manure made from a like quantity of maize. But this has no doubt been because the land was in such good heart that the maize manure was in itself sufficient to bring out its maximum fertility, and that the richer manure supplied by the decorticated cotton-cake was of the nature of a superfluity.

It is of course to be borne in mind that the values calculated in each case are average ones, and any given ton of linseed-cake, for example, may differ a good deal from another ton; but it is only on the *average* quality of each kind of food that a table for general reference could well be based without becoming bewilderingly cumbersome.

Theoretical and Realised Manure Values.—But even putting aside this consideration, there are obviously a vast number of circumstances affecting the question of how far the theoretical value given in the tables is capable of actual realisation in the field. The nearest approach to the perfect application of the whole of the manure to the crops is found in the consumption of food on the land itself, as when grazing cattle or sheep consume cake in the field. Their excreta go directly on to the land, and so the whole of the manurial matter at least reaches the soil.

The other extreme is found where the food is consumed in the farmyard, and the manure badly cared for—as when it is left to lie about in the open, exposed to the free and prolonged action of rain, in such a way as to allow the drainage from it to be lost. Wherever the rich drainings from dung are allowed to run to waste, there is a serious loss of fertilising matter; for the most valuable part of manure is the soluble ammonia, salts, &c., which it contains.

What proportion of the manurial value originally contributed to the dung really finds its way on to the land from the farmyard depends, therefore, upon individual care and management, of which no exact account can be taken in tables.

Furthermore, a herd of dairy cows will rob the food of much more nitrogen and phosphoric acid than a herd of fattening oxen, since oxen, while fattening, store up but little of these materials compared with that which is required by the cows to produce a flow of milk, and to build up the bodies of the young calves which they have yearly to produce. There are obviously, then, difficulties to be surmounted in forming an estimate of the manurial value that may fairly be assumed to be realisable in any given case.

As far as regards the guidance of the farmer to the prices which the various foods are worth, considered comparatively, and as to the best foods to use in order to at once fatten his stock and best fertilise his land, the mere "original manure values" supply sufficient information; but when the question at issue is as to the realisable unexhausted value of manure from food consumed, such complexities as we have glanced at arise and give serious trouble.

Unexhausted Value of Consumed Food.—The "county customs" which are often brought in to assess, under the provisions of the Agricultural Holdings Act, the compensation due to an outgoing tenant for unexhausted manurial value for foods consumed, are in most cases absurdly fallacious, being too often based on the *cost* of the foods used, which has no relation whatever to their manurial value. The difficulty which the valuer who proceeds on rational principles has to face is to decide on how much of the "original manure value" is to be assumed to be still left on the farm—the "compensation value," as Sir John Bennett Lawes has called it.

With a view to putting the matter on a broad general basis for practical purposes, Sir John Bennett Lawes has suggested that in the case of an outgoing tenant claiming compensation for the unexhausted value of consumed food, the "original manure value" of each ton of food (as shown in Table II.) should be discounted to the extent of 50 per cent for the food consumed within the last year. In the case of food consumed last year but one, he suggests a deduction of one-third of the allowance for last year—while for food consumed three years ago, a deduction of one-third from this sum should be made; and so on, for whatever number of years — down to eight — may be taken.

Let us, as an instance, take again the case of linseed-cake, the "original manurial value" of which is £3, 18s. 6d. For each ton of this cake consumed in the last year of tenancy, it would be assumed that a practical unexhausted value of £1, 19s. 3d. remained on the farm, realisable by the new tenant. For a ton of cake consumed last year but one, this sum would be reduced by one-third, making £1, 6s. 2d. If consumed a year previously, it would be still further reduced by a third, making 17s. 6d., and so on. In the eighth year back, the compensation would be only 2s. 4d.

As a matter of fact, most farmers would, no doubt, object to paying "compensation values" for food used more than two or three years previously; but the principle of compensation suggested —taking it as far back as may be deemed judicious—appears to be a sound one, and one that can hardly be charged with pressing too hardly on the incoming tenant. In applying it, the valuer, if he knows his business, will be influenced by his observations taken on the farm as to the mode in which manure is treated, and as to the information available on the matter of consumption. Sir John Bennett Lawes and Dr Gilbert, in the paper already quoted from, very rightly observe: "It is pretty certain indeed that every claim for compensation will have to be settled on its own merits; that the character of the soil, the cropping, the state of the land as to cleanliness, and many other points, will be taken into consideration both for and against any claim."

FOOD RATIONS.

The secret of success in economical stock-feeding lies in the perfect arrangement of "Food Rations"—that is, in so arranging the kinds, quantities, and proportions of the different articles of food as to ensure the maximum result at the minimum cost. To provide this it is necessary, not only that the mixed food shall contain in perfect proportions and in palatable and easily digestible form a sufficiency, and neither more nor less than a sufficiency, of all the elements of nutrition which the animal needs both for its own sustenance and for the production of milk, or the increase of bone and muscle, flesh and fat; but also that the market price and feeding value of the different kinds of food be carefully considered, so that these elements of nutrition may be drawn from the cheapest sources. In other words, economical feeding demands that the relative cost and feeding value, as well as the relative amounts and proportions of the various articles of food, shall be carefully studied.

What the Feeder has to determine.—What quantity of food should each animal receive per day? What should be the composition of that daily ration—that is, what proportionate quantities of the various elements of nutrition should it contain? In what articles of food can these elements of nutrition be provided in the required proportions at the lowest relative cost? These are the questions which the feeder has to determine; and they should be considered in the above order. The guiding conditions in regard to the first two will be the size and class of the animals and the purpose in view—whether being fed for increase in size, for breeding, for milk production, or merely for taking on flesh and fat. The feeder, in deciding as to the third of these questions, has to consider the composition and market price of each article available and suitable as food. The mixture must not only be perfect in weight and composition, but also be made up at the lowest possible cost.

The Animal's Requirements.—First, then, how are the requirements of the animal to be determined? In considering this, only the amount of dry matter required in the food need be taken into account. What water the animal wants to drink by itself or to moisten its food may always be had free of cost. Mr F. J. Lloyd, F.C.S., contributed a paper to the *Live Stock Journal Almanac*, 1888, which deals with the subject of "Feeding Rations," and which has excited a good deal of attention. As presented by Mr Lloyd, the information is so important and so full of interest to stock-owners, that we venture to produce here the substance of what he wrote.

As to the quantity and kinds of food required by animals, Mr Lloyd says: "By feeding animals with weighed quantities of food, the dry matter in which is known, and by weighing back that which is not consumed, we may obtain valuable information as to the quantity of food (dry food) each animal requires to maintain it. If, further, we analyse the food, so as to obtain a precise knowledge of the quantity of each constituent given, and subsequently analyse the excreta to discover what quantity of each constituent the animal has utilised, we obtain, in addition to our knowledge of the *quantity* of dry food necessary, a knowledge of what *quality* that dry food should possess. The quality is made up of three constituents—flesh-formers, heat-producers, and fat; or, in chemical language, albuminoids, carbohydrates, and fat. Many such feeding experiments have been conducted, those in Germany with greater care than anywhere else, and a brief *résumé* of the results obtained is given in the following table:—

[TABLE.

FEEDING STANDARDS.

Animal.	Live Weight.	Food required per Day.				
		Dry Matter.	Digestible.			Nutritive Ratio.
			Albuminoids.	Carbohydrates.	Fat.	
Oxen, growing—	lb.	lb.	lb.	lb.	lb.	
Age, 6-12 months . .	500	12.0	1.3	6.8	0.30	1-6.0
" 12-18 " . .	700	16.8	1.4	9.1	0.28	1-7.0
" 18-24 " . .	850	20.4	1.4	10.3	0.26	1-8.0
Oxen, fattening, per . .	1000					
First period . . .	...	27.0	2.5	15.0	0.50	1-6.5
Second "	...	26.0	3.0	14.8	0.70	1-5.5
Third "	...	25.0	2.7	14.8	0.60	1-6.0
Cow in milk, per . .	1000	24.0	2.5	12.5	0.40	1-5.4
Sheep, growing—						
Age, 5-8 months . .	61	1.7	0.17	0.86	0.04	1-5.5
" 8-11 " . .	75	1.7	0.16	0.85	0.04	1-6.0
" 11-15 " . .	82	1.8	0.14	0.89	0.03	1-7.0
Sheep, fattening, per . .	1000					
First period . . .	...	26.0	3.0	15.2	0.5	1-5.5
Second "	...	25.0	3.5	14.4	0.6	1-4.5
Horses at work, per . .	1000	22.5	1.8	11.2	0.60	1-7.0
Pigs, growing—						
Age, 3-5 months . .	100	3.4	0.50	2.50		1-5.0
" 5-8 " . .	170	4.6	0.58	3.47		1-6.1
" 8-12 " . .	250	5.2	0.62	4.05		1-6.5
Pigs, fattening, per . .	1000					
First period . . .	...	36.0	5.0	27.5		1-5.5
Second "	...	31.0	4.0	24.0		1-6.0
Third "	...	23.5	2.7	17.5		1-6.5 "

Composition of Foods.—These being the wants of the animals, by what articles of food can they be most effectually and most cheaply supplied? To be able to determine this a farmer must make himself acquainted with the composition and relative nutritive properties of the various foods, and study these in view of market prices. Upon this important point information is given in this work in the section specially devoted to a description of foods for live stock; and the reader is commended to make himself familiar with what is said there, before attempting to arrange the feeding rations for his animals.

For convenience here we present the following table given by Mr Lloyd, to show the average amount and composition of the dry matter in the most common foods:—

[TABLE.

COMPOSITION OF PRINCIPAL FEEDING STUFFS.

	Percentage Composition.				Percentage Digestible.		
	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.	Albuminoids.	Carbohydrates.	Fat.
Barley-meal	83.5	10.0	63.9	2.5	8.0	58.9	1.7
Barley-straw	81.6	3.5	36.7	1.4	1.3	40.6	0.5
Bean-meal	82.4	25.5	45.9	1.6	23.0	50.2	1.4
Beans (green)	11.7	2.8	5.1	0.3	2.0	5.2	0.2
Brewers' grains	22.2	4.9	11.0	1.1	3.9	10.8	0.8
Cabbage	13.7	2.5	8.1	0.7	1.8	8.2	0.4
Clover, red (green)	18.3	3.0	8.9	0.6	1.7	8.7	0.4
Clover, red (silage)	21.6	3.4	9.7	1.0	2.2	11.1	0.6
Clover, red (hay)	78.7	12.3	38.2	2.2	7.0	38.1	1.2
Cotton-cake	82.3	23.6	30.5	6.1	17.5	14.9	5.5
Cotton-cake (decorticated)	81.2	38.8	19.5	13.7	31.0	18.3	12.3
Grass meadow (green)	18.0	3.5	9.7	0.8	2.5	9.9	0.4
Hay (meadow)	79.5	9.7	41.4	2.5	5.4	41.0	1.0
Linseed-cakes	79.0	29.5	29.9	9.9	24.8	27.5	8.9
Linseed-meal (extracted)	84.0	32.9	38.3	3.5	27.7	34.7	3.2
Maize-meal	87.0	10.6	69.7	5.5	9.1	67.1	4.2
Mangels	11.2	1.1	9.1	0.1	1.1	10.0	0.1
Oat-straw	81.7	4.0	36.2	2.0	1.4	40.1	0.7
Peas (green)	17.0	3.2	7.6	0.6	2.2	7.4	0.3
Pea-meal	85.1	23.7	54.5	3.5	20.9	55.4	2.8
Rape-cake	81.6	31.6	29.9	9.6	25.3	23.8	7.7
Rice-meal	79.5	10.9	47.6	9.9	8.6	47.2	8.8
Swedes	12.0	1.3	9.5	0.1	1.3	10.6	0.1
Turnips (white)	7.3	1.1	5.3	0.1	1.1	6.1	0.1
Vetches (green)	16.2	3.5	6.6	0.6	2.5	6.7	0.3
Wheat-bran	80.5	15.0	52.2	3.2	12.6	42.7	2.6
Wheat-straw	81.1	3.0	36.9	1.2	0.8	35.6	0.4

It is not to be supposed that the farmer can in every case have his foods analysed, but as a rule he may assume, if they are fairly good of their kind, that their composition will approximate pretty closely to the above table of averages.

Want of Care and Precision in Feeding.—Now, with the knowledge thus obtained of the requirements of the animal, and the composition and market price of the various foods, the farmer will be better able to make up an economical feeding ration for his stock than if he were, as of old, simply groping in the dark, or following some antiquated rule, the "why and wherefore" of which may be totally unknown to him, and which may, as likely as not, be sharply at variance with the principles of profitable stock-feeding. Remarking upon the all too prevalent haphazard system of feeding stock without due attention to the proper mixing of foods, Mr Lloyd makes some pertinent remarks; and as a little criticism now and again is wholesome, we extract the following: "Here and there are to be found exact statements of the quantity of meal or cake, and the proportion of each, but generally with this remark—Mixed with chaff, roots, &c. How much chaff and roots? and how much was eaten, how much wasted? For this information one seeks in vain. Why should *they* be considered? Presumably they cost nothing—at least one would assume so, for it is seldom that their value can be found in a balance-sheet. And yet, if a scientific man's opinion is worth anything upon such a matter of practice, I venture to think that it is this very chaff, roots, &c., which is the dearest food fed. And whether that opinion be right or wrong, one thing is certain, that much of the meal and cake given with them is absolutely wasted, and affords no profit, because, without knowing the exact amount of the other portions of the food, it is impossible to estimate the proper quantity of meal and cake to give."

Rations for fattening Oxen.

By way of illustrating the application of the information supplied in these two tables, Mr Lloyd takes up a common ration used to fatten oxen for the butcher—viz., 84 lb. of swedes, 14 lb. hay, and 3 lb. linseed-cake, and proceeds: "Assuming the substances to have been of average composition, we find by the table of analyses that—

	Dry Matter.	Digestible. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.
	lb.	lb.	lb.	lb.
100 lb. swedes contain	12.0	1.3	10.6	0.1
Therefore 84 lb. contain (×84 and divide by 100)	10.08	1.092	8.904	0.084
100 lb. hay contain	79.5	5.4	41.0	1.0
Therefore 14 lb. hay contain (×14, divide by 100)	11.130	0.756	5.74	0.14
100 lb. linseed-cake contain . . .	79.0	24.8	27.5	8.9
Therefore 3 lb. contain	2.37	0.744	0.825	0.267

"We will now combine these together, and we have the following:—

	Dry Matter.	Digestible. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.
	lb.	lb.	lb.	lb.
In 84 lb. swedes	10.08	1.092	8.904	0.084
In 14 lb. hay	11.13	0.756	5.740	0.140
In 3 lb. linseed-cake	2.37	0.744	0.825	0.267
In total ration .	23.58	2.592	15.469	0.491
Ration required as shown in table .	27.0	2.5	15.0	0.5

"It will be seen that this farmer, totally unknown to himself, was really giving his animals a food as efficient as it could be in all respects save one—it did not contain quite so much dry matter as is usually necessary; but this was due to the large quantity of roots employed, and the easy digestibility of their dry matter; whereas most substances, to afford the same amount of digestible food, would have possessed more dry matter.

"There is an important lesson we learn from this example, that while the above ration was excellent for the commencement of fattening, it was not suited for continuance into the latter stages, when more albuminoids and fat are needed, but less carbohydrates. It is evident that these could best be supplied by the addition of more linseed-cake, and, as it is not necessary to increase the total quantity of food, some portion of the swedes or hay might be withdrawn. We will withdraw 2 lb. of hay and add 1 lb. of linseed-cake; the ration would then be as follows:—

	Dry Matter.	Digestible. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.
	lb.	lb.	lb.	lb.
84 lb. swedes	10.08	1.092	8.904	0.084
12 lb. hay	9.54	0.648	4.920	0.120
4 lb. linseed-cake	3.16	0.992	1.100	0.356
Total . .	22.78	2.732	14.924	0.560
Standard for last period of fattening	25.00	2.7	14.8	0.60

"It is evident that we now comply with the standard very closely, and it is to be remembered that these standards are merely guides to be aimed at and approached as nearly as possible; but they are not hard and fast limits, which must be strictly adhered to to the third place of decimals."

Making up Feeding Rations.

As a second example, Mr Lloyd explains how to build up a ration for a certain purpose and with definite foods. He says: "We will assume that roots are scarce, and that, until the tares are fit to cut, the farmer is confined to the use of silage as the only succulent food he possesses; that of this he has but little, owing to the failure of his clover crop, and so must do the best to make up the rest of the ration with purchased food.

"As the basis of the ration, he takes 10 lb. hay, 10 lb. oat-straw, and 10 lb. clover-silage. By referring to the table of analyses we find these will contain the following:—

	Dry Matter.	Digestible. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.
	lb.	lb.	lb.	lb.
10 lb. meadow-hay	7.95	0.54	4.10	0.10
10 lb. oat-straw . .	8.17	0.14	4.01	0.07
10 lb. clover-silage .	2.16	0.22	1.11	0.06
Total . . .	18.28	0.90	9.22	0.23

"Now compare these figures with the ration as shown in the table, still assuming that oxen are being fed during the first period of fattening, and each weighing 1000 lb. Here it may be stated that for animals weighing more or less, the quantity they require is in proportion to their weight.

"It will be seen that about 9 lb. more dry matter are required, and that, while the ration already affords nearly two-thirds of the carbohydrates, it only supplies one-third of the albuminoids requisite; hence we require at least one food rich in albuminoids. We can choose bean-meal, cotton-cake, linseed-cake, or pea-meal. I will take for example a substance which has recently been introduced into England as 'Cleveland Meal,' but which has for some years past been employed in America as 'New Process Oil Meal,' and which is given in the table of analyses as 'Linseed-meal extracted.' It will serve as an example by which a farmer may judge how to employ with advantage any new food, or food new to him. Take, then, 5 lb. of this meal, it will contain the following:—

	Dry Matter.	Digestible. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.
	lb.	lb.	lb.	lb.
5 lb. linseed-meal extracted . .	4.20	1.39	1.73	0.16
Add former part of ration .	18.28	0.90	9.22	0.23
Total . . .	22.48	2.29	10.95	0.39

"It will now be seen that nearly 5 lb. more dry matter is required, of which 4 lb. should be carbohydrates—in fact, a starchy food. Maize-meal stands first as supplying the highest amount of digestible carbohydrates, and we will choose 5 lb. maize-meal, which would contain the following:—

	Dry Matter.	Digestible. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.
	lb.	lb.	lb.	lb.
5 lb. maize-meal.	4.35	0.45	3.36	0.21
Adding these to the above total, we obtain	26.83	2.74	14.31	0.60
Ration required by table . .	27.00	2.50	15.0	0.50

"Such is an example of what may be termed making the best of a bad choice of feeding stuffs, owing to the want of roots and succulent food; and it is an example of how the farmer may make use of science to help him in his difficulties. The ration may not be a good one, looked at from all aspects; but this much is certain, that if so prepared as to be palatable and digestible, it would supply all the requirements of the animal.

"In a similar way to the above examples, it is possible to calculate out the rations for sheep, pigs, or dairy cattle."

Mr Lloyd very properly assumed that those who might attempt to put his directions into practice would meet with difficulties at the outset, and so he intimated that, through the columns of the *Live Stock Journal*, he would be pleased to consider any questions that might be addressed to him on the subject. The result was a plentiful crop of questions, and these, together with Mr Lloyd's replies, were read with much interest by stock-owners. Several of these queries and replies are worthy of space in this work.

Rations for Cows and Young Stock.

Mr James E. Platt, Bruntwood, Cheadle, Cheshire, submitted for Mr Lloyd's opinion the following calculations of food rations for cows and young stock, based upon Mr Lloyd's tables:—

Mr Platt's Ration for Cows in Full Milk.

	Dry Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
	lb.	lb.	lb.	lb.
30 lb. grains	6.66	1.17	3.24	0.24
10 lb. ensilage	2.16	0.22	1.11	0.06
½ lb. linseed	0.42	0.13	0.17	0.01
1 lb. bean-flour	0.82	0.23	0.52	0.01
15 lb. hay	11.92	0.81	6.15	0.15
3 lb. cotton-cake (undecorticated)	2.46	0.52	0.44	0.01
59½ lb.	24.44	3.08	11.63	0.48

Ration for Dry Cows.

	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
50 lb. turnips	6.00	0.65	5.30	0.05
18 lb. oat-straw	14.70	0.25	7.21	0.12
1½ lb. cotton-cake (decorticated)	1.21	0.46	0.27	0.18
69½ lb.	21.91	1.36	12.78	0.35

Ration for Heifers from 6 to 12 months old.

	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
20 lb. turnips	2.40	0.26	2.12	0.02
10 lb. oat-straw	8.17	0.14	4.01	0.07
2 lb. cotton-cake (decorticated)	1.62	0.62	0.36	0.24
32 lb.	12.19	1.02	6.49	0.33

Ration for Heifers from 12 to 18 months old.

	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
35 lb. turnips	4.20	0.45	3.71	0.03
14 lb. oat-straw	11.43	0.19	5.61	0.09
1½ lb. cotton-cake (decorticated)	1.21	0.46	0.27	0.18
50½ lb.	16.84	1.10	9.59	0.30

Ration for Heifers from 18 to 24 months old.

	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
45 lb. turnips	5.40	0.58	4.77	0.04
16 lb. oat-straw	13.07	0.22	6.41	0.11
1 lb. cotton-cake (decorticated)	0.81	0.31	0.18	0.12
62 lb.	19.28	1.11	11.36	0.27

Ration Heavy Milkers are now getting.

	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
30 lb. brewers' grains	6.66	1.17	3.24	0.24
40 lb. swedes	4.80	0.52	4.24	0.04
3½ lb. linseed gruel	3.08	0.50	0.66	1.23
2 lb. bean-flour	1.64	0.46	1.04	0.03
14 lb. hay	11.13	0.75	5.74	0.14
4 lb. cotton-cake (decorticated)	3.24	1.24	0.73	0.49
	30.55	4.64	15.65	2.17

Mr Platt says: "I should feel very much obliged if you would let me know whether you consider the portions and the rations generally will be right to use in my dairy. I keep about forty cows, mostly large Shorthorns, and some Guernseys. The Shorthorns are big, heavy-framed beasts, and when in full milk give very often from 20 to 24 quarts a-day. My cows are exceptionally good ones, every one being a specially heavy milker. To keep the newly calved ones up to such big results requires a large quantity of rations. Therefore, would the ration you lay down for milch cows be sufficient in my case—I mean the proportions of dry matter, albuminoids, carbohydrates, and fat? You will notice I have added at the foot of the list of tables the portions and analysis of what they are now receiving. I am much troubled with cases of abortion, and I consider we have been over-feeding, and have not the food properly apportioned, as the dry matter, albuminoids, carbohydrates, and fat seem ever so much higher than your table. Again, in my proposed table would 10 lb. of ensilage be enough with 30 lb. of brewers' grains?

"I should be much obliged, if not troubling you too much, if you would give me your opinion, and also give me a table for cows about half through their note—say, that have been milking five to six months, and getting on in calf again. They would want, I should think, something between the highest ration and the ration for dry cows, but with the dry matter, albuminoids, carbohydrates, and fat properly apportioned. Feeding dairy cows is a very delicate process, and is not at all understood by bailiffs and head-cowmen."

To these questions Mr Lloyd replied: "The ration given in the table of standards is for a cow weighing 1000 lb. A ration containing 30 lb. of dry matter would therefore be sufficient for a milch cow weighing 1250 lb. Calculations which I have made from the statements of feeding practices prove that this is practically the same amount as Mr Turnbull and other feeders have found necessary. The quality of this ration will best be studied after placing together the quantities required according to the feeding standard and the quantities which were given by Mr Platt.

		Digestible.		
	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
Standard ration for milch cow of 1250 lb.	30.00	3.12	15.62	0.50
Mr Platt's ration	30.55	4.64	15.65	2.17

"There is a great waste here of both albuminoids and fat. The former, in fact, would have to be given to counteract the effect of the other.

"Next, as regards the new ration for cows in full milk. The proportions here are fairly well balanced, provided the linseed is not whole linseed, but "extracted," or Cleveland meal. If whole linseed is referred to, the figures given in the table are inaccurate, and must be corrected according to the analysis given. At present the albuminoids are slightly too high: they might be reduced by giving two-thirds the amount of grains, the quantity suggested being, in my opinion, rather too high, making up the loss with starchy food.

"The rations for heifers err slightly in an opposite direction: they are not sufficiently rich in albuminoids.

"In applying all these tables, it must be remembered that the proportion of food must vary with the weight rather than with the age of the animal, hence, in the table of standards, the approximate weights for which these are calculated are stated.

"It need scarcely be mentioned to a practical man like Mr Platt that there are many points to be considered in feeding besides mere chemical composition. While my paper was an endeavour to draw the attention of farmers to the chemical side of feeding, the practical needs of an animal—bulk, palatability, digestibility, and variety in the food—were not mentioned, as being familiar to my readers, and points upon which they were better able to judge than myself. Whether a ration of turnips, oat-straw, and cotton-cake would meet these demands, I must therefore leave to Mr Platt to decide. Readers of my notes must please to remember that these points, although not mentioned, are not to be overlooked.

"Next, as to a ration for cows whose milk is falling off and which are getting on in calf. The falling off in milk is partly due to the call of the fœtus upon the cow, and hence upon her food. We do not know exactly what this call is, but probably it will be very largely albuminoid, so that these compounds must be well maintained in the ration. The composition of the calf, and the composition of the colostrum, or food naturally prepared for its first demands, both point to this. Therefore it would not seem wise to diminish the food until shortly before calving, when other considerations demand a little restriction. Mr Platt's ration for dry cows may therefore be dispensed with."

Feeding in Sir John Lennard's Dairy.

Writing to the *Live Stock Journal*, Sir John F. Lennard, Bart., Wickham Court, Beckenham, Kent, says: "I shall be very much obliged if you will advise me as to the food I give my cows. I have used it for many years — about twenty. It was my own recipe, and I have never yet found a better. My cows are Guernsey, all the females descended from one cow. I have been much interested in the information lately given by Mr Lloyd on this point; and it occurs to me that I may be wrong, or, at any rate, that an improvement can be made, so as to have the proper proportion of dry matter, &c., &c. I do not sell milk, but butter. I do not use decorticated cotton-cake, as I think it too dear for its value. I may be wrong in this.

"Food for cows in winter when in milk, for one day:—

4 lb. bran.
4 lb. ground oats, beans, or peas.
1 bushel hay-chaff (8 lb.)
½ bushel parsnips pulped (20 lb.)

"Half of the above to be mixed in a large tub, as soon as the mixture previously made has been given to the cows, pressed down, and covered to cause fermentation. Two tubs required. To be given morning and afternoon.

"3 lb. cotton-cake, 1 bushel hay-chaff, mixed and moistened, and given between the two mashes.

"Some oat-straw chaff at night (4 lb. each)."

In reply, Mr Lloyd says: "The above ration would contain the following constituents:—

	Dry Organic Matter.	Digestible. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.
4 lb. bran	3.22	0.50	1.71	0.10
If pea-meal	3.40	0.83	2.21	0.11
4 lb. if bean-meal	3.29	0.92	2.00	0.05
If oats	3.32	0.36	1.73	0.19
16 lb. hay	12.72	0.86	6.56	0.16
20 lb. parsnips	2.20	0.32	2.24	0.04
3 lb. cotton-cake	2.46	0.52	0.44	0.16
4 lb. oat-straw	3.26	0.05	1.60	0.03
51 lb., containing—if witn pea-meal	27.26	3.08	14.76	0.60
If with bean-meal	27.15	3.17	14.55	0.54
If with oats	27.18	2.61	14.28	0.68

"The albuminoid or nutritive ratio of these three rations is—with pea-meal 1 to 5.28, with bean-meal 1 to 5.01, with oats 1 to 6.12. It will be seen at once that the substitution of peas or beans by oats is not good, pea-meal and bean-meal being rich in albuminoids, but not so oats. The cause of the success of this ration is evident. While it supplies ample, probably more than sufficient, dry matter, the constituents are so well balanced as to be, on an average, almost identical with the standard nutritive ratio.

"This further accounts for the fact that decorticated cotton-cake has not proved so beneficial as ordinary cotton-cake, because it would augment constituents which are already present in slight excess, and would not sufficiently augment those which are at present deficient.

"The ration leaves little room for improvement, except that oats must no longer be substituted for peas or beans, though 1 lb. oats and 3 lb. beans might with advantage be substituted for the 4 lb. beans.

"The quantity of dry food is, however, very large, especially for Guernseys; and it would be well to see whether it could be gradually diminished without causing the animals to fall off in their yield of butter. To begin with, for every twenty cows, instead of preparing twenty times these quantities, I would suggest that nineteen times the quantity be prepared. No doubt, a record of the butter, if not of the milk, is kept; and if, after some time, there is no undue falling off in these—that is, no more than the natural decrease resulting from the lapse of time since calving—then the food may be further reduced to eighteen times this ration for twenty cows."

Rations for Small and Large Cows.

A correspondent, signing himself "J. D. L.," asks Mr Lloyd to tell him what quantity of hay, oats, straw, cabbage, *or* silage (meadow-grass) should be used in combination with a "dairy meal" having the following analysis:—

Oils	8 per cent.
Albuminoids	16 "
Carbohydrates	48 "
Dry matter	88 "

in order to make a perfect daily ration for dairy cows—Jerseys and Devons—the object being to produce butter of the finest quality. "A friend of mine," he adds, "is strongly in favour of equal quantities of maize-meal and decorticated cotton-cake, as superior to the same quantity of the meal; but the cowman says the meal is the best. A careful study of Mr Lloyd's tables has brought me to the conclusion that the meal is superior to the mixture in carbohydrates, but is not so good in albuminoids; and which is of the most importance, when butter is the object in view, I don't know. The fats seem to me nearly equal.

"Mr Lloyd's calculations as to the rations of a dairy cow are founded on the supposition that the cow weighs 1000 lb. I shall be greatly obliged if, in your next issue, you will tell me if I should be justified in assuming that a Devon or Jersey cow, weighing, say, 500 lb., could well be kept on half the rations he describes."

"In reply to the first question," says Mr Lloyd, "I must assume that the substances may be given in any quantity that we like. Generally, good results seem to be obtained when the succulent food is double the weight of the hay and straw, and the rest of the ration made up with dry food. Take, then, the following basis for the ration: 7 lb. hay, 7 lb. oat-straw, 28 lb. cabbage. The constituents would be as in the following table, and show that 10 lb. of meal would be necessary to make up the ration in dry matter:—

		Digestible.		
	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
7 lb. hay	05.56	0.38	2.87	0.07
7 lb. oat-straw	05.71	0.10	2.80	0.05
28 lb. cabbage	3.83	0.50	1.47	0.11
10 lb. meal	8.80	1.60	4.80	0.80
	23.90	2.58	11.94	1.03

"This, probably, would be more meal than could be given profitably, so we will increase the quantities of the other ingredients and give less meal. Take the rations of 10 lb. each hay and straw, 30 lb. cabbage, and 5 lb. meal. That would contain:—

		Digestible.		
	Dry Matter.	Albuminoids.	Carbohydrates.	Fat.
10 lb. hay	7.95	0.54	4.10	0.10
10 lb. oat-straw	8.17	0.14	4.01	0.07
30 lb. cabbage	4.11	0.54	2.46	0.12
5 lb. meal	4.40	0.80	2.40	0.40
	24.63	2.02	12.97	0.69

"It will be seen at once that this ration is deficient in albuminoids, hence it follows that, in order to obtain a perfect ration with such a meal, it would be necessary to use a very large quantity of it.

"The question then arises, 'Would equal quantities of maize-meal and decorticated cotton-cake be superior to the same quantity of the meal?' The ration would then contain the following constituents:—

	Dry Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
2½ lb. maize	2.17	0.23	1.68	0.10
2½ lb. decorticated cotton-cake	2.03	0.77	0.46	0.31
Added to hay, straw, and cabbage, giving	24.43	2.22	12.71	0.70

"The maize and decorticated cotton-cake would therefore be superior to the meal, *if ground as fine.* The want of this fine grinding is usually the cause of cakes not giving such good results as they are capable of giving—hence, probably, the cowman's opinion and its justness. It is evident that the ration would be further improved by increasing the quantity of decorticated cotton-cake, so as to bring the albuminoids well up to the standard. The importance of this is pointed out in a former reply to inquiries. Albuminoids make butter.

"Whether the demands of a cow weighing 500 lb. could be met by one-half the quantity of food necessary for a 1000 lb. animal is somewhat difficult to say, and is a subject well worthy of experiment on the part of the admirers of Jerseys, Guernseys, and Kerrys. There are many reasons and statements made which would support the view that one-half this ration would be sufficient. But the subject may be considered from another standpoint. The ration of the milch cow has to satisfy two functions—to sustain the body, and to form milk. These two portions may be divided, as in the following table. To sustain the body of an animal weighing 500 lb., we might rightly assume one-half the sustenance allowance alone to be necessary; but, in addition, we should require the quantity necessary for the supply of milk. Judging from the average production of the animals exhibited at the Dairy Show for the past eight years, this may be taken as one-fifth less than the Shorthorns.

"The following table gives these figures, and compares the rations necessary by the two methods of calculation:—

	Dry Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
Milch cow of 1000 lb.—				
Sustenance ration	17.5	0.7	8.0	0.15
Milk-production ration	6.5	1.8	4.5	0.25
Milch cow of 500 lb.—				
½ sustenance ration	8.75	0.35	4.0	0.075
4-5ths milk production allowance	5.20	1.44	3.6	0.200
Total ration	13.95	1.79	7.6	0.275
If reckoned as half the ration of 1000 lb. animal	12.0	1.25	6.25	0.20

"It would be interesting to see the relative merits of these rations tried by experiment. Personally, I think the richer would give the better results."

The Nutritive Ratio.

Another correspondent asked Mr Lloyd's opinion of the following rations which he was giving to his cows:—

	Dry Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
3 lb. long hay	2.385	0.162	1.230	0.030
50 lb. mangels	5.600	0.550	5.000	0.050
13½ lb. chaff { oat-straw, 6¾ lb.	5.514	0.094	2.706	0.047
13½ lb. chaff { hay, 6¾ lb.	5.366	0.364	2.767	0.067
3 lb. ground oats	2.571	0.270	1.299	0.141
3½ lb. decorticated cotton-cake	2.842	1.085	0.640	0.430
Proposed ration	24.278	2.525	13.642	0.765
Model ration	24.000	2.500	12.500	0.400

Mr Lloyd replies: "Upon looking at the figures of this ration, one would think that the apparently slight difference between the proposed ration and the standard would have little effect. But the object of a feeding standard is to fix the relation of the albuminoids to the carbohydrates and fat quite as much as to give the absolute quantities required. The correct relation of the albuminoids to the carbohydrates, &c., is 1 to 5.4. This relation exists in the standard. Fat is considered to have two and a half times the value of carbohydrate. By multiplying the 0.4 of fat by two and a half, we obtain 1.0 as its equivalent. Adding this to the 12.5 of carbohydrates makes 13.5 in all, which, divided by the albuminoids, shows that for one part of albuminoid there are 5.4 parts of carbohydrates.

"If we perform the same calculation with the ration quoted, the proportion of albuminoids to carbohydrates is found to be 1 to 6.1. Hence the proposed ration does not meet the requirements of the standard—it does not possess the correct "nutritive ratio." In order to make it do so, we must increase the quantity of albuminoids and simultaneously reduce the carbohydrates. A near approach to the standard would be obtained by taking 5 lb. decorticated cotton-cake instead of the 3½, and by entirely leaving out the ground oats. This would give a ration containing—

		Digestible.		
	Dry Organic Matter.	Albuminoids.	Carbohydrates.	Fat.
5 lb. decorticated cotton-cake . .	4.060	1.55	0.915	0.618
Total ration	22.92	2.72	12.418	0.809

which possesses a ratio of 1 to 5.3.

"When a ration shows a deficiency of dry matter and excess of digestible compounds it is evidence of a deficiency of the poor bulky foods. This ration would allow more oat-straw to be used."

The Nutritive Ratio the Essential Point.

Another correspondent, "M. R. M.," asked if Mr Lloyd would "kindly say if in mixing a food ration the proportion given in the standard must be strictly followed; or supposing a ration to show 1 per cent of fat instead of 0.40, would it be considered properly balanced if the carbohydrates were reduced by 1.50—that is, two and a half times as much as the fat is increased? Thus:—

Dry Matter.	Albuminoids.	Carbohydrates.	Fat.	Nutritive Ratio.
24.0	2.5	11.0	1.0	1 to 5.4

The nutritive ratio is preserved here, and I infer this is the essential point.

"I ask this because, with my present stock of roots, hay, and straw, I have not been able to compile a ration with so little fat as 0.40.

"I can only allow 10 lb. swedes, 12 lb. hay, and 10 lb. of oat-straw; to this I add 5 lb. of mixed oat-shellings and oat-dust, which I take as equal to oat-straw, although I do not know the analysis.

"I must explain I take the weight as 1250 lb. not 1000 lb., my cows being large.

"Taking this as a basis, what would Mr Lloyd recommend to make up the ration?

"May I further ask if an excess of any constituent, say of fat, in a ration is simply wasted, or will not the cow thereby either fatten herself or produce richer milk? From the reply to Mr Platt, Mr Lloyd seems to say that all excess is not only waste, but requires other excess and waste to counteract it. Will he kindly explain this?"

Mr Lloyd replies: "M. R. M. is quite right in the view he takes as to the method of correcting an excess of fat by diminishing the carbohydrates, and the standard he gives would satisfy the requirements of the nutritive ratio, which is of primary importance. [For a full reply to this last question see Mr Lloyd's article on the "Value of Fat as a Food Constituent," given in this work.] Excess of fat is wasted, so far as milk production is concerned; it may, however, tend to fatten the animal. In replying to Mr Platt, I was considering simply the question of milk production. To make excess of fat useful would necessitate the albuminoids being raised. By this means more food would be given than was necessary, and hence waste. I trust these replies will make my former answers clear.

"Now, to build up a ration, taking as the basis the foods mentioned. These will contain the following:—

	Dry Organic Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
10 lb. swedes	1.20	0.13	1.06	0.01
12 lb. hay	9.54	0.64	4.92	0.01
10 lb. oat-straw	8.17	0.14	4.01	0.07
5 lb. oat-shells and dust,[1] say	4.08	0.07	2.00	0.03
	22.99	0.98	11.99	0.12
Ration required	30.00	3.12	15.62	0.50
Still required	7.01	2.14	3.63	0.38

[1] I cannot state the exact composition; the shells are very similar to straw, the dust probably richer.

"Thus the difference must be made up of a meal containing 3½ parts of carbohydrates to 2 of albuminoids, and 2 parts of albuminoids in 7 of dry matter, which represents over 20 per cent of albuminoids—consequently there are very few substances available. Bean-meal and pea-meal would contain too much carbohydrates, about 5 to 2. Linseed and cotton-cake too little, only 2 to 2. A mixture of both would neutralise this. Try 4 lb. pea-meal and 4 lb. decorticated cotton-cake. These would contain the following:—

	Dry Organic Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
4 lb. pea-meal	3.40	0.83	2.21	0.11
4 lb. decorticated cotton-cake	3.24	1.24	0.73	0.49
Make up with ½ lb. maize	0.43	0.05	0.33	0.02
Supplying	7.07	2.12	3.27	0.62
Added to former ration makes	30.06	3.10	15.26	0.74
	Fat equivalent		1.85	
		3.1)	17.11(1 to 5.5 ratio.	
			15.5	
			16.1	

"These substances were the first I tried; it would be possible to get nearer the standard by a little further alteration."

Rations for Horses.

The chairman of a colliery company, employing 72 horses for pit purposes, asked if Mr Lloyd could suggest a more economical feeding ration for these horses than they were now using, which for strong thick horses of 14.2 hands high cost about 14s. per horse per week, or for the 72 horses £2600 a-year. He adds: "I am told, at the pit, that the daily feed given to each horse is as follows:—21 lb. meadow-hay, 13 lb. oats, and 5 lb. beans; the oats and beans being crushed, and the hay chaffed. The horses are worked very hard underground, and our loss by deaths, owing to colic and other ailments, brought about by the unnatural conditions under which the horses work, amounts to about £800 per annum."

In reply Mr Lloyd says: "There are many difficulties to be met when the feeding rations of horses come to be considered. With horses at work in the open, the chief difficulty lies in counteracting the constant fluctuations of temperature; and a ration which to-day, it being warm and dry, may be all-sufficient, will to-morrow, if it be cold and wet, prove quite inefficient. There is, therefore, always a certain amount of loss or want in a fixed ration for horses working out of doors. The temperature of a colliery will presumably be less liable to fluctuation, and on an average warmer. Hence there will be a smaller quantity of the heat-producing elements required. On the other hand, the work is excessive, and the muscular exertion being great, the proportion of albuminoids or flesh-formers must be high, and it must be accompanied by a high proportion of oil, for it has been shown that oil has the remarkable power of diminishing muscular waste, and it is supposed that on this account the oat, being of cereals the richest in oil, has been found so beneficial for horses. Thus a food will be required peculiarly rich in albuminoids.

"There is another and important consideration. The digestion of albuminoids takes place primarily in the stomach, and what escapes the stomach undergoes digestion in the intestine. It appears to me that with all animals a food rich in albuminoids tends to produce colic when those albuminoids are difficult of digestion and the main part fails to be digested in the stomach. For example, peas and beans are usually considered more liable to produce colic than barley or oats. And again, when animals are changed to a feed of rich clover there is, I believe, a tendency to disarrangement of the digestive organs. This view would further explain the statements made by practical men that cooking the food of horses renders them less liable to colic, for by so doing the food becomes softer, and is more easily acted upon by the gastric juice. The food of heavily worked horses should, therefore, be easy of digestion.

"Having cleared the way with general principles, I will next pass to the consideration of the chemical aspects thereof. From experiments hitherto made, the following standard was drawn up for horses heavily worked:—

	Dry Organic Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
Per 100 lb. live weight . .	25.5	2.8	13.4	0.8

This would have a nutritive ratio of 1 to 5.5.

"The colliery horses would probably require less carbohydrates and more albuminoids, with food not more bulky than the above, say—

Dry Organic Matter.	Albuminoids.	Carbohydrates.	Fat.
25.0	3.0	13.0	0.8

This would have a ratio of 1 to 5.

"The food now being given would contain approximately:—

	Dry Organic Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
20 lb. hay	15.90	1.08	8.20	0.20
13 lb. oats	10.79	1.56	7.24	0.78
5 lb. beans	4.12	1.15	2.51	0.07
	30.81	3.79	17.95	1.05
Standard for horse of 1200 lb. .	30.0	3.6	15.6	0.96

"The nutritive ratio of the present ration is 1 to 5.4. Unless the animals weigh 1200 lb., it would appear that they are receiving too much food, and in that case the excess of food is consumed to get at the albumen they need. The ratio is probably too wide.

"I would suggest that an experiment be first made with some of the horses, giving them the following ration, and the results carefully watched, to determine the quantity they eat and its effect:—

	Dry Organic Matter.	Digestible. Albuminoids.	Carbohydrates.	Fat.
15 lb. hay	11.93	0.81	6.15	0.15
10 lb. oats	8.30	1.20	5.57	0.60
4 lb. beans	3.29	0.92	2.01	0.06
2 lb. Cleveland meal . . .	1.68	0.55	0.69	0.06
	25.20	3.48	14.42	0.87

"The nutritive ratio of this ration is 1 to 4.8. It would supply very nearly as much albumen as the present ration, and would probably be more easily digested."

A Word of Caution.

As would be expected, a good deal of scepticism has been expressed as to the soundness of these precise directions submitted by Mr Lloyd for the mixing of feeding rations. Mr Lloyd himself has explained clearly that the "standards" he has given are merely guides, and not to be regarded as "hard and fast limits." It is well that all new teaching should be received with caution, and carefully tested in the light of practice. It may therefore be useful to give here the following extracts from a letter addressed by "A Scottish Farmer" to the *Agricultural Gazette* of April 30, 1888:—

"The article upon Feeding Rations, in your issue of the 16th inst., suggests the question whether there is yet a sufficient basis for principle—represented in this case by Mr Lloyd—dictating in such a very exact way to practice. The chemistry of manures has suffered much at the hands of its friends, and it would be a pity if the science of feeding, from which much may be expected in the future, were as much dragged by the premature theories of its professors. Experience of feeding 70 to 90 bullocks for the butcher yearly has taught me that the judgment of practical feeders, as shown by the market price, is a better index of the relative feeding values of different concentrated foods, such as linseed-cake, rape-cake, and cotton-cake, than the ordinary chemical analyses made at present, though of course the latter have their value in detecting adulteration. Moreover, I know practical men whose master-eye can fatten their cattle more quickly than I can, though my rations are probably nearer those indicated by scientific data.

"It would certainly be a great gain if experienced feeders were so far educated as to enable them to see how far science and practice agree, for when they became interested in the subject they could lend the most valuable help in advancing the science by explaining the cause of seeming discrepancies. They would become wise by learning not their own ignorance only, but also the many points about which science is at present ignorant in this matter.

A Disturbing Element.—"Roughly speaking, the cause of the difficulty in getting sufficient reliable data on this subject is that success depends more upon knowledge of the peculiarities of the individual animal than upon a unit or two of difference in the albuminoid ratio. It is all very well to arrange the food scientifically, but every practical feeder knows that fattening oxen often stick up on their food—as they say here—and you have got to change it for a little, and study the appetite and digestive powers of each, and the state of their bowels, &c. If the scientific farmer is fortunate enough to get a really good cattle-man, who is interested in the animals, and manages to keep their appetite always fresh, he will find it wiser not to force such a man to use scientific rations weighed out to a pound for each beast daily. This is especially true in these days of pleuro, when one cannot always get a great choice of store cattle, and has sometimes to take those that have been hungered in their youth, and whose digestion ever after needs a deal of pampering.

"Many scientific reasons may be given to show that it is not wise to base hard and fast rules on the German data. . . . In the meantime I do not know that any more scientific advice about feeding should be given to the farmer than this—Check your judgment and test your success by weighing your cattle as stores, and occasionally after, though of course not so frequently as to seriously disturb them."

VALUE OF FAT AS A FOOD CONSTITUENT.

This important point was discussed by Mr F. J. Lloyd in a paper contributed to the *Journal of the British Dairy Farmers' Association* (vol. iv., part i., 1888). It is now generally understood that the three functions of food are—(1) to maintain the heat of the animal body; (2) to maintain or build up the flesh; and (3) to produce fat. The question which Mr

Lloyd has set himself to consider is—"Out of what portion of the food and in what manner is this fat produced?"

Formerly it was generally assumed that the fat present in the food went directly to build up fat in the body. Recent scientific research, however, has driven physiologists to the conclusion that that is not the case, but that the fat in the food is entirely broken up and the fat of the animal formed anew—in other words, as expressed by Mr Lloyd, "that the fat formed in the animal body is formed by decomposition of the protoplasm or living nitrogenous matter of the animal; and that fat taken as food is not converted directly into fat, but, like other portions of food, is taken into the blood and supplies nutriment to the living protoplasm."

Fat in Foods.—Explaining the circumstances which give this subject its special importance at this time, Mr Lloyd says: "The amount of fat present in the ordinary crops of the farm raised for feeding purposes is exceedingly small: it is only in those bye-products which have to be bought by the farmer, such as linseed and cotton cakes, that oil exists in large quantities. These cakes are, however, made by those whose chief object is to extract the oil, and consequently of recent years, what with improved machinery and experience gained, the amount of oil which has been left in these bye-products has been gradually diminishing. By a new process—rapidly extending in America, and not unlikely to render in course of time the linseed-cake obsolete—oil is now being extracted with chemicals from the ground seed or meal, without pressure, leaving an extracted meal, instead of, as formerly, a hard-pressed cake. Hence it behoves the farmer to ask at once, Was it the oil contained in these cakes that made them valuable? and to what extent, if any, are they depreciated by this diminished proportion of oil?

"Had the old notion that oil in the cake went direct to form fat in the animal been true, undoubtedly these cakes, when rich in oil, would have possessed great value. But we have seen that this does not take place. What is more remarkable is the fact now proved, that the direct reverse is what happens.

Oily Food Decreasing Milk.—"Experiments have shown that by increasing the fat in an animal's food the fat in the milk is decreased; and the explanation of this has been found in the fact that fat retards and does not facilitate that decomposition of protoplasm which results in the production of fat. To the dairy-farmer and to the fattener of live stock this fact is of immense importance, and proves that large quantities of oil in the food are objectionable; hence, instead of being a constituent which materially enhances the value of linseed or cotton cake, it may be deemed, for their purposes, of secondary importance.

Oil Valuable for Sheep.—"But if oil has this remarkable power of preventing a waste of the nitrogenous constituents of the body, it is evident that for animals like sheep, which have to wander far to get off scanty herbage their necessary food, any artificial food which contained oil would be likely to prove of greater advantage than one deficient in oil.

Source of Fat.—"Then, what constituent in the food is it which contributes to this formation of fat in the animal body? This must depend partly upon whether the fat so formed is stored up, or whether it constitutes milk, and for this reason, in the former case there seems to be less nitrogenous waste than in the latter. In milk we all know how large is the quantity of nitrogenous matter (casein) which is secreted simultaneously with the fat. But in the building up of fat in the body, it would seem that less nitrogenous waste takes place. It has been so frequently pointed out to farmers how the food contains, and must contain, nitrogenous matter to build up the nitrogenous constituents of the body, that they will readily realise the necessity of supplying large quantities of this nitrogenous matter where the waste is large, as in the formation of milk. And the well-known properties of bean-meal and pea-meal to increase the flow of milk, and to augment the fat in that milk, it is now easy to understand, seeing that these substances are among the richest in nitrogenous constituents, and so eminently adapted to meet that nitrogenous change which produces milk.

"But, in the fattening of the pig,

while the protoplasm of the body is producing fat there seems to be little destruction of nitrogenous matter, and hence it is possible to satisfy the wants of this protoplasm by merely supplying those elements which are being thrown off as fat. These elements are, in the language of the chemist, carbon, hydrogen, and oxygen, and there can be no doubt that we might supply them to the protoplasm by feeding animals on oil. But fortunately they can be supplied at far less cost, and with equal efficacy, either as starch or sugar, both of which also contain carbon, hydrogen, and oxygen; and hence it is that starch and sugar are the chief constituents of those foods which have from time immemorial been known to produce fat.

Value of Oil in Food.—"If, then, the conclusions that we have arrived at are correct, that oil in the food does not produce fat in the animal directly, while this fat can be equally well produced from starch and sugar, what is the value of this oil? Every substance which is absorbed into the blood becomes, sooner or later, oxidised, and by that oxidation produces heat; hence it is that the heat of the body is maintained. Owing to a larger quantity of carbon and hydrogen in fat requiring oxidation than there is in starch or sugar, the heat that one pound of fat will produce is more than two and a half times as great as the heat produced by one pound of sugar; and so fat may be said to have two and a half times the value of sugar.

"Again, nitrogenous matter also contains carbon, which, by its oxidation, gives rise to heat in the animal body. Having performed its chief function of supplying nitrogen, there will then be a quantity of carbon still unused and capable of being oxidised. This quantity has been calculated, and it is found that the residual carbon in 2.5 grams of nitrogenous matter would generate by its oxidation about as much heat as 1 gram of fat. Further, it is highly probable that this residual carbon is the very portion of its food out of which the protoplasm forms fat.

Albuminoids compensating for Want of Oil.—"But that I shall not discuss here, suffice it that for our purpose we may safely estimate that every 2.5 grams of albuminoids can replace 1 gram of fat; or in other words, that in two cakes, one rich in oil and the other poor in oil—one, say, containing 10 per cent, and the other 4 per cent—the difference in the amount of oil would be amply compensated by the latter containing 15 per cent more albuminoids—that is, two and a half times as much as the deficiency of oil. But this excess of albuminoids would more than amply compensate for the deficiency in oil: it would add to the value of the cake by that portion of the nitrogenous matter not so utilised. Where we have linseed-cakes poor in oil, it will be invariably found that they are richer comparatively in nitrogenous matter, hence the albuminoids will, to a certain extent, compensate for the loss of oil.

Value of Fat per Unit.—"We have thus seen that 2.5 grams of carbohydrates, and 2.5 grams of albuminoids, are each equally capable of replacing 1 gram of fat; and probably the true value of fat as a constituent of the food of animals will lie between these extremes. In an article written some years ago, I came to the conclusion that a fair price for the constituents of feeding-stuffs was 1s. per unit for carbohydrates, and 2s. per unit for albuminoids; and I then estimated the fat as worth 2s. per unit. I am now inclined to think this was a little below its real value, and that 2s. 6d. might with advantage be taken as a more correct standard.

Oil and Milk-production.—"After carefully studying the facts stated above, I do not think the dairy-farmer will in any way fear the diminishing amount of oil found in linseed-cakes. That it is not essential to milk-production may be considered as proved in theory; and the remarkable results which have been obtained by the use of Cleveland meal—that is, linseed-meal from which the oil has been extracted chemically—show that practical results confirm that view. Several of the prize-winners at the recent milking trials at the show of the British Dairy Farmers' Association had been partly fed upon this meal, and the owners of the cows so fed have one and all certified to the improvement in both the quality and the quantity of the resulting milk-supply.

Oil and Beef-production.—"With, however, fattening animals, such results would not be obtained without the addition of large quantities of carbohydrates. For, if too large a proportion of albuminoids be given to fat animals, it will result in a loss and not in a further gain of fat.

Practical Conclusions as to Oily Food.—"The practical conclusions to be derived from this study are many and important, and some will be evident to those engaged in the feeding of dairy stock. They will see that the desire, which so many have, for cakes rich in oil is one which they can afford to dispense with; that the feeding with linseed-meal —whole meal I refer to—is a mistake; and that equally good results would attend the use of the same meal after the oil had been extracted. And it would have a further benefit: it would admit of a certain amount of the inferior corn produced on the farm and not saleable, being used with advantage as food in the place of this oil. While, lastly, I would especially urge the attention of those who consider it advantageous to buy oil and mix with the food to the facts contained in this paper, for I cannot believe that one tithe the money so spent is ever recovered."

ENSILAGE.

The preservation of food for live stock being the sole aim and end of Ensilage, a description of this excellent modern development may appropriately enough be presented here. The feeding merits of *silage*, which is the product of the process of *ensilage*—the food preserved by the system—will be more easily estimated when the theory and practice of ensilage are clearly understood. And before proceeding to describe the different methods of feeding cattle in winter, it is desirable to learn all that is worthy of being learned about all the kinds of food in use.

Ensilage is an entirely new branch of farm practice, its development in the United Kingdom dating from 1882. In a sentence, it may be defined as the preservation of green food by the exclusion of air. In a modified sense the practice is an ancient one.

History of Ensilage.—From time immemorial the storage of grain in underground pits for preservation has been practised in Eastern countries. Pliny speaks approvingly of this method as being adopted, in his time, in Thrace, Cappadocia, Barbary, and Spain. Varro indorsed his opinion of its merits, and asserted that wheat could be thus kept sweet and entire for fifty years, and millet for a century. The main object, especially among nomadic tribes, was to prevent marauders or victorious enemies from obtaining their stores of food.

In later days the practice was adopted—in Spain for example—for commercial reasons, as by its means the surplus in years of plenty and low prices could be kept for disposal in times of scarcity and high prices. In Mr H. M. Jenkins's valuable article in the *Royal Agricultural Society's Journal* (xx., second series, 1884) on "The Practice of Ensilage at Home and Abroad," some interesting details are given of the adoption of the system for the preservation of grain in France.

It appears to have been in Germany that the system of ensilage was first applied to the preservation of fodder crops, as distinguished from grain. So far back as 1843, Professor Johnston gave a detailed description of the German system of making "sour hay," in an article in the *Transactions of the Highland and Agricultural Society;* and extracts from the article were given in two former editions of *The Book of the Farm.*

In 1874, Professor Wrightson in his "Report on the Agriculture of Austro-Hungarian Empire," published in the *Royal Agricultural Society's Journal,* remarked that "the system of making 'sour hay' is also well worth the attention of English agriculturists. It is done by digging graves or trenches, 4 feet by 6 or 8 feet in depth and breadth, and cramming the green grass or green Indian corn tightly down into them, covering the whole up with a foot of earth. The preservation is complete, and the wetter the fodder goes together the better. . . . This sour hay affords a capital winter fodder, and when cut out with hay spades it is found to be rich brown in colour, and very palatable to stock." Herr Reihlen, of Stuttgart, was one of the earliest advocates of this method, in letters published by him in 1862 and 1865. These were translated and communicated to the *Journal d'Agriculture Pratique* of France, by M. Vilmorin-Andrieux, in 1870.

To M. Goffart, however, unquestionably belongs the honour of first directing general attention to the subject. This he did by his book, *Manuel de la Culture et de l'Ensilage des Maïs et autres fourrages verts*, published in 1877. The translation and publication of this work in New York, in 1879, moved American farmers—who had, however, somewhat earlier given attention to the subject—to vigorous adoption of the system. Several accounts of their successful endeavours crossed the Atlantic, and served to awaken some interest among British agriculturists in the subject.

Introduction into Great Britain.—But it was from France that the first real impulse came in 1882—although before then several stray silos had been tentatively erected by experimenters in various parts of the country. At the Reading show, in that year, Vicomte Arthur de Chezelles—one of the largest and most prominent practitioners in France — was present, and by his description aroused the curiosity and interest of those with whom he came in contact. In particular, Mr Kains-Jackson was impelled by his accounts to accept his invitation to see for himself what he was doing. In the autumn of that year the result of his investigations appeared in the columns of the *Field* and the *Times*, and at once attracted widespread interest. Mr Kains-Jackson brought back with him—after some difficulties with the Custom-house authorities, who impounded the novel product on suspicion of its being some kind of tobacco—samples of ensilage, and from that time the growth of the system in this country dates.

Since that period its progress has been astonishingly rapid, and its development in various directions altogether unexpected. In 1884 the Royal Agricultural Society took up the subject in its journal, by the article above referred to, and the Bath and West of England Society carried out some interesting demonstrations in connection with their Maidstone show.

Progress of Ensilage.—In 1883 the Ensilage Commission — a private but highly influential body, whose labours were indorsed by the Government, and embodied in official Blue-books—sat and collected a mass of invaluable evidence. The Agricultural Returns first included ensilage in their survey in 1884, and enumerated 610 silos as being in existence in Great Britain. The progress of the movement is shown most concisely and vividly by the figures for the following years. In 1885 there were 1183 silos; in 1886, 1605; and in 1887, 2694. In the last-named year there were also recorded 1362 "persons proposing to make ensilage in stacks," to which further reference will be made.

Silos.

A silo was originally a pit—the word being derived from the Greek σῖρος—which, according to Liddell and Scott, is "a pit or hole sunk in the ground for keeping corn in." The word came to us through the Spanish and French, in which languages the *r* was naturally changed to *l*. Very soon, in practice, "a pit or hole" was found to be adaptable only to special soils and situations, and a large variety of receptacles for ensilage, both below and above ground, have been constructed, which have very widely extended the original term silo.

It would be impossible even to enumerate the different descriptions of silos which have been adopted. From the most elaborately designed and expensively constructed buildings to the simplest and cheapest "converted" structure, the variety of methods adopted has been remarkable. Some idea of their diversity may be gathered from the fact that the cost per ton capacity has ranged from 8s. up to 30s. or 40s., and even 50s.

Converted Silos.—In many cases old ice-houses or barns have been converted into silos at a comparatively trifling expense. One or two instances may be mentioned. Mr W. J. Harris of Haliwell, Devon, made a silo out of a disused manure-shed. It was 35 feet long, 18 feet wide, and 10½ feet deep, with a capacity of 130 tons. The work was substantially done, a good slate roof was added, and the cost was £110, or nearly 17s. per ton. On the Marquess of Bute's home farm a silo, 18 feet long, 6 feet wide, and 8 feet deep, was formed in part of a barn, by running a brick partition across, and cementing the floor and walls. The cost was £10, 16s., and the capacity 17 tons, or about 12s. per ton. Lord Egerton of Tatton converted an old ice-house in his park into a silo (fig. 119). The walls on the inside were plastered with cement, the original entrance being blocked up, and a new entrance made at the top. The size was—diameter, 11 feet 6 inches; height to square, 12 feet 6 inches; area, 104 square feet. A section of this silo is represented in fig. 119, which, by kind permission, we produce from the *Journal of the Royal Agricultural Society of England* (second series, xx. 175). Mrs W. P. Paige, of Ongar,

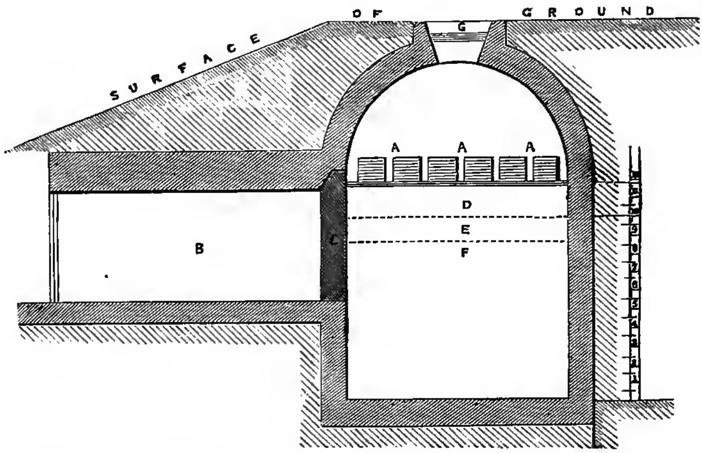


Fig. 119.—*Section of Lord Egerton's silo, showing its condition at the end of the third day's work.*

A A A Boxes filled with bricks.
B Archway from the side of the bank, by which the silo is emptied.
C New brickwork.
D Height at which silo was weighted and settled; condition of grass, juicy and damp with dew.
E Section of grass quite dry and top grass dead.
F Height to which grass put in on 4th and 5th July had sunk to when opened on July 27.
G Man-hole used for filling.

adapted an old straw-barn at an expenditure of only 10s., which was for the construction of a door in one of the gable-ends, the old door being boarded up.

New Silos.—Of the variety of specially constructed silos there is no end. In many instances the first silo erected was intended merely for experiment, and it is scarcely fair to consider such structures and their cost in a practical account of the system. The judges in the silo and silage-stack competition, instituted by the Royal Agricultural Society in the winter of 1885-86, found that the average cost per 50 cubic feet of six new silos inspected by them was 18s. 6d. It may be mentioned that 50 cubic feet is commonly calculated as equivalent to 1 ton of silage capacity. The judges reported that "with skilful and efficient management" the cost for building a moderately large silo ought not to be more than 10s. per cubic foot of capacity.

Silos, Above or Below Ground?—The first question in making a silo is obviously whether it shall be dug out or erected. Sunk silos are in many respects preferable, but the cost of excavation has to be considered. Work of this kind may be said to have a fixed rate of cost in proportion to size, because, for a pit of 10 cubic yards of capacity, it is necessary to dig out 10 cubic yards of soil; and if it be wished to make it two, three, or ten times larger, there is two, three, or ten times the amount of work to be done.

On the other hand, with a building the cost is proportionately decreased according to the size. If, for instance, the length of each wall be doubled, the capacity is quadrupled, while the cost is, of course, only twice as much. It must be borne in mind that with sunk silos it is almost invariably necessary to line them with masonry or concrete. Many instances are recorded—notably in America—where the simple "hole in the ground" silo has been found practicable and profitable; but for the success of this special conditions of soil and situation are required, which are very seldom found in this country.

From returns collected by the Agricultural Department of the Privy Council in 1885, giving details from persons possessing silos in Great Britain, it was found that 420 silos were entirely above ground, 450 partly below, and 100 altogether beneath the surface.

M. Goffart's Silo.—The plan of a silo to which Lord Walsingham's £10 prize at the Norfolk Agricultural Show in 1885 was awarded, was after the model recommended by M. Goffart—viz., with straight sides and semicircular ends, the total length in clear being 32 feet, the width 9 feet, and the depth 10½ feet.

Mr T. Potter, in his admirable book on the *Construction of Silos*, remarks, that to construct a silo of this description would require 76 lineal feet of walling, and contain 270 cubic feet for every foot in depth; whereas the same amount of walling would build a square silo containing 333 cubic feet for every foot in depth, or a gain of about 23 per cent in capacity. In fact, there seems to be no advantage in rounding the ends of the silo, in spite of M. Goffart's high authority for the design.

Mr Potter sums up a consideration of the subject from an expert point of view thus: "For all practical purposes therefore, the site of silos, their depth in the ground, their height above ground, their length and width and general contour, whether elliptical, circular, or rectangular, is a matter of convenience and local circumstances; but if the cost is to be the main point, and simplicity of construction the second, then a square silo, or group of silos, whose boundary-line forms a square, and the individual silos contained therein are also square, is undoubtedly the best."

Hillside Silos.—A very favourite form of silo is one constructed against a hillside, so that it can be both filled and emptied on the level. One of the earliest and best of this kind was that of Mr H. A. Brassey, which was utilised during the Maidstone Show of the Bath and West of England Society and Southern Counties Association in 1884, for a series of interesting operations, which were, in fact, the first in connection with any agricultural exhibition in this country. The silo was thus described by Mr R. H. Rew, assistant-secretary of the Ensilage Society, in the *Journal of the Bath and West of England Society:* "Taking advantage of a slope in the ground, the earth was banked up on the upper side, and a roadway cut on the lower side, so that while the top of the silo was flush with the land, the bottom was also accessible to carts upon the level. The silo was subdivided into six equal compartments, three on each side of a central passage. All the walls, both external and internal, as well as the floor, were substantially built of concrete, and the silo formed a permanent erection of the most durable kind. . . . Each of the six compartments had an area of 12 feet × 10 feet. The uniform depth throughout was 10 feet 6 inches. Two rolling roofs of corrugated iron were placed on rails running from side to side. Each of these covered three silos. Subsequently, however, a third roof was added for the passage, and the rails were altered to run from end to end. Each of the compartments had a doorway about 2 feet 6 inches × 6 feet, giving access for convenience of cutting out the ensilage. These, of course, were bricked up before filling. The capacity of each of the compartments—adopting 50 cubic feet to the ton as the standard of computation—would be theoretically about 24 tons, or a total capacity of something like 220 tons for the whole silo, including the central passage."

The cost of this structure was considerable, being as follows: silo, £135, 9s. 6d.; weighting, £57, 6s. 6d.; roof, £200; total, £392, 16s., or about 35s. per ton of capacity. The silo was, however, put up without special regard to cost, being intended in the first instance for experimental purposes. Some four or five different methods of pressure were also tried, and this, of course, added to the outlay.

Chezelles Silo.—One of the most famous silos is that of Vicomte Arthur de Chezelles at Boulleaume, Chaumont-en-Vexin (Oise), France (fig. 120). It is 206 feet long by 21½ feet wide, and 15 feet deep, being, it is said, the largest in the world. It is entirely below the level of the ground, and is contructed of masonry, covered with a coating of cement. The walls are about 2¾ feet thick at the bottom, and about

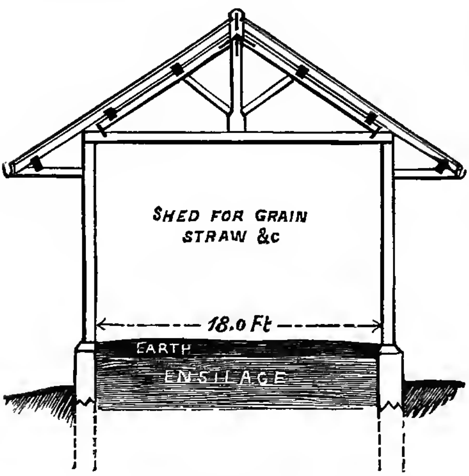


Fig. 120.—*Transverse section of M. de Chezelles's "Grange Silo."*[1]

1½ foot at the top. The Vicomte commenced with an uncovered silo, and succeeded very well by covering the top with a mass of straw. He soon "recognised the necessity" of sheltering this same straw under a roof, and by this means to make a large shed where he could place his wheat and oats instead of stacking them. The silo cost £160, and the covering £240: total, £400.

In 1882 the produce of 170 acres of trifolium, sainfoin, lucerne, tares, and artificial grasses was ensiled in this silo.

Concrete Silo.—In 1882 a silo was erected on the estate of Lord Ashburton at Alresford, on a very convenient plan. A very eligible situation was found on a spot where two roads ran parallel with each other, with just a suitable distance between to give ample room to build a silo, one road being level with the adjoining farm-buildings, and the other an ascent to higher ground. A silo with three compartments, and a total capacity of about 96 tons, was substantially built of concrete, with corrugated iron roof, at a cost of £113.

Bentall's Silo.—Of above-ground silos that of Messrs E. & H. Bentall is a notable type. It is a rectangular building, 25 feet in height, divided by a party-wall into two equal chambers 11 feet square, each chamber being capable of containing 50 tons of silage. An opening 2 feet 6 inches in width, which commences 5 feet from the ground, and continues to the top of the silo, is left in the middle of the front wall in each chamber. Through these openings the silo is filled and emptied. A crane which swings between the two openings, and a winch standing on the ground directly beneath it, constitute the necessary appliances for filling, emptying, and weighting the silo. Dead weight in the form of basketfuls of pebbles supply the pressure.

Silo with Lever-pressure.—Mr C. G. Johnson erected in 1883 a silo with special lever-pressure. It was built of brick, with slated roof. It was 18 feet long, 10 feet wide, and 28 feet high up to the eaves, but 6 feet of this height was left for working the machinery, so that the total capacity, at 50 cubic feet to the ton, would be about 80 tons. But Mr Johnson's silage weighed very much more than usual, as it reached 60 lb. per cubic foot; and at this rate, if the whole space were occupied, fully 100 tons could be put in. The total cost of the silo and apparatus was about £150, of which £65 was for masonry, £40 for pressing apparatus, and the remainder for roof, &c.; but Mr Johnson was his own engineer, and the cost would have been higher had a professional man been employed to superintend the work. Deducting £40 for pressing apparatus, the cost, at the same rate as in other cases, would be about 22s. per ton.

Concrete Slab Silo.—Among special forms of silos, those made of portable concrete slabs have been a good deal used. Mr A. M. Cardwell gave in *The Field* the following estimate, based on his own experience, of the total cost of a concrete slab silo, 24 feet long, 12 feet wide, and 12 feet deep, including roof, bricks for weighting, &c.: silo, £25;

[1] *Jour. Royal Agric. Soc. Eng.*, xx., sec. ser., 208.

fixing, £1; concrete floor, £2; carriage, £2; bricks for weighting, £10; roof, £10—total cost, £50.

Wooden Silos.—Wooden silos have also been a good deal recommended since it was discovered that lateral pressure was practically non-existent in making silage. Messrs F. W. Reynolds & Co. in particular brought out a serviceable form of this kind of silo, being of a circular shape, and the planks jointed so as to exclude the air.

Methods of Pressure.

The methods of obtaining pressure in silos are as varied and numerous as the forms of the silos themselves. Dead weights—earth, stones, bricks, iron, &c.—were the elementary form, and are still largely used. The labour of putting on and taking off the weight is, however, obviously great, and this led to the introduction of mechanical appliances.

Mechanical Pressure.—Space would fail to give an adequate idea of the many ingenious mechanical contrivances which have been adopted for pressing silage. Jacks, screw and hydraulic, have formed one of the favourite modes of obtaining pressure. In the silo of Mr John Morris, which won the prize in the silo competition of the Royal Agricultural Society of England, for instance, a screw-jack was used.

Potter's Patent.—The first application of mechanical pressure for which a claim for patent rights was made, was by Mr T. Potter, who introduced the use of a hydraulic jack. A pair or more of loose transverse beams being placed across the "covering boards" on the top of the silage, the jack was applied at each end of each beam by inserting the foot into successive notches in iron uprights fitted to the wall of the silo for the purpose.

Reynolds's Patent.—One of the earliest patents taken out was that of Messrs F. W. Reynolds & Co., which has come into extended use. This consists of pairs of chains, each imbedded in the floor of the silo, and meeting over the transverse beams, where they are drawn together by means of a screw-tightener.

Mr S. H. Stocks has a well-known method of screws running right through the silage,—and many others might be mentioned.

Stack Ensilage.

Since 1885 the system of ensilage has developed in a direction which was certainly not contemplated at its introduction to this country. Its whole history—not only from the earlier practices of Eastern nations, which gave the first idea of the principle, but among those who in France and America had extensively used it before it became known in Great Britain—implied that the making of ensilage necessitated a silo.

When, however, the subject became one of careful and scientific inquiry, it was found that there was no lateral pressure in the silo, whatever weight might be imposed. This having been realised, the idea of taking away the sides altogether—or, in other words, making a stack—followed before long. It is perhaps due to that healthy spirit of dissatisfaction which is so thoroughly British that no sooner was the practice of ensilage as carried out successfully in France and America introduced here than efforts were immediately commenced to improve upon it. Not content merely to accept the experience of such men as M. Goffart, Vicomte Arthur de Chezelles, and Mr J. M. Bailey, and to imitate them, British agriculturists have struck out entirely new lines for themselves, and have, no doubt, carried the principle of ensilage very far beyond anything which these pioneers of the system contemplated.

Stacks *v.* Silos.—Ensilage stacks start, as will be generally admitted, with two points of great advantage in their favour. The first is the saving of capital. The erection of a silo is an undertaking which only comparatively few tenant-farmers can seriously contemplate. But supposing they obtain the landlord's consent, so as to enable them to bring it if required under the Agricultural Holdings Act, and supposing also that they have the money to sink in building, there is still a second important consideration. A silo, being fixed, necessitates a great deal of cartage, and green fodder, as everybody knows, is not a cheap substance to carry long distances. A stack, on the other hand, may be erected, like a hayrick, wherever the crop is, or wherever it may be most handy for cutting out.

On the other hand, against the stacks must no doubt be placed a larger percentage of loss, not only by reason of the waste at the sides, but also probably by evaporation. The latter loss, however, is one as to which very little accurate information appears yet to exist.

Sweet and Sour Silage.

There is one other point which may be mentioned as between stacks and silos. It is as to sweet or sour silage. "Sweet" and "sour" are arbitrary terms which have perhaps been somewhat abused in the ensilage controversy. Perfect silage —that at which all makers should aim— is neither the one nor the other. But it may be observed that it is easier to make "sweet" silage in a stack, and "sour" silage in a silo. That is to say, in a stack the temperature rises very rapidly, and the difficulty lies often in preventing too great heat. In a silo it may be necessary to wait at intervals for the temperature to rise, and the work of filling has thus to be interrupted.

Making Sweet Silage.—The credit of discovering and making known the process by which sweet silage may be produced belongs to Mr George Fry of Chobham. Until the results of Mr Fry's experiments were made known in 1884, the invariable custom was to apply pressure directly the silo was filled, and the product was sour silage. Mr Fry filled his silo without close packing, and deferred weighting the mass for two or three days, until the temperature of the silage rose to about 120° or 140° Fahr., when the top of the silo was covered and pressure applied. Mr Fry's theory is, that this temperature, about 120° Fahr., is sufficiently high to kill the bacteria which produce acid fermentation; and if the bacteria be thus killed, and the silo then covered and weighted, the enclosed mass of green fodder will remain sweet, and be practically preserved under the same conditions as fruits, vegetables, or meats are preserved when canned.

The late Dr Augustus Voelcker attached great importance to Mr Fry's experiments, and remarked, that "it certainly is a fact that silage, showing not more than a trace of acidity, and as sweet and almost as aromatic as well-made hay, has been made by Mr George Fry, and could be made by anybody who would strictly adopt the directions which he gives for making sweet silage."[1]

Relative Value of Sweet and Sour Silage.—Into the vexed question of sour *versus* sweet silage it would not be profitable to enter at any length. The weight of evidence has certainly gone of late against the intense acidity which distinguished some of the silage first made. The progress of "sweet" silage has, as just indicated, been greatly accelerated by the introduction of stacks. In a silo the natural form of silage made is, under ordinary conditions, more or less acid; in a stack, on the other hand, the natural form is "sweet." The difference is merely a matter of temperature during making. As a matter of practice, from 130° to 140° will be found, as a rule, to make first-rate silage, without any unpleasant odour, and with the food constituents of the crop as well preserved as is possible. The tyro may find slight variations in dealing with different crops, in varied stages of growth, and under diverse conditions of weather, &c., but these experience alone can properly teach him. He will find that in a silo the difficulty is usually to raise the temperature sufficiently, and in a stack to keep it down sufficiently.

With the aid of a stack-thermometer, it is easy to ascertain exactly the rise and fall of temperature in either a silo or silage stack. An ingenious thermometer, designed for the purpose (Vipan & Headly, Leicester), is represented in fig. 121. See also fig. 5.

This thermometer is constructed of light steel tubing, pointed with a taper spiral and cranked handle at the other end. By turning the handle the spiral cuts its way and draws the tube into the position required. A self-registering thermometer, protected by another steel tube, is lowered or allowed to slide to the bottom of the steel tube, and, after remaining for five minutes, raises the mercurial index to the maximum temperature; it is then drawn out of the tube and the exact temperature can be read off at leisure as the index remains

[1] *Jour. Royal Agric. Soc. Eng.*, xix., sec. ser., 483.

stationary. This is a most important point, as it is not easy to ascertain by an ordinary thermometer the correct temperature, owing to the mercury running back while drawing it out of the tube and reading off the temperature.

With a silo the making of sweet silage is almost impracticable, owing to the need of interrupting operations at intervals to allow the temperature to rise. However, as has been previously remarked, dogmatism is not possible with regard to the best kind of silage, seeing that, with all varieties, records of admirable results are in evidence.

It has, in many cases, been found that sweet silage does not keep fresh and free from mould so long, after being cut out of the stack or silo, as do most kinds of sour silage.

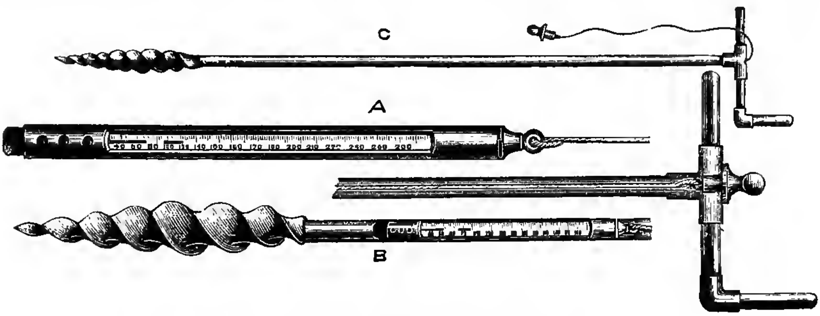


Fig. 121.—*Self-registering thermometer.*

A Thermometer, showing self-registering index.
B Showing thermometer in position when lowered to the bottom of the tube.
C General view of ensilage thermometer.

Analyses of Sweet and Sour Silage.—The extensive and successful experiments made by Mr Colin J. Mackenzie of Portmore, Eddleston, have done much to bring the merits of ensilage under the notice of Scotch farmers. He has made both sweet and sour silage very largely, and the results have been most satisfactory. He remarks that "the cattle prefer the sour to the sweet silage; that no harm appears to occur if a silo be left without addition being made to its contents for many days; and that, in spite of the great heat produced in the manufacture of sweet silage, there does not appear to be any greater loss of moisture than in sour silage. The steam was always found condensed on the upper layer of grass. The waste on the top of the silos was about equal, and did not exceed 3 inches." From sweet and sour silage made by Mr Mackenzie at his farms of Earlypier and Harcus—from grass cut from lea which had been saved from pasturing for the purpose—Dr A. P. Aitken took samples for analysis. The silos had been filled in the autumn of 1886, and the samples were taken from the silos in the following March. They gave the following results:—

	Earlypier.		Harcus.	
	Sweet.	Sour.	Sweet.	Sour.
Water	75.09	76.08	69.39	77.77
Solids	24.91	23.92	30.61	22.23
	100.00	100.00	100.00	100.00
Solids (dried at 212° Fahr.)—				
Albumen	6.52	6.33	6.71	6.33
Non-albuminoid nitrogenous matter reckoned as albumen	4.43	3.64	2.02	2.28
Carbohydrates	44.55	46.18	46.05	47.87
Ether extract	6.20	5.95	6.85	6.35
Woody fibre	28.85	25.15	30.20	28.70
Ash	9.45	12.75	8.17	8.47
	100.00	100.00	100.00	100.00

Commenting upon these analyses, Dr Aitken says that, "upon the whole, it would seem that there is very little difference between sweet and sour silage; but what little difference there is, is in favour of the former."[1]

Dr A. Voelcker gives the following as the analyses of two samples of sweet silage sent to him by Mr G. Fry of Chobham :—

	Silage from Clover and Rye-grass.	Silage from Meadow-grass.
Moisture	75.80	74.40
Albuminous compounds[1]	2.53	2.56
Sugar and other carbohydrates soluble in water	1.43	2.99
Crude vegetable fibre .	18.31	17.90
Mineral matter (ash) .	1.93	2.15
	100.00	100.00
[1] Containing nitrogen	0.40	0.40
Volatile acids, calculated as acetic acid	0.01	0.02
Non-volatile acids, calculated as lactic acid	0.01	0.02

The following is the analysis by Dr A. Voelcker of sweet silage made by Lord Middleton, Applecross, Ross-shire, from oats cut green and chaffed :—

Water	74.80
Albuminous compounds[1] .	2.18
Sugar and other carbohydrates soluble in water .	2.78
Crude vegetable fibre .	18.84
Mineral matter (ash) . .	1.40
	100.00
[1] Containing nitrogen .	0.35
Volatile acids, calculated as acetic acid . .	0.07
Non-volatile acids, calculated as lactic acid .	0.01

These analyses by Dr A. Voelcker are taken from the *Journal of the Royal Agricultural Society of England*, vol. xx., part ii., second series, to which he contributed a valuable paper upon the "Chemistry of Ensilage."

Examples of Stack Ensilage.

The best method of bringing the advantages of the stack system under the attention of practical farmers is to quote

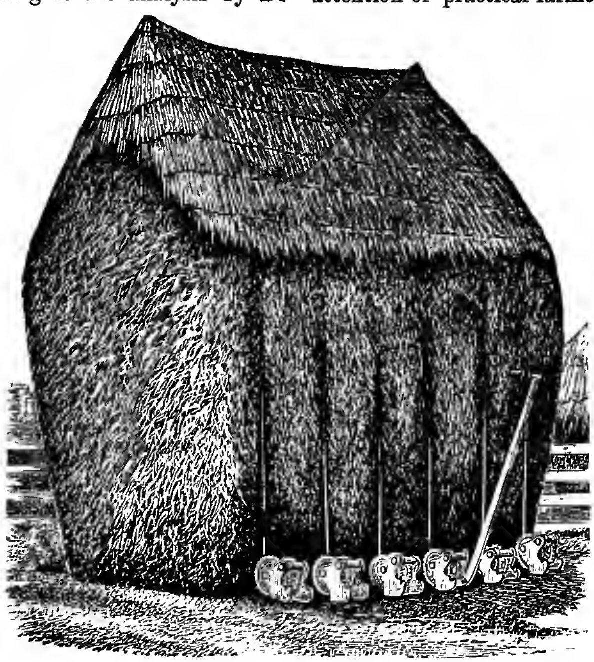


Fig. 122.—*Johnson's ensilage press.*

the experience of those who are now carrying it out. This might be easily done to a great extent. It will suffice, however, to give one or two recent com-

[1] *Trans. High. Agric. Soc.*, xix., 1887.

munications from representative men who use different methods to secure similar ends.

Johnson's Ensilage Press.—Mr G. M. Allender, ex-chairman of the London Farmers' Club, has extensively used ensilage made in stacks by the well-known method patented by Mr C. G. Johnson of Croft, Darlington, fig. 122. The Aylesbury Dairy Company, of which Mr Allender is managing director, are sole agents in the United Kingdom for this "wire-rope" method. The method, especially in its lately improved form, has been very successful in winning honours in competitions held by the Royal Agricultural Society, the Ensilage Society, and other public bodies.

Writing in August 1887, Mr Allender gave the following as his experience with silage stacks:—

"I consider that the 'outside' does not exceed 2 per cent, by *weight*, of the stack—that is, of a 75 or 100 ton stack—neither is this '*outside*' altogether waste, as our experience is, that thrown to store cattle in a yard, they pick out a good deal of it—indeed, very little is actually lost. I do not know of any means for preventing this small amount of 'outside,' neither do I consider that any precaution is necessary, as the loss is not greater, *by weight*, than in any ordinary hayrick. Care should be taken not to allow the stack to be cut or trimmed, as thereby much greater waste is caused—when left rough, only pulled, the ends form, as in a rick of hay, a natural coat.

"*The advantage of the stack over the silo*, I think, does not admit of argument. In the stack system the stack may be made in the field in which the crop is grown; and as a good crop of 'green stuff' will weigh from 8 to 12 tons per acre, as against 35 to 50 cwt. of hay, the haulage at a busy time of year of such a bulky crop is of great moment. In winter, when the food is required, haulage is cheaper—further, I think the food is of better quality.

"I do not say that silage is a cure for all evils, but in a wet season it enables the farmer to store a lot of useful food for the following winter, and in an excessively dry season such as this, it places at his disposal a breadth of green food which otherwise he would not have provided for himself."

Reynolds's Method of Pressure.—The name of Messrs F. W. Reynolds & Co. has already been mentioned in connection with their methods of pressure for silos. Since the introduction of stacks they have adopted the same system of chains and screw-tightener for use in stacks as well as silos, fig. 123.

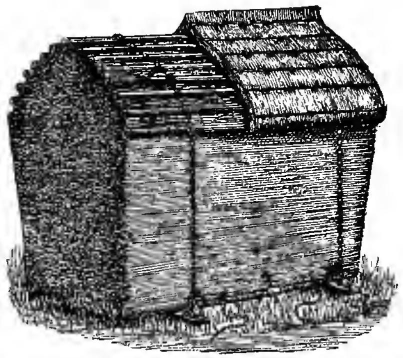


Fig. 123.—*Reynolds's ensilage press.*

As to their experience of the stack and silo systems, they write:—

"We have always held, and still maintain, that the silo is best, as it excludes the air more perfectly, thereby preventing waste at the sides, and at the same time stays the excessive evaporation that goes on continually in a stack. The first cost of a silo is no doubt a great drawback; but the saving effected by its use is far more than the interest on the capital invested. On account of this saving in first cost, we have sold probably as many sets of our patent appliances for stacks as for silos; but our own practical experience, and the reports we have received from purchasers of our system, tend to show that the loss in a silo seldom exceeds 10 per cent, whilst in a stack it is always over 30 per cent. Our principal competitor once agreed with us that the loss in a stack was fully one-third of the weight put into it, and we have seen on his farm at least 18 inches of waste in places, or varying from this to 1 foot.

"Mr C. S. Roundell (late M.P.) once made some useful experiments in stack silage with our patent pressure. He put in sixteen waggon-loads, the produce of about six acres, taking four days. After four days they cut down the sides, and added the trimmings to the top. The temperature was as follows: 3d day, 90° Fahr.; 4th and 5th, 120°; 12th, 130°; 22d, 135°; 43d, 137°; 53d, 140°. It remained at this heat for a month, when it gradually declined to 122° during six weeks, when it was cut out. With reference to the silage he remarks as follows: 'The silage is turning out very satisfactory, only 2 or 3 inches of mouldy stuff or waste on the outsides, with 4 or 5 inches of ditto on the top. The cows and horses eat it readily, cut out and mixed with hay and chaff.'

"A stack we built at our works in Blackfriars reached a temperature of 156°: this had from 6 inches to 1 foot of waste on the outsides, the remainder being excellent. The loss from evaporation, however, was considerable, and was fully one-third of the weight put in. The following is Dr A. Voelcker's analyses of two samples cut from different parts of the stack:—

	Light. Per cent.	Dark. Per cent.
Moisture	72.24	59.53
Acetic acid	0.16	0.67
Lactic "	0.33	1.48
Digestible fibre, &c.	11.30	12.28
Indigestible (woody) fibre	9.35	14.57
	93.38	88.53"

It may be mentioned that at the latest competition of the Ensilage Society the "silver medal" was won by Mr J. G. Platt with a sample of ensilage made in a stack by Messrs Reynolds's system of pressure, the "gold medal" being won by a sample made in a silo with dead weights.

Blunt's Patent.—A system of pressure very largely in use is that known as Blunt's patent (fig. 124), which is manufactured by the Ensilage Press Company of Leicester. It combines the two principles of the screw and lever, and one main advantage claimed for it is that by its means "continuous pressure" is secured.

Mr E. T. Blunt, who is a practical farmer, farming a mixed farm in the neighbourhood of Leicester, was one of the earliest adherents to the ensilage system, and has devoted a great deal of time and attention to its investigation.

Pearson's Roller Process.—The success of the method of pressing silage by water-ballast rollers, patented and manufactured by Messrs T. Pearson & Co.,

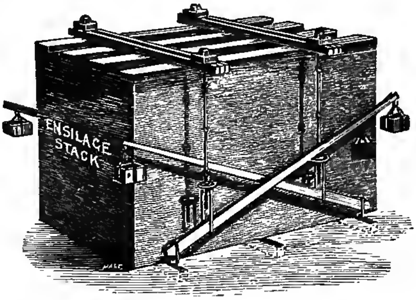


Fig. 124.—*Blunt's ensilage press.*

Wolverhampton, has done much to popularise the practice of ensiling in open stacks. This process is illustrated in fig. 125, which is almost self-explanatory. It will be seen that the *width* of stack is 15 feet; the *length* of stack is made up of the 5-feet sections (which may be 6, making it 30 feet or more, if desired). The grass is first laid down in 12-inch thick layers (or courses), and then taken in sections of 5 feet as shown on Nos. 1 and 2. The roller being 5 feet long, covers this space in rolling. The roller has just finished the pressing of No. 1 (*from side to side in the direction the boards run*), and has been turned to be raised, on the two small angular blocks marked A, to No. 2 section, where the boards are being laid to receive it. No. 1 section, before it was pressed, was same height (or thickness) as No. 2—viz., 12 inches. Other sections are added, till the desired *length* of stack is reached; the boards on No. 1 are then removed and relaid on the unpressed grass. The boards are 16 feet long (6 inches allowed to overlap each side of stack) and 9 inches by 1½ inch thick. Strips of wood, 2 inches by 2 inches, are nailed on each end to act as "stoppers" against the roller. The 12-inch thick layers of grass are pressed to about 5 inches; therefore the height from No. 1 to No. 2 is only about 7 *inches* for the roller to ascend, which occupies a *few seconds* only.

The ensilage roller is 5 feet by 2 feet diameter, made hollow and closed at both ends. The material is plate-steel. There is an inlet at one end for filling with either water or sand, which gives the ballast a weight for pressure. But although the rollers are supplied in this convenient form, Messrs Pearson's patent covers the use of any description of roller or device used to press and make ensilage in silo or open stack. The roller, it will be seen, has no gearing or mechanical attachments for its movement, no frame or handle, but is simply moved by the man pushing it in front of him. A larger size is made, 5 feet by 2½ feet, for the strongest-stemmed grasses, bracken, &c.

Messrs Pearson give the following directions for the making of sweet silage by their process: (1) You cannot press too hard to exclude all air; (2) under-pressed grass—sour silage; (3) effectively pressed—sweet silage; (4) build stack in layers; (5) grass should be wet or damp.

The roller weighs, say, 20 cwt. when filled, and is 5 ft. × 2 ft. diameter. Thus every foot is equal to 4 cwt. The roller rests or grips on every two inches of surface as it moves, and by the passage to and fro of such a weight it is obvious the amount of pressure inflicted must be great.

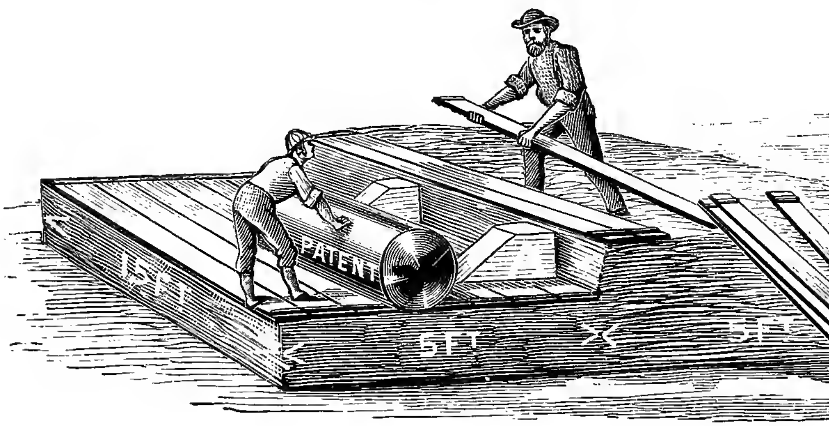


Fig. 125.—*Pearson's ensilage roller system.*

Messrs Pearson were the first to patent mechanical presses for ensilage stacks. They patented four systems early in 1884, two of which were illustrated and described in *Silos for British Fodder Crops* (*Field* Office, 1884). One of these was their combined wire-rope, winding-drum, and lever system, which they have since abandoned in favour of their roller process.

Choice of Methods.

It will thus be seen that the farmer who wishes to make silage has a wide choice of methods. The two initial questions to decide are—

1. Silo or stack.
2. Method of pressure.

On neither point is it possible to lay down a rigid rule. The first must be decided mainly by local or individual circumstances. The result is—with due care, equally necessary in both cases—practically the same. Silage of the best description can be obtained either by the one or the other.

Neither is the method of pressure adopted, whether on silo or stack, a matter for dogmatism. Any one who sets out for the first time to make silage will have to investigate the matter for himself. For a silo he will have the choice between dead weight and various mechanical appliances; for a stack he will be practically restricted to a very few mechanical methods. Dead weights have been used on stacks, but the difficulty of preventing them from slipping off, as well as the labour of lifting up and down, virtually preclude them from practical consideration.

Amount of Pressure.—Having decided for a silo or stack, and having arranged for the securing of sufficient pressure—which, by the way, cannot be safely calculated at less than a minimum of 100 lb. per square foot on silos, and 200 lb. per square foot on stacks—the question arises (if it has not previously arisen), what to put in it? In many cases less weight is employed, but then the risk of making bad silage is greater.

Chaffing for Ensilage.—In the majority of cases the crop is put into the silo or silage stack in its natural length. In a good many cases, however, it is first cut into short pieces. This no doubt helps the success of the system, especially with rank material; but it, of course, adds considerably to the expense. There are many excellent chaff-cutters made specially for this purpose, one (Crowley's) being represented in fig. 126.

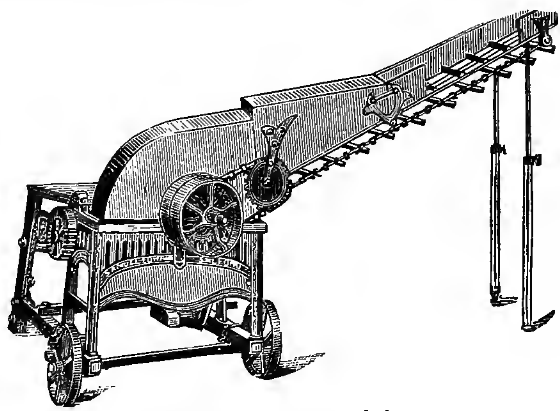


Fig. 126.—*Ensilage cutter and elevator.*

Crops for Silage.

The crops available for silage are many and diverse. It is well to bear in mind that the quality of the silage is directly dependent upon the quality of the material from which it is made. This may appear to be a simple truism, but it is by no means unnecessary to insist upon it. In the early days of the system there seemed to be a common idea that silage was silage—so to speak—whatever it might be made from. Thus a good many people favour the notion that coarse, useless grass, or waste substances, might be ensiled and transformed into valuable food. That such materials may be, and are, made into silage with advantage, is no doubt true; but it is essential for those who use them to remember that the process of ensilage does not give them any higher feeding value, other than possibly to make them more palatable or digestible to stock. No formation of food constituents goes on in the silo or stack, and practically that which a farmer puts in, that will he—if the silage be well made—take out. It follows, therefore, that those who wish for valuable silage must make it of a valuable crop.

Meadow-grass Silage.—The crop most used in this country has been meadow-grass. At the Smithfield competition of the Ensilage Society for 1885, a prize was offered for the best sample of meadow-grass silage, to be decided by analysis. Thirty-seven samples were received, and all of these were duly analysed by Dr John Voelcker. In the *Field* the thirty-seven analyses made were epitomised in a table which establishes a useful standard of value. The average percentages of the constituents of the samples were worked out as follows in their natural condition, and also when dried, with the addition for comparison of the average of fifty samples of meadow hay:—

	Average of 37 samples of ensilage.		Hay.
	In natural state.	Dried at 212° F.	Average of 50 samples.
Water	71.42	...	...
Albuminoids [1]	3.17	11.09	10.83
Indigestible fibre	9.33	32.65	30.35
Digestible fibre	10.39	36.35	51.53
Soluble carbohydrates	2.53	8.85	
Volatile acids	0.28	0.98	
Non-volatile acids	0.42	1.47	
Mineral matter [2]	2.46	8.61	7.29
	100.00	100.00	100.00
[1] Containing nitrogen	0.51	1.77	1.73
[2] Including silica	0.56	1.96	...

Water and Dry Food in Silage and Hay.—The following table shows the relative quantities of water and of dry feeding substance in a ton of hay and a ton of meadow-hay silage of different degrees of moisture—one being the average of the 37 samples above alluded to, another being the driest sample in the series (No. 26), and the third the wettest sample (No. 27), on the supposition of the quality being otherwise equal in all, and that the hay is worth 80s. a ton of 2240 lb. In a ton of hay, at the ordinary average of 15 per cent of water, there are 17 cwt. of dry food and 3 cwt. of water; and, at 80s. a ton, the value of the dry material is a small fraction over a halfpenny a pound. The quantities and values are as follows:—

	Water. Gallons.	Dry Food. lb.	Value. s.	d.
Hay	34	1904	80	0
Driest silage (sample No. 26)	49	1748	73	6
Average of 37 samples	160	640	26	11
Wettest silage (sample No. 27)	191	334	14	0

The above shows the number of gallons of water contained in a single ton of silage with different amounts of moisture. But if we look at the quantity of water which would have to be evaporated in order to make the respective grasses into hay instead of silage, the facts become even more striking. To turn the driest (No. 26) into hay of 15 per cent moisture, it would only be necessary to evaporate 20 gallons of water in making a ton of hay; and except as an experiment, it seems needless to put such very dry grass into a silo. With the average samples, however, at 71.42 per cent of moisture, there would have to be 442 gallons of water evaporated in making each ton of hay. And with the wettest sample (No. 27) 1054 gallons, or more than 4½ tons of water, would have to be evaporated for each ton of hay made.

Under such conditions, haymaking is no enviable process, and one can readily appreciate the remark made by Mr D. Wood, in concluding his report from Blairmore, Argyleshire, to the Ensilage Commissioners: "*If some of our scientific experts had just one season's experience in these wet Western Highlands, they would bless the man who invented silos.*"

Here, again, it may be remarked that there are very considerable differences in the qualities of grasses; and corresponding differences will be found in them after conservation in the silo or stack. The rough "fog" of marshy grounds, or the coarse herbage of woodlands, will produce very different silage from that of good upland grass.

Clover Silage.—Clovers make a favourite crop for silage. All kinds of clover may be ensiled with advantage, and are readily made into good silage. For second or third cuts of clover, as for aftermath crops of grass, many have used silos or silage stacks who would not grow special crops for the purpose. Mr George Fry of Chobham remarks: "*Trifolium incarnatum* with us is cut in May or early in June, and is a very heavy, succulent crop. I have always found it necessary, even in sunny weather, to cut this crop in the morning and cart it to the silo in the evening. In dull weather it should be allowed to dry on the ground for at least 24 hours before it is carted."

In the Ensilage Society's competition for 1886, Mr H. M. Proctor of Spalding took a prize for clover silage, and he describes his practice thus: "My ensilage was made of green clover in an open stack. On the top and outside of the stack we have some waste, eight or ten inches at least. I bought some railway-sleepers for the bottom and the top of the stack. Under and above them I placed transverse beams, so as to fasten the end of the fulcrum by which I received the needed pressure at one end of the stack. By the same means I secured the chains of the patent screw-press of Reynolds at the other end of the stack. I pressed the green clover in the above way so as to prevent over-heat.

"I made my ensilage stack at four times. The first cut was stacked as soon as cut, and is good. Each time I raised the stack to about 12 feet high, as high as we could conveniently lift the green clover. The heavy pressure we put on the stack soon made it ready to raise again. The second time the clover was cut and stacked after a very heavy rain. The next morning cut as we stacked the ensilage. This is very good. The third time we raised the stack, the clover was not carted and stacked as soon as cut; it, too, is good ensilage. The fourth time the clover was getting old, and is not good. More waste, too. I am afraid to name the weight of a cube yard of ensilage, it is so very heavy.

"I may briefly mention how I am using my ensilage for feeding beasts—viz., I give two beasts ensilage, mixed with chaff, bran, meal, and cake; two beasts half ensilage, half roots, mangels, chaff, bran, meal, and cake, as above; two beasts roots, chaff, bran, meal, and cake, no ensilage. All the beasts have the same weight of bran, meal, and cake. I have no means of weighing the animals to give an accurate test of the results of the different ways of feeding, but will give you the best I can from observation. From my short trial of ensilage used in the above way, I am of opinion my beasts have done the best on a mixture of ensilage and roots; indeed, better than either all roots or all ensilage, with chaff, corn, bran, cake, &c., as stated above."

Lucerne and Sainfoin.—Lucerne has made very satisfactory silage both in France and in this country. In 1879 M. Pornay was awarded a silver medal at the district agricultural show at Bourges for an excellent sample which he exhibited there. Sainfoin is another leguminous plant which has been ensiled with success.

Tares.—Tares or vetches have been found somewhat difficult to make into good silage. There have perhaps been more failures with them than with almost any other crop. Nevertheless, with care they may be easily made into valuable silage, especially if the development of acids be checked. Tares and oats have been made into some of the best silage.

Rye-grass.—Rye-grass has also been made into silage, and for sewage farms the system has been of much advantage. Sewage rye-grass needs care in making, but we have seen many first-rate samples of silage from it.

Maize.—Maize, cut green, has been very largely ensiled in France and America. The recent introduction of its cultivation in this country was a result of the ensilage system. In fact, many people seemed to think that it was necessary to grow maize to make silage. This was owing to the fact that in America, where maize is grown so extensively, the system of ensilage has been applied most largely to it.

One reason for the fact that recent attempts at the growth of maize have been successful is, that in America the area of maize-growing is being pushed gradually farther north, so that now it is possible to get seed from thence which is practically acclimatised to this country. Professor Long, in the *Journal of the Royal Agricultural Society* (vol. xxiii. part i.), remarks: "There is fortunately now little difficulty in showing that the uncertainty of the crop is reduced to a minimum, and that its profitable nature is beyond doubt. This minimum of uncertainty relates chiefly to the north of England, for observations extending over several years lead me to believe that south of the Trent maize germinates and grows almost as readily as the cereals common to this country."

The advantage of maize as a fodder plant is beyond question, though its value lies not so much in its inherent richness, as in its abundant growth and consequent cheapness where soil and climate are suitable. It is, no doubt, deficient in nitrogen, and is not so nutritious, weight for weight, as many of the ordinary fodder crops of this country. Its chief merit, however, lies in the enormous weight per acre which a crop of maize will produce.

In cold, wet seasons maize would no doubt be a risky crop in this country; and this year (1888) it has given unsatisfactory results in several instances in the south of England.

Maize *v.* Grass Silage.—On Lord Walsingham's estate in Norfolk maize has been largely experimented upon and grown, and his lordship's agent, Mr Henry Woods, who was one of the earliest and ablest advocates of ensilage, gave the following comparative statement in a pamphlet published by him:—

Value of One Acre of Green Maize made into Ensilage.

	£	s.	d.
1 acre of maize, cut green, weighed 28 tons, and produced 26 tons of ensilage, value 26s. 8d. per ton, being one-third value of hay at £4 per ton	£34	13	4
Deduct rent and tithe, cost of cultivation, manure, seed, cutting, carting, chaffing, filling silo, and all other expenses, including interest on cost of barn silo . .	14	3	10
Net value of ensiled maize per acre	£20	9	6

Value of One Acre of Grass made into Ensilage.

	£	s.	d.
1 acre of grass weighed 12¾ tons, and produced 12 tons of ensilage, value 26s. 8d. per ton, being one-third value of hay at £4 per ton	£16	0	0
Deduct rent and tithe, cost of cutting, carting, chaffing, filling silo, and all other expenses, including interest on cost of barn silo .	5	4	9
Net value of ensiled grass per acre	£10	15	3

Mr F. Sutton, F.C.S., in an analytical examination of Mr Wood's pamphlet points out that the maize is put down at the same value per ton as the grass, a conclusion which is not borne out by the chemical facts. The following table quoted from *Silos for British Fodder Crops*, a valuable and exhaustive work published at the *Field* office, gives the percentages of food constituents in the two crops above referred to:—

Constituents.	Percentage Composition.		Tons per Acre.	
	Grass Ensilage.	Maize Ensilage.	Grass Ensilage.	Maize Ensilage.
Water	73.530	86.280	8.82	22.43
Albuminoids . . .	2.805	1.149	0.34	0.30
Carbohydrates . . .	11.605	5.186	1.39	1.35
Woody fibre . . .	8.140	5.075	0.98	1.32
Ash	3.920	2.310	0.47	0.60
	100.000	100.000	12 tons	26 tons

Among the constituents there are, says Mr Sutton, "only two classes of really nutritious matters—namely, albuminoids or flesh-formers, and digestible carbohydrates or fat-formers." These nutritious matters are both shown to be higher in the acre of grass than in the acre of maize, while the chief difference in the two crops consists in the excess of water in the maize—the extra 14 tons being wholly worthless material; yet all this is included in the account at the rate of £1, 6s. 8d. per ton. If, however, this excess of worthless material were deducted from the sum quoted above, the net value of the maize would not compare well with that of the grass.

Nevertheless the culture of maize is likely to progress in this country on account of the great weight per acre—from 20 to 30 tons being not unusual, and maximum crops ranging much higher—which may be grown, and as a valuable bulky fodder crop, useful for the production of both meat and milk when supplemented by a little concentrated food, such as cotton-cake. Professor Long says, "If it is true that, chemically speaking, those foods are the most valuable which approach in the nearest degree the requirements of the animals for which they are intended, both as to their constituents and their facility of digestion, then maize must, upon these grounds, be one of the most profitable crops which can be used; but how much more so is this the case when we consider the bulk it produces, the fact that it can be taken as a second crop, and the facility with which it can be cultivated?"[1]

Sorghum has been recommended for silage, and the advantages claimed for maize apply in about an equal degree to this somewhat similar crop.

Grain Crops for Silage.—Cereals, and especially rye, have been largely used for silage. They are cut before they become fully ripe and when full of sap, and make first-rate silage.

Minor Silage Crops.—Spurry (*Spergula arvensis*) is a crop largely cultivated in Germany for fodder, and it has been grown and ensiled in this country by Lord Walsingham, with marked success. Buckwheat has been tried both in France and in this country; but although it might well be grown for silage, no very favourable results have yet been recorded with it. Among other crops which may be mentioned as having been made into silage, are prickly comfrey, beetroot, Jerusalem artichoke, turnip-tops, potato-haulms, hopbine, bracken, thistles, and gorse. Some of these, notably hopbine and bracken, have proved that substances at present valueless for feeding purposes can be made available as useful food for stock in the form of silage.

[1] *Jour. Royal Agric. Soc. Eng.*, xxiii., sec. ser., 133.

Special Silage Crops.—Among special crops for silage none are more worthy of note than those advocated by Mr C. G. Johnson of Croft, Darlington, and described by him in the *Year-Book* of the Ensilage Society. He writes therein:—

"The stack for which I was awarded first prize in Class X. was put up from 8½ acres of forage crop specially grown for ensilage. Half the field was as under, half was without the peas, their proportion being added to the tares and oats. I prefer that with the peas. It was spring sown, and cut when fully podded; in fact, the oats were just beginning to turn, but stalks still succulent.

1¼ bushel	Tares.
½ "	Peas.
½ "	Oats.
¼ "	Beans.
2½ bushels per acre.	

"I intend to have 16 acres next season, and have sown in September:—

1¾ bushel . .	Tares.
¼ " . . .	Wheat.
½ "	Beans.
2½ bushels per acre.	

"The reason of the change of mixture, of course, is that in this neighbourhood oats and peas would not stand over the winter.

"I consider this crop has an important future in connection with ensilage stacking to take the place of wheat-growing and its attendant expensive roots, especially on strong land; and am now feeding bullocks for the butcher on it alone, without cake or meal, to prove how far it will take the place of roots and hay or straw, with cake or combined, and so far have every reason to be satisfied. The above crop appears to provide the succulence of the roots, &c., the bulk of the hay or straw, and an even more bountiful supply of grain than is usually given in the form of cake or meal.

"The stack was begun on August 11, base 19 feet by 12 feet; and stacking continued every day until finished, when 90 loads, computed at 25 cwt. each, had been put on. Weather dull, and several very wet days, for which there was no stoppage. I have about 40 head of cattle, all ages, including fatting stock and milch cows; also farm-horses (which latter also get nothing but ensilage); and about 40 lambing ewes—they all prefer this tares mixture to any other ensilage. They have seeds and clover and meadow-grass ensilage to vary the diet. I use no roots, straw, or hay; find ensilage in every way the better food; and am growing nothing else for next season. The above-named stack never reached a higher temperature than 145° Fahr.; is very uniform in quality from top to bottom; and was made by my patent wire-rope and lever and ratchet press."

Feeding Value of Silage.

With reference to the feeding value of silage, the amount of evidence of a favourable character is overwhelming. The judges for the silo and stack competition of the Royal Agricultural Society of England, Messrs G. W. Baker, J. K. Fowler, James Long, T. Rigby, John Wheatley, and Tom Parry, after delivering their awards, remarked that the success of the system of ensiling green crops had been incontestably proved in every district which they visited. "In every instance, cattle of all descriptions did well on the silage; and in many instances, the opinion was conclusive that decidedly more stock could be carried per acre with silage than with hay."

Hay *v.* Silage.—At Woburn, in the winter of 1886-87, twelve bullocks were carefully experimented upon—six having hay and six silage. The hay and silage, with water, were given *ad libitum*, and each bullock also received 3 lb. of decorticated cotton-cake and 5 lb. of maize-meal per day. The hay and silage were made from the same field of grass, each alternate cart-load going to the rick or the silo respectively. Altogether, $2^2/_5$ acres of grass was made into silage, and $2^4/_5$ of grass into hay. The experiment began on December 16, 1886; and at the end of 54 days the bullocks were weighed, when it was found that the average gain of weight per head per day was, for the hay-fed bullocks 2.3 lb., and for the silage-fed bullocks 2.1 lb., giving, up to that time, an advantage of 0.2 lb. to the hay.

The experiment was continued without alteration of any kind for 30 days longer, and on March 10, 1887, the weights were again taken. This time the result was different — the hay-fed bullocks having an average gain per head of 1.4 lb. per day, and the silage-fed bullocks having gained 1.8 lb. per day. Over the whole experiment, therefore—*i.e.*, during the 84 days—the gain per head per day stood thus:—

Hay	1.96 lb.
Silage . . .	1.98 lb.

The experiment came to an end because the hay was consumed; but it is noticeable that "a little of the silage still remaining, the bullocks were kept on it for a few days longer." It would have been interesting to have known the exact amount of this surplusage, but its existence tends to show that grass made into silage will keep a certain number of stock longer—in other words, will "go further"—than a similar, and, indeed, somewhat larger breadth made into hay. Inasmuch as it also gave a slightly greater increase of weight, the economy of the silage would seem to be appreciable.

The experiment at Woburn was corroborated in its results by a similar experiment carried out on 8 Welsh bullocks at Wilmington. Here the experiment lasted 80 days, at the end of which period the 4 bullocks receiving hay had gained, on an average, 1.3 lb. per head per day, while those receiving silage had gained 1.6 lb.

So far, therefore, there is conclusive evidence that good silage is equal to good hay in feeding value, which is, perhaps, more than many of its most ardent advocates would, *primâ facie*, have ventured to claim for it.

Oat Silage *v.* Roots.—At the Woburn experimental station some trials were instituted, during the winter of 1885-86, upon the relative feeding value of oat silage and roots and straw-chaff. The following were the results of two experiments on a couple of bullocks, during periods of 82 and 28 days respectively:—

	Total gain in live weight in 82 days.			Daily gain per head.
	cwt.	qr.	lb.	lb.
Two bullocks—				
Oat silage . .	2	3	11	2
Roots and straw-chaff	1	3	25	$1\frac{1}{3}$

Daily gain in favour of oat silage, $\frac{2}{3}$ lb.

	Total gain in live weight in 28 days. cwt. qr. lb.	Daily gain per head. lb.
Two bullocks—		
Oat silage .	1 0 21	$2\frac{3}{7}$
Roots and straw-chaff	0 2 21	$1\frac{3}{7}$

Daily gain in favour of oat silage, 1 lb.

Rearing Stock on Silage.—Mr Blunt, of Leicester, published, at the end of January 1888, some interesting details of an experiment made by him, with a view to arriving at the result of feeding a steer on silage from birth to slaughter. The account stood as follows:—

First month.—1½ gallon new milk per day, 30 days = 45 gallons at 6d. per gallon	£1 2 6	
Second and third months.—2 gallons skim-milk per day, 62 days = 124 gallons at 1½d. per gallon	0 15 6	£1 18 0

Silage.

Months.	lb. per day.	days.		lb.		tons	cwt.	qr.	lb.	
From 3 to 6	28	92	=	2,576						
" 6 to 8	35	60	=	2,100						
" 8 to 10	45	61	=	2,745						
" 10 to 12	50	60	=	3,000						
				10,421	=	4	13	0	5	
" 12 to 22	55	305	=	16,775	=	7	9	3	3	
The production of 1½ acre of clover mown twice									. . .	2 19 6
						12	2	3	8	

Estimated cost of growing 1 acre clover, and making it into silage (3 years lay):—			
Sowing	£0 2 0	£0 15 8	for 1 year.
Seed	1 5 0	1 0 0	two cuttings, carting and stacking.
Carting manure 2 years . .	1 0 0	0 4 0	weighting the ensilage stack.
For 3 years	£2 7 0	£1 19 8	for 1 acre=£2, 19s. 6d. for 1½ acre.

Linseed-cake.

Months.	lb. per day.	days.		lb.		cwt.	qr.	lb.			
From 1 to 3	0½	60	=	30							
" 3 to 16	1	395	=	395							
" 16 to 19	2	92	=	184							
" 19 to 21	4	30	=	120							
" 21 to 22	7	30	=	210							
				939	=	8	1	15	at 8s. =	£3 7 0	
Allow quarter for manurial value						...	...	...		0 16 9	
											2 10 3

Straw or moss litter for bedding:—					
¼ cwt. of moss litter per week, 96 weeks	1 4 0	£2 ton		2 8 0	
Allow half its cost for manure	... ...			1 4 0	
					1 4 0
Labour and attendance 6d. per week (no chaff-cutting), 96 weeks at 6d. .				.	2 8 0
March 22, 1886, cost of calf					1 5 0
Live weight, January 25, 1888 .	10 3 8				
Dead weight, January 27, 1888 .	5 3 16	= 8 score 5 lb. per quarter, at 7d. per lb.		£19 5 0	
			Balance . .		7 0 3
					£19 5 0

£7, 0s. 3d. balance for rent, rates, and taxes and profit on 1½ acre of land, = £4, 13s. 6d. for 1 acre.

With reference to the above, Mr Blunt writes:—

"In every instance I have given the maximum amount of milk, silage, and cake; for instance, the calf was reared with the others, and the milk, at the end of the first fortnight, would be probably mixed partly new and partly skim, depending somewhat on the requirements of the dairy.

"From inquiries I have made of dealers, I find it pretty generally admitted that a crop of clover mown twice will produce from 10 to 12 tons of green clover to the acre. I take the lower figure, and deduct 20 per cent for loss in making it into silage. If the ensilage is made at a temperature not exceeding 140° Fahr., I believe the loss by fermentation will not be more than 10 per cent. The loss by waste so damaged at the sides of a stack should not be more than 5 per cent, which together makes a total of 15 per cent, so that I think an allowance of 20 per cent is a very liberal one.

"The cost of cutting, carting, stacking, and weighting (this latter by my own press, which, I believe, is the cheapest), I have arrived at by actual experiment; of course a little will depend upon the distance the crop has to be carted. I need scarcely say the silage has been of the best quality—viz., the sweet and green made at a temperature of about 140°. Once I tried sweet dark-coloured silage, but soon found this would not do; and once with some sour green silage, but this was not satisfactory. The silage, for the first eighteen or nineteen months, was a mixture of clover and meadow-grass; the last three months it was principally trifolium and tares, with a slight mixture of the meadow-grass. I feel sure the quality of the meat will be first class, and I believe they will show a small profit even at 6d. per lb.

"I think we may fairly conclude from the experiment (at any rate it is worth a trial on a larger scale), that the best and cheapest way to feed our stock is to keep them altogether in covered sheds or yards (never let them lose their calf flesh): feed them during the winter on silage, straw, and cake; and in the summer substitute the green crops for silage, as I consider this would rather lessen the expense. A few roots the last three or four months would also be an advantage. Feeding beasts always do so much better without water, and this can only be dispensed with by the use of a few roots."

The experience of Sir John Bennett Lawes, and others, with ensilage as food, will be found referred to in the descriptions of different systems of feeding.

General Advantages of Ensilage.

No better evidence as to the general advantages of the system of ensilage could be adduced than is furnished in the conclusions of the Ensilage Commission already referred to. The Commission classify the advantages claimed for ensilage under these three heads: "1. In rendering the farmer independent of weather in saving his crops. 2. In increasing the productive capabilities of farms: (*a*) in greater weight of forage saved; (*b*) in greater available variety and rotation of crops; (*c*) in increased facility for storage. 3. In connection with feeding: (*a*) dairy stock; (*b*) breeding stock; (*c*) store stock; (*d*) fattening stock; (*e*) farm-horses." Taking each of these points in order, the Commission remark upon them as follows:—

"1. *Independence of Weather in saving Crops.*—In this respect it has been abundantly proved to us that ensilage is of great economic value. In Scotland, in Ireland, and in the north and west of England, few seasons occur in which more or less difficulty is not experienced in reducing green fodder crops to a sufficiently dry condition for stacking in the ordinary way. This is especially the case with second crops of clover and aftermath. The loss occurring through ineffectual attempts to dry such crops, or through their inferior condition when carried, is often very considerable; and it is obvious that any system which enables a farmer to store these in good condition for future use must be a great saving of expense and anxiety.

"2. *Advantages in increasing the Productive Capabilities of Farms: (a) In greater Weight of Forage saved.*—It is obvious that unless the forage in a weighty condition be of more feeding value per acre than when saved in a less weighty form, there can be no gain to the farmer. It has been contended that the loss of weight in the process of drying is simply loss of water by evaporation, and that by avoiding this nothing is saved. If such were truly the case, dry forage should give the same feeding results per acre as green forage. No practical farmer would contend that it does so, and the difference is especially noticeable in the case of dairy stock. So far as we have been able to ascertain the opinion of competent men on this subject, we estimate the value of green forage well preserved in a silo at somewhat more than one-third, weight for weight, of the value of the same material made into hay under favourable conditions. The very wide difference of value between good and bad silage cannot be too strongly insisted upon. It is found that grass well preserved in a silo, after deduction for loss, will yield approximately five times the weight of the same grass made into hay. We have therefore, say, five tons of silage, which, taken at one-third the value of hay per ton, yields a profit of over 60 per cent as compared with one ton of hay. If we take it at one-fourth, it still leaves a profit of 25 per cent. Any waste that may occur to reduce the weight of nutritious forage, whether by evaporation or by excess of chemical change, must necessarily affect this calculation, which is based upon the highest degree of perfect preservation so far known to be attainable.

"(b) *In Available Variety and Rotation of Crops.*—By the process of ensilage many crops can be preserved which would not otherwise be found profitable if used in the form of green forage. Rye, oats, millet, maize, barley, and even wheat, if cut about the time of attaining their full development, but before the seed begins to harden, have been successfully used as food for cattle through the medium of the silo. Such of these crops as are found to reach the required condition before the middle of June, if cut before that time, will leave the land free for a second sowing, and thus increase its capabilities of annual production, while maintaining the fertility of the soil. Where land is well treated, maize, buckwheat, or, in some parts of England, also turnips, can be sown after green rye or oats are cut and carried, and thus a second crop may be secured for preservation in the silo, or for consumption by sheep on the land.

"(c) *In Increased Facility for Storage.*—This advantage has been forcibly impressed upon us. It enables farmers to guard themselves against emergencies, such as frequently arise in our climate through prolonged cold in February, March, and April, causing great scarcity of food for cattle and sheep, where the supply of roots is inadequate.

"3. *Advantages connected with Feeding: (a) Dairy Stock.*—We have received the strongest evidence of the undoubted advantage of the system for the feeding of dairy stock. The effect of dry winter food given to such stock has always been to reduce in quantity and to deteriorate in quality milk, cream, and butter, as compared with the same products resulting from green summer food. Although the degree of perfection attainable in summer has not been reached, it has been at least much more nearly approached by ensilage than by the use of hay and other dry foods, while at the same time the objections inseparable from the employment of roots for this purpose have been overcome. A sensible improvement in the colour of butter has been especially noticed.

"(b) *Breeding Stock.*—Green fodder preserved by ensilage has been successfully employed in feeding sheep and cattle at the time of breeding; and as it has been shown to increase the flow of milk, it will undoubtedly be found useful for this purpose, although the proportion of its admixture with other kinds of food must always require care and judgment.

"(c) *Store Stock.*—It forms a complete and wholesome food for store stock.

"(d) *Fatting Stock.*—The value of this process for the purpose of forming flesh and fat has not yet perhaps been so widely demonstrated as in the case of dairy produce. At the same time the results attained show that it compares favourably with the use of roots, and, if given in proper proportions with other food, it affords a cheap substitute for the same bulk, which would otherwise be required in some different form. The advantage of its use is most apparent in the degree to which it enables a farmer profitably to consume straw-chaff, rough hay-chaff, and other dry materials, which, without admixture with some kind of moist food, would not be palatable or advantageous to the growth of stock.

"(e) *Farm-horses.*—Strong as the evidence has been of the advantage of ensilage for keeping all stock in healthy condition, farm-horses have by no means been excepted. We have received highly satisfactory accounts from several quarters of the health of working teams when given a limited proportion of silage mixed with other food."

In conclusion, the Commissioners state that they endeavoured to discount all exaggerated estimates, as well as to make allowance for a considerable amount of prejudice and incredulity which they met with, and they add: "After summing up the mass of evidence which has reached us, we can without hesitation affirm that it has been abundantly and conclusively proved to our satisfaction that this system of preserving green fodder crops promises great advantages to the practical farmer, and, if carried out with a reasonable amount of care and efficiency, should not only provide him with the means of insuring himself to a great extent against unfavourable seasons, and of materially improving the quantity and quality of his dairy produce, but should also enable him to increase appreciably the number of live stock that can be profitably kept upon any given acreage, whether of pasture or arable land, and proportionately the amount of manure available to fertilise it."

The judges on the competition for £100, offered by Sir Massey Lopes, "For the best Silo in England and Wales in actual work during the winter of 1885-86" (conducted by the Royal Agricultural Society of England), reported quite as strongly in favour of ensilage as did the Ensilage Commission. The judges who examined the silos in the northern districts of England thus summarise their experience: "We are of opinion that the great question of satisfactorily ensiling green crops has received ample confirmation. It has been proved to us incontestably, that its success has been manifested in every district. We have seen silos of brick, of stone, and of wood; we have seen old barns and other buildings converted into silos; we have seen them sunk into the ground and built on the level; we have seen them containing 20 tons, and we have inspected others capable of containing 700 tons; we have found silos constructed at a little over £20, and others at £400; we have found them filled with all sorts of green crops, and we have found some sour and some sweet—the latter in by far the greater proportion; we have seen them weighted with bricks, with stones, with slates, with sand, with earth, and also with ingenious mechanical contrivances; we have inspected some chaffed, and in others the fodder spread out and put in whole,—in all cases the practice was successful, and in every instance cattle of all descriptions did well on the silage, and in many instances the opinion was conclusive that decidedly more stock could be carried per acre with silage than with hay. . . . In conclusion, we would say that we consider the system of ensiling will probably affect the future of agriculture on strong land, as in most instances, especially in such where it is necessary to obtain winter foods for the stock, a crop of winter-grown tares or trifolium, or other strong-growing green crops, may be sown in the autumn at little expense, and mown and put in the receptacle by the first week in June, and thus do away with the immense expense and great uncertainty of the cultivation and consumption of roots on such land."

The judges wind up their verdict as follows: "The chief advantages of silage-making against hay-making is its comparative independence of the weather; that the fodder is handled, while green, without any risk of the tender and nutritious leaves being lost on the ground, as in hay-making; that the resulting silage is succulent and palatable; and that on purely grazing farms it is now possible to obtain a portion of the grass crop for winter in such a state as to equal the effect of summer-fed grass for the purposes of the dairy."

The Future of Ensilage.

What the future of ensilage in this country may be it would be rash to predict. Whether it may develop in the future in anything like the same ratio of progress which it has achieved during the past five years—in which case it may well effect an agricultural revolution—or whether it has now reached the stage when all its features are before us, it may at least be urged that farmers in all districts should carefully consider its adaptability to their circumstances.

It surely behoves agriculturists in these times to cultivate an "open mind" with regard to all improvements which come before them in what Hamlet terms "a questionable shape." Ensilage has already been well questioned by all sorts and conditions of inquirers. There is ample evidence available for all who wish to form an independent judgment of its merits. That it deserves from all who have not yet tried it so much of their unbiassed attention, will not be denied by any who have considered either its achievements or its possibilities.

PREPARATION OF FOOD FOR CATTLE.

It is desirable that the best methods of preparing food for cattle, so as to ensure the best possible results in the progress of the animals, should be carefully thought out by farmers. In this, as in most other farming matters, it is impossible to lay down hard and fast rules which would be equally applicable to all cases. Certain well-known methods of preparing food for cattle will be explained, and farmers must decide for themselves which of these fit in most advantageously with their own peculiar circumstances. This much, however, is applicable to all—let the food be prepared and presented to the animals in as cleanly and palatable condition as possible. There is perhaps almost as much in "good cooking" for cattle as in "good cooking" for human beings. Depend upon it, the animals, be they mere calves or old cattle, will amply repay in increased progress any extra care required in presenting their food to them in a cleanly, inviting, and wholesome condition.

Washing Roots.—Dirty roots should never be placed before cattle, either cut or uncut. Very often turnips literally covered with mud are given to cattle; yet a little consideration might surely lead the cattle-man to see that it must be bad for the animals to have to eat dirty food. In a little dry earth there may be no harm, but the filth on roots is more frequently in the form of wet muddy earth, which is well known to have a tendency to cause scouring, and thus seriously retard the progress of the animals.

If, therefore, by unseasonable storing and carting, or by any other means, turnips should become very wet and muddy, they should, by some means or other, be washed before given to cattle. Where there is a small brook or stream at hand, it is easy to do this by turning the load of roots into a shallow pond prepared for the purpose, the roots, after being stirred so as to get clear of the mud, being thrown out of the water by a graip. A much slower method is to wash them in small quantities in a large tub or tank, the roots being thrown in and out by a graip. Several machines have been made for washing roots, one of the best of these being the Archimedean Root-Washer (Crosskill, Beverley) shown in fig. 127. These machines wash turnips, potatoes, and other kinds of roots. The roots are put into the hopper, and by turning the cylinder (which is partly immersed in water) they are effectually washed; and by simply reversing the motion, the Archimedean screw delivers them at once into the basket. Large sizes are made for turnips and mangels.

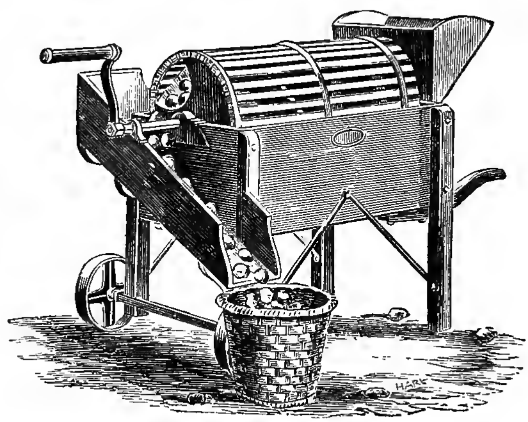


Fig. 127.—*Root-washer.*

Frozen Roots.—It is very unwise to give frozen turnips to cattle. The animals get chilled eating the cold roots, and the temperature of the body becomes so much lowered that there must be considerable waste of food or of condition in the animal in raising it to the normal degree. A speedy way of thawing turnips is to steep them in a pond or tank of cold water. But here, as in many other cases, prevention is better than cure. Timely storing prevents the necessity of having to use frozen roots.

Cutting Turnips.—Young cattle and sheep, with tender, imperfectly developed teeth, cannot comfortably consume uncut roots, and should never be expected to do so. Fully grown cattle can quite well eat whole roots; yet even with these it is desirable, in all cases where practicable, to have the roots cut before being given to them. The slicing is the most common method of cutting turnips for cattle. The slices, as a rule, vary from a half to three-fourths of an inch in thickness. It is bad practice to slice more turnips at one time than can be used immediately. In the juice which exudes from the cut surface nutritive matter passes away, and if the slices lie even for a few hours they become withered and unpalatable to the cattle. For every meal, therefore, a fresh supply should be sliced.

Turnip-cutting machines are almost innumerable. The barrel and disc forms are in general use throughout the country, and they both do excellent work. One of the best known is Samuelson & Co.'s Gardner's cylindrical cutter, shown in fig. 81. Fig. 128 represents an excel-

Fig. 128.—*Combined pulper, slicer, and finger-piece cutter.*

lent combined cutter made by Bamford & Sons, Uttoxeter. It is of the disc form, and is made so that by it roots may be pulped, sliced, or cut into "finger-pieces," as desired.

There are large turnip-slicers for driving with horse, steam, or water power; and in very many cases the old-fashioned hand-lever slicers, with some modern improvements, are still in use.

Pulping.

The pulping system consists in this. The roots are cut by machines into pulp or small chips, and mixed with cut straw, chaff, or other fodder, and this mixture is given to cattle either with or without the addition of crushed cake, meal, or other concentrated food, according to the class and condition of animals receiving it.

Economy of Pulping.—The pulping system is an outcome of an enforced desire to economise costly roots. That it does so has been proved beyond doubt. To be sure it increases the cost of labour somewhat, and on this account it has lately been argued that the pulping system should be discouraged, and that the animals themselves should be left to do the work that is now done for them by pulping. This, however, is superficial reasoning. The subject demands deeper consideration than is here indicated. The real question to determine is not merely whether pulping increases the labour bill or outlays of any kind, but whether it enables the farmer to turn his roots, straw, and chaff to better account—in short, whether it is *more profitable* than the older method of giving the roots by themselves whole or sliced. For the pulping system may be *more costly and yet more profitable.* Experience has proved it to be both; and, as would therefore be expected, it is now practised very extensively throughout the country. A common expression amongst farmers who have pursued the pulping system is that it makes their roots "go a great deal further" than under the old method. That means that by this system they have been able either to curtail the extent of their risky and costly root crop, or maintain a larger stock of cattle, or perhaps part of both.

Economises Fodder.—Another great virtue in the pulping system lies in the fact that in the sweetly flavoured heap of pulped roots cattle readily consume, and thrive well upon, fodder such as chaff, which they would not willingly eat by itself. If judiciously and timeously allocated, every particle of the pulped mixture will be consumed by the animals, and it thus at once becomes evident that the pulping system is an excellent economiser of fodder as well as of roots. By it no particle of wholesome straw, chaff, or hay need be wasted, and every practical farmer will readily understand the advantage of this.

Turnips as Cattle Food.—It has long ago been proved to demonstration that turnips in large quantities, such as were usually given before the introduction of the pulping system and other improved methods of feeding, are both costly and unprofitable food for cattle. They are much more so now than ever, for through insect and fungoid attacks, and the land becoming tired or "sick" of turnips as it were, the cultivation of the crop is now attended with greater risks than prior to 1870. It has been shown in the analyses of turnips that they contain only a very small proportion—barely 10 per cent—of dry or solid nutritive matter; and that as much as from 90 per cent of the bulb is made up of water. Now it becomes quite obvious that where turnips form a large proportion of the food of cattle, the animals must swallow an excessive and unnecessary quantity of water before obtaining in the watery roots a sufficiency of dry, solid, and nutritive food.

Cattle undoubtedly require a considerable quantity of water in some form or other, for water enters largely into the composition of their frames. Still the proportion of water in roots is far beyond the requirements of the animal, and the absorbing of an excessive quantity of cold water is positively detrimental to the progress of fattening cattle, besides being wasteful of valuable food constituents.

Let it ever be remembered by farmers that in fattening or rearing stock a certain portion of the food is required for the mere purpose of maintaining the heat of the animal. Anything, therefore, which lowers the temperature of the animal's body, be it exposure to inclement weather, or a bellyful of cold water or of raw, cold, watery roots, causes loss to the feeder, by the greater quantity of heat-giving food which the animal must consume to enable it to raise the depressed temperature of its body, and to repair the unduly increased waste of tissue which the abnormal lowering of temperature had occasioned. Hence the importance—it should rather be said the absolute necessity, if profitable stock-feeding is desired—of giving turnips to cattle, not in large quantities as the sole or main food as in former times, but in moderate quantities, along with a judicious mixture of other drier and more concentrated foods.

On behalf of turnips it is contended that their succulent character renders them a useful and correcting accompaniment of the hard and dry food such as hay, straw, and grain, which are usually given to cattle in winter. It is argued that turnips are a serviceable substitute for the fresh succulent grasses upon which stock subsist during summer. No doubt they are so to some extent, if used within moderate limits. But on the other hand, it is asserted that, merely as the source of this necessary amount of succulent matter for winter feeding, turnips are by far too costly. Indeed scientific men have contended that "as the water in a turnip is just the same as that out of the pump," it would be far better—far cheaper and quite as effective—to give the solid food in other forms diluted with water. Practical farmers are slow to swallow this doctrine in its entirety. They cling to the belief, perhaps with some little justification, that there is in the sweetly flavoured juice of the watery turnips some peculiar virtue not possessed by the "pump water." Nevertheless it is most desirable that farmers should have enforced upon their attention the true character of the turnip as an article of food, so that it may be used in more moderate quantities, and with greater care and better judgment than in former times.

Nutrition in Dry and Green Food.—In this connection it will be interesting to read the evidence of a recognised American authority, Professor Sanborn, as to the relative feeding value of green and dry food. He refers particularly to silage, but his remarks are equally applicable to roots. Two extracts run thus:—

"1. Is green food more nutritious than dry food? Out of the abundance of critical data so far gained there are none at my command that show any material difference, while a cloud of trials witness to their practical equality, and to the lessened value of the green food in winter when fed in large quantities. For four years I fed the various root crops in weighed rations, and weighed cattle, milk, and butter, and found that a pound of digestible organic matter in roots had no more value, if as much, than the same in hay and meal, or hay alone.

"2. 'Cattle need green food in winter.' It is said to aid digestion, &c., &c., when fed in winter with dry food. It can only be said, as under No. 1, that this popular view conflicts with the facts ascertained to date, both at home and abroad. By many weighings, I find that 3 pounds of water is all our American cattle care to drink in winter for each pound of organic matter eaten. Succulent food forces stock to warm up a double portion of water to blood-heat, and to vaporise from lungs and skin an extra amount at a great tax for nothing, as is well known. But of course a full ration of green food need not and should not be fed alone."[1]

Proportions of Foods.—The concluding sentence in the above extract touches the kernel of the whole question. Certainly "a full ration of green food need not and should not be fed alone." What is it to be fed with? What should be the proportion of the green food and of its accompaniment? Herein lies the secret of the science of cattle-feeding. In detailing various methods of feeding pursued by successful farmers, which shall be done presently, certain proportions—certain quantities of green and dry food—will be stated. Here, in connection with the consideration of the pulping system, it may be said that the introduction of that system has done much good by demonstrating to farmers that the former practice of giving cattle all they could eat of watery turnips was wasteful and unprofitable, and that a new and much more excellent way of rearing and feeding stock has been opened up for them.

Evidence in favour of Pulping.—There is at hand an abundance of evidence showing the benefits of the pulping system, but the practice has become so well established that there is no need to produce all that could be said in its favour. The late Mr John Algernon Clarke described it as "decidedly a fine thing for the arable farmer who may have been wastefully expending large quantities of straw in litter—a large portion being now saved for use as food." He adds: "There is economy of food; for the roots, being pulped and mixed with the chaff, render the whole mass of cut stuff very palatable to the animals, no part of the cut hay or straw, or of the chaff from the threshing-machine, being rejected. The animals are not able to separate the chaff from the pulped roots, as is the case when the roots are merely sliced by the common cutter; neither do they waste the fodder, as when given without being cut. We can thus utilise mean and inferior hay or straw. After being mixed with the pulp for about twelve hours, a fermentation commences, and this soon renders the most mouldy hay palatable, and the animals eat with avidity that which they would otherwise reject. This fermentation to some extent, I believe, softens the straw, putting it in a state to be assimilated more rapidly. The pulper is of great value, particularly upon corn farms, where large crops of straw are grown, and where there is a limited acreage of pasture, as by its use a larger proportion of the pastures may be grazed, the expensive process of haymaking reduced, and consequently an increased number of cattle kept. The accident of choking with large pieces of root is avoided, and hove is less frequent than under the sliced-root system."[2]

Mr Thomas Duckham, M.P., Baysham Court, Roos, Hereford, relates similar experience of the merits of pulping, and adds: "Choking is utterly impossible; and I have only had one case of hove in three years, and that occurred when the mixture had not fermented. There is an advantage in mixing the meal with the chaff and pulped roots for fattening animals, as thereby they cannot separate it, and the moisture from the fermentation softens the meal and ensures its thorough digestion, whereas when given in a dry state without any mixture, frequently a great portion passes away in the manure."

Mr Thomas Buttar, Corston, Coupar-

[1] *Farmers' Review*, Chicago, June 15, 1887.

[2] *Jour. Royal Agric. Soc. Eng.*, xiv. 242.

Angus, placed the pulping system upon its trial alongside the old method of sliced roots, and the results were so decidedly in favour of the former that he has since used the pulper persistently and extensively. Mr Buttar found the advantage from the pulping system was more marked in rearing store cattle than in fattening. See Mr Buttar's notes on his system of fattening cattle in winter.

The pulping system has been pursued with great advantage in the rearing and feeding of sheep, as well as in the case of cattle.

Preparing Pulped Mixtures.—The pulping process is very simple. The pulped mixture should be prepared every day, and allowed to lie from 12 to 24 hours before being given to the animals. The fermentation which takes place in this time is entirely beneficial. It softens the fodder and cake or meal, or whatever else there may be of dry food, sweetens the whole mass, and renders it not only more pleasant to the palate of the animal, but also more easily digested and assimilated than if the roots and dry food had been given separately. Never on any account allow the pulped mixture to lie so long as to become mouldy or sour. If made the one day and consumed the next the mixture should with ordinary care be in good condition for using.

The *principal ingredients* in the pulped mixture will, of course, be turnips and fodder; but there will also most likely be some crushed cake, maize-meal, or bruised grain, with a sprinkling of salt, and perhaps a small quantity of dissolved treacle sprayed over the heap. The turnips are pulped by a machine made for the purpose, as already explained. It may be driven either by the hand, or by horse, steam, or water power, according to the extent of the farmer's operations. The machine shown in fig. 128 is devised so as to be capable of pulping as well as slicing roots. A very good pulper is that represented in fig. 129, made by Woodroffe & Co., Rugeley.

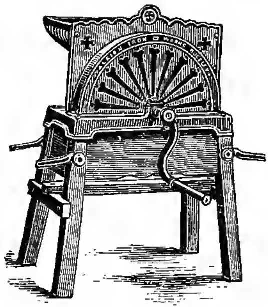


Fig. 129.—*Root-pulper.*

The grain has either to be bruised or ground into meal. In former times it was no uncommon thing for farmers to give whole grain to cattle as well as to horses; but in both cases the practice is bad, and leads to great waste of valuable food. The animal cannot fully digest and assimilate the grain unless it has first been well bruised or ground into meal. Implement-makers have lately given much attention to the devising and perfecting of machines for bruising and grinding corn, and there are now in the market many admirable machines or mills of this kind. Fig. 130 represents a modern and very ingenious mill which has been brought out by R. G. Morton, Errol, and which, like a certain historical article of furniture, "contrives a double debt to pay," for it either crushes flat or grinds into meal, as may be desired, doing both perfectly and with great rapidity.

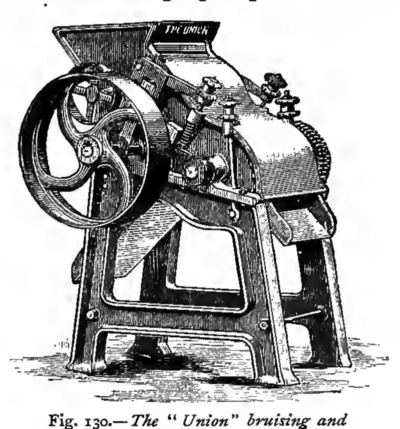


Fig. 130.—*The "Union" bruising and grinding mill.*

The fodder may be of straw or hay or chaff. As shown in a previous section, all these possess useful feeding properties, which are in this system utilised to the fullest extent. The straw and hay have to be cut into short pieces by specially designed machines called chaff-cutters. Fig. 131 represents one of the best of these very useful machines, made by Richmond & Chandler, Manchester.

The cake has to be broken into small pieces, and there are several excellent

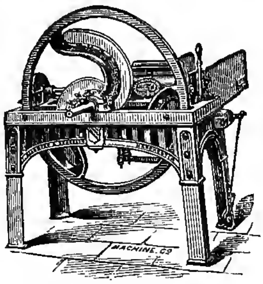


Fig. 131.—*Chaff-cutter.*

machines for this purpose, driven by hand or other power. See fig. 85.

Motive Power in Preparing Food.—These food-preparing appliances, as already indicated, are sometimes driven by hand-power, and sometimes by other agencies. Where there is a water-supply, the providing of the motive power is a simple and inexpensive matter; it may be taken by a shaft from the mill-wheel. Where steam is the motor, moderate cost is unavoidable. Where there is no water, horse-gear is usually preferred to steam, as being better adapted to moderate holdings. Several very convenient forms of horse-gear have been brought out—some for one, and others for two or more horses.

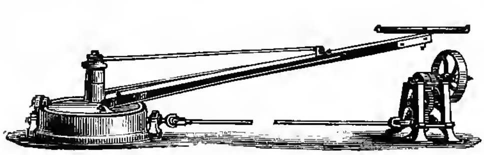


Fig. 132.—*Horse-gear.*

Fig. 132 represents a very useful form of horse-gear, made by Richmond & Chandler.

Method of Mixing.—Now, when the roots have been pulped, the fodder cut into chaff, the cake broken into small pieces, and the grain bruised or ground into meal, the mixing of the "pulped mixture" may proceed. The total and the relative quantities of each ingredient will have been arranged beforehand, the intention being, say, to mix in the forenoon the entire quantity required for the cattle next day. Clean a portion of the floor in the food-preparing compartment, and begin by laying down a layer of the cut fodder; follow with layers of pulped roots, meal, or cake, or both, as the case may be, and repeat layers in this order till the heap is complete, sprinkling a handful of salt now and again, and pouring the treacle-water over all, or amongst the layers now and again, as may be thought best. Then turn the entire heap over three or four times, taking care to have the various ingredients thoroughly intermixed. Let it lie still now till next morning, when the first meal will be taken from it.

In Mr Buttar's case, already referred to, "the pulped mixture is made up each forenoon, and allowed to lie till next day before being used. A layer of straw is laid down first, then turnips, then cake, and, lastly, the diluted treacle. The heap is at once turned over three times, and then left untouched till close on, but never more than, twenty-four hours. In two hours, two men and a boy make up a mixture for a day's feed for over 120 head of cattle. The pulping and bruising apparatuses are driven from the turbine-wheel of the threshing-mill, so that there is no extra cost for the motive power."[1]

In many cases for store cattle no cake or meal is added to the pulped mixture; and, in regard to fattening stock, it is often found desirable to give only a portion of the more concentrated food, such as cake and grain, along with the pulped roots and chaffed fodder, the other portion being retained to be given by itself. Many animals will be found to appreciate this arrangement, and it is well to humour them. Then, in determining the proportion of cut fodder to be introduced into the mixture, it is important to bear in mind that it is necessary to give an allowance of long straw or hay as well, for cattle require bulky food to suit their digestive system.

Food-preparing Compartment.—Where pulping, or any of the other

[1] *Trans. High. Agric. Soc.*, xiii. 4th ser., 1881.

modern systems of feeding are pursued, it is found convenient to have a food-preparing compartment adjoining, or part of, the turnip-store. Adjoining this also, or in the same house practically, should be the cake and meal compartments. A handy arrangement is to have the cake and meal stores on a floor right over the food-preparing compartment. In this floor the cake-breaker and grinding or bruising mill are situated, as also the chaff-cutter; and the broken cake, cut fodder, and bruised grain are dropped through hoppers into the apartment below, where the mixing of the food takes place. This system is, of course, subject to many variations and modifications in detail, in accordance with the peculiarities of different steadings, and the extent of the holding. The chief points to be aimed at, are convenience and the saving of labour, these two terms being, in this connection mainly, but not entirely, synonymous. Fig. 133 represents one of many excellent and convenient food-preparing sets

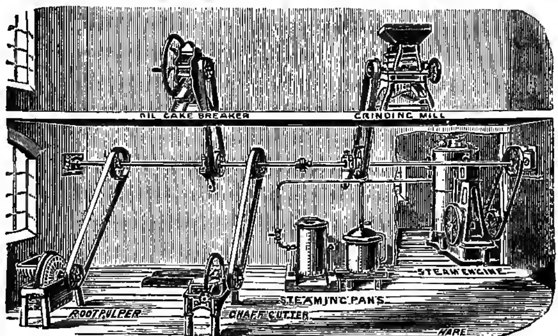


Fig. 133.—*Steam food-preparing machinery.*

erected in farm-steadings, by Barford & Perkins, Peterborough. Provision is also made in this set for steaming the food. The small vertical engine is fixed in an outhouse or lean-to, and in addition to driving the grinding-mill, oilcake-breaker, root-pulper, and chaff-cutter, &c., it supplies steam to the two steaming-pans, one of which is used for roots, chaff, &c., and the other for boiling milk or compounds. The cost of a complete set of this kind is rather less than £150.

Cooking or Steaming.

The cooking or steaming system of preparing food for cattle is gaining in favour in certain districts of the country, and is losing ground in others. It was at one time practised to a considerable extent in fattening cattle; but for this purpose the pulping system, and other economical methods of feeding, have superseded it. In dairying districts, however, the cooking system is extensively pursued.

Beneficial for Dairy Cows.—Dairy farmers have found that the flow of milk is increased by the high temperature of the cooked food. "They say that Fifeshire does not suit dairying, but I suspect it is that Fifeshire farmers do not know how to conduct it. Why, they do not even know how to feed their cows. They give them *raw* turnips and straw; and just think of that for cows giving milk." The speaker was an Ayrshire farmer's daughter, who had been residing for a time in Fifeshire, and was shocked to see the careless manner in which the farmers in "the Kingdom" attended to their cows. "And how do you feed your cows in Ayrshire?" "Well, we steam it, and give it to them warm. Cold food, like a cold day, is bad for milking-cows." Who that has had anything to do with cows, has not observed a sudden falling off in the yield of milk, as the unfailing result of the cows being exposed on a cold, wet, or stormy day?

Professor Primrose M'Connell says, "It has been proved over and over again as the result of direct experiment and general practice, that cold food retards the flow of milk, while if it is warmed it promotes it."[1] And Mr Gilbert Murray, Elvaston Castle, Derby, states that "by far the best method of using home-grown cereals, is to steam or cook the grain." "This," he adds, "can be done at a trifling cost, rendering the food more nutritive, and entailing less exertion on the organs of digestion and assimilation."[2] Mr George Bryer, Markeaton Park, near Derby, winner of the Royal Agricultural Society's first prize in the Large Dairy Farm Competition in 1881, pursued the steaming system, and the judges speak well of it, remarking that "the steaming renders damaged hay palatable, obviates any danger from dust, and kills the seeds of all weeds that might be in the fodder."[3]

Method of Cooking Food.—On a small or moderate scale food may be cooked for cows either by being boiled over a fire, or by hot water being poured over it. Steaming or cooking boilers are frequently built in a corner of the food-preparing compartment or other convenient division of the steading. The food is usually cooked in the form of a mixture, consisting most probably of a few turnips, cut straw or hay, and chaff, a little grain, or perhaps the "shorts" or "tails" from the corn-dressing machine. Some boil it and give it to the cows moist and warm. Many, however, prefer

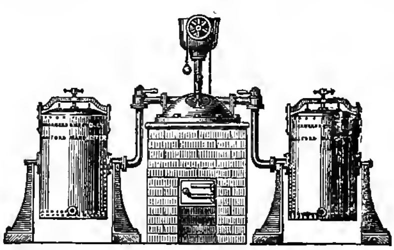


Fig. 134.—*Food-steaming apparatus.*

simply heating the food by pouring hot water over it and giving it in a wet "sloppy" condition—this warm mash, as it is called in some parts, being alternated with other foods, such as cake and grain and dry fodder. Apparatuses for steaming food for stock have been brought out by several leading firms, and fig. 134 represents a safe, economical, and durable apparatus, made by Richmond & Chandler, Manchester.

Where a steam-engine is used in working the threshing-mill, arrangements may be made for utilising the steam in cooking food for stock.

Chaff-cutting.

It has been well proved in practical experience that hay and straw are economised by being cut into short pieces, or chopped, as it is generally termed. In the short condition fodder is not so liable to be wasted by the animals to which it

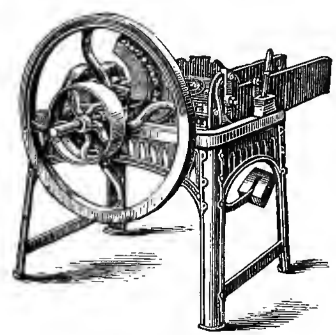


Fig. 135.—*Chaff-cutter.*

is given as food, as when it is put before them in its natural length. On the score of economy, therefore, chaff-cutting is to be commended, while it has the further advantage of rendering hay and straw more suitable for mixing with linseed-gruel, warm mashes, or with meal, cake, and roots, as in the pulping system. Modern chaff-cutters accomplish their work most admirably, and it is wonderful how long some of them withstand the great tear and wear they undergo. See fig. 131. Another excellent chaff-cutter, made by John Crowley & Co., Meadowhall Ironworks, near Sheffield, is represented in fig. 135.

Highland and Agricultural Society's Trials of Chaff-cutters.—At the Highland Show at Glasgow in July 1888, a prize of £25 was offered for "the best combination of machinery for cutting chaff as the straw is delivered from ordinary threshing-machine, and transport-

[1] *Trans. High. Agric. Soc.*, xix., 4th ser., 1887.
[2] *Live Stock Jour. Almanac*, 1886.
[3] *Jour. Royal Agric. Soc. Eng.*, xvii. 479.

ing by blower or otherwise the cut chaff for storage in bulk or in bags." Four competing machines were tested in connection with a threshing-machine at the farm of Bellahouston, near Glasgow, and the judges divided the prizes between two machines entered by Robert Maynard, Whittlesford, Cambridge—£15 for his patent portable combined sifting and bagging chaff-cutter, fitted with automatic feeder, and £10 for his patent portable combined sifting and bagging chaff-cutter, which is similar to the other, but adapted for hand-feeding. The judges, in their official report, remark that the former machine, which is represented in fig. 136, is "simple in construction, and admirably adapted for the

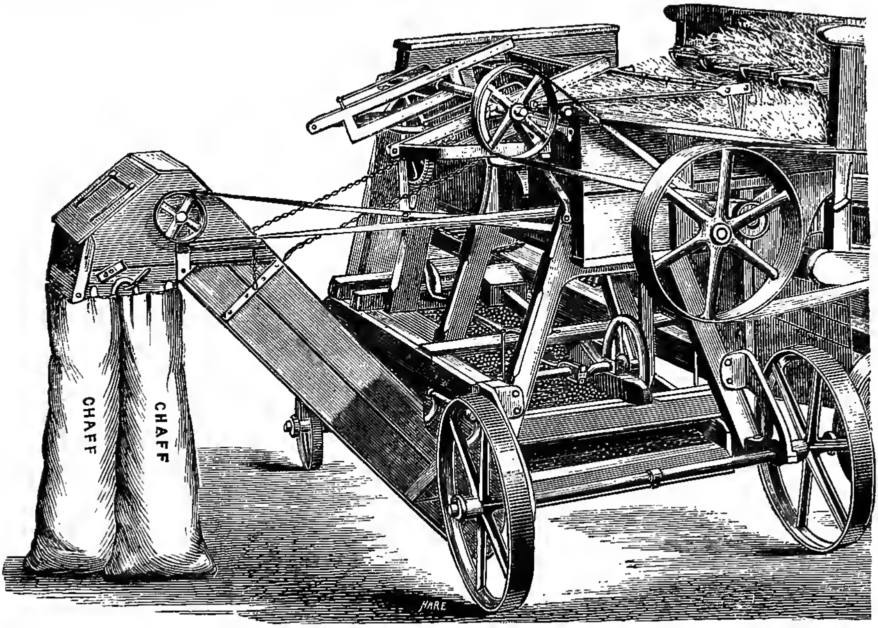


Fig. 136.—*Self-feeding chaff-cutter.*

purposes required." As to the latter, they say it is "also a machine of great merit."

Bruising Grain.

The importance of having all kinds of grain bruised flat or ground into meal before being given as food to stock, has already been pointed out. More care is now exercised in this matter than in former times; still it is only too true that even yet farmers not unfrequently permit the feeding of whole grain, especially to horses. It is a very wasteful practice, and should not be pursued on any account. This for the simple and sufficient reason that the raw grain overtaxes the animal's organs of digestion and assimilation, and that therefore a portion of valuable nutritive matter supplied in the raw grain, perhaps even whole grains, pass through the animals and become wasted in the manure-heap.

Farmers may have their grain bruised or ground for stock-feeding at any of the country meal-mills; or, which is much better, they may have it done at the steading by one of the many first-class little mills now made for the special purpose. About a dozen leading firms have given careful attention during the past two years to the perfecting of grist-mills for farmers, and they have succeeded so well that their mills leave little to be desired in their working. In the improved modern grinding-mills the stone has been supplanted by metal plates, which can be replaced at will, and which render the mill more serviceable. A combined bruising and grinding mill is represented in fig. 130. One of the best known grist-mills, with metal grinding surfaces, is the Royal First Prize Mill, which has long been made by Barford

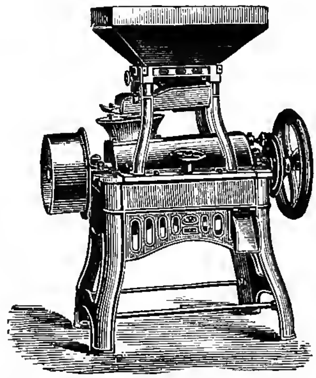


Fig. 137.—*Corn-grinding mill.*

& Perkins, Peterborough, and which is illustrated in fig. 137.

As would be expected, grist-mills require considerable power to work them, and this has to be supplied by steam, water, or horses. A wonderfully serviceable little flour or grist mill for hand-power has lately been brought out by R. A. Lister & Co., Dursley, Gloucestershire —fig. 138. It can be worked by one man or two women, means being provided for attaching a second handle.

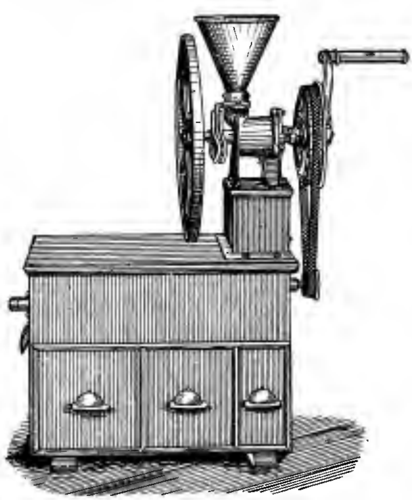


Fig. 138.—*Hand flour or grist mill.*

Cake-breaking.

For all kinds of stock, cake, as obtained from the makers, has to be broken into small pieces. Where only very small quantities are used, a hammer is made to do the work; but, except in these few cases, the cake-breaking has to be done by machines, which may be driven by hand or by other power. Fig. 85 represents a machine for this purpose.

Recapitulation.

Since the foregoing was put in type, a valuable paper upon the preparation of food for stock has been published.[1] Mr H. F. Moore, Frome, Somerset, sent a series of questions to about two hundred leading stock-owners throughout the country, asking them to give their experience and practice as to (1) chaffing, (2) mixing, (3) cooking, and (4) steaming foods. The replies are printed at considerable length, and in a concise and intelligent summary Mr Moore states the conclusions that may be arrived at from the investigation.

(1) There is a general consensus of opinion in favour of chaffing foods. "No less than 70 per cent show chaffing to be adopted, while in 20 per cent more it is partially adopted, and in 10 per cent only is the answer in the negative." Reference is made to the utilising of straw as food and using moss-litter for bedding, a practice pursued by forty-six of the two hundred correspondents, who indicate that "there is a saving of 55 per cent in the cost of moss-litter as compared with the value of straw."

(2) The replies are entirely in favour of mixing foods; but Mr Moore has found it impossible to evolve any very general rules as to what the mixture should be.

(3 and 4) Experience and opinion have varied greatly as to cooked and steamed foods. Sir John Bennett Lawes points to recent experiments at Popplesdorf, which showed that the digestibility of hay was decreased by steaming, and he adds that the digestibility of concentrated fodder is not increased by cooking. Still, several of the correspondents refer to certain practical advantages

[1] *Jour. Royal Agric. Soc. Eng.*, xxiv., sec. ser., 447.

in cooking and steaming—such as the avoidance of waste by making the most of the foods so prepared, and by the more thorough incorporation of the various mixtures employed; in the restoring of damaged hay, and making it more palatable for stock; and for aged or young cattle with defective teeth. Reference was made by several farmers to the tendency of cooked and steamed food to impair the hardiness of animals; and some gave "a very decided opinion that animals that have been fed with cooked or steamed food in covered yards do badly afterwards when grazing."

In connection with this point, attention may be directed to the advantages claimed for warm food in the feeding of cows giving milk. See "Winter Feeding of Cows."

SYSTEMS OF FEEDING.

In describing the various systems of feeding cattle, it will be convenient to deal separately with the different classes of stock. At the beginning of winter, then, there are in houses, to be fed by the cattle-man: (1) cows in calf—most of them still giving milk, and some dry, or almost so, according to the date of their next calving; (2) young store cattle to be kept in good growing condition; and (3) cattle from 18 months to 3 years old to be fattened—some in good condition, and intended to be sold at the Christmas markets, when beef is generally at a high price, and others only just beginning to be fattened, and intended to go to the "pole-axe" as they get fat, or as the tone of the markets may suggest between January and June.

Calf-rearing is more fully identified with Spring, so that consideration of it may be conveniently left for that division. There are many calves dropped during winter—more now than formerly—but it will be easy to look ahead and see what is said upon "Calf-rearing" in the Spring portion of this work.

WINTER FEEDING OF COWS.

In the winter feeding and general treatment of cows practice varies greatly. The conditions which most largely regulate these variations are, the class or breed of cows, the purposes for which they are kept, the locality, and general systems of farming pursued. As would be expected, where *dairying* is the sole or dominant feature in the system of farming, the cows are fed and managed differently from what they are in *mixed farming*, where cows are kept chiefly to breed and rear calves, and provide milk and butter to the farmer's household. Again, even within the limits of dairying itself, there are distinctive conditions which induce different methods of feeding. Where the main object is the production of milk for disposal as milk, the feeding differs—unfortunately, sometimes differs too much for the quality of the milk—from that considered best for butter-production. Then surrounding circumstances, such as the varieties of food which may be most easily and most cheaply grown or procured, also tend to regulate and modify the systems of feeding; while it is well known that food which does well with one lot of cows is often less acceptable and profitable as food for others. Thus it becomes manifest that there are good reasons for great variations in the systems of feeding cows.

Regulating Food by Yield of Milk.—There are few points of greater importance in connection with the management of cows than that of maintaining the proper relation between the allowance of food and the production of milk. Unfortunately it is very imperfectly understood; and it is desireable that, before proceeding to describe any particular methods of feeding cows, we should earnestly commend the reader to carefully peruse, and contemplate, and endeavour to bear in mind, the following remarks which Sir John Bennett Lawes, Bart., made upon this subject at the Dublin Dairy Conference in April 1886. Sir John was describing an experiment which he had been conducting at Rothamsted, upon silage and mangels as food for dairy cows, and he says: "When so much of our attention was directed to the weighing of the food and milk, we thought that the opportunity should be taken to ascertain whether a considerable saving might not be effected in the more costly foods by regulating the amount each week to the yield of milk of the previous week. In every large dairy there will be newly calved cows coming in which may yield, possibly, 5 gallons of milk per day, while others, which may be coming nearly dry, may not be yielding more than ½ a gallon. From an estimate of the composition of milk, we calculated that it would require nearly the whole of the 4 lb. of cake and 4 lb. of bran to furnish the ingredients contained in 3 gallons of milk. Such being the case, we decided that while each cow yielding 3 gallons of milk per day should receive 4 lb. of cake and 4 lb. of bran, ¼ lb. of each of these foods should be added or taken off for each rise or fall of 2 lb. of milk. By this means, a cow which yielded only 2 gallons instead of 3 would have 1¼ lb. less food—or, altogether, only 2¾ lb. of each food; while a cow which yielded 4 gallons would receive 5¼ lb. of each food.

"For the last two years the whole of the milk and foods of our dairy, of from 50 to 60 cows, has been weighed daily; and the purchased food has been regulated in accordance to the yield of the milk in the way I have mentioned. The mass of figures accumulated is exceedingly large, and no attempt has been made at present to prepare them for publication. There is, however, evidence of a very considerable saving of food having been effected; and it could hardly be otherwise, when we consider the vast differences in the yield of milk in different cows, and the large amount of nutritive ingredients in the milk itself.

"A practical farmer cannot be expected to weigh all his milk and food day by day; still he might, without any great trouble, adopt some scale by which his more costly foods could be used with economy. The engine-driver regulates his fuel to the work done by his engine: why should not the farmer regulate the food of his cow by its yield of milk? In these times of severe competition and low prices, more accurate methods of feeding must be introduced; and each pound of food given to our stock must be made to do its full amount of work. Owing to the large amount of nitrogenous matter in milk, and the fluctuation which necessarily takes place in the yield of each cow, from the time of calving to that of dryness, there is far more scope for economy in the feeding of a milking cow than there is in the fattening of a bullock."

Home-grown and Purchased Foods.—A prize of £25, offered in 1887 by Lord Vernon for the best report on "How to make the most of Home-grown Produce by the Addition of Purchased Food," brought out some very useful information. The successful report, written by Mr G. H. C. Wright, Sigglesthorne Hall, Hull, appears in the *Journal of the British Dairy Farmers' Association*, vol. iv., part 1, 1888. Mr Wright is strongly in favour of the use of purchased foods along with home-grown produce, and considers that, notwithstanding the fall in the price of beef, cakes, which are cheaper now than in the memory of man, are more than ever a profitable investment. He regards linseed-cake, or cotton-cake, bran, rice, or brewers' grains, as the most useful artificial food for cows.

Mr Wright urges the importance of keeping in view the difference in the weight of cows in arranging the quantities of food for each animal. To a cow weighing 100 stones he would give exactly twice as much as to one of 50 stones, and to one of 70 stones two-thirds of the quantity allowed to the 100-stone cow. He states the following as the proportions of the different elements of food required by a cow weighing 70 stones: 2.50 albuminoids, 12.5 carbohydrates, and .40 lb. fat; and for a 50-stone cow, 2 lb. albuminoids, 10 lb. carbohydrates, and .30 lb. fat. The foods which have given the best results in milk, butter, fat, or beef, are those which show an albuminoid ratio of about 1 to 5 or 5.5—that is, 1 part of nitrogenous to 5 or 5½ parts of non-nitrogenous compounds. And Mr Wright also mentions that experiments and practice have shown that cattle consuming 12 lb. of dry matter per 100 lb. of live weight per week, will give 1 lb. of increase for that 12 lb.

An interesting feature in Mr Wright's report are two tables of rations showing the summer and winter feeding of a cow of 1400 lb. live weight, (1) where no purchased foods are used, and (2) where purchased foods are employed. These tables are produced here, and it will be seen that the figures work out strongly in favour of purchasing and using artificial foods along with the home-grown produce. In cost there is a balance of £1, 4s. 1d. per cow in 44 weeks in favour of the artificial food, while there is the further advantage of being able, with the help of the artificial food, which is in itself a profitable investment, to maintain a larger stock of cattle upon the farm:—

Table I.

Food per day.	Length of time.	Grass.	Hay and Chopped Straw.	Turnips.	Meal.	Dry matter, per day.	Cost.	Manurial value.	Net cost.
Summer Keep of a Cow without Artificial Food.									
	weeks.	tons.	tons cwt.	tons cwt.	tons cwt. qrs.	lb.	£ s. d.	£ s. d.	£ s. d.
12 stones grass . .	24	12	...	...	...	...	3 10 0	No allowance.	3 10 0
3 lb. meal	24	...	...	...	0 4 2 At 10s. per stone.	[1]31	1 10 0	0 6 7	1 3 5
									4 13 5
Winter Keep of a Cow without Artificial Food.									
2 stones hay (meadow and clover)	20	...	1 15 at £4 per ton.	...	...	[1]31½	7 0 0	2 12 3	4 7 9
½ cwt. roots . . .	20	...	...	3 10 at 15s. per ton.	...		2 12 6	0 15 9	1 16 9
3 lb. meal	20	...	...	...	0 3 3		1 5 0	0 5 3	0 19 9
When Dry.									
	8	...	0 17	0 10	...	...	...	...	...
Total	52	12	2 12	4 0	0 8 1	...	...	...	11 17 8
							Acreage required.		
50 cows will therefore consume	600	...	...	...	...	...	60 acres		170 acres.
" " "	...	...	...	20 12 0	...	...	22 "		
" " "	...	...	200 0	...	...	...	14 "		
" " "	...	130 0	...	...	...	...	74 "		

[1] The dry matter contained in Cakes and Corn is about $\frac{7}{8}$ of the total weight.
" " Mangels " $\frac{1}{8}$ " "
" " White Turnips " $\frac{1}{12}$ " "
" " Hay " $\frac{6}{7}$ " "

[Table II.

TABLE II.

Food per day.	Length of time.	Grass.	Hay and Chopped Straw.	Turnips.	Artificial Food.	Cost.	Manurial value.	Net cost.
SUMMER KEEP OF A COW USING ARTIFICIAL FOOD.								
	weeks.	tons.	tons cwt. qrs.	tons cwt. qrs.	tons cwt. qrs.	£ s. d.	£ s. d.	£ s. d.
12 stones grass	24	12	...	...	...	3 10 0	No allowance.	3 10 0
3 lb. cotton-cake (undecorticated).	24	...	...	...	0 4 2 at £5 per ton.	1 2 6	0 14 6	0 8 0
								3 18 0
WINTER KEEP OF A COW USING ARTIFICIAL FOOD.								
stone roots	20	...	...	0 17 2 at 15s. per ton.	...	0 13 0	0 3 8	0 9 4
½ stone hay (meadow and clover).	20	...	0 8 3 at £4 per ton.	...	...	1 15 0	0 13 0	1 2 0
½ stone straw	20	...	0 8 3 at £2 per ton.	...	...	0 17 6	0 4 9	0 12 9
3 lb. rice-meal and decorticated cotton-cake.	20	...	...	...	0 3 3 at £5, 2s. 6d. per ton.	0 19 0	0 13 3	0 5 9
1 stone brewers' grains or silage *ad lib.*	20	...	...	...	0 17 2 at £5, 10s. per ton.	4 16 3	0 10 6	4 5 9
WHEN DRY.								
	8	...	0 17 0	0 10 0	...	...	...	...
Total . .	52	12	1 17 2	1 7 2	...	...	...	10 13 7
					Acreage required.			
50 cows will therefore consume . .		600	...	...	60 acres	119½ acres.		
" " " . .		...	...	68 15 0	4½ "			
" " " . .		...	93 15 0	...	55 "			

Warm Mashes.—Professor Primrose M'Connell, Ongar Park Hall, Ongar, Essex, already quoted as an advocate of "cooked" or warm food for dairy cows, states that twenty years' experience with "boiling," with the experience of a previous generation superadded—and with results always pre-eminently satisfactory—has confirmed him in his good opinion of the "warm mash" as food for dairy cows. His herd numbers about 70 cows of the Ayrshire breed, and he directs his attention mainly to the production of milk for sale in London. He makes a contract to supply specially rich milk, and to ensure this he gives a more liberal allowance of rich food than is given by many whose principal business is milk-selling. The mash which he has used most largely is composed principally of oat-chaff or chopped straw, bran, bean-meal, and ground oats, mixed with boiling water, and allowed to infuse for from 6 to 12 hours. He gives a bucketful of this daily to each cow in place of the usual allowance of turnips, and the proportions of ingredients thus allowed to each cow are 4 lb. of chaff or chopped fodder, 4 lb. of bran, 2 lb. of bean-meal, 2 lb. of ground oats, and 24 lb. of water —total 36 lb. The 12 lb. of solid matter in this mixture costs about 5d.—or nearly £4 per ton. About 450 gallons of water are required to make a ton of this dry matter into a sloppy mass suitable for the cows, and with coals at 15s. per ton, Professor M'Connell found that the firing required to heat this quantity of water up to boiling-point is under 1s., "so that the total cost of a ton of mash, *plus* the warm water, is just about £4."

Mash compared with Turnips and Silage.—Taking the market value of turnips at 10s. per ton, of silage at 15s., and the dry mash at 80s. per ton, Professor M'Connell makes the following comparison as to the relative value of these articles as food for cows: It will be best to take the same equal money-value of each—that is, one ton of turnips, two-thirds of a ton of ensilage, and one-eighth of a ton of the dry material of the mash—and in the absence of direct experiment, take their chemical food-equivalents as a basis of calculation. One ton of swedes contains 89 per cent of water and 11 per cent of solids, or tabulated, all three will appear thus, taking the valuable ingredients only into account:—

	Albuminoids.	Fats.	Carbohydrates.	Ash.
Turnips	1.4	0.20	7.1	0.60
Silage (⅔)	1.5	0.04	9.0	1.60
Dry mash (⅛)	1.7	0.35	4.5	0.36

"From these analyses it will be seen that the dry material of the mash contains 21 per cent more albuminoids than the turnips, or 13 per cent more than the ensilage; or, in other words, the same money can buy 14 tons in the turnips, or 15 in the ensilage, and 17 in the mash. So also 20 tons of fats in the turnips, 4 in the ensilage, and 35 in the mash, all cost the same. The case is, of course, reversed with the carbohydrates; but then these are the least valuable of the three; two and a half parts being required to equal one of fat for feeding, while for milk-production they (in the form of starch, sugar, &c.) have been shown to be of very little importance, as it is the albuminoids which are used in the body for this purpose. We find this in practice, and exemplified in the fact that maize and other starchy foods do not give good results with cows, so that a superabundance of them is not desirable. Taking only the albuminoids and fats into account, therefore, we find the mash is 28 per cent better than the turnips, and 33 per cent over the ensilage, all at the same money-value, shilling for shilling."[1]

He further points out the advantage of *warm* food to cows, which has been explained under the heading of "Cooked Food," p. 334. Replying to the argument that warming the food entails cost, he states that in his case, where, in wintering 70 cows, warm mash is given once a-day during one half of the winter, and twice a-day during the other half, the cost of heating (with coals at 15s. per ton) was only 1s. 3d. per cow for the whole winter. He adds: "Suppose we double this—surely no one will argue that 2s. 6d. is a serious item in a cow's annual cost, which averages, say, £20." It is also pointed out that in the warm mashes, by-products, such as chaff of all kinds, tails, or dressings from grain, overheated or inferior hay which would otherwise be liable to be wasted, may be turned into good and palatable food. Wheat, barley, and bean straw, which do not make good fodder for cows by themselves, are very suitable for the mash when chopped. Bean-straw emits a most delightful and appetising aroma when soaked in the hot water.

Mangels and Turnips for Cows.—In another paper[2] Professor M'Connell gives additional information as to his experience and practice in the feeding of dairy cows in winter. He conducted an experiment extending over four weeks, with the view of testing the relative value of mangels and turnips as food for dairy cows, and he found that, weight for weight, mangels gave 6 per cent less milk and slightly less cream than turnips.

[1] *Live Stock Jour. Almanac*, 1887.

[2] *Trans. High. Agric. Soc.*, xix., 4th ser., 1887.

Winter Rations for Dairy Cows.—In the article last referred to, Professor M'Connell gives the following tables of rations, "taken from some in actual practice by different people, . . . to illustrate the winter food of a cow in milk."

1.

5 A.M.	2 lb. decorticated cotton-cake.
7 "	warm mash.
8 "	4 lb. oat-straw
12 NOON	8 lb. hay.
3 P.M.	warm mash.
6 "	8 lb. oat-straw.

The warm mashes in the above consist each of about 5 lb. chop, 2 lb. of meal (bean and oat mixed), 2 lb. of bran, 20 lb. water—all together forming a bucketful.

2.

	lb.
Maize-meal	4
Decorticated cotton-cake	4
Pulped roots	20
Chop with pulp	10
Hay *ad lib.*	

3.

Rape-cake	6
Malt-combs	1
Roots	28
Bran	2
(All cooked together.)	
Hay	9

4.

Bean-meal	2
Pease-meal	1½
Maize-meal	1½
Bran	1½
Linseed-cake	1
Chop	7
(All mixed with boiling water.)	
Pulped turnips with	18
Straw-chop	9
Straw *ad lib.*	

5.

Cotton-cake undecorticated	4
Turnips	56
Hay or straw *ad lib.*	

A Liberal Ration.—Mr Gilbert Murray, Elvaston Castle, Derby, considers 28 lb. of roots per day the "extreme limit to a dairy cow in full milk." He submits the following as an average daily ration for a cow giving full milk in winter,[1] which may be regarded as a liberal ration:—

	lb.
A mixture of cut hay and straw	20
Bean-meal	2
Ground oats	2
A mixture of wheat and barley-meal	2
Linseed	2
Bran	2
Roots	25
Long hay divided into two rations	5
	60

Mr Murray recommends the whole, excepting the hay, to be cooked or steamed, mixed with a large quantity of pure water, and fed in a semi-liquid state at a temperature of 55° to 60° Fahr.

Skim-milk as Food for Cows.—In the paper just referred to, Mr Gilbert Murray commends the utilisation of sweet skim-milk as an ingredient of mixed food for dairy cows. He states that in some butter dairies it is difficult to dispose of skim-milk, and that in some instances it is being returned to the milk-suppliers at 2d. per imperial gallon. "At this price, mixed with other foods, it is capable, when used in moderate quantities, of being profitably used as an adjunct to the food of cows in milk. Contrasted with other foods, it is the cheapest that can be used."

Professor Arnold, a leading American authority, also speaks highly of the value of sweet skim-milk as a food for milk-production. He says: "All easily digested foods which contribute to the building up of flesh and the framework of the body are especially efficient in stimulating a flow of milk. Among the foods of this kind are cotton-seed meal, linseed-meal, bran from the various cereals, and every kind of clover and every species of peas. These foods influence the quantity of milk by reason of the high per cent of albuminous or flesh-forming matter they contain. The composition of skim-milk would entitle it to be classed with that sort of food, and its use as a milk-producing food proves it worthy of the position. Just as flesh when used as food is perfectly adapted to forming flesh again, the use of milk by milk-giving animals is perfectly adapted to reconstruct milk. It is decidedly an albuminous product, and consequently contributes to swelling the flow.

"To secure the best results, skim-milk

[1] *Jour. Brit. Dairy Farm. Ass.*, vol. ii., No. 2, 101.

should be fed in good condition. Its value is not destroyed by souring, but it is thereby considerably reduced. Sweet skim-milk is believed to be about 50 per cent better than sour milk as cow-feed.

"It would have a special value for producing milk for cheese-making, but it also contributes to making milk rich in butter. Like all other foods rich in albumen, it does this in an indirect way. One source of fat in animal bodies lies in the destruction or waste of bodily structure. The more structure there is built up, the more there is to be dissolved for the evolution of fat. Milk, like other albuminous matters, is active in building up the structure, and hence also in the production of fat, of which the newly formed milk gets a share. Feeding milk to cows also contributes to the richness of their milk by utilising the fat the butter-maker leaves in it—usually from 5 to 10 per cent of the original quantity. When fed back, cows utilise every atom of the fat, and in the course of a whole season it amounts to enough to make from 25 to 50 lb. of butter, and add to their product from 10 dols. to 20 dols. each in a season.

"As a milk-producing food its value is also affected by the quality of the food used with it. Milk is a highly nitrogenous food, and should be fed with those that abound in unctuous matters and starch and sugar, to make it a part of a properly balanced ration. It would not be so efficacious fed in connection with cotton-seed and linseed-meal as corn-meal or fodder corn or sweet ensilage, or with most soiling plants except clover, which, like milk, is highly nitrogenous. When given as a part of a well-balanced ration, sweet skim-milk gives about equal results whether fed to good new milch cows or to thrifty calves or young pigs."

Feeding in Milk-selling Dairies.—Feeding cows for the production of milk is a subject that demands the most careful study. It is illegal, and therefore punishable, to sell, or attempt to sell, milk which does not contain at least 10 per cent of solid matter. In ordinary practice it is found that liberal feeding with rich food is required to raise the percentage of solid matter very much above the standard; and, on the other hand, it has been demonstrated in experience that by using an excessive proportion of weak succulent foods such as brewers' grains, the flow of milk may be considerably increased, but its quality so much reduced as to bring it under the legal standard, and thus expose the seller to the risk of punishment. The milk-sellers, as a rule, therefore, endeavour to hit the happy medium. Some are able to obtain a contract to supply milk of exceptionally high quality, at a special price, and accordingly they can afford to, and indeed must, use rich food. But, generally speaking, milk-sellers get little or no benefit by supplying milk of very high quality, and naturally enough—except where they pursue the system of fattening off the cows as they become dry, when high feeding is necessary—they aim at feeding their cows so as to produce the maximum quantity of milk of sufficient quality to reach the required standard. To do this, to go as "near the wind" as possible, and yet keep on the "respectable side" of the standard line, requires experience and good judgment. It is highly reprehensible, certainly, to carry too far the practice of feeding for quantity, regardless of the quality of milk; yet it is but natural and reasonable that, within proper limits, milk-sellers, as well as others, should pursue an economical system of feeding—the most economical food in their case being that which will at the lowest cost produce the maximum quantity with moderate quality.

Mr H. A. Howman, Halloughton, Coleshill, Warwickshire, who from his two farms sells about 60,000 gallons of milk annually, states that in his experience the best *milk-producing foods* have been silage, cabbages, roots, vetches, and brewers' grains. He does not believe that such rich artificial foods as linseed-cake, cotton-cake, and grain will increase the flow of milk "in proportion to their cost." He tried an experiment on four cows in the winter of 1885, with the view of testing this point. The cows were being fed with a full supply of the milk-producing foods just mentioned, and their milk was accurately measured. In addition to the food formerly given, 5 lb. of meal was given to each cow per day, and again the milk was measured twice a-day for a week. The cows put on flesh rapidly, but they did not gain an ounce in the quantity of the milk. In this case the cows had no doubt been receiving a full allowance of food before the meal was given, so that very little increase in the flow of milk might be expected from any kind of food, be it succulent or dry. Still, the experience of Mr Howman, as an extensive milk-seller, upon the economy of cake and meal in milk-production, is worthy of being recorded.

Mr Howman remarks that as milk contains about 88 per cent of water and 12 per cent of total solids, it seems absurd to give dry food to produce water! What dry food the cow requires to sustain life is supplied in sufficient quantity in the milk-producing foods spoken of.[1]

Brewers' grains are the characteristic food in milk-selling dairies in or near towns—indeed wherever they can be reasonably or conveniently obtained. These grains consist of the spent malt which has yielded the saccharine extract from which beer or spirit is obtained. Mr J. C. Morton says that in town dairies "a bushel or more, sometimes two bushels, are given daily to each cow, besides which she has mangels, hay, and meal. In fact, the object is, having purchased a good shorthorn cow, not only to stimulate her milk-produce to the utmost, which grains are especially supposed to do, but to feed her so well that she may begin to lay on flesh as soon as the season of greatest milk-produce begins to decline. A cow which will fatten, as well as yield milk abundantly, is the agent by which the cowman realises his profit. She is milked at 4 A.M., receives perhaps 2 or 3 pecks of 'grains' immediately after milking is over; then 4 or 5 lb. of hay are given, and after being cleaned out, she gets at 9 A.M. from 20 to 25 lb. of chopped mangels, and another 3 or 4 lb of hay. At 1 P.M. the cows are milked again, and again fed as much as before, being well watered in the course of the afternoon. Or, when they have meal and oilcake, this is given 3 or 4 lb. a-day, either with mangels or in a gruel over the grains.

"In the country, where grains cannot easily be had in quantity, dependence is placed on hay and mangels, with meal of barley, and bean or Indian corn, or decorticated cotton-cake; and in summer and autumn of course, both in town and country, the dependence is largely on clover and vetches and cabbages, in addition to grains and meal."[2]

Silage and Mangels for Dairy Cows.—In the winters of 1884-85 and 1885-86 Sir John Bennett Lawes, Bart., carried out an important and instructive series of experiments, mainly with the view of testing the relative merits of silage and mangels as food for dairy cows. Sir John thus describes the experiments and their results:—

"For 3 months we fed 20 cows on clover-silage and 20 cows upon mangels, the rest of the diet, which consisted of 4 lb. of decorticated cotton-cake, 4 lb. of bran, and 10 lb. of chaff (half hay, half straw) per day, being given equally to the lot. The daily amount allotted to the 20 cows which received clover-silage was 50 lb., and for those fed on mangels, 90 lb. The 50 lb. of silage contained about the same amount of dry food as the 90 lb. of mangels. The average amount of milk yielded per cow by those which received the silage was 25 lb. 12 oz. per day, and that of the cows which received the mangels, 27 lb. 5 oz.; they had therefore rather the advantage of the two lots.

"The cows were all weighed at the beginning and end of the experiment, and the silage cows showed the larger increase; it was also evident to the eye that they showed more tendency to fatten. When the clover was finished, the cows were fed with silage made from meadow-grass, the result being, that although the milk did not decline, the cows began to lose weight. As regards the quality, both to the eye and the taste, the silage milk had the preference; but careful analysis showed a slight superiority in the butter-fat of the milk yielded by the cows fed on the mangels.

"These experiments were carried out in the winter of 1884-85, and a second year's experience does not alter the general conclusions. The cows have been fed all through the winter with clover-silage and mangels—not separ-

[1] *Jour. Brit. Dairy Farm. Ass.*, vol. ii., No. 2, 15.

[2] *Jour. Royal Agric. Soc. Eng.*, xiv. 405.

ately, as was the case last year, but together—and careful observation leads us to the conclusion that the addition of silage to mangels has a tendency to lay on flesh, more than would be the case if the cows were fed on mangels alone. It will be observed that the silage and mangels formed but a small part of the whole of the food consumed by the cows, which were large shorthorns, weighing about 1200 lb. each, and consuming daily about 25 lb. of food, calculated as dry. Of this amount the silage did not supply more than 10 or 11 lb.

"A very considerable amount of the home-grown food—the hay, straw, roots, or silage—was consumed by the animals for what we call existence purposes, that is to say, to keep life and warmth in the body, while purchased food furnished the material to form the milk. I may say that it would be impossible to keep up anything approaching to an average yield of 3 gallons of milk per cow, over the whole number, during the winter months, without having recourse to purchased foods."[1]

Sir John further explains that all the cows did not really receive 4 lb. each of cotton-cake and 4 lb. of bran all through the experiment. These quantities were set apart for each cow, but, as explained at the outset of this section, an attempt was made to economise food by regulating its amount each week by the yield of milk of the previous week,—a point specially deserving the most careful consideration and attention of dairy-farmers —of all, indeed, who keep cows.

Silage in the Duke of Manchester's Dairy.—Silage has been extensively used as food for the cows in the Duke of Manchester's large dairies at Kimbolton. The results have on the whole been very favourable. In the winter of 1885-86, from the opening of the silo in November till the end of May (when the silage was exhausted), the cows received daily, in two feeds, a mixture composed of 9 lb. of tail wheat and oats ground into meal, 30 lb. of cut mangels, and 44 lb. of silage each, 7 lb. of long hay being allowed in addition. With this treatment the cows gave more milk, and maintained a much higher condition than in previous years, when fed on roots, grain, and cake, at a greater cost than that entailed by the above mixture.

The mixture of meal, mangels, and silage was allowed to lie in a heap for 12 hours before being given to the cows. The silage consisted of tares and oats sown together, which were cut, chaffed, and put into the silo at the end of July. The cows evidently relished the flavour of the silage, and rarely have we seen dairy cows in such high condition as these were in the month of April 1886, when they were all milking heavily. The cost of the above feeding, reckoning the silage at £4 per ton, and including attendance, is estimated at 10d. per head per day.

Mr Carrington's System of Feeding Cows.—The late Mr Carrington, who pursued dairy-farming extensively in Staffordshire, was recognised as one of the highest English authorities of his day. In 1878 he described his system of feeding cows in winter as follows: "The cows are wintered on straw or hay and roots; those which have not calved are turned out for a few hours in a sheltered sound field of turf, near the homestead, every day, except when the weather is very bad. I consider the fresh air and exercise beneficial. . . .

"A few days after calving I commence to give the cows from 4 to 6 lb. of cake or meal, with plenty of mangels and hay or cut straw. A cow in full milk, kept on hay and roots alone, rapidly loses flesh, and her milk will neither be so abundant nor so rich in butter or curd as when extra stimulating food is supplied. Decorticated cotton-cake is a valuable food for milch cows, either alone or in conjunction with maize-meal, which is very largely used for all kinds of stock in Lancashire and Cheshire, within easy reach of the Liverpool market. Palmnut meal (a food very rich in oil) is a valuable food where it can be mixed with chop and pulped roots; it is not, however, palatable to stock unless mixed with other food."[2]

Milk-fever Preventive.—In connection with the above, Mr Carrington says: "To those of my cows which are in high condition I give 1 lb. of Epsom

[1] Paper read at Dublin Dairy Con., 1886.

[2] *Jour. Royal Agric. Soc. Eng.*, xiv. 391.

salts and 1 oz. of ginger just before calving, and in some cases I give this dose twice before calving. This I consider a *safeguard against milk-fever*."[1]

An American Example.—Mr Edward Burnett's dairy at Deerfoot Farm, Southborough, Mass., has been regarded as one of the most successfully conducted in the United States of America. Writing in 1880, Mr Burnett thus describes his system of winter feeding: "The essentials to produce the best results are good cows, good feed, regularity, cleanliness about the stables [cowhouses] and dairy, and a thermometer. I will give you my own method of feeding, and in so doing those dairymen who aim at *quantity* will realise that we are shooting at different targets, for with me quantity is secondary, quality being the greatest desideratum. . . . When in winter quarters I begin feeding at about 5.30 in the morning with hay, a little jag or wisp at a time, not so much but what the cows will eat it up clean. Then, after milking, the grain—from 3 to 6 quarts, according to the cow—consisting of two parts of Indian-meal and one of shorts or bran; or feeding entirely on ordinary cabbage (corn [Indian] and cob ground together). After this more hay, which lasts until about 9 A.M. I begin again at 3 P.M. with a little hay, followed by roots (mangels) cut fine, a bushel being divided between three cows; then more hay again, which lasts them until about 6.30 P.M. I maintain that, if more shorts are fed than are necessary to counteract the heating quality and condensed richness of the corn-meal, it deteriorates the butter."[2]

Feeding Dairy Cows in the Netherlands.—The late Mr H. M. Jenkins, Secretary of the Royal Agricultural Society of England, in his most useful reports (in the Society's *Journal*) on Continental dairying, has explained the systems of management pursued by the successful and enterprising dairy-farmers of the European continent. In the methods of feeding, except as to the exclusion of turnips, there is not much variation from the systems pursued in this country. There, also, large quantities of distillery refuse are used as food for cows giving milk. In winter the cows are in many cases fed chiefly on hay, linseed-meal, linseed-cake, beans, and distillery refuse, some giving as much as 6 to 7 lb. of linseed-cake per day.

Mr Carrington Smith's Practice.—An experienced Staffordshire farmer, Mr T. Carrington Smith, Adamston, Rugeley, says: "It is my practice to chaff all the straw used as fodder, with the addition of chaffed hay and pulped swedes. Whilst the chaffing and pulping are going on simultaneously, some rice-meal is added to the whole mass. From this heap all the dairy cows, whether dry or in milk, are fed, and they all receive also one foddering of long hay, say at 5.30 P.M. Those cows which are in milk receive in addition 4 lb. of linseed or cotton-seed cake, and 2 lb. of meal. I do not attempt to weigh chaff, pulp, or long hay. The cows may be said to be fed *ad libitum*, and the proportions of straw, hay, and swedes are regulated principally by the actual qualities of the hay and straw and the quantity in store of the roots.

"Cows vary so in their appetites that it seems to me almost impossible to lay down a standard ration applicable to all. We try to fodder all in such way that there shall be no waste, and careful regard is had to apportion the constituents of food used relatively to each other in such sort as to keep the evacuations in the right degree of thickness, avoiding scour on the one hand, and constipation on the other. Again, the cows not in milk during the winter are turned out in the pasture for a considerable portion of the day, and therefore they supplement the fodder they receive in the sheds by the grass and foggage to be found out in the open field. In winter the first feed of chaff-mixture takes place at 6 A.M., the second at 7.30, the third, on coming in from pasture, at 3 P.M., the fourth at 4.30, the fifth (long hay) at 5.30. If the weather be severe, an additional serving of chaff-mixture is given."[3]

Feeding in Norfolk Dairies.—At Necton Hall, Swaffham, Mr R. Harvey Mason keeps a herd of well-bred red polled cattle, largely but not entirely for dairying, "therefore the health and

[1] *Jour. Royal Agric. Soc. Eng.*, xviii. 483.
[2] *Ibid.*, xix. 391.
[3] *Live Stock Jour.*, May 13, 1887.

breeding of the cows has the first attention." His system of feeding, and the cost of the food, are stated thus:—

Cost of Feeding Cows.

Each cow.

From May 1 to September 18—				
20 weeks on grass	£0	2	6	= £2 10 0
From September 19 to October 31—				
Grass	£0	1	6	
2 bushels roots (white turnips, 10s. per ton)	0	0	6	
7 lb. cotton-seed meal, £5, 15s. per ton	0	0	4½	
7 lb. palm-nut meal, £4, 2s. 6d. per ton	0	0	3	
Six weeks at	£0	2	7½	= 0 15 9
From November 1 to March 4—				
7 bushels roots, swedes and mangels, 13s. 4d. per ton	£0	2	4	
7 lb. cotton-seed meal	0	0	4½	
7 lb. palm-nut meal	0	0	3	
3½ stone meadow-hay, chaffed, £4 per ton	0	1	9	
Eighteen weeks at	£0	4	8½	= 4 4 9
From March 5 to April 30—				
3½ bushels roots, swedes and mangels	£0	1	2½	
7 lb. palm-nut meal	0	0	3	
14 lb. undecorticated cotton-cake, £4, 12s. 6d. per ton	0	0	7	
1¾ stone meadow-hay	0	0	10½	
Eight weeks at	£0	2	11	= 1 3 4
Each cow, total the year				£8 13 10

"From May 1 to October 11 the cows were out both by night and day, and only in the house at milking-time, during which time, from September 18, they were fed as above. During the whole winter they were on the pasture a portion of every day, at which time they had the roots. Immediately on being milked, they are turned loose into a large covered yard, but whilst in it they get nothing to eat. The hay, meals, and cake are all mixed together, and given to the cows to eat while tied up in the house for milking."[1]

Mr G. M. Chamberlin, Stratton Strawless Hall, Norwich, states that during the winter months he gives his cows (Shorthorns, Ayrshires, Jerseys, and Guernseys), according to their size and milk-product, from 3 to 3½ bushels per day of a mixed food, consisting of mangels, bran, surplus corn of the farm, linseed, malt-combs, hay and wheat chaff.

Feeding in Jersey Herds.—In the leading herds of Jersey cattle in England, a very careful and systematic course of feeding is pursued. These delicate and heavily milking little cows require liberal feeding during winter. The system pursued by Mr J. F. Hall, Erleigh Court, Reading, is a fair sample of good management. He endeavours to feed so as to increase butter productiveness. Artificial food—*i.e.*, ground oats, maize-meal, decorticated cotton-cake, and bran—are given in limited quantities all the year round, but *forcing* has never been attempted. The soil being gravel, the grass is of a light character. The cows are turned out to grass in the latter end of May, and remain out till mid-September. During the winter months they receive, in addition to artificial food, hay, carrots, and parsnips, and ensilage (meadow-grass stored in silo); also mangels in late winter. The daily allowance of each food is given in the table annexed. Sweet ensilage is very valuable, as it is a cheap food, easily procured, and gives an excellent colour to winter butter, besides promoting the flow of milk

Food Record, exclusive of Grass, 1886.

Per Cow per Week.	Mixed Meat.	Hay.	Bran.	Ensilage.	Carrots and Parsnips.
	lb.	lb.	bush.	lb.	bush.
Jan. to March	42 - 56	56-112	¼	196	1
April to June	52½-35	56 - 14	...	...	...
July to September	35 - 38½	...	...	...	...
October to December	38½-42	28	...	196	1[2]

[1] *Live Stock Jour.*, May 13, 1887.

[2] *Ibid.*

In Lord Braybroke's herd of Jersey cows at Audley End, Essex, the winter feeding is as follows:—

October.

	Pecks.
Crushed oats	½
Wheat-germ meal	½
Malt-dust	¼
Straw and hay chaff and cabbage	2

On grass about nine hours each day.

November to March.

Crushed oats	½
Wheat-germ meal	½
Malt-dust	¼
Dried grains	¼
Straw and hay chaff and cabbages	2 or
Carrots, parsnips, or mangels .	10 lb.

On grass from one to four hours each day, according to the weather.[1]

Mr John Swan, Stonefield, Lincoln, feeds his Jersey cows in winter with silage (made from grass, rye, buckwheat, vetches, and maize), and 2 lb. oatmeal and 2 lb. of bean-meal, or an equivalent of cotton-cake or linseed-cake and bran daily. The same quantities of these concentrated foods are given summer and winter.

An Irish System.—Mr Smith Barry has a large dairy herd of cross-bred and shorthorn cows in County Cork, and the food given in winter consists of 50 lb. roots, 10 lb. hay, and 4 lb. of barley-meal and crushed oats; the roots are grated, and about 5 lb. of hay chaffed and given to the cattle in equal portions with the corn, at 6 A.M. and 4 P.M. every day; the rest of the hay is given the last thing at night. The cows have a run over the pasture every tolerably fine day. In summer the cows are on pasture day and night, except in very hot weather, when they are kept in during the hottest part of the day and given some vetches or other soiling.

Mr Richard Barter's System.—At St Ann's Hill, County Cork, Mr Richard Barter maintains a large dairy of mixed bred cows, chiefly shorthorn crosses. As far as he can he pursues winter dairying; and his cows, when in full milk during the winter, are fed as shown in the following table, which also indicates the cost of the ingredients of the food and the value of the manurial residue[2]:—

Daily Food.	lb.	Dry substance.	Albuminoids.	Fat.	Carbohydrates.	Price per Ton. £ s. d.	Cost of Ration. d.	Nitrogen.	Phosphoric Acid.	Potash.
Hay . . .	7	6.	.67	.17	2.87	2 0 0	1.5	.12	.036	.13
Gorse . . .	42	10.5	1.33	.37	3.35	0 12 0	2.7	.276	.074	.168
Mangels .	42	4.83	.5	.042	3.44	0 10 0	2.25	.074	.029	.164
Grains . .	7	1.58	.336	.098	.679	0 1 8 per bus.	1.	.05	.03	.003
Oats and barley	6	5.19	.7	.24	3.52	4 10 0	2.89	.108	.04	.028
Bran . . .	2	1.72	.28	.08	1.	5 15 0	1.21	.044	.064	.029
Total .	106	29.82	3.816	1.	14.859		11.55	.672	.273	.522
Equivalent of fat— 1 × 2⅓					2.333	Deducted for 10 quarts milk .		.16	.051	.046
					17.192			.512	.222	.476
Albuminoid ratio, 1 to . .					4.5					

	s. d.
Cost of ration per week . .	6 8¾
Value of residue per week .	2 5¾

Value of residue . .	4¼d.
Taking nitrogen at .	5d. per lb.
Phosphoric acid at	3d. "
Potash at . . .	2½d. "

[1] *Live Stock Jour.*, May 13, 1887.

[2] *Jour. Brit. Dairy Far. Assoc.*, ii. 127.

Feeding Cows in Ayrshire.—The great development of the cheese industry in Ayrshire has induced the farmers in this county to give careful attention to the feeding and management of cows. In this part of the country the Ayrshire breeds hold undisputed sway. Mr Andrew Allan, Munnoch, is well known as an experienced and successful breeder of Ayrshires, and his system of feeding cows in winter and spring is as follows: The cows are allowed to go dry for about three months during winter, as is the case on most farms where cheese is made, and in that period they are fed thus: 5 A.M., oat-straw, 5 lb. each; 7 A.M., soft turnips, 20 lb. each; 7.30 A.M., oat-straw, 5 lb. or so each; 10 A.M., oat-straw, 5 lb. or so each; 11 A.M., out for exercise and water; 2 P.M., brought inside and get oat-straw, same quantity as before; 4.30 P.M., soft turnips, 20 lb. each; 5 P.M., oat-straw, 20 lb. each; 8 P.M., oat-straw, 20 lb. each. The cows mostly calve in March and April, after which the feeding is as follows: 5 A.M., hay, 4½ lb. each; 7 A.M., boiled roots, with chaff or cut hay mixed with bean-meal, 2½ lb. of meal each; 7.30 A.M., hay, 4½ lb. each; 10 A.M., ditto; 11 A.M., put out to a court for water, and hay when brought in, same quantity as before; 4.30 P.M., steamed or boiled roots with chaff or cut hay, and 2½ lb. of bean-meal per cow; 5 P.M., hay, 4½ lb. per cow, with the same quantity of hay at 8 P.M.; then left for the night.

Feeding in Lord Egerton's Dairy.—Lord Egerton of Tatton keeps a dairy herd consisting of Dutch and shorthorn crosses. The amount of cake and corn allowed per head is 4 lb. daily; but the quantities each cow receives depends upon her size and the milk she is giving. To a cow in full milk as much as 7 lb. daily is given both in summer and winter; and for the first fortnight after calving all heavy milking cows have two quarts of oatmeal-porridge, with a small quantity of skim-milk added, twice daily. The cake and corn are mixed with chopped hay and straw in winter, and with green meadow-grass or comfrey in summer. The Indian corn and peas are sent out from the mill in the form of meal, ground together in the proportion of two of Indian corn to one of peas. The cotton and linseed cakes are mixed in equal proportions.

Feeding in a Tyneside Dairy.—Mr William Trotter, South Acomb, Tyneside, states that in winter he gives 6 or 7½ lb. of barley, or a similar quantity of equal proportions of barley and maize-meal, with about 21 lb. of hay and 42 lb. of turnips per day. The most satisfactory and economical mixture he had tried was made up thus:—

	Per ton.		
2 tons of coarse barley, at	£3	5	0
1 ton best barley-meal, at	5	10	0
1 ton of wheat sharps, at	4	10	0
1 ton of oatmeal-dust, at	1	10	0

The cost of this mixture comes to 5½d. for 14 lb., or £3, 13s. 4d. per ton. Mr Trotter has given up using cotton-cake as food for cows. When it was used he had often lost cows from milk-fever; but since discarding the cotton-cake he has not lost a cow from this cause.[1]

Wintering Dry and Breeding Cows.—It will be observed that the foregoing notes relate mainly to the feeding of cows where the production of milk is the chief, or at any rate a specially important consideration, and where, on this account, the cows are fed with such quantities and qualities of food as are calculated to stimulate and maintain a bountiful flow of milk. In herds in which the yield of milk is a secondary consideration, the systems of feeding are somewhat different, and, as a rule, the rations are arranged upon a more moderate scale.

Then, in all cases, cows are fed more sparingly when not giving milk. By far the most general practice is to feed dry cows upon oat-straw or hay and turnips or mangels. The Ayrshire system, as described above by Mr Allan, Munnoch, is fairly representative of the prevailing custom in Scotland, although there is, of course, considerable variation both in the hours of feeding and the quantities allowed. Formerly turnips were given to cows much too freely. Large meals of cold watery turnips are positively injurious to cows that are heavy in calf; and in all respects it is better practice to feed roots sparingly to cows. From 40 to 50 or 60 lb. of roots per day, given in

[1] *Jour. Royal Agric. Soc. Eng.*, xxiv. 231.

two meals, are now very general quantities in well-managed herds, and with plenty of good sound fodder, either oat-straw or hay, or both, the cows should thrive well and sustain no harm upon these allowances. Still dry cows may be kept in good condition with even less than 40 lb. of roots, as is often the case where the pulping system is pursued, or where recourse is had to warm mashes composed of cheap food, largely of chopped hay, straw, chaff, and perhaps a few roots. In England, as already indicated, dry cows are usually kept on hay and straw and turnips and mangels, and in many cases they receive no roots of any kind. With plenty of good hay, or hay and silage, a run out daily—in fine weather, of course—free access to water, and perhaps a small allowance of bran or some other cheap food, they thrive fairly well.

Professor M'Connell on Wintering Dry Cows.

Writing (for this edition) upon the wintering of dry cows, Professor Primrose M'Connell says:—

"These cows, it is assumed, have been yielding milk during the previous summer, having dropped their calves sometime in the spring months, and it may also be assumed that their produce has been made into cheese or butter, or disposed of in some way that does not require a supply of milk to be kept up through the winter. In such cases it is usual to have the cows keeping up a flow of milk for about eight or nine months out of the twelve, not because they are not able to milk for a longer period, but because that at the appearance of winter their united yield has fallen so low as to make it less worth the trouble of manufacture, and because the quality of the produce from hand-feeding is liable to be inferior to that produced on the summer pastures. The feeding of the actually dry animals is thus in winter carried on over a period of only some three or four months. The change from pasture to this diet is generally very gradual, and covers a space of at least one month, about October and the beginning of November.

"As soon as the grass begins to fail in autumn on farms where roots are grown, an allowance of these—say, 28 lb. daily per head—is meted out, usually in the morning immediately *after* milking. In this way the objectionable flavour is dissipated before the next milking comes round. Cabbages are generally the first to be used, followed next in order by soft turnips, then swedes, and so on according to the supply of each. Cabbages have obtained a pre-eminent name as food for dairy cows; and all dairymen—especially those holding clayey land—endeavour to have a good acreage of them.

"Some farmers scatter a supply of roots about the pastures, and also the tops of those being raised and pitted. This, however, cannot be called a good practice, for the reason that the animals, in place of looking after grass, will continue to nibble away at the roots, and thus increase the chances of tainting the milk. Moreover, an excess of such watery food as turnip-tops often ends in an attack of scouring very difficult to cure.

"As soon as the nights become cold and stormy, the animals are kept indoors, and must then, in addition to the foregoing, get a supply of oat-straw or meadow-hay as fodder — say, 4 lb. per head in the morning, and 8 lb. as the last thing at night. Where ensilage is used, it ought to take the place of roots; and it is probable that in the near future turnips and other root crops will give place to ensilage for milch cows.

Putting Cows dry.—"Towards the middle of November the animals are generally put dry, partly by stinting their food for a few days, and partly by refraining from milking as long as the animals do not feel any distress. They usually require to be stripped out at intervals while being dried, so as to prevent the engorgement of the cavities of the udder from the coagulation of the milk, and the giving rise to mammitis, with suppuration and sloughing of a part. Mild cases of mammitis—called "weed," or catarrh of the udder—often arise from a chill, and require to be treated with a mild blister, such as ammonia liniment.

"It is usually not difficult to put the milk off the cows, and when dry they may then be turned on to a cheap and simple diet. In many cases this consists of turnips with hay or straw alone—mere 'maintenance diet'—in which the animals get only what keeps them living in health and no more.

Stinted Feeding of Dry Cows Injudicious.—"Modern experience has taught us, however, that this is a mistake, and that something more ought to be added on. It must be remembered that the cow is carrying a calf, and at the time of putting dry is about the fifth or sixth month of pregnancy, when she requires almost as much food for the development of the fœtus as was necessary before for yielding milk. In addition to this, it is found that if the animal's system has been allowed to get too low before parturition, she never milks so well during the next season. In fact the summer may be half over before she can be again worked up to a full-bearing state by extra food. For these reasons, it is generally a wise policy to feed the dry cows fairly well, and give a pound or two of linseed-cake daily, or some bean-meal in the mash, or whatever other concentrated food may be at hand.

Caution against Milk-fever.—"Care must be taken, however, not to overdo cows in this respect, for fear of the deadly disease known as 'milk-fever,' which is induced by overfeeding, and a too plethoric state of the body at parturition.

Cotton-cake and Milk-fever.—Decorticated cotton-cake in particular has a bad name in this respect, its great richness in nitrogenous material producing, as it were, a corresponding excess in the blood and tissues of animals consuming it.

Rations for Dry Cows.—"The following tables will exemplify the methods of feeding and times adopted by farmers in different parts of the country for cows actually dry in the dead of the winter.

1.

6 A.M.	Straw.
8 "	20 lb. pulped turnips, 10 lb. chopped straw.
12 NOON.	Hay.
3 P.M.	1½ lb. linseed-cake.
6 "	Straw.

"The fodder not restricted.

2.

7 A.M.	Straw.
8 "	56 lb. roots.
12 NOON.	Straw.
3 P.M.	4 lb. bean-meal.
6 "	Straw.

"Straw *ad lib.*, and the bean-meal made into a dough with hot water and thoroughly 'burst' before giving in a lump.

3.

5 A.M.	Mash.
7 "	Straw.
12 NOON.	Hay.
4 P.M.	2 lb. linseed-cake.
7 "	Straw.

"The mash in above consists of 5 lb. chop with 2 lb. of bean-meal, all soaked in boiling water

4.

7 A.M.	Straw.
8 "	28 lb. roots.
12 NOON.	Hay.
4 P.M.	28 lb. roots.
5 "	Straw"

Feeding Cows in Pure-bred Herds.

In high-class herds of pure-bred stock there is, perhaps, even greater variety in the system of feeding cows than in other stocks. Some breeders always keep their stock in high condition, giving the cows in winter not only straw, hay, and roots, but also 2, 3, or 4 lb. of cake or meal, or a mixture, perhaps, of cotton-cake or linseed-cake, and bruised grain, Indian corn, or bran—feeding them as liberally, in fact, as represented in any of the dairy herds referred to above.

Alnwick Park Shorthorns.—In the Duke of Northumberland's valuable herd of shorthorn cattle at Alnwick Park, "the food of the cow in winter, when she is in milk, consists of hay, with an allowance of two mashes (a mixture of bran and bean and Indian meal) given night and morning; and when not in milk, it is hay and 2 or 3 lb. of bruised cake in the day. When turnips or mangel-wurzels are plentiful, an allowance of three or four stones *per diem* to each cow has a most beneficial effect. An outrake in winter, where a good deal of rough herbage has been left from summer, is considered almost indispensable, especially if no roots are given."[1]

Dereham Abbey Shorthorns.—In one of the best-known shorthorn herds in England, that of Mr Hugh Aylmer, West Dereham Abbey, Norfolk, the cows are fed sparingly. During the summer months they get grass only; in winter long hay, if

[1] *Jour. Royal Agric. Soc. Eng.*, xvi. 395.

hay happens to be plentiful; if not, cut hay and straw mixed. They have no roots, but go out to grass every day in winter. If the ground is clear of snow, they thus get a little picking of grass; while the snow lies they have no green food, yet the air and exercise keep them in health, and they can help themselves to water *ad libitum*. Mr Aylmer's opinion is confirmatory of the belief that too large a proportion of turnips has a tendency to cause abortion, and he never allows his in-lamb ewes to have any.[1]

Ardfert Abbey Shorthorns.—In Mr W. T. Talbot-Crosbie's celebrated herd of shorthorn cattle at Ardfert Abbey, County Kerry, Ireland, a very careful system of feeding is pursued. "In the winter the breeding cows get nothing but straw, turnips, and water, until they calve, except for about a week before calving, when they get scalded bran. Soon after calving their warm bran-mashes are discontinued, and they have hay, turnips, and bran wetted with cold water. If, as is sometimes the case, a calving cow has become on this ordinary keep very fat, a little linseed-oil is given to her on pulped turnips. As a rule, very little, if any, medicine is given. Regulation of the system of diet is preferred to physic. No cake is given to breeding cows; but if, as is not usual, a yearling heifer happens to be in calf, she has, if she seems to need it, a little oilcake to keep up her strength and condition. In the ordinary way the heifers live their second winter on straw and turnips."[2]

Polled Aberdeen-Angus Herds.—In Sir George Macpherson Grant's famous herd of Polled Aberdeen-Angus cattle at Ballindalloch, cows get from 40 to 50 lb. of turnips in two meals, supplemented by a mixture of about 1 lb. of bran, 1 lb. of crushed oats, and 1 lb. of linseed-meal, in a mash of cut straw and chaff. For about three weeks before and three weeks after calving, cows get about 2 lb. of linseed-cake per day. The overfeeding of breeding stock is studiously avoided, and the result is that the herd has been more than ordinarily prolific.[3]

Mr Hannay of Gavenwood, Banff, gives nothing during winter to his Polled Aberdeen-Angus cows excepting turnips and straw, until within six weeks of their calving, when they get 3 lb. of oilcake daily, and this allowance is usually continued for a month or so after calving.[4]

Hereford Herds.—In the milder and richer grazing parts of England, cows spend a great deal of their time, and pick up not a little of their food, out of doors all through the winter. This is the case in many noted herds of Hereford cattle. In Mr John Hill's valuable herd of Hereford cattle at Felhampton Court, Church Stretton, Salop, the earlier calving cows are put up at nights about November and fed with straw—a little hay and a few turnips if they can be spared. When they calve their food is increased, perhaps a little meal is added —to keep up the supply of the milk in winter, this is often necessary. The late calvers are wintered entirely out of doors on the pastures, where there are rough sheds. These fields are allowed to grow well in the autumn, and get full of foggage. In the winter of 1885-86, about 50 cows were thus wintered, and had no assistance before February, when they received a little straw and rough hay drawn on to the fields in the mornings. As the cows spring for calving, they are put into the house.[5]

At Rockview, in the fine grazing district of Killucan, Ireland, Mr R. S. Fetherstonhaugh also leaves his cows out on the pasture all winter, only taking them in just before calving. These instances, however, although very numerous, are exceptional, and are confined to first-class grazing districts.

The general system is to house the cows as soon as winter sets in, and feed them upon straw, hay, and a moderate allowance of roots, or upon hay and straw alone, with plenty of fresh water, or perhaps with the addition of a little bran, cake, or bruised grain. When the weather is dry and not very cold, it is desirable to let the cows and all store cattle have a run out in the fresh air about mid-day. When the weather is wet and stormy, or very cold, they are much better in the house.

[1] *Jour. Royal Agric. Soc. Eng.*, xvi. 416.
[2] *Ibid.*, 423.
[3] *Hist. of Polled Aberdeen-Angus Cattle*, p. 386.
[4] *Ibid.*
[5] *Hist. Hereford Cattle*, p. 275.

Winter Dairying.

The various systems of dairying will be noticed fully in subsequent divisions of the work. Here it may be mentioned that increased attention has lately been given to the production of both milk and butter in the winter months. At this season of the year fresh butter is always scarce and dear, and it is contended by many that the extra price obtained for both butter and milk in winter would more than counterbalance the greater expense involved in maintaining cows in milk during the cold months of winter. Latterly the consumption of fresh milk in towns has increased vastly, and in winter the supply is rarely equal to the demand; thus giving additional stimulus to winter dairying.

This winter dairying is confined mainly to farms near railway stations and towns where the new-milk trade is followed, or where there is a good demand for fresh winter butter. The expense of maintaining the production of milk and butter in winter must be considerably higher than it would be in summer, and it could not be safely attempted except where there is a ready sale and high prices for the produce.

Where this system is pursued, cows drop calves at various times throughout the year, so that there are some in full milk in the winter months as well as in other seasons. Cows giving milk in winter have to be fed liberally and kept in comfortable well-aired houses. The various methods of feeding to stimulate a full flow of milk have already been described, some of the warm rations recommended by Professor M'Connell being specially adapted for this purpose.

Mr R. Barter, St Ann's Hill, County Cork, is an enthusiastic advocate of winter dairying. He thinks that the extra cost it incurs in labour and food will be more than made up by the following advantages which he claims for the system: "(1) Cows carried through the winter, and in profit, at a season when milk and butter command the highest prices; (2) cows calving in December and January give the largest return of milk—for, say, ten months in milk—as they come on a second spring of milk when they get the grass at the end of April and in May, and yield during the summer nearly as well as if calving in March; (3) the calf is reared in time for the grass, and so has the whole summer to grow and mature, and, if vealed, is sold when veal is dear; (4) a large quantity of manure is made, and the land steadily improves from the quantity of feeding stuffs consumed on the farm; (5) a market at home for most of the farm produce, and not selling grain, &c., at such prices as are now ruling; and (6) a much better chance of commanding a higher average price through the year for milk and butter by keeping up a continuous supply."[1]

WINTER HOUSING OF STORE CATTLE.

The influence of locality is very great, and must be carefully considered by the successful stock-owner. In the cold regions of the north, even the young store cattle have to be housed throughout the entire winter. In the greater part of Ireland, and in the southern and milder parts of Great Britain, young growing cattle spend a good deal of the winter, when the weather is dry and favourable, on the pasture-fields. Between these two extremes of *in* all winter, and *out* all or the greater part of it, there are many gradations, which farmers must judiciously and carefully arrange for themselves. So much depends upon local circumstances as to climate, house and field shelter, class of cattle, supply of outdoor and indoor food, &c., that a series of hard and fast rules cannot be laid down.

Err on the Side of Shelter.—This one rule, however, we would lay down with all the emphasis and firmness that can be given to it. It is better to err on the side of caution—better to have the animals *inside when you think they might perhaps suffer little harm by being out, than outside when they would have been better in.* How often is it the case that even a reputedly careful farmer allows his cattle to remain out on the fields when he *thinks* they *might* be *as well in?* As well in." Depend upon it, that means that the animals ought to be inside. The *thought* may or may

[1] *Jour. Brit. Dairy Far. Assoc.*, iii., 128.

not be expressed—when there is *thinking* in the play, be it ever so little, *always* let the animals have the benefit of the doubt—and the shelter too!

Fresh Air for Cattle.—Not for a moment would we depreciate the value of fresh air for cattle. Fresh air is most essential, more particularly perhaps for young growing cattle. But it is easy to provide this without exposing the cattle to excessive cold, and drenching, chilling sleet, and winter rains. Cattle certainly cannot thrive well in close, stuffy, ill-ventilated houses. But while a few farmers are so careless as to let their cattle suffer in health, and be retarded in progress by want of proper ventilation or fresh air, the prevailing error is entirely the other way.

Loss from Exposure to Bad Weather.—It is not in the least overstating the case to say that for every twenty shillings lost by want of ventilation in cattle-houses, there are hundreds of pounds sterling sacrificed by the exposure of cattle to inclement weather. If the value of property, in the shape of raw material for producing meat and dairy produce, which is lost every year through the imprudent and avoidable exposure of cattle to inclement weather, could be accurately stated in plain figures, the vastness of the sum would astonish everybody, no one perhaps more so than the defaulting stock-owners themselves. It would certainly run into millions of pounds sterling per annum!

For be it remembered that exposure to bad weather does more than retard the progress of cattle. It likewise incurs great waste of feeding material. While the animals are thus exposed more food is required to maintain the animal heat, not to speak of increase either in size or condition. It is a proverbial saying amongst observant if not always pains-taking farmers, that cattle will thrive better upon moderate feeding with sufficient shelter, than with all the food they can eat in exposure to cold and wet.

"By exposure to wet or extreme cold, and by lying, through cold nights, on wet beds, cattle are not only retarded in progress, but often thrown back in condition, and perhaps permanently injured in constitution—stunted in growth, and rendered less able to turn to good account good food and judicious treatment when these are bestowed upon them. Farmers think little of having their cows or lean stock exposed to an excessive cold or wet. How great an error it is! They would never think of so exposing animals being prepared for slaughter, because the ill effects of the exposure would thus at once become manifest. But all the same, although the loss may not be so great or so apparent, the exposure of cows and young lean stock is certain to cause damage to valuable property.

"If the animals do not go back in condition, the cows fall off in milk, the young stock lose flesh and rate of growth, they must be consuming an excessive amount of food—because under exposure to cold, an abnormal amount of food is required to keep up the necessary standard of animal heat. So much of the food consumed goes to keep up the animal heat, the rest to promote growth, lay on flesh and fat, or encourage the flow of milk. The greater the cold the animals are exposed to, the more food is required for the vital functions, and, as a natural consequence, less of the food consumed becomes available for increase of size, condition, or of flow of milk. These are mere truisms, but I repeat them here, with the view of urging them upon the attention of those who are mainly concerned in the matter. It is sad to think how easy-going farmers are on these points, which so very materially affect their welfare."[1]

These remarks are applicable to all classes of cattle, but they are introduced here because it is in the management of store cattle that the careless and injurious custom prevails most largely. Again, harm is done to cattle by exposure to excessive heat as well as to extreme cold. Fuller reference will be made to the former point, in speaking of the summer treatment of cattle. And we discuss the question of housing here, because the housing and feeding are in this particular connection quite inseparable.

Economical Rearing of Cattle.—The proper housing of cattle has much to do with their economical feeding.

[1] *Our Resources in Live Stock.* J. Macdonald.

It is perhaps not overreaching the mark very far to say that the thriving of store cattle in winter is regulated almost as much by how they are housed or sheltered as by the system of feeding. This statement will suffice to show the young farmer that, if he wishes his cattle to make satisfactory progress, if he desires to secure in his store cattle the greatest possible progress, at the lowest possible outlay of time and money, he must give as careful attention to shelter as to feeding. Unfortunately this is not always done.

It cannot be said that even our best-known systems of cattle-feeding are as good as they might be, for we are always learning—constantly discovering that in some little point or other former practice was in error. But, as a rule, greater attention has been given to the question of feeding than to housing, and other points in the management of cattle. In very many cases, farmers who are known to be liberal and careful feeders, are lamentably negligent in providing proper shelter for the stock. More particularly does this remark apply to England and to Ireland—still more notably to those very districts in which comparatively little house or shed accommodation would supply all the shelter that is required.

Page after page might be written illustrating the mischief that is done by the imprudent exposure of stock. The practical man, however, must already be fully aware of the character and extent of the evil, and the student is assured that he need have no hesitation in accepting the truth and soundness of the general statements just made on the subject.

Turning over a New Leaf.—Now, turning our back on the errors of the past, we will endeavour to proceed with the winter feeding and management of young store cattle, upon lines and in a manner calculated, according to our present lights, to ensure the best possible results with the greatest possible economy.

The winter is before us, with its many moods of weather—rain, sleet, snow, biting winds, and bitter frosts, interspersed with occasional bright genial glimpses, which are always welcome, sometimes deceptive. Most probably the cows and fattening stock are already assigned to their winter quarters,—for cows giving milk, and cattle being pushed on for slaughter, should be housed as soon as the weather begins to get chilly. The young store cattle are still on the fields; but now the question of how they are to be efficiently protected from the rigours of winter must have *immediate* attention.

The First Essential.—The matter of feeding will not be touched till that of housing or providing shelter has been satisfactorily settled. First, let us see that the young animals are provided with protection from the winter blasts, that they are, as it were, rendered independent of the weather — provided with quarters in which the severest storms and frosts of winter cannot reach them, or retard their progress. Let this be the *first essential;* and, when it is fulfilled, we can consider the systems of feeding with the confidence that, however they are fed, the animals will be able, in spite of the character of the weather, to turn the food to the best possible account.

How, then, is this winter shelter to be provided? By various means, regulated mainly by the climate—by a close house with substantial wall and roof, an open wholly or partially covered court, or by a temporary-looking shed, with light side-walls and just roof enough to ensure a dry bed for the stock.

Houses for Cattle in Cold Districts.—Where the winter is long and usually severe, as in the greater part of Scotland and higher parts of England and north of Ireland, substantial houses have to be provided for all kinds of cattle in winter; but where the winter is usually mild and open, very cheap erections are quite sufficient for store cattle. In cases where close houses or courts are required, care should be taken to have them well ventilated; for, as already stated, "stuffy" houses, which get filled with impure air, are very detrimental to the health and progress of cattle, while fresh air, *properly admitted*, is highly beneficial. The words *properly admitted* are emphasised, because it is very important that live stock of all kinds should be protected from draughts—that is, the currents of air necessary for ventilation should not be allowed to play directly upon the animals. Let out the foul and in the fresh air by carefully placed ventilators. Depend upon it, cattle, by better health and increased progress, will amply repay the farmer for careful attention to the matter of ventilation.

Cattle-sheds in Southern Districts.—Going at once from the one extreme to the other, from where the winter is severest to where it is mildest, we find in the latter parts simple forms of winter shelter for store cattle used with satisfactory results. Very often it is a large open court, with access to a roofed compartment where the animals can take shelter from rain or snow, eat their food, and lie over night. Perhaps a roof is thrown over a portion of the court—a roof of sheet-iron or wood resting upon the wall of the court at one side and upon pillars at the other. The roofed compartment may be merely a "lean-to" on another building. It matters little how it is provided, and in these mild districts it need not be costly, substantial, or elaborate. Be sure that there is plenty of roofed space to protect the cattle from rain, to enable them to eat their food in comfort, and have a dry warm bed. A drenching with rain in winter is exceedingly injurious to cattle, and above all guard against this. Store cattle need not be kept in such a *warm* temperature as milking cows and fattening cattle. Keep them dry and *comfortable*, and so long as *comfort* is secured, the young growing animals will be all the better of some open space to move about in when the weather is favourable. It is easy to discover when the animals are comfortable; the merest tyro can tell by their appearance when they are not so. Never forget, when you see your cattle wet, cold, and shivering, that great and avoidable waste is going on—waste of food and waste of time, which mean in the end considerable waste of hard cash.

Cattle-courts.—Between the close byre and open court and shed there are many forms of winter shelter for store cattle. The most general is the partially covered court, which is perhaps, upon the whole, the most serviceable and advantageous of all. With surrounding buildings and boundary walls the court is usually well sheltered in "a' the airts the win' can blaw"; and with a half, two-thirds, or three-fourths of it roofed, there is ample protection from rain and snow.

The finer points, as to the relative merits of feeding in boxes, stalls, wholly and partially covered courts, will be referred to later on. Here enough has been said to show the desirability of exercising great care in the housing or sheltering young store cattle during winter.

WINTER FEEDING OF STORE CATTLE.

The variations in the systems of feeding young store cattle in winter are regulated mainly by (1) the locality and methods of cropping and general farming pursued; (2) the condition and time at which the animals are to be sold; and (3) the class and character of the stock.

Apportioning Home-grown Foods.—The farmer will have to consider and arrange at the beginning of winter what proportions of his supply of home-grown winter food, such as roots, straw, hay, silage, and grain, he is to allocate to the various kinds of stock. The proper allocation of the home supply of food amongst the various kinds of stock, and the careful distribution of that supply so as to make it extend evenly throughout the entire season, are points of the very greatest importance in farm management. For instance, too free use of roots or fodder at the beginning of the winter may cut short the supply before the next grass season comes round, and the blank thus created through want of forethought may have to be filled up at disproportionate outlay by the purchase of expensive foods.

At this particular time the farmer will take special note of the quantity of roots available for the young store cattle, so that he may be able to decide and explain to the cattle-man not only what daily allowance of roots is to be given to these store cattle, but also what kinds and proportions of other food will have to be provided for them. Probably the supply of roots available for the store cattle may decide whether or not the pulping system is to be pursued. If the supply of roots is very abundant, possibly the farmer may think it better to give the store cattle a liberal quantity of roots in the ordinary way by themselves, than to give a larger proportion of the roots to other kinds of stock or to buy in more store cattle. Circumstances alter cases; and the farmer must, at the beginning of every winter, consider carefully how he can turn the produce of his farm to the best possible account.

Economise Turnips.—Now that the turnip-break is being curtailed, it is more probable that the supply will be scrimp than abundant. In any case, it may prudently be urged as a general principle that farmers should endeavour to economise the turnip crop. It is the most costly and most risky crop in the ordinary rotation; and, all things considered, it is not by any means cheap food. As a rule, therefore, farmers should be encouraged to adopt methods which would advantageously economise the supply of roots, and render them less dependent upon the turnip-break than they have been in the past.

What Foods to be Bought and what Sold.—When it has been ascertained what quantity of roots can be had for the store cattle, the farmer will next consider what kinds and quantities of other foods are to be given to them. Whether these other foods are to be home-grown or bought, or part of both, will depend upon the supply of such home-grown foods as straw, hay, silage, and grain, and the current market prices of these and other commodities used as food for cattle. For instance, hay may be worth more in the market than as food for store cattle, so that it may be advantageous to sell hay, and—if the home supply of straw be deficient—buy oat-straw or some other food. Again, "ups" and "downs" in market prices may enable the farmer to derive profit by selling grain and buying maize, cake, or other food; or the home-grown grain may be selling so badly, and the cattle so well, that he may find it beneficial to use the grain in pushing on the live stock.

Advantage in Using Home-grown Food.—There is a growing tendency to use more and more of the home-grown produce as food for cattle and sheep, the great reduction in the price of grain being the chief influence in bringing this about. Other things being equal, there is an advantage in consuming instead of selling farm produce. It is true economy to make the produce of the farm "walk itself" to market, in the bodies of well-conditioned cattle, sheep, and swine.

No Hard and Fast Rules.—Yet farmers must not be tied by rules. They should sell their farm produce, and buy food whenever it is advantageous to do so. Thus it will be seen that if the farmer is to turn his produce to the best possible account, and rear his cattle as economically and efficiently as may be, he must be able to watch the condition and tendency of market prices, as well as the quality and quantity of his own crops, with keen intelligent perception, and sound, ready, and careful judgment.

Ages of Store Cattle.—Formerly there were two generations of *store cattle* to receive attention at the beginning of winter—namely, the calves of this and the previous year. Latterly, however, the adoption of the "early maturity" movement, of which more anon, has advanced the latter, the calves of the previous year, now from eighteen to twenty months old, into the ranks of *fattening cattle.*

Now, therefore, the winter feeding of store cattle begins with mere calves, some of them eight or ten months old, others considerably younger. Late calves may be either sucking their dams or receiving milk at the beginning of winter; but as a rule the calves will have been weaned from two to several months before then, and have become well accustomed to eat such foods as grass, hay, cake, and meal.

Care in beginning Winter Feeding.—In dealing more particularly with calf-rearing, the importance of keeping the calves progressing steadily from birth will be strongly enforced. "Never let your cattle lose the calf-flesh," is sound advice to give to farmers; and it is one which the farm-student should store up carefully in his mind. In this particular section of the work we take up the care of these young cattle at the threshold of winter. They are, as indicated, of various ages, mostly from six to nine months, and in good thriving condition. As the supply of grass diminished and the evenings became chilly, the calves had been receiving indoor food, such as cake, meal, vetches, grass, or hay. By degrees they are worked into their winter rations. It is well to avoid sudden changes in the feeding and treatment of cattle. Give small quantities of the new food at the outset, increasing the new and lessening the old, until almost imperceptibly the complete substitution has been effected.

Turnips and Straw for Store Cattle.—In the colder districts the young store cattle, which may now be said to have emerged from calfhood, will be entirely dependent upon house-feeding by the time the winter has fairly set in. In the turnip-growing districts the food throughout the winter will consist mainly of turnips and oat-straw. Very many farmers still give the young cattle all the turnips they can eat comfortably; but as has already been indicated sufficiently, the allowance of roots is being lessened with advantage.

Study the Animal's Appetite.—Where it is intended to feed the young store cattle solely with turnips and straw, and where there is an abundance of both roots and straw, the cattle-man may decide for himself, from time to time, by carefully watching the appetite and progress of the individual animals, what quantity of each kind of food is to be given to each animal. He will be careful not to gorge the young beasts with cold roots, for in all probability some of them, of a greedier disposition than others, would eat more turnips than would be good for them. Keep within the limit of sufficiency rather than overstep it. Do not on any account give more roots at one meal than will be eaten up cleanly without delay at that time. It is a bad, wasteful practice to have roots lying for hours before cattle. Valuable food is thus destroyed, and the animals thrive best when they have their stated meals at fixed hours, getting no more roots at each time than will be at once consumed. The same remark applies to meals and cake, but with straw and hay the case is different.

Feed Sparingly and Frequently.—The long fodder is usually, and ought always to be, supplied in a rack sufficiently high to be within easy reach of the animal's head. Many good farmers think it beneficial to have a little fodder always in the rack, so that the animals can take a mouthful when they feel the desire for it. There is something to be said for this, and the fodder in the rack is not so liable to get spoiled by the animal's breath, as are roots or other food lying in a box or crib lower down. Still it will be found more advantageous to supply the fodder sparingly and frequently than in large quantities at a time. The fresher and sweeter it is, the more keenly will it be relished by the animals; and if too much is given at a time, the cattle are apt to pull out more than they eat and waste it amongst their feet.

Feeding Hours.—The most general custom where the turnip and straw system prevails is to give the roots in two meals, one in the forenoon, between 8 and 10 o'clock, and another between 2 and 3 in the afternoon; and the fodder in three meals, between 5 and 6 in the morning, between 11 and 12 in the forenoon, and between 3 and 4 in the afternoon. In some cases a fourth meal of straw is given between 6 and 8 o'clock at night.

In many instances the daily allowance of turnips is divided into three meals, given at 6 A.M., 10 A.M., and 3 P.M.; and the young animals will be more contented and most likely thrive better with three small or moderate meals of roots than with the same quantity in two meals.

Different Kinds of Roots for Store Cattle.—At the outset, perhaps for two or three weeks, soft white turnips are given whole, "tops and all," but if the tops are very wet and muddy, they should be given very sparingly, or, better still, not at all, as in that condition they will be apt to cause scour. The white turnips are succeeded by yellows, and where a large proportion of swedes is grown, these take the place of the yellow turnips perhaps as early as the second or third week in November, probably not for several weeks later, according to the proportionate supplies of the two kinds of roots.

It is not often that the soft white turnips need to be cut; but in every instance yellow turnips and swedes should be cut for young cattle—for all kinds of cattle, indeed, whose teeth are not fully developed and in good order.

Roots, Cake, Meals, and Fodder for Store Cattle.—From choice or necessity store cattle are now being reared with much smaller allowances of turnips than in former times—say, prior to 1875. The advantages of this change have already been noticed. In certain cases the curtailment of the root-supply has been moderate, and little or nothing introduced in place of that withheld, excepting an increased quantity of straw or hay, and an offering of fresh pure water.

The more general plan, however, has been to give, along with the lessened allowance of roots, small quantities of other more concentrated foods, such as cake, bruised grain, bean-meal, or Indian corn meal, and the usual full supply of long fodder. With two small rations of roots, from 35 to 50 lb. the two, plenty of good oat-straw or hay, and from 1½ to 3 lb. of cake or meal per day, young store cattle will be found to thrive admirably. The allowance of meal or cake is usually given early in the morning, perhaps about 6 A.M., and the roots at from 9 to 10, and about 3 P.M.; the fodder as already stated. It is considered undesirable to give a large feed of cold roots upon an empty stomach in the morning.

In other cases where still fewer roots are allowed, these are given at one time, perhaps about 10 or 11 A.M., the concentrated food being given early in the morning and afternoon, the former meal smaller than the latter. Again, in some farms the whole of the cake or meal is given in the morning, and the roots reserved till the afternoon. It cannot be said that any one plan is best for all cases; but as a rule, at any rate where the animals run out daily, it is considered most suitable to give the turnips in the forenoon.

Where the animals are able to pick up a little grass outside, they will relish a feed of cake or meal as soon as they come in, and an allowance of fodder may be reserved till later in the afternoon. Where no food is to be had outside, the animals, after a run in the fresh air and a drink of cold water, will welcome a substantial ration of oat-straw or hay.

Southern Systems of Feeding Store Cattle.—In the principal grazing districts of England and Ireland, and also in the south-west of Scotland, where the climate is mild, and the winters comparatively free from frost and snow, the young store cattle are out on the pastures almost daily throughout the winter—out many a day when they ought to be in. Where there is a good deal of rough pasture, and where care is taken to have the animals comfortably housed at night and in wet or exceptionally cold weather, the young cattle thrive wonderfully well under this system, with but very little extra food of any kind. Most likely no roots are given, perhaps nothing but long oat-straw, or a little hay or silage, once or twice a-day. In other cases a small allowance of cake or meal, from 1 to 2 lb. per day, is given.

Occasionally in these parts the extra food is given in racks and boxes outside. This, however, is not a good plan. Let the animals have it under a roof, with a dry place to stand upon, where they will have plenty of fresh air, but be free from draughts.

It is not uncommon, indeed, to see turnips given to cattle on fields even in cold days in winter. In an exceptionally mild dry day there may be little harm in this, but, generally speaking, the practice is to be condemned. The animals will turn the cold roots to better account if allowed to consume them in comfortable quarters.

Pulped Food for Store Cattle.—As already indicated, the pulping system is specially serviceable in the feeding of store cattle. It enables the farmer to turn his straw and chaff to better account as food for stock than could be done otherwise. The straw of wheat and barley are not much relished by cattle when given by themselves, and cattle will not willingly eat chaff. Yet there is considerable feeding value in all these, and in a judiciously prepared pulped mixture cattle will eat them with appreciation. There is not the same advantage in pulping good oat-straw and hay, for if given in a fresh condition, and in small quantities at a time, cattle will consume these in the long form with exceedingly little waste. But the utilisation of the less palatable kinds of fodder is an important consideration, and this, together with its great influence in economising roots, commends the pulping system very strongly as a most useful agent in the rearing of store cattle.

Proportions of Pulped Mixtures.—Already, in describing the pulping system, full details have been given as to the manner of preparing pulped mixtures. The proportions of roots to other foods will, of course, depend largely upon the supply available for the store cattle. Some mix equal quantities, bushel by bushel, of pulped roots and chopped fodder; but a much smaller proportion of roots is more general. One bushel of pulped roots is often made to serve for two, three, or even more bushels of chopped fodder, and when the allowance of roots is very small, it is desirable to add to the mixture a little crushed cake, meal, or bruised grain, perhaps from 1 to 2½ lb. for each beast per day. Decorticated cotton-cake is most largely used for store cattle, but many give a mixture of this and linseed-cake or linseed-meal. The market prices should be watched carefully, and the kind of cake or other food bought which is comparatively cheapest at the time. Many careful feeders sprinkle a little common salt over the pulped mixture, and still a larger number sweeten it with dissolved treacle.

When it is intended to push the animals from their youth, and have them fattened at an exceptionally early age, the richer and more concentrated foods are increased in quantity.

FATTENING CATTLE IN WINTER.

"Meat manufacture," the chief function of the bovine race, is coming more and more within the domain of science. We are still, so to speak, but on the threshold of the great subject of the "science of cattle feeding." We have not kept pace with some other countries in the investigation of it, yet we do know a great deal more about early maturity, and the economical production of beef, than was known prior to 1870. There is still so much more to learn, and the spirit of inquiry has been so thoroughly aroused, that in all probability the acquisition of fresh knowledge within the next fifteen or twenty years will bring about greater changes in the practice of rearing and feeding cattle than have taken place in this industry during the past two decades.

EARLY MATURITY.

Farmers have, fortunately, learned to set a higher value than most of them seemingly did before both upon time and food. They are now turning both to better account than their forefathers did. The progress that has been made in the matter of "early maturity"—in the rearing of stock at a more rapid rate, and fattening them at an earlier age—has been very marked and gratifying. Along with this movement—as an essential element in it, in fact—has come a great saving of cattle food. Apart from the question as to the influence which this early "forcing" of stock may exercise upon the constitutional stamina of the bovine race—in regard to which some misgivings are entertained by eminent authorities, and as to which something may be said at a later stage—there can be no doubt that substantial immediate benefit has resulted from it to feeders of cattle. In feeding cattle, as in most other industries, time means money. It is important, therefore, that time as well as food should be economised. Indeed, the economical use of the one involves the thrifty use of the other, and by a careful study of these considerations farmers have raised their system of "meat manufacture" to a decidedly better footing.

The progress of the "early maturity" movement in the south of England is traced in the following notes, contributed to this edition by Mr Henry Evershed:—

Quick feeding has become the order of the day. As a certain quantity of food is necessarily required for respiration, the maintenance of heat, and other vital functions, a system which matures an animal for market at an early age must be based on a sound principle, since it reduces the total quantity of food required for these purposes.

With the progress of farming during the past 150 years a constant advance in the early maturity of stock has been accomplished. Southdown sheep, previous to the improvements of Ellman, were rarely fattened earlier than three years old. "They are now usually fattened," says Youatt, writing just before 1830, "after having completed their second year."

Improvement in Sheep.—Mr Ellman had begun his improvements by 1790, and through his system of careful selection he moulded the Southdowns into perfect shape and form, and by so doing placed them at the head of modern breeds. The early maturity of improved Hampshire Downs and Shropshires, and the recent improvements in Suffolk sheep, are all derived from admixture with Ellman's breed, and they are all accompanied by improved shape. Mr J. J. Colman's "Royal Newcastle," a Southdown, and the champion ram of the year (1887), is of course a perfect model. His length is great, but the extraordinary depth and thickness of the carcass make him appear a short sheep. His neck is the shortest possible, the head appearing almost to spring from the shoulders. A grand masculine head, with bright eye and fine fleece, complete the picture of this perfect meat-making creature. The judges described him in the *Journal of the Royal Agricultural Society of England* as a wonderful sheep, whose leg of mutton surpassed anything they had ever seen before in a one-year-old sheep. This picture is worth painting, because when "Royal Newcastle" was required on one occasion to prepare himself for exhibition in quicker time than usual, he clothed himself with meat with unparalleled speed. Perfect form, then, implies aptitude in feeding. Mr Youatt speaks of "those properties of form which evince a tendency to arrive at early maturity of muscle and fatness."

The Southdowns having been endowed with model form—by selection, not by inbreeding—sooner than any other breed, their earlier maturity was assured, and they were naturally used, as Youatt states, in modifying other breeds far beyond the limits of Sussex, whose short-woolled sheep formed the original type.

Early Maturity and Perfection of Form. — The same physiological law which connects early maturity with perfect form, from a butcher's point of view —a parallelogram without the angles— applies to other animals besides sheep. All the breeds have been improved in modern times. Probably the earliest example of a perfect model of form among shorthorns was the famous bull which Mr Collings "picked up in a lane." But there are now four or five breeds, besides the crosses between some of them, which are alike finished examples of what cattle should be—inflated parallelograms set up on fine legs, with the breast near the ground, just as they are seen at the cattle-shows.

Rapid Fattening of Cattle in Sussex.—The earliest reported examples of the very rapid feeding of recent years in the south of England came from Sussex, not far from Mr Ellman's parish of Glynde; and for the sake of showing the modern date of the system, it may be here stated that the earliest account of this practice in Sussex appeared in the *Journal of the Royal Agricultural Society of England* in 1878.[1]

Sussex System of Feeding for Early Maturity.—The Sussex method of preparing bullocks for slaughter at from 15 to 20 months old does not differ materially from that pursued in other districts. The calves are weaned at birth. The new milk they at first receive is soon replaced by skim-milk thickened with boiled linseed or oatmeal. They are gradually induced to feed on linseed-cake and hay. At 3 or 4 months old, up to 7 or 8 months old, their daily rations consist of 3 or 4 lb. of linseed-cake and bean-meal in equal parts, with a little hay and straw, half a bushel of roots, and a small quantity of salt. The cake and meal are gradually increased, till at 12 months old they get about 6 lb. each daily.

In summer their succulent food consists of various forage crops, such as trifolium, tares, grass, and second-cut clover. Some feeders allow the young bullocks to feed in a cool pasture during the daytime in summer. Others prefer keeping them indoors, in which case they do not quit their sheds till they are sent to the butcher.

The same principle of feeding is pursued in all cases, and the food is gradually increased, so that the beasts continually outgrow it, so to speak, till they are sold for slaughter.

Calves for Early Maturity.—Under ordinary circumstances a cow rears five calves while in milk; and the purchase of well-bred calves, which are alone adapted for early fattening, is an essential part of the system here described.

It is most important that the calves should be of the best possible quality.

1 "Early Fattening of Cattle," xiv. part I.

Ill-bred ones are always very unprofitable, and particularly so when quick feeding is attempted. In the larger dairy districts, calves in the season are plentiful, and are often sold at very low prices compared with their value elsewhere. It would be worth while, therefore, for those who rear calves for early fattening, to obtain them direct from the dairy counties, instead of buying them second-hand. They should be sent off in passenger trains at a week old, tied up in bags packed with straw, with the head at liberty.

Calf-rearing for Early Maturity.—The rearing of calves successfully is a knack dependent on experience and painstaking, and is so important in the business of early fattening that one or two other examples will not be out of place. A Staffordshire dairy-farmer with 100 cows, who has been successful in this department, says:—

"It is my practice to rear nearly 40 of my earliest heifer calves. They are not allowed to suck their dams; they have from 4 to 8 quarts of new milk per day, according to age, for three or four weeks. They are then fed with skim-milk, thickened with boiled linseed or oatmeal, and are taught as soon as possible to eat hay and a small quantity of linseed-cake. They are allowed to run out in a grass-field in May and June, and are then generally left out altogether, with a shed to run into in very wet weather, or to avoid the heat of the sun and the teasing of flies. The wet-nursing is generally discontinued when they are about four months old. They are, however, supplied with about 1 lb. each per day of linseed-cake all through the year.

"In order to have all the milk available for cheese-making, we have hitherto often fed the calves, when taken from new milk, with whey thickened with meal." But he thinks skim-milk a safer food. His 1 lb. of linseed-cake all through the year would, of course, not suffice for fattening bullocks.

The following detailed dietary is a good one: 6 quarts of new milk daily for fourteen days from birth, and for the next six weeks 2 gallons of skimmed milk, warmed and mixed with ½ lb. of linseed-cake, ¼ lb. boiled linseed, and ½ lb. split beans.

Examples of Rapid Feeding.—Mr Joseph Blundell of Southampton, a frequent prize-winner for young bullocks at the cattle-shows of the Botley and South Hants Farmers' Club, sold one of his first-prize shorthorn heifers to Mr Lunn of Southampton, 18 months 3 weeks old, weighing 98 stone (of 8 lb.) 6 lb., and his skilful treatment of the young animals is well worth recording. He says:—

"My calves are weaned at a few days old, fed with new milk at first, gradually introducing with the skim-milk, linseed-cake, meal, and barley-meal, with a little sweet meadow-hay for a time in the rack allowed them until they can safely take to green fodder, which they get in succession—first rye, second trifolium, third clover, with a portion of old mangel, then early turnips. To commence the winter they get hybrid turnips, carrots, or swedes; and lastly mangel, until the green fodder comes in again, being supplied with clean fresh oat or barley straw always in the rack whilst feeding either on green fodder or roots, the portion not eaten being removed for littering the boxes daily. As soon as they begin to take green fodder, they are allowed a small portion, say 2 lb., of cake-meal per day, mixed with the old mangels, which are cut with Gardner's turnip-cutter. As soon as root-feeding commences, they get 4 lb. of cake per day, and continue to receive this quantity until they are sold at 18 to 20 months old; having, however, during the last three months, 1 lb. of bean or barley meal extra; but at no time after they once take to their green food are they allowed hay, as this would be found to absorb the profit and injure the health of the animals also, for since I adopted the method of straw-feeding I have never had an animal hoven or unhealthy."

Another excellent manager, having some good pastures, feeds as follows: "Two calves are put on each cow, and are suckled by them from March or April till July or August, when they are weaned on the rowans [leys] and get 2½ lb. of linseed-cake each daily. They are placed in the yards in October, and wintered on the same quantity of cake, with one-third of a bushel of roots daily, straw and rough hay. In April or May, when 12 or 13 months old, they are put on a good pasture and summered, with 2½ lb. of cake daily. In autumn they again come into the yards in excellent condition, and they are then fed on 5 lb. of linseed-cake and 1¼ bushel of roots daily for three months, and finished in April or May with the addition of 5 lb. of pea and barley meal." With this treatment they weighed at the neighbouring butcher's one year: May 23, a steer, 108 stone 5 lb.; a heifer, 100 stone. May 27, a steer, 117 stone 1 lb. May 29, a steer, 106 stone; a steer, 101 stone 7 lb. June 5, a steer, 97 stone 1 lb. June 7, a steer, 122 stone 2 lb. June 26, a heifer, 79 stone 9 lb. June 29, a steer, 115 stone 4 lb. —that is, stones of 8 lb. The heaviest of these cattle was just 105 weeks old.

Rapid Fattening on Pasture.—Bullocks are never fattened so cheaply as with the aid of good pasture. There are several methods by which early maturity may be accomplished in pastures. Irish heifers may be brought to calve in March. They suckle their calves for about five weeks to the value of £3 or £4, and with a little trouble they then accept good shorthorn calves as changelings. In May the heifers and calves go on the pastures, with 4 lb. of decorticated cotton-cake daily to each heifer. The calves suck through the summer and following winter till February, and in May, at 14 months or 60 weeks old, such calves have been sold (beef being then very dear) at £24 each.

Return for Rapid Fattening.—These calves had gained 8s. per week, which is almost the maximum recorded gain at that age for ordinary farm stock. On arable farms, under more costly management, when beef sold at 6s. 2d. or 6s. 4d. per stone of 8 lb., a farmer in Sussex disposed of his young animals at his sale as follows:—

	Guineas.	Return per Week. s.	d.
11 months old Shorthorn steer	16	7	0
13 " " steer	22	8	3
14 " " heifer	20	7	0
15 " " heifer	22	7	1
16 " " steer	27½	8	4
18 " " steer	25	6	9
18½ " " steer	28	7	4

Feeding Cow and Calf together.—In rich pastures mother and calf are sometimes fattened together to great advantage—that is, in cases where, from some defect or other cause, it is not intended that the cow should breed again. But it is occasionally done in a more systematic manner, when Devons or Herefords, or a cross between Sussex and Devon, produce their calves at two years old. These breeds are not good milkers; but a heifer nevertheless lends a great deal of help to two calves at grass. She receives cotton-cake *ad libitum*, and if she calved in March, she will fatten fast on grass, and be as ripe as summer beef should be in July at 2⅓ years old.

The calves will be summered on grass a second season, going to the butcher at 16 to 18 months old. It is a great advantage in the fattening of young animals that they grow and fatten simultaneously, and may be either sold as early as 15 months, or kept three or four months longer, according to circumstances.

Rapid Feeding on a Surrey Farm.—An agriculturist in Surrey found, in closing his year's accounts in October 1885, that he had fattened and sold 170 young bullocks during the year. All of them had been reared at home, and he considered that the business had been profitable. The bullocks had all been sold at market under the hammer at the average net price of £17, 15s., the price of beef having averaged 5s. 6d. per stone of 8 lb., so that the weight of the animals must have been 65 stone each. Their average age was 16 months, and each bullock had returned 5s. 3d. per week. The result had not been quite so satisfactory as in former years, when the price of beef had ranged from 5s. 9d. to 7s. per stone for choice young bullocks. But 5s. 3d. per week is regarded by this large feeder as a good return, which leaves the manure free of cost. Some of the calves were bred on the farm, and the rest were purchased at about a week old, at prices varying from

50s. to 60s. each. On arrival, the calves passed to the care of an excellent cattleman, whose management was thus described by his employer: "The calf is fed on new milk, which is gradually reduced in quantity, as this food of nature is in great demand, and must needs be used with economy. I did not question the feeders closely, hoping to do so another day, but here is a hint they gave me. They find that in substituting other food for new milk, it is better to bring the calves gradually to take the equivalent in the form of dry food. Mixing linseed-cake dust in the milk was tried, but apparently it occasioned scouring. We all know that hay-tea is mixed with the milk by many farmers, who can have it prepared by some careful person indoors; and in a farmhouse kitchen, with a good careful Mrs Poyser to prepare the food, linseed-cake dust might prove as safe in the milk as hay-tea. But in the case before us we have only cottagers for this grandmotherly sort of work, with large families, and owing to this the calves are managed entirely by the men, and it may be they avoid pot-boiling on this account. At all events, they prefer teaching the calves to munch several sorts of dry food as soon as they can be induced to do so. A nice sweet piece of hay helps them greatly at an early age, and it is given to them long, instead of being cut into chaff, so that the young things may amuse themselves with nibbling and chewing it. At the time of year when the calves are allowed to run out in the pastures—that is, during seven or eight months of the year—they are never allowed to remain out all night. In warm weather they spend the whole day in the pastures, running out after the first meal, and remaining out till night, when they are brought in for shelter. As for their sleeping-places, the scattered homesteads of Surrey sand farms are well known for their big barns. A big barn, thatched or tiled, forms the main building of each little homestead." [1]

At the date just mentioned, the price of calves had fallen to 40s. each. Good calves had been carefully selected, many of them being the offspring of large shorthorn dairy cows by a pedigree bull. Owing to good breed, capital condition from birth, and the warm sheds in which they were wintered, the young fattening bullocks ate comparatively little, even when nearly ripe. Nothing like the extravagant quantities of corn given by old-fashioned feeders had been allowed. The quantity of roots had been very small, and that of straw, chaff, and the cheaper kinds of dry food proportionately large. In fact, many bullocks were fattened on this farm, after the drought of 1885, without any roots. It must suffice to say that mixed meals had been used, and a well-balanced ration carefully adhered to. With regard to the quality of the beef, the young animals from this farm were always eagerly bid for at the auction-mart at Guildford; and the feeders of older bullocks were mortified to find that their costly cattle, finished perhaps with 10 lb. each of linseed-cake daily, were neglected in favour of the younger bullocks, especially in summer, small joints suiting customers better than large ones.

Rapid Feeding of Sheep.—The age of sheep has been shortened quite as much as that of bullocks. Before the time of Ellman, as already stated, Southdown wethers were rarely killed till the end of their third year. They are now commonly killed at ten months and a year old, and frequently younger. Previous to 1874, comparatively few "lambs," born in the year of the show, were exhibited at the show of the Smithfield Club. In 1875, and two following years, only 76 such lambs were exhibited. In 1885, and two following years, between 70 and 80 were exhibited in each year. In December, when the show is held, the age of these sheep, called lambs, would be ten or eleven months; and at that age, Hampshires are made up to the weight of 16, 17, and 18 stone of 8 lb. each.

Lamb Feeding, by Messrs de Mornay.—Lambs were first admitted to competition at Smithfield in 1875, through the exertions of Messrs de Mornay, of Col d'Arbres, Wallingford, who were early in the field as breeders and feeders for early maturity. In 1877 their own pen of three lambs won the first prize, and the animals weighed, when dead, 17½ stone each. At the present time Mr Alfred de Mornay, of Col

[1] *Field*, December 26, 1885.

d'Arbres, fattens the whole of his wether lambs at from seven to nine months old. A show-wether at ten months old scaled 18½ stone, dead weight.

Mr A. de Mornay's System of Feeding Sheep.—Mr de Mornay's farm consists of 583 acres, of which only 20 acres are in permanent pasture. The rest is mainly fertile land in the upper greensand, with 80 acres on chalk. It is all admirably suited for sheep-farming. The flock, in spring, is placed on rye, consumed with roots, and after that crop they are folded on *Trifolium incarnatum*, and on succession crops of vetches, which form the main summer food. A quantity of mangel is reserved for the summer. During the winter, the ewes eat all the barley and oat straw, and a good deal of the wheat-straw, and in years of drought they have been maintained through the winter in good health, almost entirely on dry food. A portion of the land is always in sainfoin, laid down for three or four years, and this is most valuable sheep food, both green and as hay.

The following statistics, relating to the flock, are borrowed from the pamphlet, "Early Maturity of Live Stock."[1]

The number of ewes lambed down in 1883 was 461. The produce of the above sold for as follows:—

Ram lambs . .	£879	16	7			
189 wether lambs (fat mutton from 7 to 10 months old) .	708	9	4			
Draft ewes . .	641	6	6			
Wool (unsold), say, 143 tods at 28s. .	200	4	0			
Increase of ewe flock, 22 at £5 . .	110	0	0			
				£2539	16	5

The number of ewes lambed down in 1884 was 483. The produce of the above sold for as follows:—

Ram lambs . .	£619	18	0			
157 wether lambs (fat mutton from 7 to 10 months old) .	503	4	4			
Draft ewes . .	647	2	9			
Wool (unsold), say, 146 tods at 24s. .	175	4	0			
Increase of ewe flock, 16 at £5 . .	80	0	0			
				2025	9	1
Gross total				£4565	5	6

The great difference in the result in the two years was caused by the fall in the price of mutton and wool, and the smaller number of twin lambs in the year 1884.

The produce per ewe ranged from £5, 10s. 2d. in 1883 to £4, 3s. 10d. in 1884, or an average, for the two years, of £4, 17s. per annum. Each ewe paid 1s. 10d. per week, a sum which would allow of the profitable use of a large quantity of artificial food, by which the fertility of the soil and the yield of the crops would be much increased.

Rapid Feeding of Sheep in Hampshire.—Very high returns from early fattening have been made in Hampshire, where an annual competition takes place among neighbouring flocks. The highest recorded prices are those of pens which have won the prizes at the local fairs. On October 23, 1882, Mr G. Judd, of Barton Stacey, Micheldever, penned 200 wether lambs, born in January, and averaging nine months old. They were sold by auction at an average of 84s. each, within a fraction, for the 200, besides £70 won in prizes, and they brought their owner and breeder 91s. each, less the auctioneer's charge. Mutton was very dear at that time, and the lambs probably sold at 7s. per stone, their estimated weight being 12 stone. At 91s., they brought their owner 2s. 4d. per week from birth; or, omitting the prize-money, they brought him nearly 2s. 2d. per week.

With regard to management, Mr Judd says of these lambs, that they "were born in January, or early in February, and were weaned as soon as the water-meadows were fed off, about the 13th of May. They were fed on tares, sainfoin, and oilcake till July, when rape took the place of tares, and the amount of cake was gradually increased, until the daily allowance reached about 1½ lb. of oil-cake, with ½ lb. of split beans; and during the last six weeks immediately preceding the show, turnips were substituted for rape."

Mr Judd's weights are not unrivalled, however; for Mr W. Parsons, in reading a paper before the London Farmers' Club, on "Early Maturity of Live Stock," 1884, recorded that Mr East of Longstock, Stockbridge, took the first prize at Winchester Fair that year for 100 lambs,

[1] "Early Maturity of Stock." By H. Evershed.

which were sold, by auction on the spot, at 80s., and were estimated to weigh 12½ stone. There were 500 lambs in the class, weighing not less than 11 stone each on the average.

Early Maturity Profitable.—These details prove that early maturity is profitable. It enables us to sell the wether lambs in autumn, and consequently to increase the number of ewes, and to reserve a larger number of ewe lambs for breeding. The Hampshire and Wiltshire sheep-farms are, no doubt, particularly healthy for sheep, and adapted for carrying them through the summer, by means of a succession of forage crops.

Sheep on Heavy Land.—But many heavy-land farms, on which a great deal of money has been lost in recent years, might, too, pay their way well under sheep breeding and fattening. One-third or more of the land should be in pasture, to carry the ewes in winter; and in spring and summer the flock could be maintained on mangel, trefoil, and rye-grass, clover, tares, aftermath, and early turnips. Few roots should be given, with plenty of chaff and corn, and the flock, whether on arable or pasture, should be frequently shifted, and well supplied with water. It is a great error to overstock. In the Vale of Aylesbury a few ewes are kept on the rich cow pastures—formerly Hampshires, crossed with a Cotswold ram, or, in modern times, Oxford Downs. The lambs are sold, as lamb, at twelve and fourteen weeks old, at 45s. and 50s. each, and the ewes are fattened off the grass in August and September. Little, if any, corn is given either to the ewes or lambs.

By supplying corn liberally, poorer pastures may be made available for early fattening, as described above.

Breeding from Lambs.—It has been well said, that successful feeding depends upon good breeding. The sheep usually selected for early maturity are the Downs, rather than the heavier and coarser long-woolled breeds. It is the general practice in Hants to use ram lambs, and some persons attribute the habit of early maturity, in great measure, to that practice. One of the most eminent of Southdown prize-winners informs the writer that ram lambs produce better and bigger progeny than older sheep, and that all his prize-winners have been the offspring of ram lambs. Like many other breeders, he finds that ewe lambs can be profitably bred from. Every year he selects some of his coarser ewe lambs, and breeds from them with success.

Many others might be named who have tried the same experiment, including Mr James Stratton of Chilcombe, Winchester, who has bred from 300 ewe lambs in a year; while a breeder of the Southdowns, within the writer's knowledge, always pursued this practice without observing any deterioration of his flock, and his lambs were always as good as his neighbours'.

Mr de Mornay, however, is the most systematic experimenter in this department. His idea is to induce a habit of early breeding in the ewe lambs, by selecting the most forward and matured among them, and mating them with a lamb of the same stamp. His selections are made from a flock where early maturity has been already encouraged during some years past; and Mr de Mornay has good reason to anticipate that the habit of early breeding will be established. It is, of course, indispensable that the young ewes should be well fed, and carefully managed; and this expense can readily be afforded, since a flock of ewes at four years' old will produce four crops of lambs instead of three, which they would yield under ordinary circumstances.

Weights of Cattle.—The weights attained by prize animals, as shown by the reports of shows at Chicago, where the carcasses are weighed, and Smithfield, where the live weight only is taken, have no very practical bearing on our subject. We have already given some maximum weights of picked animals under ordinary feeding, and some average weights, as estimated from the price at which the animals were sold. As a matter of curiosity, however, it may be stated that a Hereford at Chicago weighed 920 lb. at 350 days old, having gained 2.62 lb. daily; a Devon steer at Islington weighed 809 lb. at 388 days old, having gained daily 2.09 lb.; but a champion shorthorn at Chicago, 1372 days old, had only gained from birth 1.74 lb. daily. Taking account of the cost of production, the Chicago Society found that the beef made by five animals in their second year cost 4d. per lb., in the third year it cost 6½d. per lb.

The Smithfield and Birmingham Societies have found, by weighing the live animals, that bullocks well fed up to about 1 year 8 months old have very little to show for the expense of feeding them another year. The average live weight of steers at 1 year 8 months old has been 11 cwt. 2 qr. 19 lb., and at a year older they weighed only 15 cwt. 20 lb.

The following Smithfield Club statistics afford similar comparisons as to live weights in a more elaborate form:—

Steers under Two Years.

	Average gain per day in pounds in		
	1879.	1881.	1887.
Aberdeen-Angus .	...	...	2.21
Cross-bred . .	...	2.26	2.20
Hereford . .	1.91	2.35	2.19
Sussex . . .	2.07	2.06	2.17
Shorthorn . .	2.35	2.09	2.07
Devon . . .	1.63	1.71	1.81

Steers under Three Years.

	Average gain per day in pounds in		
	1879.	1881.	1887.
Aberdeen-Angus .	1.62	1.99	1.90
Shorthorn . .	2.00	2.00	1.89
Sussex . . .	2.03	1.71	1.89
Hereford . .	1.75	1.79	1.85
Cross-bred . .	1.89	2.01	1.81
Norfolk . .	1.48	1.59	1.61
Devon . . .	1.22	1.45	1.49

Steers over Three Years.

	Average gain per day in pounds in		
	1879.	1881.	1887.
Welsh . . .	...	...	1.64
Cross-bred . .	1.78	1.74	1.61
Shorthorn . .	1.60	1.57	1.60
Aberdeen-Angus .	1.13	1.73	1.58
Sussex . . .	1.64	1.53	1.56
Hereford . .	1.43	1.60	1.55
Norfolk . . .	1.47	1.37	1.43
Devon . . .	1.20	1.24	1.31
Highland . .	1.19	1.09	1.23

Weights of Sheep.—Birmingham statistics afford the following striking comparisons with regard to sheep:—

First Prize.	Age.		Weight of each Sheep.	Daily gain per Sheep since birth.	
	Months.	Weeks.	lb.	lb.	oz.
Lincolns	21	0	311	0	7¾
Cotswolds	22	0	321	0	7¼
Shropshires	21	0	244	0	6$\frac{1}{10}$
Oxford downs . . .	20	3	251	0	6⅓
Cross-breds	21	0	297	0	7⅝

First Prize.	Age.		Weight of each Sheep.	Daily gain of each Lamb from birth.	
	Months.	Weeks.	lb.	lb.	oz.
Lincolns	9	0	191	0	11¼
Cotswolds	10	0	180	0	9½
Shropshires	9	0	144	0	8⅔
Oxford downs . . .	9	1	197	0	11⅓
Hampshire downs . . .	10	0	246	0	13½
Cross-breds	0	46	192	0	9½

Unfortunately there are no lamb classes for Southdowns or Leicesters, and no older classes for Hampshires. But these figures suffice to show that sheep make mutton most rapidly when they are under a year old.

Early Maturity in Scotland.—The fattening of lambs has not been carried to such a great extent in Scotland as in England, but the fattening of cattle for slaughter under twenty months old was pursued in some parts of Scotland before even the earliest examples referred to in the preceding notes by Mr Evershed. Throughout Scotland generally, as in England, the movement for early maturity has made rapid progress since 1875. It is now seldom that a bullock is kept beyond its third year, and the great majority are fed off when about two years old. A very large number of cattle go to the butcher when from 18 to 22 months old, and the proportion fattened off under two years old is steadily increasing.

The systems of feeding cattle have undergone important changes to suit this more rapid fattening. It is, of course, to the more modern methods that attention is here mainly directed.

Lawes on High-pressure and Profitable Feeding. — Sir John Bennett Lawes has been an able and persistent advocate for early maturity. He has often pointed out, however, that the "high-pressure system of feeding" may, in the sense of economy, be overdone. He says: "Every day of an animal's life, a certain amount of food is required for sustenance purposes alone. An animal which does not increase in weight is kept at a loss, as it merely turns food into manure. On the other hand, if you require to produce as much weight of beef in one year as is produced under ordinary feeding in three years, it can only be done by a large expenditure in costly foods; and, except for show purposes, this very rapid fattening is not necessarily the most profitable. As the rate of increase is limited, however highly an animal is fed, much waste of food takes place under a high-pressure system of feeding; while on the other hand, an animal is unprofitable if it does not increase in weight every day. Between these two extremes there ought to be some point which marks the minimum cost at which a pound of beef can be produced. I have once or twice tried to construct a table for my own satisfaction, but without much success."

Cheaper Meat from Young Animals than Old.—In the experiments of Sir John Bennett Lawes, Professor E. W. Stewart (United States), Professor Wrightson, and others, it has been clearly demonstrated that a greater consumption of food is required to form a pound of meat upon an old and heavy animal than upon a young animal of smaller size—in other words, that young meat can be manufactured at a cheaper rate than old.

Referring to a statement by Professor E. W. Stewart, to the effect that every additional pound put upon an animal costs more in food than the previous pound of growth, Sir John Bennett Lawes says: "I quite accept the fact, and am prepared to account for it. Professor Stewart is not quite correct when he says that our investigation on the cost of the production of beef 'bears mostly on the cost of putting on weight during the fattening period.' Our early inquiries began upon lambs, calves, and store stock, and we traced their growth and composition from birth to the store, fat, and very fat state. These experiments are recorded in the transactions of the Royal Society for 1860.

"A reference to the composition of a store and very fat sheep will show at once why every additional pound we add to the weight of an animal is more costly than the previous one. Our store sheep contained, in every 100 lb. of live weight, 39 lb. of dry substance, and 61 lb. of water. The very fat sheep contained in each 100 parts, 63 lb. dry substance, and 37 parts water. Two store sheep, each weighing 100 lb., would contain 75 lb. dry substance and 122 lb. water. The very fat sheep under experiment weighed considerably more than double the weight of the store sheep. Taking its weight at 200 lb., it contained 74 lb. water and 126 lb. solid matter. The very fat sheep of equal weight with the two store sheep would contain 45 lb. more solid matter, almost entirely fat. Each pound of fat requires about 2½ lb. of starch, or some similar digestible non-nitrogenous substance for its production.

"However, while these experiments show why the displacement of water by fat is one of the reasons why each pound added to an animal is attended with additional expense, they do not touch the question of early maturity, or the relative economy of one, two, or three year old beef." [1]

Professor Wrightson's Experiments.—Evidence of a similar import is provided by the following account, given by "H. F. M." in the *Field*, of some interesting and instructive experiments carried out at the College of Agriculture, Downton, by Professor Wrightson, in 1886-1887. The experiments were intended to demonstrate to the students the increase in weight per day

[1] *Albany Cultivator*, 1886.

and per 1000 lb. of live weight, and the increase also during the various stages of fattening. The experiment lasted from April 10 of 1886, through the summer and winter, and on till May 11, 1887, when the animals were sent off to the butcher. Six animals were taken, of different ages, and during the summer were grazed, having, in addition, a mixed food, consisting of chaff over which an emulsion of boiled linseed was thrown. In the winter they received a food consisting of the following: Mixed cotton and linseed cake (1 lb. linseed), 7 lb.; hay *ad lib.*; also chaff and pulped mangel.

In February this was altered, and the following richer food given: Cake (half each cotton and linseed), 7 lb.; maize and bean meal, 4 lb.; hay, 3 lb.; chaff and roots, with boiled linseed mixed, 47 lb.

In the middle of March the food was again made richer, when the following foods were given: Linseed-cake, 8 lb.; maize and bean meal mixed, 4 lb.; hay, 8 lb.; roots and chaff (as above), 21 lb.

The results of this feeding, together with the weights and details of increase at various periods, is given in the following table:—

Date.	Cherry Prince.	Snowflake.	Hereford Duke.	Knight of Charford.	Whitefaced Roan.	White Bar.
	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.
April 10 (weight)	4 1 7	3 0 2	3 2 26	2 1 7	2 1 21	2 1 7
May 21 (weight)	5 0 2	3 3 11	4 1 6	3 0 10	2 3 24	2 3 22
Increase per day	2.27 lb.	2.02 lb.	1.56 lb.	2.12 lb.	1.44 lb.	1.73 lb.
" per 1000 lb.	4.60 lb.	5.80 lb.	3.73 lb.	8.18 lb.	5.27 lb.	6.68 lb.
June 25 (weight)	6 0 0	4 1 15	4 2 24	3 2 9	3 1 27	3 3 3
Increase per day	2.46 lb.	1.71 lb.	1.31 lb.	1.57 lb.	1.68 lb.	2.66 lb.
" per 1000 lb.	4.19 lb.	3.96 lb.	2.72 lb.	4.54 lb.	5.06 lb.	8.06 lb.
August 6 (weight)	6 2 7	4 3 26	5 1 10	4 0 25	4 0 16	4 1 7
Increase per day	1.50 lb.	1.60 lb.	1.67 lb.	1.71 lb.	1.74 lb.	1.43 lb.
" per 1000 lb.	2.23 lb.	3.26 lb.	3.16 lb.	4.26 lb.	4.45 lb.	3.38 lb.
October 21 (weight)	8 2 0	7 0 0	7 0 21	5 3 0	5 2 14	5 2 21
Increase per day	2.86 lb.	2.97 lb.	2.72 lb.	2.25 lb.	2.18 lb.	2.03 lb.
" per 1000 lb.	3.89 lb.	5.32 lb.	4.62 lb.	4.75 lb.	4.70 lb.	4.20 lb.
November 19 (weight)	8 1 24	7 0 7	7 1 3	6 0 10	5 3 19	6 0 3
Increase per day	...	0.24 lb.	1.34 lb.	1.31 lb.	1.14 lb.	1.31 lb.
" per 1000 lb.	...	0.30 lb.	0.42 lb.	2.03 lb.	1.80 lb.	2.05 lb.
December 3 (weight)	9 0 9	7 2 17	7 2 14	6 1 14	6 0 27	6 1 10
Increase per day	4.93 lb.	4.71 lb.	2.79 lb.	2.29 lb.	2.57 lb.	2.50 lb.
" per 1000 lb.	5.20 lb.	5.95 lb.	3.42 lb.	3.35 lb.	3.88 lb.	3.70 lb.
December 16 (weight)	9 0 4½	7 2 23	7 3 10	6 2 24	6 2 7	6 1 27
Increase per day	...	0.46 lb.	1.85 lb.	2.92 lb.	2.77 lb.	1.31 lb.
" per 1000 lb.	...	0.53 lb.	2.17 lb.	4.09 lb.	3.96 lb.	1.84 lb.
January 27 (weight)	10 0 0	8 2 6	8 2 0	7 2 7	7 1 4	6 3 11
Increase per day	2.56 lb.	2.26 lb.	1.76 lb.	2.26 lb.	1.93 lb.	0.95 lb.
" per 1000 lb.	2.53 lb.	2.62 lb.	2.00 lb.	3.00 lb.	2.62 lb.	1.30 lb.
February 16 (weight)	10 1 0	8 3 14	8 2 7	7 2 20	7 2 16	7 1 0
Increase per day	1.40 lb.	1.80 lb.	0.35 lb.	0.65 lb.	2.00 lb.	2.25 lb.
" per 1000 lb.	1.25 lb.	1.88 lb.	0.36 lb.	0.76 lb.	2.40 lb.	2.93 lb.
March 16 (weight)	11 0 7	9 2 0	9 0 14	8 2 0	8 1 9	7 3 6
Increase per day	3.25 lb.	2.50 lb.	2.25 lb.	3.28 lb.	2.75 lb.	2.21 lb.
" per 1000 lb.	2.83 lb.	2.53 lb.	2.34 lb.	3.81 lb.	3.21 lb.	2.72 lb.
April 9 (weight)	11 1 21	9 2 23	9 1 18	8 3 9	8 3 0	8 0 15
Increase per day	1.75 lb.	0.95 lb.	1.33 lb.	1.54 lb.	1.95 lb.	1.54 lb.
" per 1000 lb.	1.41 lb.	0.94 lb.	1.30 lb.	1.61 lb.	2.09 lb.	1.76 lb.
May 11 (weight)	12 3 0	10 2 6	10 1 0	9 0 12	9 1 18	8 3 14
Increase per day	4.59 lb.	2.75 lb.	2.63 lb.	0.97 lb.	2.31 lb.	2.59 lb.
" per 1000 lb.	3.58 lb.	2.53 lb.	2.49 lb.	0.98 lb.	2.46 lb.	2.84 lb.

In explaining these results to the students, Professor Wrightson pointed out that the weights of cattle are generally given as they are obtained per head. But it is evident that a bullock of 10 cwt. ought to increase more rapidly than one of 7 cwt., if the feeding of both is to be equally economic. It is therefore very instructive to calculate the increase per 100 lb., or, better still, per 1000 lb., of live weight.

Calculated in this way, there is no doubt but that young stock weighing from 3 cwt. to 5 cwt. increase proportionately much more rapidly than heavier cattle, and it is now being stated widely that the expense of increasing the weight of cattle becomes heavier and heavier as they increase in actual weight.

The above table is a powerful argument in favour of the economy of early maturity. Cherry Prince, when weighing 4 cwt. 1 qr. 7 lb., increased at the rate of 2.27 lb. per day, and of 4.6 lb. per 1000 lb. of live weight. The same bullock, when weighing 10 cwt., increased at the rate of 2.56 per day, but only at the rate of 2.53 lb. per 1000 lb. of live weight. For this to be accomplished the food had to be much richer and more expensive. Again, Snowflake, when weighing 3 cwt., increased at the rate of 2.02 lb. per day, and of 5.8 lb. per 1000 lb. of live weight. The same animal, when close upon 8 cwt. in live weight, increased at the rate of 2.26 lb. per day, but only of 2.62 lb. per 1000 lb. of live weight. The whole experiment shows that the heavier an animal gets, the more food is required to maintain the system before any can be utilised in the manufacture of beef.

Professor E. W. Stewart on Early Maturity.—In his volume on *Feeding Animals*—one of the best works of the age—Professor E. W. Stewart (U.S.A.) lays it down as an axiom that "profitable feeding must be done before maturity." He submits numerous experiments in support of this axiom, and remarks that as the digestive and assimilative organs are in the greatest activity in the young animal, "the stock-grower must take advantage of this period to produce the best results in feeding. Careful experiments show a constant increase in the food required to produce a pound of live weight, as the animal increases in size and weight."

A Golden Maxim to Feeders.—What has been submitted under the heading of early maturity may be fittingly summed up in the following "golden maxim" to the feeder: "Early maturity at a minimum of expense, with a maximum of meat and manure."

METHODS OF FATTENING CATTLE IN WINTER.

When we enter upon the round of the farm-work at the beginning of winter, we find, as already indicated, that all the cattle being fattened for slaughter have already been comfortably housed. In what manner they may be accommodated has been noticed under the heading of the "Housing of Cattle in Winter."

What Food is to be Used?—The question to be considered at this point is, What food should be given daily to the cattle that are being fattened? It has been seen that in the methods of feeding breeding and milking cows and store cattle in winter, there is almost endless variety. In the winter fattening of cattle the variation of practice is quite as great. The system of cropping and the supply of home-grown food are leading factors in determining the method of feeding pursued. The farmer should, of course, consider carefully the market price of the various recognised articles of food and of his own produce, and after due deliberation he will decide whether his own home-grown or purchased foods will be cheapest and most profitable. Other things being equal, he will give the preference to his home-grown food, for, as already pointed out, there is economy in making the farm produce "walk itself to market."

An important point at this time is to estimate the supply of fodder and roots, and so apportion the daily use of these as to extend them over the season. Want of care in this matter may lead to inconvenience and loss towards the end of the winter or house-feeding period.

Feeding Rations. — The fattening cattle will most likely be at various stages in their advance towards maturity.

Some, already in high condition, may be intended for the Christmas markets, when winter-fed beef usually brings the maximum price. Others, most probably younger animals, will be leaner, and may require from 4 to 6 months' feeding. Both classes will be accustomed to the house-feeding before winter sets in (for all fattening animals should be housed as soon as the cold nights of September begin to be felt), and both should now be liberally fed. They should not be gorged, but have as much as they can eat, given to them at fixed intervals in as palatable and tempting a form as possible, and in such quantities as will ensure that, without any food being left or wasted, the animals will be perfectly satisfied. As to the gross bulk, there may be little difference in the food given to the cattle, but the riper animals will get the richer food. As the cattle approach maturity, the more concentrated foods, such as cake and grain or meal, are increased, and the bulkier commodities, such as roots and straw, may be slightly lessened.

As to this variation of meals, no hard and fast lines can be laid down. It would be worse than useless to attempt to do so; it would be positively unsafe. The immediate wants, the condition, progress, and appetite, of each individual animal must be carefully considered, and in accordance with these and these alone is it safe to arrange or modify the daily meals. Thus, again, it is seen that the office of cattle-man is a responsible one. The success or failure of the feeding operations is largely dependent upon him, for by careful and constant attention to the adapting of the meals to the wants and capacities of the animals, he may greatly facilitate the fattening, as well as economise valuable food.

Balancing Food properly. — As to the importance of having the foods properly balanced, a good deal has already been said. And at this critical time, when the feeder is arranging or modifying the food to suit his fattening cattle at the different stages of their progress, we would strongly urge him to consider carefully the question of mixing foods, so that the various ingredients shall be present in the proportions most perfectly adapted to the requirements of the animal. See in particular the information given under the heading "Albuminoid Ratio."

Scotch Feeding Customs.

As already indicated, great economy has been introduced in recent years in the use of turnips; yet, as a rule, Scotch cattle-feeders still place much reliance upon them. On nearly all Scotch farms turnips still form a dominant or important element in the rations of feeding cattle. Yellow turnips are used at the outset, and these may last for one month, two months, or longer, as the case may be. The more advanced feeders, especially those intended for the Christmas market, will receive swedes as soon as practicable, perhaps about the beginning of November. All changes in the food should be introduced gradually. In putting cattle on roots in winter, small quantities should be given at the outset; full meals being allowed only after the animals have become accustomed to the new mode of treatment.

Daily Allowance of Turnips.—What quantity of turnips should a feeding bullock receive daily? This, we have seen, is a vexed question, as to which opinions of practical men have undergone, and are still undergoing, considerable change. Not a few still give the animals all they can comfortably consume in two meals daily. That would be perhaps from 8 to 12 or 14 imperial stones, according to the size of the animal. We have endeavoured to show that this is improvident feeding, and that a more prudent and more profitable system is to give much smaller quantities of roots and larger proportions of other foods. The general tendency now is in the latter direction. The majority of the more successful feeders nowadays limit the daily allowance of roots to from one-half to about three-fourths of what was given in the "turnip and straw" days prior, say, to 1870. From 60 to 100 lb. per day to cattle from twenty months to three years old are now very general quantities. The smaller allowances are usually given in the pulping system, which, as we have seen, helps greatly in economising roots.

Feeding Hours.—When cattle have

all the turnips they can eat, or nearly so —say from 112 to 140 lb.—the roots may be given in three meals, about 8 A.M., early in the afternoon, and in the evening, the first two meals being the largest. Under this system very little, if any, cake or grain is given, seldom more than about 2 lb. a-head, till within two months or six weeks of the time of slaughter, when the allowance of roots is slightly lessened, and the quantity of cake or meal, or both, increased by degrees to perhaps from 4 to 6 lb., given in two equal meals, forenoon and afternoon.

The more general plan is to give the turnips in two meals, about 8 or 9 A.M., and from 1.30 to 3 P.M. Some give the roots as the first meal in the morning, following with oat-straw or hay, cake or meal, or both, about 11 A.M., turnips again early in the afternoon, followed by straw or hay, and cake or meal, as in the forenoon.

Others think it better to give about half the daily allowance of cake and meal, say at 6 A.M., to be followed by turnips at 9 A.M., and thereafter a moderate supply of good oat-straw or hay; the afternoon meals coming in the same order, beginning with cake and meal at 1 P.M., and ending with straw and hay at 8 P.M. Others, again, give a very small feed of straw or hay as the first mouthful in the morning, say from 6 to 7 A.M.

Turnips or Cake for Breakfast? —Some experienced feeders contend that it is unsafe to give cattle a feed of cold watery turnips upon an empty stomach in the morning, yet many successful feeders have all their lives pursued the system of giving roots as the first meal, and say they have never discovered any evil effects from it. Upon the whole, the weight of experience is in favour of giving a small allowance of cake and meal as the first feed in the morning.

Daily Allowance of Cake and Grain. —Where the allowance of turnips is restricted to from 80 to 100 lb. per day for cattle weighing from 6 to 8 cwt. (estimated dead weight), the quantity of cake and meal may vary from 4 to 8 or 10 lb. per day, beginning the winter with the smallest, and finishing off the fattening period with the largest, quantity. The concentrated food at the outset often consists of a mixture of decorticated cotton-cake and linseed-cake, or these two and bruised oats, peas, beans, or perhaps Indian corn. Some lessen the proportion of cotton-cake and increase the quantities of linseed-cake and meal as the finishing-time approaches, the maximum allowance of concentrated food being given for a period of about six weeks at the end.

Where a still smaller quantity of turnips is allowed, perhaps under 60 lb. per day, it is usual to give the roots either in two pulped mixtures, one in the morning and the other in the afternoon, or by themselves in one feed early in the forenoon. In either case, with this small allowance of roots, the quantities of the more concentrated foods must be increased. The necessary bulk will be made up by straw or hay; the essential nutriment mainly in cake or bruised grain.

The Pulping System for Feeding. —When the minimum quantity of turnips is allowed, the pulping system will be found specially serviceable. As already shown, it permits of greater economy of roots than can be secured by any other method. Comparatively speaking, it is perhaps more useful in rearing store cattle than in fattening. The laying on of flesh and fat cannot be accomplished without the employment of a certain amount of rich food, which, of course, is as costly in a pulped mixture as by itself. But the pulping method turns the small allowance of roots to better account with fattening as well as with store cattle, and it is easy to add the required cake or grain. With mixed foods used as in the pulping system, it is easier to ensure that the ration shall be properly balanced, with all the essential elements present in due proportion, than when turnips, cake, grain, and fodder are each given separately. It is possible, also, by careful preparation, and perhaps by a sprinkling of a little condiment or diluted treacle, to present the pulped mixture in an exceptionally palatable and inviting condition. In the fattening of stock both these points are of much importance.

Mr D. Buttar's Pulping System.— Mr David Buttar, Corston, Coupar-Angus, has long been an advocate of the pulping system. He pursues it not only in the rearing and feeding of cattle, but also in the feeding of sheep; and all through, the results are decidedly favourable to the system. In response to our request, Mr Buttar thus describes his system of feeding cattle :—

"The class of cattle I generally feed are well-bred shorthorn and Angus crosses, numbering from 120 to 140 head. A few milch cows are kept, merely to supply the house and servants with milk. These feeding cattle are generally purchased about the month of October, and as I believe in early feeding, I buy them young, generally rising two years old, at prices ranging from £6 to £10 each. For the first two or three weeks they are put to some distant field of grass, till I am satisfied that they are free from disease. They are then brought into the courts during night, and get a little pulped food evening and morning, and going out to the pastures during the day. This treatment is continued till about the end of November, after which they are kept in day and night, and get during the whole winter pulped food three times a-day. The first feed is given about 5 A.M., the second between 10 and 11 A.M., and the third between 4 and 5 P.M.

"The cattle at Corston are mostly all fed in covered courts and loose-boxes, which I prefer to stall-feeding, especially for young growing cattle. As their food by the pulping system is comparatively dry, it is absolutely necessary that they should have ready access to plenty of water, which they have in the courts at all times, as they require it.

"During December the cattle are fed very sparingly, as I have found when they are first put on this kind of food they are sometimes apt to eat more than they can well digest. They therefore get only about 30 lb. a-day of the pulped mixture during December. After the month of December, I increase the daily allowance to 45 lb., and on the first day of every month thereafter 15 lb. more are added, till by the first of March each animal is getting its full allowance of from 70 to 75 lb. daily of the pulped mixture. This mixture is made up as nearly as possible in the following proportions :—

	lb.	d.
One skullful of cut straw or chaff, weighing about	14	
Which, at 55s. a ton, would cost		4
One skullful of pulped turnips, weighing about	56	
Which, at 10s. a ton, would cost		3
Of decorticated cotton-cake, about	4	
Which, at £6, 10s. a ton, would cost		2½
Of molasses or locust-bean meal, about	1½	
Which, along with 2 oz. salt, would cost		1
Altogether, per day, about .	75½	
At a daily cost of . .		10½

These ingredients, after being carefully turned over two or three times, and well mixed together, are allowed to ferment for 24 hours or so before being used—in other words, the pulp for to-morrow's feeding is always made up to-day.

"More than this allowance the cattle do not care to eat, and cattle ought never to get at any one time more than they are able to eat and to digest, otherwise they do not go with the same relish to their next feed, and consequently never do so well. About the 1st of April, however, the pulped mixture is enriched by from 1 to 2 lb. additional linseed-cake for every beast being fed.

"I also at this time (1st of April) draw out generally from 80 to 100 of the best of the cattle—those which show a tendency to take on fat most readily—and give them, at about 8 P.M., an extra feed of from 2 to 4 lb. each of linseed-cake, grain, &c. By the month of June these are generally all prime fat, weighing from 6 to 7½ cwt. *dead weight*, and are then sold to the butchers at prices ranging from £17 to £22. The other 40 shotts or winterings are either kept on, or sold about the beginning of May for the grass, at prices ranging from £12 to £15 each. When they are kept on by myself, I put them on the best pasture I have, and continue to give them a daily allowance of from 4 to 5 lb. cake or other artificial food.

"I am sorry I cannot give the actual weight gained by each animal every month of their feeding, as at present I have no means of weighing cattle alive, which I much regret; but I can give the actual cost of feeding during each month, and for the whole season, by the pulping system, and also by the ordinary way of feeding with sliced turnips. I have satisfactorily tested both systems over and over again, with the result that I find the pulping system not only the most profitable, but preferable also in other respects.

Cost of feeding a two-year-old bullock from 1st December to 15th June.

I.—*By the pulping system.*

	£	s.	d.
1. During December, with an allowance of 30 lb. of the pulped mixture (including straw) at the prices stated in p. 374, the cost would be	£0	10	10
2. In January, with an allowance of 45 lb.	0	16	3
3. In February, with an allowance of 60 lb.	0	19	7
4. In March, with maximum allowance of 75 lb.	1	7	1
5. In April, with the addition of 3 lb. linseed-cake	1	11	3
6. From 1st May to 15th June, with the addition of other 3 lb. cake, grain, &c.	2	17	6
Total cost of feeding, 28 weeks, from 1st December to 15th June	£8	2	6
Deduct from this the value of the manure, which I estimate at not less than *one-third* of the whole cost of feeding (just equivalent to the value of the straw eaten, and which to meet the value of the manure left is never charged for in cases where turnips are let for consumption by cattle), and which would be	2	14	2
Thus leaving as the net cost for feeding from 1st December to 15th June	£5	8	4

"The same cattle fed in the usual way with sliced turnips require to get, by the *beginning of March*, not less than a skullful of turnips three times a-day, which would be about 1½ cwt.—a fair allowance only for a two-year-old bullock,—and if they are to be fed off and finished by the middle of June, they must get in addition after the 1st April an allowance of from 3 to 6 lb. of cake or other artificial food daily.

II.—*By the ordinary system.*

	£	s.	d.
To simplify the calculation in this case, I will allow the fodder to stand against the value of the manure. Commencing, then, with a short allowance of 1 skullful of turnips a-day for the first month, the cost of feeding (exclusive of straw) during the month of December would be	£0	7	9
In January, with an allowance of 1½ skull a-day	0	11	6
In February, with an allowance of 2 skulls a-day	0	14	0
In March, with the maximum allowance of 3 skulls	1	3	3
In April, with the addition of 3 lb. cake daily	1	8	6
From 1st May to 15th June, with the addition of other 3 lb. cake, &c.	2	13	6
Net cost of feeding by the ordinary system	£6	18	6
Net cost of feeding by the pulping system	5	8	4
Showing a saving per head in favour of the pulping of about	£1	10	2

"Besides this saving, there is a decided advantage gained by such great economising of turnips, thus enabling one to keep more than double the number of stock that could be kept otherwise, and at less cost too.

"Moreover, the manure made under the pulping system is much richer in ammonia, and of considerably more value, owing to the quantity of cake consumed in place of turnips, which is a very material point in favour of the method."

It will be noticed that in Mr Buttar's system, detailed above, the hard feeding is delayed till well into spring. When it is desired to have the animals finished earlier, the extra supply of rich food, cake, or corn, or both, will be begun sooner. With a pulped mixture, such as is described by Mr Buttar as the basis of the meals, the daily rations may be readily adapted to the purposes in view, and the capacities of the stock, by increasing or lessening the richer and more rapidly fattening elements.

Sliced Roots preferred to Pulp.—Mr R. Turnbull, The Mount, Wolverhampton, gives his fattening cattle in winter sliced swedes, oat-straw, and hay chaffed, and mixed with meal, and long hay at night. He considers that cattle thrive better on sliced roots than when fed on pulped roots, and adds, "sliced roots appear to cause a better flow of saliva than pulped food, and as stalled cattle get no exercise, this is a very important consideration. The sweet juice of swedes appears to agree with fat cattle better than pulped roots that are slightly fermented. Fat cattle, after eating sliced roots, rest and sleep more contentedly than after a meal of pulped food."[1] This is not quite in accordance with the experience of others, but feeders should hear what is said for and against the various systems, and experiment and judge for themselves.

Cattle-feeding in Aberdeenshire.—The fame of Aberdeenshire beef is world-wide. In the attainment of this the people, the land, and the cattle have each played a creditable part. To reverse the order, the stock of cattle are of the very best class of beef-producing animals, chiefly crosses between the native black polls and the shorthorn breed. Then the land is peculiarly adapted for the raising of turnips of the highest feeding value. It is well known that there are turnips *and turnips*, some much richer than others in feeding properties. The roots grown on the well-farmed granite soils of Aberdeenshire are of exceptionally rich quality. And as to the people, the knack of how to make a bullock hard-fat would seem somehow to have become the special birthright of the Aberdeenshire farmer. He treats his land well, and he knows that in so doing he is enriching the raw materials which afterwards go to the production of his annual "crop of beeves," which form such a large portion of the revenue of his farm. Aberdeenshire cattle-men are as proverbial for their proficiency as are the Aberdeenshire cattle and the Aberdeenshire beef for their high quality.

Mr M'Combie's System of Feeding.—Aberdeenshire owes not a little of its reputation for cattle-feeding to the late Mr William M'Combie of Tillyfour, who was far in advance of his time as a feeder of cattle. His little volume, *Cattle and Cattle-breeders*,[2] is full of useful hints to breeders and feeders of cattle. Here we cannot do more than present the following extracts, relating particularly to his mode of winter feeding. He says:—

"The practice of tying up cattle early in Aberdeenshire is now almost universal; the success of the feeder depends upon it, for a few weeks may make a difference of several pounds. I sow annually from 12 to 16 acres of tares, and about the middle of June save a portion of the new grass full of red clover, and from the 1st to the 20th of August both tares and clover are fit for the cattle. I have for many years fed from 300 to 400 cattle; and if I was not to take them up in time, I could pay no rent at all. A week's house-feeding in August, September, and October, is as good as three weeks in the dead of winter. I begin to put the cattle into the yards from the 1st to the middle of August, drafting first the largest cattle intended for the great Christmas market. This drafting gives a great relief to the grass-parks, and leaves abundance to the cattle in the fields. During the months of August, September, and October, cattle do best in the yards, the byres being too hot; but when the cold weather sets in, there is no way, where many cattle are kept, in which they will do so well as at the stall. You cannot get loose-boxes for 80 or 100 cattle on one farm. In former years I bought nearly all my grazing cattle in Morayshire, but now I purchase a great many in Aberdeenshire.

Tying Cattle.—"Many of the Morayshire cattle have never been tied. I adopt the following system with them: A rope is thrown over the neck of the bullock; the other end of the rope is taken round the stake; two men are put upon it, and overhaul the bullock to his place. When tightened up to the stall the chain is attached to the neck, and the beast is fast. We can tie up 50 beasts in five hours in this way. When tied, you must keep a man with a switch to keep up the bullocks. If you did not do this you would soon have every one of them loose again. They require to be carefully watched the

[1] *Jour. Royal Agric. Soc. Eng.*, xxiv., sec. ser., 460.

[2] William Blackwood & Sons, Edinburgh and London.

first night, and in three days they get quite accustomed to their confinement, except in the case of some very wild beast. I never lost a bullock by this method of tying up. This system is like other systems—it requires trained hands to practise it.

Tares and Clover for Fattening Cattle.—"I never give feeding cattle unripe tares; they must be three-parts ripe before being cut. I mix the tares when they are sown with a third of white peas and a third of oats. When three-parts ripe, especially the white peas, they are very good feeding. Fresh clover, given along with tares, peas, &c., forms a capital mixture. I sow a proportion of yellow Aberdeen turnips early, to succeed the tares and clover. It is indispensable for the improvement of the cattle that they receive their turnips clean, dry, and fresh.

"In a week or ten days after the first lot of cattle is taken up from grass, a second lot is taken up. This is a further relief to the pastures, and the cattle left in the fields thrive better. This taking up continues every week or ten days to the end of September. At this period all feeding cattle ought to be under cover that are intended to be fattened during the succeeding winter. The stronger cattle are drafted first, and the lesser ones left until the last *cull* is put under cover.

"From August till November a man may take care of 30 cattle very well, or a few more, if the cattle are loose; but when the day gets short, 20 to 25 are as many as one man can feed, to do them justice, if tied up.

Allowance of Cake, Corn, &c.—"I change the feeding cattle from tares and clover on to Aberdeen yellow turnips, and afterwards to swedes, if possible by the middle of October. I do not like soft turnips for feeding cattle. The cattle that I intend for the great Christmas market have at first from 2 lb. to 4 lb. of cake a-day by the 1st of November. In a week or two I increase the cake to at least 4 lb. a-day, and give a feed of bruised oats or barley, which I continue up to the 12th or 14th of December, when they leave for the Christmas market. The cake is apportioned to the condition of the different animals, and some of the leanest cattle get the double of others which are riper. The cattle being tied to the stall places this quite in your power, while in the strawyard it could not be done.

"The method I adopt as to using cake and corn is the following: On the different farms where I feed the cattle, I put a fourth part of their number only upon cake and corn at one time, and six weeks is about my limit of time for cake and corn, &c., paying the feeder, before they are to be sent to the fat market. The above does not apply to the 70 or 80 bullocks for the Christmas week. They get an extra allowance from 1st November. I cannot impress this opinion too strongly on the inexperienced feeder. When the six weeks are expired they are sent away; another fourth part of the original number take their place, and get their six weeks' cake. When they leave, the other cattle in succession get the same treatment. When turnips are plentiful the system works very well. The cattle draw beautifully, week by week, from the different farms, and come out very ripe. I may mention that almost all the cattle I graze are generally kept during the previous winter upon as many turnips as they can eat, and are in high condition when put to grass.

Return for a Month's Keep.—"In Aberdeenshire I consider that a large bullock ought to pay 25s tc 30s. a-month for keep, if he is properly treated. We often get less, and sometimes a little more, owing in some measure to the way in which the cattle are bought, the price of beef at the time, the season of the year the cattle are bought, and the time they are sold."

Mr G. Wilken's System of Feeding.—Mr George Wilken, Waterside of Forbes, situated in the same district of Aberdeenshire as Tillyfour, also pursues a liberal system of feeding. Most of his cattle are about two and a half years old when tied up in stalls at the end of the grazing for fattening. They are already in good condition, and as soon as fully accustomed to the winter fare they receive as many turnips as they can eat readily, getting little or no extra food until the last few weeks, when they receive from 2 to 3 lb. of cake, and from 4 to 6 lb. of oats or bere, according to price. The cattle usually go off for slaughter at about 2 years and 9 months old, when they weigh in the carcass from 7 to 8 cwt.

Feeding in a Polled Herd.—Mr Anderson, Wellhouse, also in the Vale of Alford, ties up his two-year polled steers for preparation for the Christmas market about the end of August or first week of September. When two-year-old bullocks are casting their teeth they get their turnips cut, and along with the turnips 2 lb. a-day of bruised linseed, until their teeth are up so that they can again eat the turnips, either yellows or swedes. He provides an abundant supply of tares, mixed with oats, peas, and beans, to feed with before turnips are ready. Such a mixed food, after the oats have come into the ear, is a very valuable diet. About the middle of September, in favourable circumstances, early turnips will be ready for use, and two diets a-day will improve the feed. Since grain has become so cheap, he uses oats or barley bruised and mixed with linseed-meal for feeding animals. The proportions are about 1 lb. of meal to 4 lb. of oats or barley. One feed of 4 lb. of oats or barley once a-day is given until the end of October, and after that, on to Christmas, two feeds a-day. The feeding animals get what they can eat of oat-straw, and of turnips also, until, say, a fortnight before being despatched for the Christmas market, when the turnips are reduced. In ordinary circumstances, Mr Anderson's rule in the use of turnips is,—give what the animals will eat, but do not give to purge them. In years when turnips were scarce he substituted, largely, more concentrated foods; but he states that while the animals took on a fair "chip" of fat under these, they never increased in bulk as they do when they get a plentiful supply of turnips. He sells his polled bullocks at two rising three years old, the dead weights being from 7 cwt. to 9 cwt.

Feeding in a Prize Herd.—One of the most successful cattle-feeders of the present day—and he is as successful in breeding as in feeding, for he breeds all he feeds—is Mr James Bruce of Inverquhomery, Longside, Aberdeenshire, whose name and cattle are well known in Smithfield circles. The success of cattle-rearing he thinks depends principally upon three things: 1st, a good strain of blood, and judicious selection in breeding; 2d, feed the land liberally as well as the cattle; and 3d, a good cattle-man. In the fulfilment of these three conditions Aberdeenshire certainly stands well to the front; hence its fame for cattle-feeding.

Mr Bruce himself has an exceptionally good herd of pure-bred shorthorn cattle, which he devotes almost entirely to the direct production of beef, few of his male calves being kept for breeding purposes. He "feeds" the turnip-break with from 10 to 12 loads of farmyard manure, 8 cwt. bone meal, and 4 cwt. guano. The farmyard manure is put on in autumn. From this liberal treatment he usually gets over 30 tons of swedes and 26 tons of yellow turnips per acre, and he considers that this extra manuring makes all the food grown upon the farm richer than it would otherwise be, giving it a potency in fattening cattle which he thinks could not be imparted by manufactured feeding-stuffs. As will be imagined from this, Mr Bruce relies mainly upon the produce of his farm, chiefly on turnips and straw, in the feeding of his cattle; but those of his animals which are being pushed for showing or for the Christmas markets receive a good deal of cake.

Cattle-feeding in Easter Ross.—The district of Easter Ross has become famous for the large number of "prime beeves" it sends to the London Christmas market. The system of feeding pursued is very liberal and carefully thought out. The majority of the cattle there fattened for the London market are put up for finishing at the end of the grazing season, when they are approaching three years old. They are well-grown cattle of first-class quality, mostly crosses between the shorthorn and Aberdeen-Angus breeds. They are well grazed, and are in good condition when housed for hard feeding.

Mr John Gordon, Balmuchy, Fearn, one of the largest feeders in Easter Ross, states that when his feeding cattle are housed he starts them with 2 lb. decorticated cotton-cake and 2 lb. linseed-cake, gradually increasing to 3 lb. each, and then by degrees withdrawing 1 lb. of the cotton-cake and substituting a like quantity of linseed-cake. About six weeks before the animals are sent away to the London Christmas market, they get in addition to the cake 2 lb. each of bruised oats or finely ground peas or beans, very slightly moistened with water. Half the daily allowance of cake is given at 6 A.M., and a feed of cut turnips follows at 9 A.M. While the animals are eating their turnips the byres are cleaned out and the cattle groomed, and as soon as the turnips are eaten, a moderate supply of sweet oat-straw or hay is given. Mr Gordon is adverse to the use of racks for straw, as the fodder is apt to get stale in them. The cattle are then allowed perfect rest till 1 P.M., and in the afternoon they receive cake, roots, and straw or hay as in the forenoon, with a "bite" of oat-straw or hay at 8 P.M. Mr Gordon considers it of great importance to have the feeding, grooming, and cleaning done with the regularity of clock-work, and remarks that a cattle-man will never be a successful feeder unless he knows how to give a beast as much as it can eat and yet not a "pick" more. He must also watch the bowels of the animals carefully, as if an animal is purging or costive it cannot be doing well.

A Popular Scotch "Blend."—The following mixture of foods is largely used in the Lothians and other parts of Scotland both for sheep and cattle—viz., Decorticated cotton-cake, linseed-cake, bran, maize, ground locust-beans, and peas in equal proportions, and all mixed together. The albuminoid ratio is about correct in this mixture, while sheep and cattle consume it with a relish, and thrive well upon it. When oats are cheap and maize dear, the former may take the place of the latter. This mixture costs about £5, 15s. per ton in Leith.

Linseed-oil and Oats.—In these times of cheap oats a good many feeders rely largely upon bruised oats, moistened with a glass of linseed-oil. It is a cheap food, and gives good results.

Cattle-feeding in England.

In many cases English methods of cattle-feeding differ considerably from the prevailing practice in Scotland. The warmer climate and longer period of growth provide the farmer in the south of England with greater variety of winter food than can be grown to advantage upon average Scotch farms. Comparatively fewer turnips are grown in England than in Scotland, and, as a rule, southern farmers place less reliance than northern farmers upon turnips as food for cattle.

Feeding Cattle should be Housed Early.—In the south, cattle may, of course, in average seasons remain longer out on the pasture-fields in autumn than in the colder regions north of the Tweed. Still English as well as Scotch farmers will be all the better of a reiterated word of warning upon this point. Indeed it is well known that English farmers, as a body, are not so careful as they ought to be in the winter housing of their cattle. They leave the animals too long in the fields towards the end of the grazing season, so that the cattle are not only often checked in progress, but sometimes even "put back" several weeks by exposure to inclement autumn weather. Treatment of this kind is especially detrimental to cattle that are being fattened, or are about to be put up for feeding. These should be housed overnight as soon as the chilly evenings set in; and while they may have a run out daily for some time after, it should be remembered that it is short-sighted policy to keep feeding cattle, or cattle about to be fattened, scampering over a bare pasture-field in search of sustenance. Depend upon it, it will pay far better to house them early, and put the food before them in plentiful quantity and in palatable condition.

Roots and Green Food for Feeding Cattle.—As has been indicated, a greater quantity of green food, other than roots, is grown in England than in Scotland for cattle. This is extensively used in autumn and early winter before the turnips or mangels are available. By many of the best feeders in England very large quantities of cake and corn are given to cattle. Mr Charles Howard, Biddenham, Bedford, feeds extensively upon grass-land during summer; but any of the cattle not quite fattened on the fields are housed at the end of the grass season, and finished for the Christmas markets upon hay, hay-chaff, a small allowance of roots, and about 7 or 8 lb. of cake, with a peck of barley and bean meal mixed, per head per day.

In the spring months mangels are extensively used in feeding stock in England.

Hereford Examples. — Mr George Child, Court of Noke, Hereford, has been exceptionally successful in the feeding of young Hereford steers, which he turns out in admirable condition for slaughter at from 18 to 20 months old. He feeds his animals liberally from their birth onwards, and in the autumn of their second year the steers get on the grass an allowance, beginning with 4 lb. daily, of cotton-cake and ground corn, wheat, barley, or oats. About the end of September they are housed, and receive the best quality of hay and pulped roots, and as much linseed-cake, cotton-cake, and bruised corn as they can eat—usually from 8 to 9 lb. per day. By Christmas they are in prime condition for slaughter, and their average dead weight would then, at from 18 to 20 months old, be about 640 lb.—*i.e.*, 8 *score* per quarter. The cake and corn is given in two feeds, the first thing in the morning and about 4 P.M.

Many of the Hereford farmers finish off their bullocks on grass with cake or corn. With those who do fatten in the house in winter, the pulping system has attained considerable favour, and is extensively pursued; so that, with few turnips—from 60 to 100 lb.—and from 5 to 9 lb. of cake and corn, their steers are made prime fat at an early age.

Norfolk Systems. — In Norfolk, on the other hand, with the four-course system of cropping, there is little scope for grazing, but an abundance of turnips and straw. Here, therefore, roots are extensively employed in the feeding of cattle. Cattle, for most part animals rising two years old, are purchased in autumn, and fattened during winter in courts or yards, upon turnips, straw, hay, cake, and grain. Mr Robert Wortley, Suffield, states that these cattle are given an unlimited supply of roots all through the winter. Some people expend up to £5 for artificial food for each animal; others give but little. He adds that since the price of beef has fallen, he himself buys in young cattle (in the autumn) at from £8 to £14 each. He begins selling in March, and has them all off in June, generally making about £10 per head for feeding. Each animal eats from £2 to £5 worth of artificial food — according to the supply of home-grown food and the stock of cattle—and this artificial food consists chiefly of cake, with perhaps a quantity of home-grown corn, mixed with maize and lentils ground together.[1]

A Group of English Rations. — From Mr H. F. Moore's interesting paper on the "Preparation of Food for Stock,"[2] we cull the following notes as to the daily meals given to fattening cattle in winter by a number of leading English farmers:

Mr H. Simmonds, Bearwood Farm, Wokingham — 6 lb. oil-cake, 2 gallons mixed meals, ½ to 1 bushel of roots, with hay-chaff and a little long hay; cake and meal given morning and night, with chaffed hay, roots after breakfast, and a little long hay at 8 P.M.

Mr Joseph Paget of Stuffynwood, Mansfield — 4 lb. cake, 4 lb. corn, 7 lb. hay, 60 lb. roots, and oat-straw *ad lib.*

Mr John Watts, Falfield, Gloucestershire—as much as they can eat of chaff, scalded with linseed-tea, about 100 lb. of swedes, 4 lb. of meal, and 4 lb. of cake.

Mr Henry Woods, Merton, Thetford, Norfolk—6 to 8 lb. linseed-cake, 1 gallon crushed beans or peas, hay and cabbages.

Mr Gilbert Murray, Elvaston, Derby —4 lb. of meal (oats, wheat, white peas, and linseed, all ground together), 4 lb. of linseed-cake, with chaffed hay and straw, and 28 lb. of pulped roots.

Feeding without Turnips. — Mr Edwin Ellis, Summersbury, Guildford, says: "I have no hard and fast rule of feeding, as I think it should be so elastic as to accommodate itself to the farm produce of the day. I feed with good sweet barley-straw (in preference to secondary hay), oatmeal, and barley-meal, and last season (1885), when the root crop on my farm was a perfect failure, fed treacle, with chopped hay and straw, without any roots whatever. My bullocks never came on quicker or

[1] *Live Stock Jour.*, Dec. 3, 1886.

[2] *Jour. Royal Agric. Soc. Eng.*, xxiv., sec. ser., 447.

better, teaching me plainly that *better no roots than too many.*" [1]

For feeding cattle without roots the following plan is recommended by the *Farming World:* "One pailful of cut hay or straw three times a-day, mixed with bean-meal, Indian corn, meal, linseed-cake meal, and cotton-cake meal in equal proportions. Four to ten lb. of the meal to each beast according to size, &c. Mix the whole day's feed, chop and meal together, in a large box. Then take 1 lb. of treacle for each animal and dissolve in sufficient boiling water; after which pour the sweetened liquor over the mixture of chop and meal in the box, and turn the whole over to let it mix thoroughly. Next cover up the feed in the box and let it stand twenty-four hours. Give a pailful three times a-day with a little salt. If the cattle have to be pushed very fast, they may get each 2 lb. daily of cotton and linseed cake mixed, in addition to the above feed." [2]

Mr W. J. Edmonds of Southrope, Lechlade, states that he fed his Christmas cattle very satisfactorily with only one peck of roots per day and the following mixture: 5 bushels of mixed hay and straw chaff, 4 or 5 lb. of oilcake, and ½ peck of meal (barley, bean, pea, or wheat meal), increased to 1 peck per day about six weeks after the fattening began. The oilcake and meal were boiled for about one-half or three-quarters of an hour, and thrown as a rich soup over the chaff, with a little salt, about eight hours before being used. Care was taken not to let the mixture lie till it would become sour.

Mr Charles Randell's System.—In Mr Joseph Darby's very useful paper on "Straw as Food for Stock," [3] the late Mr Charles Randell of Chadbury, Evesham, an eminent English farmer, thus describes his system of fattening cattle, and making manure without roots:—

"After having heard how readily and profitably straw, aided by roots, cake, and corn, is converted into beef in Norfolk and other root-growing counties, and the manure, essential for the reproduction of the means of carrying on the process preserved, you may like to know how the occupier of a clayland farm (where to attempt to grow turnips is in the opinion of some good practical farmers in the neighbourhood a sufficient qualification for a lunatic asylum) tries to convert his straw into manure which deserves the name without serious loss.

"I have 15 two-year-old steers feeding, 25 milking and in-calf cows, 2 bulls,	These with their manure are entirely under cover.
6 two-year-old heifers, 15 yearlings,	In small yards, shedding spouted.
—	

"These 63 animals consume daily as follows:
"As much steamed chaff, one-fourth hay, three-fourths straw, as they will eat.

	£	s.	d.
4 bushels Indian corn, costing .	0	14	0
1½ cwt. decorticated cotton-cake, ...	0	12	6
1 cwt. bran	0	5	6
1 cwt. malt-dust	0	5	6
½ bushel Black Sea linseed (boiled)	0	4	6
Per day	£2	2	0

for purchased food only. Now this cannot pay in the shape of a direct money return, and can only be excused by estimating highly the value of the manure—an estimate which will be fallacious or otherwise in proportion to the extent to which the manure is protected from rain. If it be made in large open yards, with the surrounding buildings unspouted, the loss is certain; in small yards, where the open space is not—and it should never be—more than as five to two of the spouted shedding, it is questionable; but in covered yards the cost of food may be recovered, while only one-half the litter is necessary, thus economising straw and carting; for it is obvious that a much smaller quantity per acre of this concentrated and unwashed manure will be required for any crop. The cattle too, so protected, will give a greater increase for the food consumed.

"It will frequently happen that by rigid economy in the use of hay—the most expensive food, looking at its selling value, that a farmer can give to his cattle—he may be able to sell some to

[1] *Live Stock Jour.*, Dec. 3, 1886.
[2] *Farming World*, Oct. 21, 1887.
[3] *Jour. Royal Agric. Soc. Eng.*, xiii., sec. ser., 144.

cover in part the cost of purchased food."

Winter Feeding on Fields.—Although the system must necessarily involve a heavier consumption of feeding material to maintain the animal heat, some English farmers nevertheless derive satisfactory results by fattening cattle in dry well-sheltered fields during winter. Mr Richard Stratton, The Duffryn, Newport, Monmouth, one of the most experienced cattle-feeders in the country, says: "I give feeding cattle cake and meal on grass up to 14 lb. per head per day in winter, when they do well on dry pasture, with shelter under banks and hedges. I prefer feeding in this way to either tying up or in open yards. Straw is scarce and dear here, and the system saves litter, and prevents all waste of manure. I begin in October with about 6 lb. of cake and meal, and finish off with 12 or 14 lb. in December or January, given at 7 A.M. and 5 P.M.; the animals going away fat when from 2 years and 6 months to 2 years and 9 months old. But my practice in feeding varies according to the prices of the different commodities. Sometimes I use cake, sometimes corn; also hay or straw, according to the market prices of these. Again, as to roots, if scarce and dear, I sell them and use artificial foods; if plentiful and cheap, I consume them." Mr Stratton's farm, it should be mentioned, is in a warm locality and well sheltered.

In *Ireland* cattle-feeding is in many cases carried on with as much care and success as in either England or Scotland. There also, however, great loss is sustained through want of proper attention to comfortable housing.

History of a butcher's beast.

The following account of the system of rearing and feeding cattle pursued on the farm of Sheriffston, near Elgin, by Lord Provost Black, will be perused with interest: "In 1882, in order to produce the most superior cross I possibly could for a feeding stock, I decided to procure the best black polled cows that could be bought for ordinary market prices, or a moderate sum above these. My intention was to cross them with a shorthorn bull of the best blood and form that were obtainable, without going too far into fancy figures. I bought forty black polled one-year-olds in the neighbourhoods of Ballindalloch, Drumin, and Advie, at an average of about £14. Twenty-four of the lot were heifers. They were all served by a son of Arthur Benedict 40986 of Gordon Castle, and all calved correctly. After their calves were weaned, I selected sixteen for keeping as cows, and sold eight for £180, or £22, 10s. each.

"Several of these sixteen I have on the farm still. Some of them that missed settling in calf have been fed, sold, and replaced by daughters of those that proved of most value in producing young stock and in milking.

"It is from a herd of females got up in this way that my young animals come, so far as they are bred on the farm, the sires being always pure shorthorn bulls of good form and pedigree. My first lot of calves from these came to be one-year-olds in the spring of 1884, and in the middle of April of that year I sold four of the pick of the bullocks when fourteen months old at £20 a-head. Of the lot, eight bullocks remained, and these were kept on till the middle of March 1885, when, at twenty-five months old or thereby, they were sold at £26, 5s. a-head. This is an example of what was done on farms of the character of mine in this part of the country when beef was at about 74s. per cwt. In 1886 my two-year-old bullocks brought only £22, 3s., and in 1887 they realised only £18, 2s. 6d.

Fall in Price of Beef.—"In tabulated form the results for two-year-old bullocks are as follows:—

Spring 1885	£26	5	0
" 1886	22	3	0
" 1887	18	2	6

"Breeding and feeding were exactly the same all through, until within two months or thereby of the time of selling, when a little cake was given in the earlier year, but not in the two latter years.

"I have never till this year (1887) tried the feeding of two-year-olds, or six-quarter-olds as they are called, for the Christmas market. Out of twenty-five heifers of that age ten have been finished and sold this season (1887). They girthed from 5 feet 7 inches up to 6 feet 3 inches, and were calculated to weigh a little over 5 cwt. all over. Price £16 a-head. The remaining fifteen will not be fit for the butcher till February 1888, when they will be about two years old. Cattle of this age I have hitherto always kept on till March or April. Till this year (1887) I have not been able to bring heifers to nearly the same value as bullocks at the same age.

"For feeding for the Christmas market I have generally bought from twelve to twenty two-year-old bullocks as opportunity offered during the summer and early autumn. I put them into folds about the 20th of August, fed them on tares till near the end of September, and then on turnips, straw, with a little oilcake and grain, when beef was at a paying price, but with only a little bruised grain since beef came down to 60s. For this class of cattle I received, about end of November:—

In 1883,	£29	10	0	a-head.
" 1884,	27	15	0	"
" 1885,	24	7	6	"
" 1886,	25	5	0	"
" 1887,	20	0	0	"

Calf-rearing.—"You ask me to give you an outline of how young stock thus brought to the market are reared and fed. About one-half of the calves of the year are suckled. Two are put to each cow, and they are not weaned till they are between six and seven months old. The other half of them are milked from the pail, and get about 4 pints each of warm milk three times a-day after they are a month old. At first they get only about a pint and a half. This is increased gradually after the first two weeks or thereby, until it come to the full quantity of 4 pints each feeding-time at the age of about four weeks. When nearing six months old their mid-day allowance is reduced by a third, a week afterwards by two-thirds, and in another week the mid-day milk is discontinued altogether. Their morning and evening allowances begin to be lessened, and this process goes on till the milking is completely stopped at about the age of seven months, usually a little before it.

"I arrange to have a park of rich second crop after hay to put the calves into as they are taken off the milk, special attention being given to having them comfortably housed at night when the weather is cold, if they have not sufficient shelter in the field. Of calves "blowing" when first put on rich clover many people are afraid, but I have never had any difficulty with it. In six years we have had only one case of it so far as I remember, and the "probe" is always at hand, though it has never been required. The cattle-man exercises the greatest care and caution in putting the calves on the clovery second crop to begin with only when it is dry, and in putting them on to it only at night as it is getting dark.

"By the time the hay second crop is over, the barley stubbles are in good form. The barley fields have been sown out with grass, and some weeks after the stooks are taken into the stackyard, they afford a most "toothy" bite for the calves. We preserve a park specially for them, and keep them out on it as long as the weather continues passably good—often well into October. When nights are cold, however, they are taken into a fold, and get a feed of tares so long as they last. After tares are exhausted, turnips take their place—yellows, tops and all at first. This only, however, for a few days. The calves take to the tops first. Then they think of the bulbs, and to encourage them to try to bite them, we break a few in the troughs. Soon only bulbs are given, and still a few are broken. While this education in the biting of the turnips is going on, another educating process is begun.

"A little oilcake is put into the troughs in the morning before turnips are supplied. It very speedily commends itself to the notice of the youngsters. They get fond of it shortly, and it is continued all through the winter until within a fortnight or thereby of the young animals being put out to grass early in May. The quantity given at first is not over 1 lb. each per day. It is gradually increased, but never exceeds 1½ lb.

Wintering Calves.—"By the time for the complete housing of them for the winter, the calves are generally quite up to the eating both of turnips and cake.

Then the turnips are cut for them. Yellows generally last till past the middle of November. Swedes take their place, and they, with straw—oat-straw when it can be got—and the small allowance of cake in the morning, form the feeding of the calves on to the end of April, or until they go out to grass. Three times a-day turnips are supplied to them—at six and at ten in the morning and forenoon, and at three in the afternoon. They get as many as they can consume, but no more. The cattleman takes care to keep their eating capacity right. On his skill and success in this rests more than half his value. Another most important matter is punctuality to a minute in the hours for feeding, and scarcely less important is it to feed and bed-up quickly, and not disturb the fold any more till feeding-time come again, thus allowing as much time for rest as can possibly be given.

Attention to Health.—"The calves have all 'setons' put into their briskets in the autumn. I am not sure that this does much good, but it can do no harm; and it is an old practice, costing little either in money or trouble. My opinion is that the health of the animals is due mainly to good constitutions to begin with, to care in protecting them from cold, to regularity in feeding, to a uniform supply of good fresh nutritive food, to good bedding, and to good ventilation without cold, and especially without draughts.

Covered Folds.—"I am a recent convert to completely covered folds. Until last year I favoured having about one-third open in the good climate of Moray. Last year, however, I found reason to change my mind. A severe snowstorm, with very keen frost and biting cold, came on about the beginning of December. My calves in a two-thirds covered fold looked shivery and uncomfortable. One, weaker than the others, took ill and died. A *post-mortem* examination did not show that cold was the cause of death; but I felt satisfied that it at least aggravated and hastened the fatal effect of other ailments.

"I had the open part of the fold covered with beams laid flat across it, and brushwood and straw laid on the top of them. Rain this did not keep out, but it shut out the wind, changed the atmosphere of the fold completely, and the calves throve twice as much afterwards. During the past summer I have had all the folds on the farm fully covered, except a small opening in one, and see every day abundant reason for being convinced of the advantage of it.

Grazing Young Cattle.—"When at the beginning of May the calves, then one-year-olds, go to grass, they are taken in at night for a short time, until the weather become warm enough for leaving them all the twenty-four hours in the field. No cake is given to them after about the middle of April. They fall off a little usually, for the first week or two, on the grass, but soon make it up again if care is taken to have a good, full, and fresh bite for them. I found it advantageous not to keep them too long in one park. A shift to pastures new they relish much. I often put a temporary fence across a field, dividing it into two, giving the cattle one-half of it first, then the other, next shifting them back to the first half again, and so on throughout the season. Plenty of fresh water is of great importance. We separate the bullocks from the heifers, and do everything possible to give both plenty of fresh sweet grass—new grass to the younger stock as far as we can—plenty of shelter, and plenty of peace and rest.

Extra Feeding and Care in Autumn.—"This goes on till August. If the fields pastured through the summer become bare by that time, as they often do, some second crop after hay comes in to keep up the condition of the young stock. Failing this, sometimes tares are spread on the pastures to eke out the feeding they supply. This is the most difficult part of the year to tide over. It takes some scheming and care, frequently, to keep the one-year-olds from falling off until the usual time for putting them in on turnips in September. Many give them cake in the fields. This I have never done. Nor have I ever housed one-year-olds to be fed on tares, or cut second crop after hay. I have always kept them up in condition in the best way I can till the turnips are ready. I have succeeded thus in keeping them in the fields till about the second week of September, sometimes a little later, sometimes even into October. But whenever there is risk of falling off outside they are put in, whatever the time be, and fed in the folds. Cold nights are as bad as scarcity of keep. I never hesitate to take cattle in at night in bad weather, even though the time for complete housing has not come.

Shelter in Fields.—"It should be mentioned that in several of my fields the cattle have access to houses all the summer through at will. And they seek the shelter of them as often from the strong heat of the sun as from the biting of the blast. Some other fields are well sheltered with woods. A few have no shelter. From them the cattle are often taken into the folds in the evening when the nights begin to get long and the weather is cold, and even occasionally during the summer.

Winter Feeding.—"Once one-year-olds — six-quarters they now are — get housed for the winter, the usual feeding of turnips and straw is begun. Yellow turnips are used till well into November. At first they are given sparingly, tops and all. Shortly the tops are taken off, and in a week or ten days cut turnips are begun. The change of feeding is made as gradual as possible. And when yellow turnips get nearly done, one feed a-day of swedes is given, and only two of yellows. By-and-by it becomes two of swedes and one of yellows. Then it is tapered off to swedes altogether. No cake is allowed when beef is under 66s. to 70s.; but two months or so before the time for selling, if grain is cheap, a feed of it is put into the troughs at 8 o'clock every evening—at first 1½ lb. per head, or thereby, which is increased gradually until it comes to 2 to 3 lb. a-head before the finish. When beef was 70s. and upwards, I gave cake for the last two months as well as grain —1½ lb. a-day at the outset, increasing it to about 3 lb. It was the first feed in the morning.

Rest and Comfort.—"Care is taken to keep the animals well combed and clean. Skin affections are promptly treated; and everything possible is done to let the animals enjoy, along with the feeding I have detailed, a full measure of rest and comfort. These are unsensational and unspeculative methods, but they have been satisfactorily successful."

Cattle-Rearing in Devon and Somerset.

Mr John Risdon, Roadwater, Washford, Taunton, has favoured us with the following notes on the system of rearing and feeding cattle pursued in the counties of Devon and Somerset:—

"The Devon breed of cattle prevails, and the principle generally adopted on mixed farms is to breed and feed off. On the hill-farms the cattle are generally sold as stores, and fattened by graziers occupying more favoured localities.

Calf-rearing.—"The system of hand-feeding calves used to prevail—that is, feeding them from the pail. This has, in a great measure, been abandoned. In many instances two calves are given to one cow to be suckled, followed, possibly, by another pair or a single calf, according to circumstances. Calves are generally allowed to suck for three or four months, some breeders letting them remain with the cow until double these ages. Youngsters born in the winter are supplied with hay, roots, and either cake or corn. This is continued for some time. By some it is given up when they go to grass, by others continued throughout the summer. In the case of calves born, say, in April or May, or during the summer months, these run on the pastures with the cows, and seldom get artificial food.

Feeding Store Cattle.—"Store cattle intended to be fed young should be well done. Yearling steers get hay and roots, whilst their sisters have to be content with a feed of straw and as liberal an allowance of hay, &c., as circumstances permit. After the first winter, or when heifers are nearly two years old, most breeders consider good sweet straw, with an allowance of roots, amply sufficient for them.

Pulped *v.* Whole Food. — "Much variety of opinion exists as to the advantages of giving the straw and hay chaffed, mixed with pulped roots, or giving both hay and straw entire, and the roots either whole or cut with the slicer. The advocates of the latter plan contend that the cattle are enabled to select that part of the straw which they find most palatable, instead of being obliged to eat the whole. I decidedly lean to the principle of giving long straw; and find that when well harvested, and served to the cattle in small quantities, there is but a very small proportion left for litter. One of the most successful exhibitors of fat cattle in this neighbourhood gives all the roots to his cattle whole, from the young calves to the specimens in preparation for the Smithfield Club and other shows.

"Wherever practicable, it is highly desirable to give breeding animals a run on the pastures for a few hours daily, weather permitting.

Extra Food on Grass.—"The giving of artificial food to cattle when feeding on the pastures has increased very much in the last few years. Linseed-cake, or a mixture of this and cotton-cake, is much used; the latter having a tendency to prevent the animals from running out when the grass is quick. Others condemn its use altogether, fearing it may be served in mistake to young calves, &c., and prove injurious to them. Of course hay is given when the weather gets wet and the grass soft.

Age for Feeding.—"The age at which cattle are set aside for feeding varies considerably. No hard and fast rule would apply to the division of West Somerset. Around Bridgewater and Pawlett there is rich alluvial soil of several feet in depth. A friend of mine told me he sank a well 15 feet deep, and the bottom soil was as good as the top. On the other extreme, we have the wilds of Exmoor, the natural home, it is said, of the wild red deer, with Dunkery Beacon 1668 feet above the level of the sea. The rich lands about Bridgewater are, from the strength of the herbage produced, quite unfit for breeding purposes. Graziers in this district prefer three-years-old steers for feeding; but, except on cold high farms, they are not kept till this age. The majority of the farmers in the intermediate district breed and feed their own cattle. In all cases where it is the aim to bring out steers fat, at from two to three years old, it is highly desirable to dispense with them as scavengers on the pastures; and they should be kept steadily progressing from birth. The majority of the steers fed by the breeders are turned out fat at from two to three years old.

Housing of Feeding Cattle.—"Feeding cattle are, for the most part, tied up in stalls. This plan economises both space and litter. But few graziers have any option in this matter. For my own part, if roomy well-ventilated stalls are available, I should much prefer this to any other accommodation for feeding cattle for a length of time, as by this means they are enabled to lie at their ease, and can groom themselves with their tongues when necessary. For store stock I prefer small open yards, placing a few animals that agree well together in each.

System of House-feeding.—"We give our breeding cattle a feed of straw or hay the first thing in the morning, about 7 A.M., in the dead of winter. Between 8 and 9 they get about 20 lb. of turnips, swedes or mangels. After this they are turned on to the pastures (except in the case of young calves), the time they remain out varying according to the state of the weather and the quantity of grass on the land. On their return to the yards they get a feed of roots, and afterwards are supplied with dry food as in the morning. Should the weather be very cold or wet, a small supply of dry food is given before the roots, and a further supply is given the last thing in the evening. Both hay and straw are supplied without chaffing.

Weight of Devon Steers.—"Steers are generally fed at from two to three years old. Ordinary animals in this neighbourhood, such as are turned out for the Christmas markets, would average from 100 to 120 stones (8 lb.) each. Of course, animals that have received extra attention for exhibition would far exceed these weights. Mr John Bult, of Kingston, near Taunton, had a Devon cow fed on hay, grass, and roots only—no cake or corn of any description—whose dead weight was 1448 lb.; and an ox of this breed, bred and fed by Mr J. D. Hancock, of Halse, also near Taunton, weighed 1788 lb. This one was worked in the plough until the last 12 months, was grazed on the pastures without artificial food, and was stall-fed for three months only. These two, of course, are exceptional weights."

PREPARATION OF SHOW CATTLE.

The preparation of cattle for the show-yard is in a special sense a continuous process throughout the year. It would be inconvenient to break up its treatment into the "seasonable divisions" observed in the main body of the work. It may therefore be well to introduce here what is to be said on the subject. The following notes upon the preparation of cattle for both breeding and fat stock shows are from the pen of Mr Robert Bruce, Great Smeaton, Northallerton, Yorkshire, than whom no one is better qualified to speak on the subject.

Preparing Cattle for Breeding Shows.

By far the largest amount of prize-money given for breeding cattle at the shows in the United Kingdom is allotted to shorthorns. In writing, therefore, as to the preparation of a young animal for the breeding shows, one naturally has a shorthorn in one's mind's eye. And here the difficulty at once crops up as to the typical animal one has in view during the process of preparation.

Inutility of "Fancy" Cattle.—Every unprejudiced authority will acknowledge that too many of our shorthorn breeders have been off the track for some time past. They have, speaking generally, been persistently working against rather than with the laws of nature, and, as a natural consequence, have "come off second best." Breeding from pedigree solely—mating cattle because their pedigrees *ought* to make a good blend—judging animals by their herd-book names and numbers, in place of also looking at them, as the founders of the breed did, from the point of view of their individual merit—too many of our modern breeders have established a type of excellence of their own, the utility of which, to put it mildly, is not recognised by more practical breeders, whose aim is to produce a useful rent-paying class of cattle.

Nevertheless, those breeders of the modern school often act as judges, and if one means to win, one must show cattle that will be appreciated by those judges.

No matter what the ordinary rent-paying farmer may say, no matter what the butcher may say, no matter, indeed, what the millions of meat-consumers may say, the "high-class judge" of breeding animals at our great shows will accord prizes as he thinks right. Nor does it end here: the lesser lights, taking their texts from their masters in the profession, preach sermons over animals in many a local show, and award prizes in a way to completely upset practical opinions. This animal was set aside on account of its hair or handle, that animal on account of its style and character, and another preferred, that by the farmer, the butcher, or the meat-consumer would be regarded as of infinitely less value.

Different Types.—Nor, in the shorthorn world, even amongst what may be termed the pedigree men, is there perfect accord. We have factions, even amongst them. We have the "Bates" and the "Booth." What the Booth men like in an animal, wants style and character to a Bates man; and what a Bates man likes, a Booth man says is of no value to an animal of the cattle kind.

The Type to Cultivate.—This being so, might we not assume a middle course? Might we not go, as many of our most successful breeders of prize shorthorns have gone, for good animals, animals that are accepted as good by the three great authorities we have mentioned above—the practical rent-paying farmer, the butcher, and the meat-consumer. What, it may here be asked, do they say? Are they enthusiastic about hair, handle, touch, style, and character. They like hair at the season it is needed, they like handle that indicates flesh or muscle, they like the touch that keeps one's fingers off the bones, and they certainly know that one steer in a market can show himself when another never looks his best. What do too many of our famous breeders say? They want to find, even in the summer season, hair artificially kept on; they like "handle" that indicates fat—an unsaleable product in these days; they like full flanks and prominent briskets in preference, it would almost seem, to wide chests and well-covered ribs.

Choosing the Calf.—In selecting a calf for showyard purposes, we would look well at its parents, choosing our subject from strong-constitutioned, healthy, good-looking sires and dams.

Calfhood of the Show Animal.—In ordinary practice the calf ought to run with its dam for eight or nine months, and before being weaned it should be learned to eat cake, and perhaps bran. There can be no doubt milk is a great factor in feeding for breeding shows, and many successful professional showmen depend much upon it. To make a calf that has suckled its dam, or even a nurse cow, for eight or nine months, take to milk from a fresh nurse or drink it from a pail, is a most difficult matter. Means must therefore be adopted at an early age to accustom the youngster to a change of milk. This may be done if we foster the future showyard "crack" on the pail; and once started to drink milk from a pail, it will continue to do so through life whenever it gets the chance.

It, however, requires the greatest care and much labour to raise calves on the pail to have the same bloom as suckling calves; and consequently, when expense is not so much a consideration as the attainment of the object in view, calves are early accustomed to a change of nurse cows, and so educated, so to speak, to suck any cow. While under the ordinary practice we would wean our calves intended for show animals at eight or nine months old, those under the milk treatment would continue to get milk in addition to the other food we shall speak of.

Assuming, therefore, that we have calves at nine months old—and to be a proper age for showing at our great national societies they would be at this age in the autumn—they ought to be early under shelter. Without being kept close or over-warm, they ought to have a dry comfortable crib to lie in, as, indeed, all youngsters should have. It is nothing but a waste of food to subject cattle of any age, and more especially young growing stock, to outside life in our long cold nights of autumn, not to speak of winter.

Exercise.—With a comfortable crib to shelter in, our young breeding animal ought to have plenty of outdoor exercise to develop its muscles, and, under such artificial training, to strengthen its constitution. It is of the utmost importance that all animals intended for breeding shows should walk well, and to ensure that they do so, a considerable amount of outdoor exercise is imperative. No doubt such exercise hinders to some extent their rapid development, but no amount of bodily development will win in a breeding show if the animal has weak or crooked legs to walk upon.

First Winter Rations.—Two to three lb. of linseed-cake, 1 lb. of cotton-cake, 3 lb. of bran and 2 of barley and bean meal, with a few roots, and oat-straw *ad libitum*, may be put as the first winter's feed per day. To an animal full of muscle or flesh that does not get milk, 1 lb. of linseed per day, bruised and scalded with boiling water and made into a thin drinkable jelly, may be of great use; but to many this would be over-rich in fattening properties, tending to develop unevenness of flesh, or what in showyard language is known as "bumps."

After the first winter, as the animal increases in size and age, the diet ought to be increased; but it must always be borne in mind, that in every case of cattle-feeding not one ounce more should be given than will be eaten up. Access should at all times be provided to water and salt.

Summer Feeding.—In the summer months, animals intended for showing ought not to be subjected to too much sun and heat, and instead of grazing out during the day, if at all convenient, they ought to get a run out on a sweet pasture at night. Instead of roots, their winter fare, they ought to get such a supply of grass and green food as they will consume with relish; and it will be found in practice that now and again, while on green food, a bite of good dry hay or fresh good oat-straw will be greedily picked up.

Baneful Influence of Sugar.—And here we may speak of the baneful practice some feeders pursue of giving sugar to breeding stock which are being prepared for shows. As surely as it is given in any considerable quantity, so surely will breeding disappointment follow. Let professional men explain this as they may, our practical experience has clearly proved that such is the case.

Milk-fed Show Animals.—With these observations we may leave this subject, but would say a few words upon our milk-fed animals, to be seen at our great national shows. We have tried to represent faithfully the standpoint many of our judges take as their ideas of excellence; and if our remarks are understood, it will at once be seen that what is required to win prizes can always be supplied. Much as practical men condemn what we may term a soft "handle," and much as even those same recognised breeding-show judges would, if called upon to adjudicate in a fat-stock show, deprecate such a handle, this soft undesirable handle does, all the same, win at the breeding shows. To ensure this soft handle, animals must almost live on milk, after nature has provided them with teeth to bite and eat instead of suck; and living on milk they win the prizes.

We do not hesitate to say, however, that the day is not far distant when what is now termed a hard handle will be looked upon as indicating sound constitution, and consequently muscle or flesh; while that peculiar, soft hair and handle, now so much admired, will be avoided as an indication of tuberculosis, disease, and untimely death.

Preparing Fat-show Cattle.

We can well remember the late Mr M'Combie of Tillyfour buying, against great opposition, a wonderful two-year-old steer at a sale when a well-known breeder and feeder was retiring from farming. The animal referred to had been well kept from birth, and no doubt had got an extra amount of good things before the sale, and when sold was really as fit in May as most showyard two-year-olds of that day would have been in December. Meeting Mr M'Combie some months after, we inquired about the steer, and the old gentleman said, "Oh, we are taking the poison out of him." Knowing that by this he meant he was keeping him on "short commons," we reremarked that, with such treatment the steer could not be fit for showing at Christmas. "Ah," said Mr M'Combie, "he is such a good one, we can afford to wait a year or two to bring him out, as he is sure to tell a tale when he is an old one."

Early Maturity at Fat-stock Shows.—This occurred only some twenty years ago, and yet since then, in spite of what some people say as to things in the agricultural world standing still, great changes have taken place. Speaking of fat shows, we would class them all under the head of Smithfield, one of the best-managed and most instructive shows in the world.

In preparing cattle for Smithfield shows nowadays, there could be no years wasted in "taking poison out of them," not even months, as, with the general approval of all practical breeders and feeders of stock, we shall soon see the classes for steers over three years old discontinued in the Smithfield prize-lists. This being the case, it is at once apparent that no time has to be lost from date of birth, if one is to bring out an animal fit to win at fat-stock shows.

The Calf.—Let us then suppose we start with a calf likely to grow into a Smithfield winner, and point out how he should be fed and treated till he appear at Smithfield. In doing so, it must be borne in mind that one that has to be shown in the class under two, and one that is not intended to be brought out till nearly three, years old, ought to some extent to be treated differently. This, however, we shall notice as we proceed.

Let us, however, hark back to the calf likely to grow into a Smithfield winner, and see if we can in some way define what this fellow should be at the outset.

In the first place, he ought to be the son of good parents—parents full of flesh, and we must not mix up flesh with fat in thinking of an animal full of flesh,—and therefore with strong constitution. He must, even when quite young, stand well on his legs, be wide in front and behind, and yet in no way bandy-legged; in other words, his "legs should be well outside of him." Along with this, his back should be straight and not too long, his loins strong and wide, and his breast and twists deep and full. His head will, to some extent, indicate his feeding powers, and ought to be wide and not too long, with large ears and big placid eyes, set wide apart.

The most common system in rearing such stock is to allow the calf to suck its dam for eight or nine months; but breeders are to be met with who raise their calves on the pail, so that they can continue to give the milk, which they do, throughout their whole showyard lives. There can be no doubt of the wonderful effects of milk on all animals, and more especially, as we have seen, on those intended for breeding shows; but in practice we have found it to be quite unnecessary expense in preparing stock for fat shows.

Given, therefore, our supposed steer calf running with his dam through his first summer on a fairly good pasture, we would recommend that towards the autumn he should have an opportunity to learn to eat cake—that is, if this habit has not been acquired before he went to grass in the spring months, when he began to need other food than his mother's milk. He should then be gradually weaned, being tied in a stall alongside his dam for a few weeks, allowing him to suckle her at first three times a-day, reducing it to twice, and afterwards from once every day to every other day, till his dam is dried off.

By this plan of weaning fretting will be obviated, and he can then be taken away and put in a loose-box by himself, having had an opportunity to eat small quantities of meal, cake, roots, and hay when alongside his dam.

A well-developed bullock at this stage —say, when he is nine to ten months old —ought to girth about 5 feet, and in practice we have for thirty years adhered to the system of keeping an exact register of each feeding animal's girth on the 1st of each month. There is no surer way of knowing how stock are doing, month by month, than for those who see them daily to judge by the expansion of their girth-measurement.

The Bullock's First Winter.—Now that our bullock has to depend entirely upon himself, let us put strongly and clearly our great disbelief in condiments and spices. We know we are treading on many toes, but nevertheless we have found in practice that, as a rule, those animals that need any of those condiments are of little good. We do not for a moment deny that many of our show-yard winners have been fed upon food seasoned with condiments, but we hold distinctly that most, if not all, of those winners would have done quite as well, with ordinary care in feeding, without them. Be this as it may, we can point to the most successful feeder of these times—a pupil of ours—who, through his very extensive experience of winning the champion prizes in all the fat shows of any account in England, time after time, has never used an ounce of such compounds.

The "Secret" of Successful Feeding.—Before speaking of the kind of food the bullock should get, we would at once give, in a single sentence, the whole secret of successful feeding for the Smithfield shows. In feeding, never give an animal a chance of leaving food. This is the whole secret, and it is, to say the least, amusing to hear even practical people talking as if a successful feeder must have some secret he kept to himself, when all the time they may very likely be using exactly the same food with different and less-paying results. To be a successful feeder a man must study the habits, the temperament, and constitution of the different animals under his care.

If he do this, he will find that not two animals can be fed alike, and fed as they should be. One will take more of one description of food than another; one would eat more of a particular food than it ought to get, while others, to go on as desired, must get all they can take of the different ingredients in their bill of fare.

Having determined, principally by the state of their bowels, the quantities of the different foods to be given, the great secret of the business comes in, in not giving an animal one ounce more of anything, at any time, than it eats at once, and eats with relish. The moment there is the slightest indication to surfeiting, there ought to be a decrease of supplies.

The Winter Feeding and Treatment.—To return to our young bullock in his loose-box, his daily fare when once he is fairly started, say, in the autumn, when he is ten months old, should be—at 6 A.M., 2 lb. of best fresh-made linseed-cake, with a bite of good hay. At 7 A.M., he ought to have a turn in a small paddock for an hour, and at 8 get about 15 to 20 lb. of good turnips or other roots, with a small quantity of sweet oat-straw or hay.

From 8 to 9 he ought to be well brushed and cleaned, particular attention being given to see that his skin is kept clean. We have a very strong belief in keeping all animals clean, and have found that irritation in the skin, arising from whatever cause, hinders thriving and feeding. All our young stock, after being put in their winter quarters, are dressed over with a weak solution of tobacco-juice, with lots of soft soap. A few days after this has been applied to the ordinary stock, they are caught and well curried and brushed, so that the "scurf" which the dressing raises from the skin may be removed.

With cattle preparing for shows we take more pains, and wash them well with hot water and soap, followed by a cold-water *douche* three or four days after they have been dressed. One dressing is generally sufficient in a season; but sometimes it is necessary to repeat it in spring after an autumn dressing, with those animals that are under full pressure of feeding. During their whole feeding life we strongly recommend washing now and again, whenever their skins get at all dirty, so that after feeding they may rest quietly, undisturbed by any skin irritation.

From 8.30 to 12 our bullock ought to rest undisturbed. At 12 to 1 he ought to get about 3 lb. of linseed-cake, with a fresh bite of hay, to be followed soon after with 15 to 20 lb. of roots. In all cases we advise the roots being put through a sheep root-cutter, as this obviates any risk of choking. From 1 till 5 he ought to be left undisturbed, and at the latter hour again get about 20 lb. of roots, with a little hay or oat-straw in his rack. At 8 P.M. he should get the principal feed of the day, consisting of, say, 2 to 3 lb. of bran and 4 lb. barley and bean meal. The meal by many is given dry, but we prefer swelling it with water at least four hours before it is given.

If we add that in each loose-box the

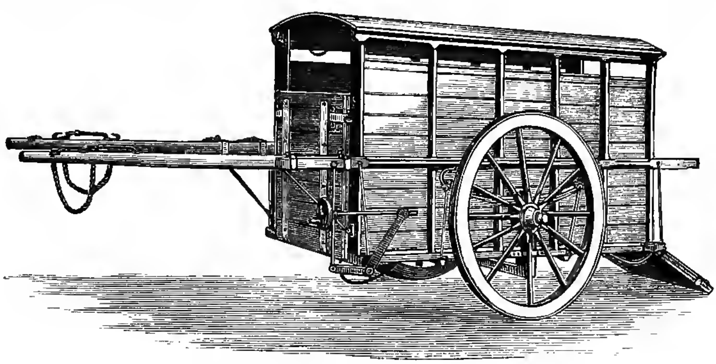


Fig. 139.—*Cattle-cart.*

animals have access to water, while there is always a lump of rock-salt in the manger, we have defined in a general way our bullock's daily fare till the root-season is over.

Summer Feeding.—As soon as cut grass can be obtained, if we substitute grass for roots, we then fix the summer diet. At the same time, as our bullock increases in age and size, his food should be increased, so that by the time he is two and a half years old, he may be eating, say, 7 lb. of linseed-cake, 4 lb. of bran, and 6 or 7 lb. of meal, with perhaps a little more weight of turnips. If the steer is to be exhibited under two years of age, he ought, for four months before being brought out, to get as much cake, meal, and bran as he can readily consume, while if he is to go on for another year, he must be kept considerably under what he could eat.

At 1 year and 10 to 11 months old, a good bullock should girth about 7 feet 3 inches, and weigh 13½ to 14 cwt. At 2 years and 10 to 11 months a well-fed steer should girth about 8 feet 6 inches, and weigh from 18 to 18½ cwt. The best steer under three years we have ever seen weighed at 2 years and 10 months almost 20 cwt., and girthed 9 feet.

Size and weight are a poor criterion by which to prove a good animal, as very often big ones are rough made, with lots of bone and offal, and wanting very much on those parts of their bodies where they should carry the most valuable meat. The animal, however, to which we refer above was exceptionally good on all points where a good one should be strong.

Cattle-cart.—Heavy show cattle unable to walk comfortably are conveyed in a float or cattle-cart, such as that (Crosskill's) shown in fig. 139.

HORSES IN WINTER.

HOUSING AND WINTER MANAGEMENT OF FARM-HORSES.

Dimensions of Stable.—The standard width of well-constructed stables is 18 feet 6 inches inside the walls; and it, of course, varies in length according to the extent and requirements of the farm. The side walls should be 8 feet high, from the level of the floor to the top of the wall-plate. A low stable is very inconvenient and unhealthy. The amount of cubic space allowed to each horse varies greatly—from as little as 500 or 600 to over 2000 cubic feet. Usually about 1200 to 1400 cubic feet will be enough; less than 1000 is very undesirable. The doors should be 4 feet wide.

Stable Windows.—All stables should be well lighted: the windows should be 3 feet wide, and at least 4 feet high. The upper half should be glazed with rough corrugated glass, and the lower half fitted with wood arranged to slide, so as to admit, when desired, a large current of air. All the windows should be placed in the front of the stable—that is, in the wall behind horses. A common form of window in stables is shown in fig. 140. The opening is 4½ feet in height by 3 feet in width. The framework is composed of a dead part *a*, of 1 foot in depth; 2 shutters *b b* to open on hinges, and fasten inside with a thumb-catch; and *c*, a glazed sash 2 feet in height, with three rows of panes.

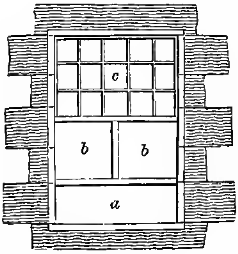


Fig. 140.—*Stable window.*

The object of this form of window is, that generally a number of small articles are thrown upon the sole of a work-horse stable window—such as short-ends, straps, &c., which are used only occasionally, and desired to be at hand when wanted. This confused mixture of things, which it is not easy for a farmer to overrule, especially in a busy season, prevents the shutters being opened, as it is scarcely possible to do it without first clearing the sole of every article; and rather than find another place for them, the window remains shut.

"Hit-and-Miss" Window.—A still better plan for the lower part of a stable window is to have it on what is known as the "hit-and-miss" arrangement. This can be provided as follows: boards 2½ to 3 inches broad and ¼ inch thick are nailed upright on the lower part of the window at intervals of 2½ to 3 inches, so that a board and an open space alternate. Another frame of similar boards and open spaces is fitted over this part of the window, so as to slide in grooves backwards and forwards, and thus, when the lower part of the window is open for ventilation, the bars of the moving frame are opposite the fixed bars, and when close they cover the spaces between the fixed bars. The ventilation can be modified by leaving only part of the open spaces uncovered by the moving frame.

A cupboard in a corner, or a press in a wall, suggests itself for containing such small articles; but the front wall of the stable, in which it would be convenient to make a press, is occupied by the harness hanging against it. When a dead piece of wood, as *a*, is put into stable windows, small articles remain on the sole, while the shutters are easily opened and shut over them.

Large *v.* Small Stables.—Some imagine that twelve horses are too great a number in one stable, and that two stables of six stalls each would be better. Provided the stable is properly ventilated, no injury can arise to a larger or a smaller number of horses in it; and there are practical inconveniences in having two stables on a farm. These are, that neither the farmer nor farm-steward can personally superintend the grooming of horses in two stables; that the orders given to the ploughmen by the steward must be repeated in both stables; and that either all the ploughmen must be collected in one of the stables to receive their orders, or, part of them not hearing the orders given to the rest, there cannot be that common understanding as to the work to be done which should exist among all classes of work-people on a farm.

Stalls for Horses.—Another particular in which most stables are improperly fitted up, is the narrowness of the *stalls*, only 5 feet 3 inches being allowed, in old-fashioned stables, for an ordinary-sized work-horse. A narrow stall is not only injurious to the horse itself, by confining it peremptorily to one position, in which it has no liberty to bite or scratch itself, should it feel so inclined, but it materially obstructs the ploughman, in the grooming, in supplying the horse with food, and in putting on and off the harness. No work-horse should have a narrower stall than 6 feet from centre to centre of the travis, in order that it may stand at ease, or lie down at pleasure with comfort. This is the width provided in well-constructed modern stables.

The standing space in the stall should be 6 feet in length from the manger to the outside of the heel-post. The division or travis should be 7 feet high at the front, and 5 feet high at the heel. The top and bottom rails are built into the wall in front, and morticed into the heel-post, and the division boards are 1¼ inch thick; and, to give greater strength, two pieces of wood, each 4 inches wide and 1½ inch thick, with their edges tapered off, are fixed directly opposite each other on these boards, these two pieces being securely spiked together.

In many stables the hind-posts of travises are of cast-iron, rounded in front, grooved in the back as far as the travis-boards reach, and run with lead at the lower ends into stone blocks. These posts are most durable and able to withstand the kicks of the horses, some of which are apt to strike out when groomed. When wooden posts are used, they are generally fastened at the upper ends to battens stretching across the stable from the ends of the couple-legs where there is no hay-loft, and from the joists of the flooring where there is, and sunk at the lower ends in stone blocks placed in the ground. The head-posts are often divided into two parts, which clasp the travis-boards between them, and are kept together with screw-bolts and nuts, their lower ends being also sunk into stone blocks. Their upper ends are fastened to the battens or joists when the hind-posts are of wood. In many cases the heel-posts are simply imbedded firmly in the ground, perhaps filled into a cutting in a large stone.

The top bar of the travis should be lined over with sheet-iron, to prevent the horses from biting the wood; and a small plate of iron should be fixed to timber hind-posts for striking the currycomb.

Swung Bale *v.* Travis.—Some prefer swung bales to fixed partitions as divisions for stalls. Dr George Fleming says: "For stalls separated by partitions more width is required than for those divided by swung bales. For sanitary and economical reasons bales are preferable to partitions, inasmuch as they are considerably less expensive, allow the horses more liberty to move about and get up and lie down, facilitate the circulation of air through the stable, and permit cleaning and disinfection to be more easily carried out; in case of fire there is also much less danger, while at all times the horse will be much more easily seen. The bale consists of a thick plank the length of the stall, slung from the manger in front, and from a joist or beam behind; it usually has a shorter plank suspended from its lower border towards its posterior end, and this receives the kicks which the horse may feel inclined to give it. The bale is suspended about 2½ to 3 feet from the ground."[1]

Floors of Stables.—The *floor* of all stables should be made hard, to resist the action of the horses' feet. That of a work-horse stable is most frequently causewayed with small round stones, embedded in sand. This is a cheap but not

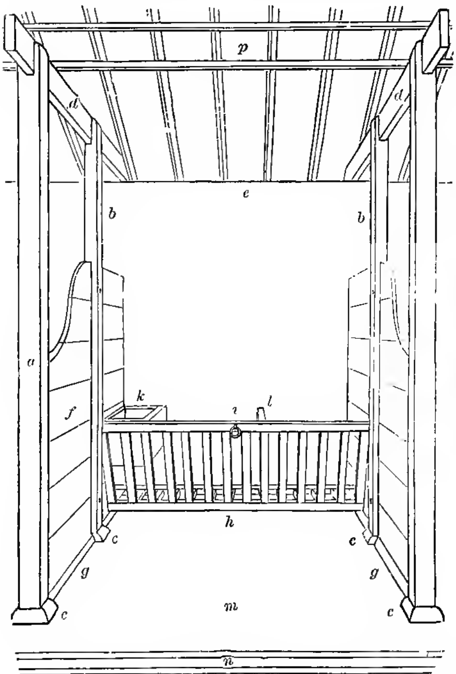


Fig. 141.—*Stall for a work-horse stable.*

a a Hind-posts.
b b Head-posts.
c c Stone blocks for head-posts.
d d Battens from wall to wall *e*.
f f Travis-boards.
g g Curb-stones for travis-boards.
h Sparred bottom of hay-rack.
i Ring for stall-collar.
k Corn-manger.
l Bar across hay-rack.
m Causeway in the stall.
n Stone gutter for urine.
o Causeway of roadway.
p Two spars from batten to batten for fodder.

good mode of paving. Squared blocks of whinstone (trap-rock, such as basalt, greenstone, &c.) answer the purpose much better. An excellent flooring for a stable is rough flags pick-dressed and laid neatly on 9 inches of hydraulic lime concrete. The pick-dressing makes the surface sufficiently rough to prevent the horses from slipping. The floor of the stable should have a fall of 3 inches from the front to the grip or gutter at the heel. It is desirable to have a channel 4 inches wide and ½ inch deep cut down the centre of the stall, and there should be a slight fall from each side into this channel. This will ensure a perfect system of stall-drainage. The grip or gutter behind the horses should be 12 inches from the heel-post, and should be 16 inches wide and 1½ inch deep. The channel in the centre of the stall will empty its liquid

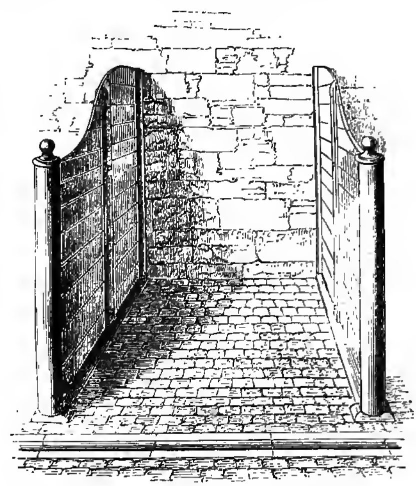


Fig. 142.—*Stall with cast-iron hind-posts.*

contents into the gutter, which will, in turn, discharge its contents into a trapped grating outside the walls of the building. The absence of all underground drains ensures the stable being kept in a fresh and healthy sanitary condition.

Principal Fleming considers that the best form of concrete floor for stables is that known as Wilkie's—a mixture of cement and crushed iron-slag. This, he says, makes a beautiful floor, very durable, impermeable to urine and wet, and possessing the great advantage of wearing rough instead of smooth, while it can also be easily cleaned.[2]

Fig. 141 gives a view of the particulars of a *stall for work-horses*, fitted up with wooden travis-posts, which is yet the common method.

Fig. 142 shows the cast-iron hind-posts.

[1] *The Practical Horse-Keeper*, 53.

[2] *Ibid.*, 52.

Ventilation of Stables.—The roof of a work-stable should always be open to the slates, and not only so, but have openings in its ridge, protected by ventilators. It is distressing to the feelings to inhale the air in some farm-stables at night, particularly in old steadings economically fitted up, which is not only warm from confinement, moist from breathing, and stifling from sudorific odours, but cutting to the breath, and pungent to the eyes, from the volatilisation of ammonia. The windows are seldom opened, and can scarcely be so by disuse. The roof in such a stable is like a suspended extinguisher over the half-stifled horses. This evil is still further aggravated by a hay-loft, the floor of which is extended over and within a foot or two of the horses' heads. Besides its annoyance to the horses, the hay in it, by nightly roasting and fumigation, through the openings above the racks, soon becomes dry and brittle, and contracts a disagreeable odour. The only remedy for all these annoyances is the removal of hay-lofts and erection of ventilators.

The object of *ventilation*, to any apartment which constitutes the abode of animals, is to procure a constant supply of fresh air to meet the demands of the animal economy. The practice which has long prevailed, as regards ventilation, seems to deny its utility, and to doubt the injury accompanying its neglect. James Clarke of Edinburgh was among the first who protested against close stables. "He insisted they were hot and foul, to a degree incompatible with health, and he strongly recommended that they should be aired in such a manner as to have them always cool and sweet. Previous to the publication of Clarke's work, people never thought of admitting fresh air into a stable; they had no notion of its use. In fact they regarded it as highly pernicious, and did all they could to exclude it. In those times the groom shut up his stable at night, and was careful to close every aperture by which a breath of fresh air might find admission. The keyhole and the threshold of the door were not forgotten.

"The horse was confined all night in a sort of hothouse; and in the morning, the groom was delighted to find his stable warm as an oven. He did not perceive, or did not notice, that the air was bad, charged with moisture, and with vapours more pernicious than moisture. It was oppressively warm, and that was enough for him. He knew nothing about its vitiation, or about its influence upon the horses' health. In a large crowded stable, where the horses were in constant and laborious work, there would be much disease—glanders, grease, mange, blindness, coughs, and broken wind would prevail, varied occasionally by fatal inflammation. In another stable, containing fewer horses, and those doing little work, the principal diseases would be sore throats, bad eyes, swelled legs, and inflamed lungs, or frequent invasions of the influenza. But everything on earth would be blamed for them before a close stable."

"Moreover," he observes, "the evils of an impure atmosphere vary according to several circumstances. The ammoniacal vapour is injurious to the eyes, to the nostrils, and the throat. Stables that are both close and filthy are notorious for producing blindness, coughs, and inflammation of the nostrils; these arise from acrid vapours alone. They are most common in those dirty hovels where the dung and urine are allowed to accumulate for weeks together. The air of a stable may be contaminated by union with ammoniacal vapour, and yet be tolerably pure in other respects. It may never be greatly deficient in oxygen; but when the stable is so close that the supply of oxygen is deficient, other evils are added to those arising from acrid vapours. Disease, in a visible form, may not be the immediate result. The horses may perform their work and take their food, but they do not look well, and they have not the vigour of robust health;—some are lean, hide-bound, having a dead dry coat, —some have swelled legs, some mange, and some grease. All are spiritless, lazy at work, and soon fatigued. They may have the best of food, and plenty of it, and their work may not be very laborious, yet they always look as if half starved or shamefully overwrought. When the influenza comes among them it spreads fast, and is difficult to treat. Every now and then one or two of the horses become glandered and farcied." [1]

[1] Stewart's *Stable Economy*.

Vitiation of Air by Animals.—In order to show in a striking light the necessity of proper ventilation in all places occupied by animals, the quantity of air vitiated every day by an ordinary-sized animal has been thus estimated by Dr Robert D. Thomson. "In a cow consuming per day 7 lb. of carbon and ¼ lb. of nitrogen, it will be found how insignificant is the quantity of carbon required for repairing the loss of the muscular system $\frac{53 \times 25}{16} = 0.828$ lb. Hence we see that 6172 lb. of carbon, of the daily food of a cow, must be employed for a purpose totally distinct from proper nutrition. We are at present acquainted with only one other purpose for which the carbon of the food can be employed—viz., the generation of animal heat throughout the body, a function undoubtedly carried on, not only in the lungs, but also throughout the entire capillary system of the skin, at least in man and perspiring animals. If this view be correct, then it follows that upwards of 6 lb. of carbon are expended by a cow daily in the production of animal heat. And as 1 lb. of carbon, when combined with the necessary amount of oxygen to form carbonic acid, gives out as much heat as would melt 104.2 lb. of ice, it is evident that the quantity of ice capable of being melted by the heat generated by a cow, in one day, would amount to upwards of 625 lb., or it would heat 1 lb. of water 87,528 degrees. It would consume, at the same time, the enormous quantity of 330,429 cubic inches of oxygen, or 191¼ cubic feet of this gas; and as this amounts to one-fifth of the atmospheric air, we find that a cow, consuming 6 lb. of carbon for respiratory purposes, would require 956¼ cubic feet of atmospheric air, a sufficient indication of the immense importance of a free ventilation in cow-houses, and of the danger of overcrowding, if the animals are expected to retain a healthy condition." [1]

How Ventilation is to be Provided.—Here are data furnished of the quantity of air required to be admitted into a byre, for the necessary daily use of a single cow of ordinary size. How, then, is this large quantity of fresh air to be admitted into a byre, when all the doors and windows are shut? This question involves another—How is so large a quantity of vitiated air to be expelled from the byre?—for expulsion must first take place ere ventilation through the byre can be maintained. The popular notions regarding ventilation are very undefined. As Mr Stewart observes, "Most people do not imagine that one set of apertures is required to carry away the foul, and another to admit the pure air. Even those who know that one set cannot answer both purposes in a perfect manner, are apt to disregard any provision for admitting fresh air. They say there is no fear but sufficient will find its way in somehow, and the bottom of the door is usually pointed to as a very good inlet. It is clear enough, that while air is going out, some also must be coming in, and that if none go in, little or none can go out. To make an outlet without any inlet betrays ignorance of the circumstances which produce motion in the air. To leave the inlet to chance, is just as much as to say that it is of no consequence in what direction the fresh air is admitted, or whether any be admitted. The outlets may also serve as inlets; but then they must be much larger than when they serve only one purpose, and the stable, without having purer air, must be cool or cold. When the external atmosphere is colder than that in the stable, it enters at the bottom of the door, or it passes through the lowest apertures, to supply and fill the place of that which is escaping from the high apertures. If there be no low openings, the cooler air will enter from above—it will form a current inwards at the one side, while the warmer air forms another current, setting outwards at the other side. But when the upper apertures are of small size, this will not take place till the air inside becomes very warm or hot." [2]

So little do many people see the necessity of ventilation, that they cannot distinguish between the *warm* air and the *foul* air of a stable; and consequently, if the admission of fresh air is wanted to expel the foul, they immediately conclude it must be cold, and do harm. Now it is the proper action of ventilation to let away all the warm air of a stable that

[1] Thomson's *Food of Ani.*, 113, 114.

[2] Stewart's *Stable Econ.*

is foul and no more, and then, of course, no more than the same quantity of fresh air can find its way into it.

A ready means of letting out the foul air from a stable is by a number of ventilators, figs. 106 and 107, on the ridge of the roof; and one means of admitting fresh air below, is by the windows when they are open; but when they are shut, other means must be supplied. As doors and windows are usually situated in farm-stables, the fresh air should not be allowed to enter by them through the night; so they should not be left open, for fresh air coming directly from the doors or windows upon a horse must strike his body and limbs forcibly, and do him more harm than good. A good method of admitting fresh air is by ventilators built into the wall on a level with the floor, behind, not before, the horses.

Great care should be taken to have the stable kept clean as well as well ventilated. The walls and roof should be lime-washed twice a-year. It is important to note that by the better construction of stables blindness in horses has become almost unknown.

Temperature of Stables.—It cannot be said definitely what is the best temperature for all stables. It should be kept as equable as possible, not lower than 50° nor higher than 68° to 70° Fahr.

"In a stable (or byre) with an open roof the outlet for the foul air should be provided at the ridge, either by a continuous louvred opening on each side of the ridge, or by turrets at regular intervals. Where there is about 6 feet of the length of the building allowed for each stall, such louvred openings with a vertical depth of 6 inches would give 6 square feet of outlet. This is a large allowance, but it has to be remembered that only one side of the louvred opening is efficient at one time, for when there is any current across the ridge the foul air will issue only by the opening on the leeward side. To prevent the entrance of snow or rain, it is well to make the upper edge of each opening well overlap the lower edge, and if very much exposed it may be advisable to break the force of the wind and prevent down-draughts by guarding the opening with wire-netting. As to the inlet apertures, they should be equally distributed on both side walls, and they ought to discharge their stream of pure air at a level above the animals' heads, and with an upward inclination. In brick buildings a continuous row of perforated bricks carried along the top of each side wall, immediately under the eaves, serves this purpose admirably. In stone walls, square or round holes may be made at regular intervals, the outer mouth of each opening being protected by a grating. It is better to have these apertures numerous and small, rather than to have a few large ones, as the distribution of pure air is thereby made more uniform, and the currents are more broken up."[1]

Revolution in System of Feeding Horses.—Since the third edition of this work was issued, the system of feeding farm-horses has in many parts of the country been entirely revolutionised. Mr Gilbert Murray says: "On the best-managed farms the food is now all prepared for horses, the straw cut into chaff and mixed with the corn, meal, or other foods. There is thus no necessity for hay-racks, and the mangers are constructed on an improved principle. If at any time a small quantity of hay or straw is given to horses, it is placed in the manger. The system is a vast improvement on the old plan. The horses are not only kept at less cost, but, what is of equal importance, they are more healthy under it."

Hay-racks for Horses.—Hay-racks, however, are still by no means uncommon in stables, and there has been much discussion as to how they should be constructed and placed. The prevailing opinion may be learned from the general practice, which is to place them as high as the horses' heads, because, as is alleged, the horse is thereby obliged to hold up his head, and he cannot then breathe *upon* his food. Many better reasons may be adduced for placing the racks low down. A work-horse does not require to hold up his head at work, and should not have to do it in the stable, where he should rest and be at ease as much as possible. A low rack permits the neck and head, in the act of eating, to be held in

[1] *Farming World*, 1888, 488.

their ordinary position: he is not so liable to pull the hay among his feet: his breath cannot contaminate his food so much in a low as in a high rack, inasmuch as the breath naturally ascends: he chooses his food by the sense of smell easier from a low rack: he is less fatigued eating out of a low rack, every mouthful having to be pulled out of the high, from its sloping position, by the side of the mouth turned upwards: mown grass is much more easily eaten out of a low rack: and lastly, we have heard of peas falling out of the pea-straw, when pulled out of a high rack, into an ear of a horse, and therein setting up a serious degree of inflammation.

The front rail of this low rack is made of hardwood, and may be lined with sheet-iron, in case the horse should put his foot on it, or bite it. The front of the rack is sparred, for the admission of fresh air among the food, and inclines inwards at the lower end, to be out of the way of the horses' fore-feet. The bottom is also sparred, and raised 6 inches above the floor, for the easy removal of hay and other seeds that may have passed through the spars. In this form of rack the manger is placed at the near end of the rack, for the greater convenience of supplying the corn. A spar of wood is fixed across the rack from the front rail to the back wall, midway between the travis and the manger, to prevent the horse tossing out the fodder with the side of his mouth, which he will sometimes be inclined to do when not hungry. The *ring* through which the stall collar-shank passes, is fastened by a staple to the hardwood front-rail.

Metal Mangers and Racks.—Dr George Fleming recommends that mangers and hay-racks should be constructed of metal—cast-iron galvanised, or the manger of iron, enamelled inside—instead of wood. Wooden racks and mangers, besides being more liable to become foul, are dangerous when broken or when contagious diseases occur. White enamelled mangers are easily kept clean, and are tidy-looking as well as durable.

Fire-clay Mangers.—An improved manger for horses consists of fire-clay troughs specially designed and manufactured for the purpose. They are both durable and cleanly, and can be used either for food or water. This manger is 2 feet wide at the top, 15 inches deep, and 20 inches wide at the bottom. The manger should be 3 feet 6 inches above

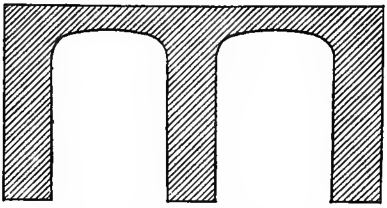


Fig. 143.—*Support for manger.*

the level of the floor of the stall, and should be supported on arches thus (fig. 143).

Fig. 144 represents a section of a

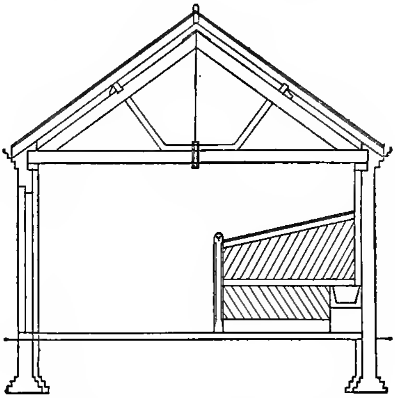


Fig. 144.—*Position of improved manger.*

modern stable, showing the position of the improved manger.

Harness-pegs.—The *harness* is hung upon pegs against the wall behind the horses, and not on the posts of the stalls, against which some of it is too frequently placed, to its injury, from the horses' breath and perspiration, and aptitude to be knocked down amongst their feet. Strong hardwood pins driven into a thick narrow board, fastened to the wall with iron holdfasts, is perhaps the most substantial way of erecting harness-pins, when a new stable is building. The harness belonging to each pair of horses should just cover a space of the wall equal to the breadth of the two stalls which they occupy; and when windows and doors intervene, and which of course must be left free, this arrangement requires some consideration.

We have found this convenient: A spar of hardwood nailed firmly across the upper edge of the batten *d*, fig. 141, which stretches from wall to wall across the stable, will suspend a collar from each end, high enough above a person's head, over the passage. One pin is sufficient for each of the cart-saddles, one will support both the bridles, while a fourth will suffice for the plough, and a fifth for the trace harness. Thus 5 pins or 6 spaces will be required for each pair of stalls; and in a stable of 12 stalls—deducting a space of 13 feet for 2 doors and 2 windows in such a stable—there will still be left a space of about 18 inches between the 5 pins. Iron hooks driven into the board betwixt the pins will keep the cart-ropes and plough-reins by themselves, and such will also carry the curry-comb, hair-brush, and foot-picker, while the mane-comb finds room usually in the ploughman's pocket.

In many stables the bridle and collar are hung on to a pin and a hood on the hind-post. When the hind-posts are of cast-iron, iron hooks may be suspended from the couple-legs to hang the collars upon.

Recess in Wall.—It is a good plan to have a recess in the wall for holding small tools and useful stable articles. This should be secured by a door and lock.

Harness-room.—The above is the usual mode of arranging the harness and small articles in a farm-stable. It is convenient for the men, and in no way injurious to the harness, when there is ample room behind the horses. Still it is better to have a harness-room, where trees can be placed for the saddles, and pins upon the walls for the smaller pieces of harness. Such an apartment is convenient for cleaning the harness in, when the men and horses cannot be employed in outdoor work, in a bad day. The best receptacle as such an apartment undoubtedly is for the harness, it must be owned that more trouble is imposed thereby upon the men in carrying the harness to and from their horses at every yoking; for it must not be supposed that the harness may be left on the horses between the yokings, as is too often practised by slovenly farmers.

A harness-room should be large, to contain the harness easily, and give room to clean them. It should be well lighted, and have a large fireplace for a wet time. The harness-room should enter from the centre of the stable, to give the men the least distance to walk. In a very long stable, such as is required on a large farm, it might be advisable to have two harness-rooms of smaller dimensions.

Binding Horses.—Each horse should be bound to his stall with a leather strap and buckle with an iron chain or raw hide collar-shank to play through the ring *i* of the hay-rack, fig. 141, with a turned wooden sinker at its end, to weigh it to the ground. Iron chains make the strongest stall collar-shanks, but are noisy when in use; and, on the whole, raw hide is preferable. Dr George Fleming says that "all horses ought to be fastened by a rope on each side of the head-collar."

Boxes for Horses.—Some who have paid particular attention to the management of farm-horses prefer boxes to stalls for these. Mr Gilbert Murray says, if it were not for the extra cost the boxes incur, he would greatly prefer boxes to stalls for all kinds of horses, as he considers them more healthy and more comfortable. For ordinary farm-horses the boxes should be 10 feet square, so that two boxes would occupy as much space as three stalls, which is of course a point against the former and in favour of the latter. In any case, even if the regular force of working horses are kept in stalls, it is well to have one or two loose-boxes. They are useful for a young stallion, for a mare at foaling-time, or for a sick animal. Dr George Fleming prefers loose-boxes to stalls, and mentions among other advantages, that horses kept in boxes are much less likely to acquire the bad habits of kicking, "crib-biting," and "weaving," than those tied up in stalls.

Foaling-box.—A box for a mare at foaling-time should be rather larger than an ordinary horse-box, and it will be found advisable to have it circular in shape. Many accidents have happened to mares and foals in square boxes which could not have occurred in a circular box. A round box is of course more difficult to make than a square one, but the importance of avoiding accidents at this critical time would justify the extra trouble and expense. The box need not be perfectly round. The point is to have no sharp corners. Mares often give little or no warning of the approach of the hour of foaling, and it is desirable therefore to have them in a safe compartment in good time.

A loose-box is an excellent place in which to rest a fatigued horse for a few days, with liberty to turn round or lie down; as also for a foal when its mother is absent at work in the fields, and until both are turned out to grass.

For use as a "sick-room" it is preferable to have a loose-box situated outside the stable.

Hay-house.—The hay-house should be adjoining the work-horse stable. There should be a wide door and window in front, and an inside door on the one hand to the work-horse, and one on the other hand to the riding-horse stable. It should have a wooden or concrete floor to keep the hay sweet and dry. It should have a giblet-check at the outer door to open outwards, with a hand-bar to fasten it on the inside. It should also have a partly glazed window, to afford light, and shutters to let in air. The walls should be plastered.

Corn-chests.—As the hay-house communicates immediately with the work-horse stable by a door, it may find room for the work-horse corn-chest, which may there be conveniently supplied with corn from the granary above, by means of a spout let into the fixed part of the lid. For facilitating the taking out of the corn, the *end* of the chest should be placed against the wall at the side of the door which opens into the stable, and its back part boarded with thin deals up to the granary floor, to prevent the hay coming upon the lid of the chest. In large stables a space may be left in the centre for the corn chests or bins, which are replenished from time to time.

The form of the corn-chest is more convenient, and takes up less room on the floor, when high and narrow than when low and broad, as in fig. 145, which is 5 feet long and 4½ feet high at the back above the feet. A part of the front *b* folds down with hinges, to give easier access to the corn as it gets low in the chest. Part of the lid is made fast, to receive the spout *d*, for conveying the corn into it from the granary, and to lighten the movable part *a*, which is fastened with a hasp and padlock, the key of which should be in the custody of the farm-steward: *c* is the corner of the doorway into the work-horse stable,

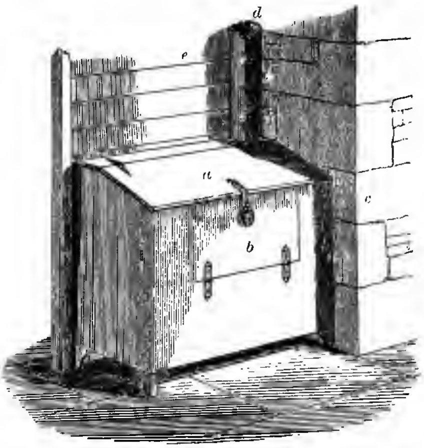


Fig. 145.—*Corn-chest for work-horses.*

and *e* is the boarding behind to prevent the hay falling on the lid. A fourth part of a peck measure is always kept in the chest for measuring out the corn to the horses.

Measuring Corn to Horses.—Although the spout, *d*, fig. 145, supplies corn from the granary when required, it does not supply it without measure. The corn appropriated for the horses is previously measured off on the granary floor, in any quantity, and then shovelled down the spout at times to fill the chest, or the chest is filled by measured quantities. Or a way to ascertain the quantity of corn at any time in the chest is to mark lines on the inside of the chest indicative of every quarter of corn which it contains. Measuring the corn into the chest is the most accurate and satisfactory way.

In some parts of the country the corn for the horses is put into small corn-chests, given in charge to each ploughman, who keeps the key, and supplies his horses with corn at stated times. These small chests are placed in the stable for convenience within the bay of the windows, and in recesses made on purpose in the wall. A certain quantity of corn is put into each chest at a time, which is to last the pair of horses a certain number of days. This plan saves the steward the trouble of giving out the corn to the horses, but he must still see that the ploughmen do not misappropriate the corn intended for the horses.

In some stables excellent corn-boxes are made of flagstones set in the window-bay.

TREATMENT OF FARM-HORSES.

Farm-horses are under the immediate charge of ploughmen, one of whom works a pair, and keeps possession of them during the period of his engagement. This is a favourable arrangement, for horses work more steadily under the guidance of the same driver than when changed into other hands. It is also better for the ploughman himself, as he does his work most satisfactorily with horses familiar to him. The man and his horses must become acquainted before they can understand each other; and when the peculiar tempers of each are mutually understood, work becomes very pleasant to both. Some horses show great attachment to their driver; others, no particular regard: and as great differences may be remarked in the ploughmen towards their horses. Upon the whole, there exists a good understanding in this country between the ploughman and his horses. Few masters will allow their horses to be ill-treated. Horses which have been brought up on a farm, and have gone through the same routine of work every year, become so well acquainted with what they have to do, that, when a misunderstanding arises, it will usually be found that the man is in the wrong.

Watering Horses.—The treatment which farm-horses usually receive in winter is as follows: The ploughmen get up before daybreak, and then go to the stable, where the first thing they do is to take out the horses to water—that is, if there is not a regular supply of water within reach of the horses. In improved modern stables water is constantly supplied to horses in a trough conveniently placed in the travis between each pair of horses. The water is obtained from a tank sufficiently high to ensure a steady pressure on the pipe leading into the troughs near the horses' heads. The water-trough stands 1 foot or 18 inches above the manger, and by ball and cock is arranged to provide a constant supply of water.

Where this convenience does not exist, the usual place at which horses drink is at the horse-pond, or horse-trough, or tank, and should ice prevent them, it must be broken. To horses out of a warm stable, water at the freezing-point cannot be palatable; and yet it is not easy, except by the means just described, to devise a better plan, for though the purest water were provided in a trough in the outer air, it would be as liable to freeze as in a pond. When there is a constant run of water where horses drink it will rarely be frozen.

The quantity of water required by horses varies greatly; some drinking more than others. If allowed frequent access to fresh pure water, horses will not, as a rule, drink more than necessary—indeed, they are themselves the best judges as to quantity. When an animal is very hot, or chilled, or exhausted, or has been long without water, only a small quantity of water should be allowed at first. In such cases, a safe drink is water thickened with a handful or two of oatmeal, or, better still, oatmeal gruel. Very cold water should be given in small quantities at a time. Keep watering troughs scrupulously clean, and see that the water in them is changed frequently.

Water before Feeding.—When horses are allowed to drink water freely immediately after feeding, they are liable to suffer from colic, as the water is apt to carry some of the undigested food into the intestines. Water should therefore always be given to horses before, and not after, feeding.

From habit, horses may not each require to be led to and from the pond, one man seeing they do not wander away. It is better practice, however, to insist on each man leading out his own pair of horses. The horses receive their morning allowance of corn as soon as they have had water, and the men then remove the dung and soiled litter into the dung-house, with their shovels, wheelbarrow, and broom.

Stable-brooms.—Fig. 146 is a broom suited to a work-horse stable. It is made of the twigs of the birch-tree. The twigs are tied together with stout twine in bundles of 6 inches diameter at the tied end, and 2 feet in length. A wooden handle, about 3 feet in length, is driven into the tied end, and is kept in its place by a peg passed through it and the twigs. The sweeping end receives such a trimming with a knife as to give a flattened face to the ground, sloped away to a point. Fresh twigs make the best brooms, and after they are dry, become brittle and break off, and must be renewed. Stable-brooms are made of other materials.

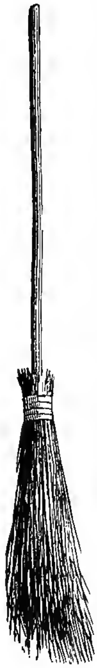


Fig. 146.—*Birch broom for stables.*

Morning Feed of Corn.—Each ploughman supplies his mangers with corn from the corn-chest; or the steward himself, in small farms, puts the corn into the mangers while the men are employed in cleaning the stable; which plan, if the steward is provided with a light trough beside the corn-measure, saves time in a short winter's morning. All corn should be bruised; and the best plan is to give it mixed with chaffed hay or straw. The men then go to breakfast, and the horses are left in quietness to eat their corn.

Quietness at Feeding-time.—Ploughmen are apt to curry and wisp, and put the harness on the horses while eating their corn; but it should never be allowed. Let horses eat their food in peace. Many horses, from sanguine temperament or greed, bolt their corn when handled during the time of feeding. Harness can be quickly enough put on after the feed is eaten, and time should be taken to groom the horses very carefully. An allowance of a little time between eating their corn and going to work is of advantage to every horse, as severe work, when undertaken at once with a distended stomach, is apt to bring on an attack of *butts* or colic.

Mid-day Care of Horses.—When the horses come in from the morning work they get a drink of water but no wetting of legs, and a feed of bruised corn, and chaffed hay or oat-straw, and the men their dinner. Some keep the harness on during this interval of an hour, but it should be taken off, to allow both horses and harness to cool. After dinner the men return to the stable, when the horses will have finished their feed, and a small ration of fresh straw or hay will be well relished. The men have a few minutes to spare, when they should wisp down their horses, put on the harness, comb out the tails and manes, and be ready to put on the bridles the moment one o'clock strikes.

Feeding Outside.—When work is in a distant field, rather than come home between yokings, some farmers feed the horses in the field out of nose-bags, and make the men take their dinners with them, or it is brought to them. This plan may do for a day or two in good weather, on a push of work; but it is bad for horses to cause them to stand for even half an hour in a winter day, after some hours' work, as they may thereby receive a chill. A walk home can do them no harm; and if work is behind, let them remain a shorter time in the stable. The men dine more comfortably at home.

Hours of Work.—The hours of work vary in different parts of the country, and, of course, also with the season. The most general rule is ten hours per day—from six to eleven A.M. and one to six P.M. In Scotland this method is strictly adhered to, when daylight admits, but in England there is less regularity in working hours.

Long Yokings Undesirable.—A practice exists in England of doing a day's work at one yoking. For a certain time, horses, like men, will work with spirit; but beyond that time they lose both strength and spirit, and will work in the latter part of the yoking in a careless manner. Horses kept for seven or eight hours at continuous work must be injured in their constitution by loss of vigour. Common-sense may tell a man it is better for a horse to be worked a few hours at full natural pace, and have his hunger satisfied before becoming fatigued, than be worked the whole day without feeding, even at a slow pace.

Work expected of Horses.—No definite rules can be laid down as to the amount of work which should be accomplished by horses. The local circumstances, such as the character and fitness of the horses, the nature of the work, the exigencies of the time, and the supply of food, must always be duly considered, and the farmer must at the time decide for himself how much work of any particular kind he is to expect from each horse or pair of horses.

One general principle may be laid down—one not so fully observed as is desirable—and that is, that in working horses long days are preferable to quick pace. It will be much easier for a pair of horses to plough a certain extent of land in six days of ten hours than in six days of nine hours each, easier still than in six days of eight hours. In the two cases exactly the same amount of work will have been done—the same amount of earth turned over, the same number of miles paced,—yet the pair made to accomplish the work in the shorter day, even although they had the extra hours of rest, will be found to be more fatigued at the end of the week than the pair allowed to go over the ground at a slower pace—that is, of course, assuming that the natural pace of the two pairs would be about the same. With the farm-horse, as with the roadster and hunter, "it is the pace that kills." This point should never be lost sight of by farmers.

Let horses work at an easy natural pace; if the work presses, lengthen the hours, if you wish, but continue the "easy natural pace." We do not mean that the horses should be kept longer at work at one time, but by giving twenty minutes or half an hour of rest and a little food, even if it should be only a drink of oatmeal gruel, the work-hours of the day may be increased. This will do less harm to the horses than hard driving. It is true economy to husband a horse's strength; the very opposite to overtax it.

Rubbing Horses.—In the dead of winter the afternoon yoking is short, not lasting longer than sunset, which at this season is about 4 P.M., when the horses are brought home. On the horses entering the stable, and having the harness taken off, they should be well strapped down by the men with a wisp of straw. Ploughmen use two wisps, one in each hand, which are handy to rub down the legs and clean the pasterns. Work at this time in the stable is nearly done in the dark. The steward ought to have a light ready when the horses enter the stable, and then the strapping would be done in a satisfactory manner.

Evening Care of Horses.—After the horses are rubbed down and receive a feed of hay or straw, the men go to the straw-barn, the steward having the light, and prepare bundles of straw for their horses, or perform other work, until the stopping hour, which is usually 6 P.M. The stable has had but half litter all day, since its cleansing out in the morning, and the horses have stood on the stones at mid-day. This is a good plan for purifying the stable during the day, and is not so much attended to as it deserves. Fresh straw is brought by the men from the straw-barn, and shaken up with the old litter to make the stalls comfortable for the horses to lie down upon for the night. Leaving the horses with their fodder, and shutting the stable-doors, the men retire to their homes, to whatever occupation they please, until the hour at which horses receive their suppers, which is usually 8 P.M.

Supper-hour.—When 8 P.M.—the supper-hour—arrives, the steward, provided with light in the lantern, fig. 117, summons the men to the stable to give the horses a grooming for the night, and their suppers. Lights hang at convenient distances behind the horses, to let the men see to groom the horses. Paraffin lamps of improved and safe construction are now most frequently used.

Grooming Horses.—The grooming consists first in currying the horse with the curry-comb *b*, fig. 147, to free him of the dirt adhering to the hair, and which, being now dry, is easily removed. A wisping of straw removes the roughest of the dirt loosened by the curry-comb. The legs ought to be thoroughly wisped—not only to make them clean, but to dry up any moisture that may have been left in the evening. At this time the feet should be picked clean, by the foot-picker *a*, of any dirt adhering between the shoe and foot. The brush *c* is then used, to remove the remaining and finer portions of dust from the hair, and it is cleared from the brush by a few rasps along the curry-comb. The wisping and brushing, if done with

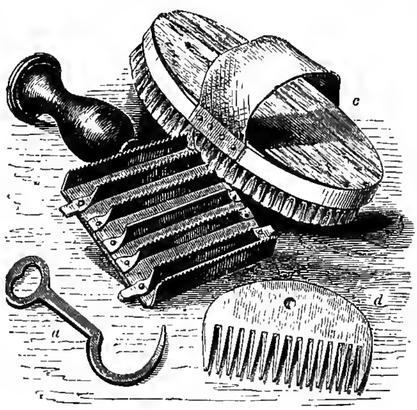


Fig. 147.—*Curry-comb, brush, foot-picker, and mane-comb.*

some force and dexterity, with a combing of the tail and mane with the comb *d*, should render the horse pretty clean. But there are more ways than one of grooming a horse, as may be witnessed by the skimming and careless way in which some ploughmen do it. It is true that the rough coat of a farm-horse in winter is not easily cleaned, and especially in a work-stable where much dust floats about and no horse-clothes are in use; but, rough as it is, it should be *clean* if not *sleek*. It is the duty of the steward or farmer to ascertain whether the grooming has been efficiently done. A slap of the hand upon the horse will soon let be known the existence of loose dust in the hair. Attendance at this time will give the student an insight into the manner in which farm-horses ought to be cleaned and fed and generally treated in the stable.

Brushing preferable to Combing.—The use of the iron curry-comb is disapproved by many. Dr Fleming says it "should never, as a rule, be applied to the skin of horses." For long rough coats, he considers nothing is better than a good dandy-brush to remove dandruff, dust, and dirt; for finer-coated horses a good bristle-brush, supplemented by the wisp and rubber, will suffice. He regards the brush as the best appliance for cleaning the skin thoroughly, and he points out how essential it is, for the health of the animal, that the skin be kept clean, so that it may at all times be in a fit condition to perform its important functions.

Rubbing Wet or Heated Horses.—If a horse comes into the stable heated or wet, it should at once be well rubbed down with a handful of straw. If it has been excessively warm, it may be well to throw a rug over it till it has regained its normal temperature. It may perhaps, after two or three hours, or sooner, break out into a cold perspiration, and if so it should again be well dried.

Water-brush.—For washing the legs

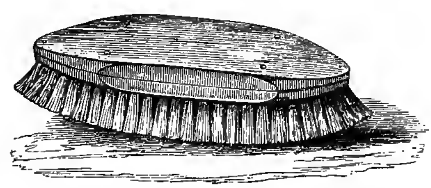


Fig. 148.—*Water-brush.*

and heels of a horse, a water-brush, fig. 148, is very useful.

Littering Horses.—The straw of the bedding is then shaken up with a stable fork, fig. 149, which is most handy for shaking up straw when about 5 feet in length, and the prongs least dangerous for the legs of horses when blunt. The prongs terminate in a tine driven into a looped ash shaft. This mode of mounting a fork is better than with socket and nail, which are apt to become loose and catch the straw. Fig. 150 is a steel-pronged fork, and is an excellent instrument for working among straw.

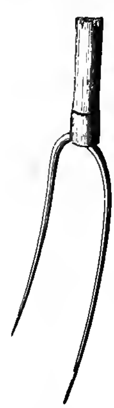


Fig. 149.—*Common straw-fork.*

The horses then get their feed of bruised oats and hay or straw, after which the lights are extinguished, and the stable-doors barred and locked by the steward, who is custodier of the key. In some stables a bed is provided for a lad, that he may be present to relieve any accident or illness that may befall a horse. But where the stalls are properly constructed, there is little danger of this.

Fig. 150.—*Steel straw-fork.*

A Visit to the Cattle.—From the stable the steward takes the lantern, and, accompanied by a few of the men, or by all—and of necessity by the cattle-man—inspects all the courts and hammels to see if the cattle are well; and if it be moonlight, and any of the cattle on foot, apparently desirous of more food, the cattle-man gives them a few turnips. The byres in which cattle are feeding are also visited, and the fresh windlings of straw, laid up in reserve by the cattle-man, are now given them, any dung in the stalls drawn into the gutter, and the bedding shaken up with a fork. Cows, both the farmer's and servants', are visited and treated in like manner. Bulls, heifers in calf, and young horses, all are visited at this time, to satisfy the mind, before retiring to rest, that every creature is well and in safety.

Working Horses in Winter.—The horses are themselves the better of being out every day; but the kind of work they should do daily must be determined by the state of the weather and soil. In wet, frosty, or snowy weather, the soil cannot be touched; and the threshing and carrying of corn to market or railway station may then be effected. In frost, the dung from the courts may be taken out to the fields in which it is proposed to make dunghills. When heavy snow falls, nothing can be done out of doors with horses, except threshing corn, when the machine is impelled by horse-power. In very heavy rain neither men nor horses should be exposed to it. When fair above, however cold the air, one or another of the above outdoor works should be done by the horses. It is better for them to work at least one yoking a-day than to stand idle in the stable.

Exercise for Horses.—Work-horses soon fret when confined in the stable even for one day—on Sundays, for example; and when the confinement is much prolonged, they even become restless. When such occasions happen, as in continued snowstorms, the horses should be ridden out for some time every day, and groomed as carefully as when at work. Exercise is necessary to prevent thickening of the heels, a shot of grease, or a common cold. Fat horses, unaccustomed to exercise, are liable to molten grease.

Work for Bad Weather.—Such bad weather affords a favourable opportunity for cleaning harness, carts, the bushes of cart-wheels, the implement-house, any neglected place in the steading, and the roads around it.

Breeding Horses.—It is advisable for a farmer to breed his own horses. On a farm which employs 3, 4, or more pairs, two mares might easily bear foals every year, and perform their share of the work at the same time, without injury to themselves. The advantage of breeding working stock at home is that, having been born and brought up upon the ground, they not only become naturalised to the products of its soil, and thrive the better upon them, but familiarised with every person and field upon it, and are broke into work with ease and safety.

Working Mares in Foal.—Mares in foal should work together, and be driven by a steady ploughman. Their work should be confined to ploughing in winter and spring when big with young, for the shaking of the shafts of a cart, or going round in the horse-course, is quite unsuited to their condition. When ploughing cannot be performed, their driver should assist the other men at their carts with manual labour while his mares rest. There is nothing better for a mare in foal than to keep her at easy work till within a day or two of foaling. Complete idleness is bad for mares in foal, although some give them rest for a few days—not more than a week—before foaling.

Old Men and Brood-mares.—A good plan, followed by some farmers, is well adapted to elderly married ploughmen, in having brood-mares and old horses under their charge, and keeping them always at home, ploughing and doing easy jobs, and never allowing them to go with loaded carts upon the highway. This subdivision of labour has the advantage that odd sorts of work are done by the old men and mares without trenching upon the time of the more efficient teams.

Weaning Foals.—Foals are usually weaned when from 5 to 6 months old. Before then the foal will have learned to eat grass, and most likely also some concentrated food such as bran, oats, or linseed-cake. Some breeders of high-class horses begin giving grain and cake to foals when they are little more than a month old, but this is the exception. It is undesirable to force the very young animals; and if the dam has a fair supply of milk, no extra feeding will be required for either the mare or the foal (unless the mare be hard-worked, in which case she, of course, must have rich concentrated food) until six weeks or a month prior to weaning, when a little bruised oats should be given. This will help to prepare the mare for her full share of hard work when she is turned on to it, and will also accustom the foal to other means of subsistence than its mother's milk.

When the foal is weaned it should—if the grass season is over—be put into a loose-box by itself, where it should receive small and frequent allowances of cut grass or other green food, and 2 or 3 lb. per day of bruised oats. Green food of some kind should be given at this time—there is nothing better than cut grass—and fresh water should always be within its reach or offered to it frequently. If it is not too late in the season, the foal may be put right into a piece of sweet grass. The Hon. E. Coke says: "When the foal is weaned, it should be put on a nice sweet pasture that has been saved purposely, and then fed once a-day with a mixture of 2 lb. of boiled barley, 2 lb. bruised oats, and 2 lb. of chaff, which will cost 6d. a-day.'

Wintering Young Horses.—In the south of England young horses are kept out on the fields all the year round, and in many cases do not even have a shed in which to lie overnight. The Hon. E. Coke (Derbyshire), in speaking of the wintering of his Shire bred foals, says: "I do not care much about there being a hovel or shed in the field, as my experience is that the young things rarely make use of it, but will lie on the bare ground in preference. Of course it is desirable that there should be good shelter—either a high hedge or a plantation—on the side from whence the cold winds blow."

Mr Frederick Street, Somersham, Huntingdon, strongly recommends, where practicable, the advisability of young animals being raised on pasture instead of in loose-boxes or warm yards. Late or delicate foals he would take inside, at least during night. He says: "I do not even care for a hovel for shelter, for however severe the weather, in ninety-nine times out of a hundred you will find the foals in the open. I have never known a case of injury from eating frosted grass. By this treatment the growth of bone, muscle, and hair will be encouraged, the constitution strengthened, the elasticity of action retained, whilst the danger of getting over on their joints, or flying at the hocks, is reduced to a minimum. Nine of my earliest foals have never been under shelter other than hedges this winter, whilst the very late foals lie in a cool yard at night and run on a pasture in the daytime."[1]

Housing Necessary in Cold Districts.—But in the colder districts the young as well as the adult horses have to be housed in winter, at any rate overnight. When the weather is not wet or very cold the young animals should have a run out daily, and be brought back to a dry but airy bed at night. Covered sheds afford excellent shelter for young horses in winter nights, and where these are not available, loose-boxes or hammels are preferable to stalls.

Exercise for Young Horses.—It is specially important that young horses should have plenty of exercise, for this is essential for the development of strength and activity. Contrive, if possible, to let them have a run out every day; and if they should come in wet rub them down with a handful of straw.

Handling Young Horses.—Young

[1] *Cart Horses*, p. 11.

horses should be frequently handled by their attendant, who by his kindly handling should make himself welcome and familiar amongst them. Mr R. O. Pringle says: "It is a good plan to put a plain halter upon each, the short shank of which being sometimes trodden upon, accustoms them to a check on their movements afterwards, without exciting any feeling of alarm, or any idea of resistance. They should also be occasionally tied up to the manger, which, along with a rack, is placed at the inside back-wall of the shed. It is also well that they should be accustomed to have their feet lifted, and the sole gently beaten with a wooden mallet, as this will render them more easy to handle when the time comes that they must be shod. Many people never think of training a colt till they put him to work; but training should be commenced at the earliest stage of the animal's existence. And if this is done in a steady, quiet, careful manner, it will prevent a vast amount of serious trouble at a later period. In the treatment of the colt, as well as of the mature animal, kindness should be the ruling principle."[1]

Young horses are not regularly groomed, but they will be all the better of a turn of the brush now and again. They should be rubbed with straw, if wet, and any clay or earth adhering to their hair should be removed.

Colts and fillies may be kept together their first winter, but afterwards entire colts should be kept by themselves.

Nomenclature of Horses. — The names given to the horse are these: The new-born is called a *foal;* the male being a *colt foal*, the female a *filly foal*. After being weaned, foals are called simply *colt* or *filly*, according to the sex, which the colt retains until broken in for work, when he is a *horse*, and remains so all his life; and the filly is changed into *mare*. When the colt is not castrated he is an *entire colt*, which he retains until he is fully grown or serves mares, when he is a *stallion* or *entire horse;* when castrated he is a *gelding*, and it is in this state that he is a draught-horse. A mare, when served, is said to be *covered by* or *stinted* to a particular stallion; and after she has borne a foal she is a *brood-mare* until she ceases to bear, when she is a *barren mare* or *eill mare;* and when dry of milk she is *yeld*. A mare, while with young, is *in foal*. Stallions are sometimes worked.

Work for Ploughmen in Bad Weather.—There are various ways of employing ploughmen in winter, when the horses are laid idle from the state of the weather. Some farmers always employ them to dress corn for the market. Ploughmen may be employed in threshing corn with the mill, when not engaged with their horses; but to lay horses idle for the sake of employing their drivers at barn-work is poor economy; and with the improved machinery for dressing, elevating, and sacking grain, there is now little hand-work in barns compared to former times. When all the roads of the farm are blown up with snow, the men may be usefully employed in cutting roads to the field of turnips where the sheep are feeding, or to that in which it is proposed to make a dunghill. Services of this sort may even be required on the highways, to the extent they pass through the farm, when it is determined to open the road for the public convenience. The men may assist the shepherd to open channels in the snow among the stripped turnips, for the sheep to get at them, and in carrying hay to the ewes.

In heavy falls of rain, and sudden breaking-up of snowstorms, rivulets and ditches often overflow the arable ground on each side, to the injury of new wheat, or souring of ploughed land. It is the duty of the hedger to attend to the ditches; but the exertions of no one man are adequate to stem a torrent of water. Small rivers, on a sudden breaking-up of frost, bring down ice, which, on accumulating at sharp turns in them, form dammings of water, which, finding vent over banks or embankments, destroy the soil on either side. Where such an incident happens, the men should be prepared with proper instruments, to break and guide the shoals of ice, as a means of averting more damage. Such occupations are quite befitting the strong men; and if the steward be on the outlook for such casualties, he may save much valuable property to his master in a severe winter.

Intelligence of Horses.—The horse is an intelligent animal, and seems to

[1] *Live Stock of the Farm*, 317.

delight in the society of man. It is remarked by those who have much to do with blood-horses, that when at liberty, and seeing two or more persons standing conversing together, they will approach, and seem to wish to listen to the conversation. The farm-horse will not do this; but he is quite obedient to call, and recognises his name readily from that of his companion, and will not stir when desired to move until *his own name* is pronounced. He discriminates between the various sorts of work he has to do, and will apply his strength or skill in the best way, whether in the threshing-mill, the cart, or the plough. He will walk very steadily towards a feering-pole, and halt when he has reached it. He seems also to have an idea of time. We have heard a horse neigh daily about 10 minutes before the time of loosening from work in the evening, whether in summer or winter. He is capable of distinguishing the tones of the voice, whether spoken in anger or otherwise.

Horses are fond of nearly all kinds of music. Work-horses have been known, even when at their corn, to desist eating, and listen attentively, with pricked and moving ears and steady eyes, to music on various instruments. We have seen a kilted Highlander playing the bagpipes riding on the back of a farm-horse, which showed every sign of pleasure. The recognition of the sound of the bugle by a trooper, and the excitement occasioned in the hunter when the pack give tongue, are familiar instances of the power of particular sounds on horses, in recalling old associations to their memory. The horse's memory is very tenacious, as is evinced in the recognition of a stable in which he had at times been well treated. He is very susceptible of fear, and will refuse to pass into a road or a particular locality in which he had received a fright.

Names Suitable for Farm-Horses.—As to the names of farm-horses, they should be *short and emphatic*, not exceeding two syllables, for long words are difficult to pronounce when quick action is required. For geldings, Tom, Brisk, Jolly, Tinker, Dragon, Dobbin, Mason, Farmer, Captain; for mares, Peg, Rose, Jess, Molly, Beauty, Mettle, Lily, seem good names. For stallions, they should be important, as Lofty, Matchem, Diamond, Blaze, Samson, Champion, Bold Briton, &c.

FEEDING HORSES.

The feeding of horses is quite as important in its way as the feeding of cattle. The one is fed to perform work, the other to produce meat. In each case the performance will depend mainly upon how the matter of feeding has been attended to. Experience has shown exactly the amount of fuel a steam-engine of a certain number of horse-power will require to enable it to work up to its full capacity. Less fuel than that ascertained amount will cause a diminution of power; more than that will certainly incur a waste of fuel, and may also prove injurious to the vital parts of the engine. The same principles apply to the feeding of horses. He who would feed his horses perfectly must know and consider not only the duties, powers, condition, and consequent food requirements of each animal, but also the composition and character of the available articles of food. It is only by properly adapting the one to the other that he can ensure the best possible results. Perfection may be beyond our reach. Let us get as near to it as possible.

Articles of Food for Horses.—In the chapter on "Foods," information is given as to the composition and character of all the commodities used as food for horses. The reader is urged to study that information carefully before attempting to arrange food rations for horses. Here may be enumerated the articles of food most largely used for horses—viz., hay, straw of various kinds, oats, wheat, barley, beans, Indian corn, bran, linseed, linseed-cake, turnips, mangels, carrots, parsnips, potatoes, furze (or gorse), silage, vetches, fresh grass, clover, &c.

Food Requirements of Horses.

It is far from easy to properly understand and determine the food requirements of different horses—horses of various kinds, ages, conditions, and sizes, and performing different kinds of work.

It is important in approaching this subject to consider carefully the functions performed in the body by the different elements of food. As pointed out by Dr George Fleming (principal veterinary surgeon of the army), in his admirable and most instructive work, *The Practical Horse-Keeper*,[1] the non-nitrogenous elements supply material for the maintenance of animal heat, and repair waste caused by the unceasing functions of respiration and transpiration; the reparation of nervous and muscular waste, and the function of general nutrition depend alone upon nitrogenous matter (albuminoids); while the woody fibre or cellulose stimulates digestion, and assists in separating the richer particles of the food, so that the digestive juices may the more effectually play upon them; and the ash and salines in food furnish material for renewal of the bodily frame, and assist in the elaboration of secretions. A portion of any excess (over immediate requirements) of non-nitrogenous matter consumed is stored up in the body of the horse in the form of fat, and will be reabsorbed and appropriated to maintain heat and respiration in the event of a deficiency in the supply of non-nitrogenous matter in the food at any time. No such safeguard is provided by the nitrogenous (flesh and muscle forming) matter, for any excess of this given at any time passes away to the dung-heap at once. It is thus a matter of great importance for the healthy and economical feeding of horses that the utmost care should be exercised in allocating to a horse the proper quantity of nitrogenous elements (albuminoids) in food.

Ration for Idle Horses.—The amount of various food elements required by a horse will, of course, vary with such conditions as the size, state, and duties of the animal. For a horse doing no work, the food, to properly maintain its bodily functions for twenty-four hours, should contain over 12 lb. dry matter, made up as follows:—

Albuminoids . .	8.36 oz.
Fats	3.19 "
Carbohydrates . .	11.4 lb.
Salts	0.5 oz.
Total food, free from water,	12.472 lb.

It is calculated that this amount of food, so composed, is capable of producing force equal to 27,855 foot-tons. "And if the weight of a horse," says Dr Fleming, "is estimated at 1000 lb., he would require 87.3 grains for each pound of body weight; or the whole body would require about 1-80th part of its weight in food every twenty-four hours, the animal undergoing no toil of any kind. A pony weighing 440 lb. requires 46 grains of nitrogenous matter for each 2 lb. 3¼ oz. of weight. This essential diet is supposed to be theoretically totally devoid of water, but in reality it would contain from 15 to 20 per cent of that fluid; so that, to allow for it, something like 1.87 lb. or 2.49 lb. must be added to the 12.472 lb."

But this is merely a ration for the bare subsistence of a horse. To enable the horse to perform work, additional food is necessary.

Additional Food for Work.—The amount of additional food required to enable a horse to perform work and maintain its condition will depend upon several circumstances, such as the nature and amount of work to be done, the season of the year, condition and size and powers of the horse, &c. The mere weight of the animal is not so reliable as a guide to the quantity of food required by a horse as it is in the case of cattle. The food requirements of small horses are relatively greater than those of larger ones.

Quick Pace and Food Requirement.—A point of some importance is this, that there is less waste of energy and tissue—and therefore less food requirement—when the labour performed is slow and prolonged than when it is brief and severe. Dr Fleming says it has been calculated that the useful work of a horse, which would be represented by 100, with a velocity of 2 miles per hour, would not be more than 51 with a velocity of 7½ miles, or more than 7 with a speed of 11½ miles an hour. In practice it has been found that the amount of food sufficient for slow work for ten hours will not suffice for more than five hours' exertion at a trot. Increased speed in work increases the demand for albuminous food.

A horse working at walking-pace requires from 6 to 9 grains of albuminoids

[1] Cassell & Co., Limited.

for each 7233 foot-pounds of work performed; while for work at a trot the requirements of albuminoids would be as much as from 15 to 24 grains for the same number of foot-pounds of energy expended.

Force exerted by Horses.—In order to know how to properly adjust the quantity and composition of food, it is necessary to ascertain as nearly as possible the amount of force exerted by horses in performing work, be it pulling a load or carrying a rider. With regard to this Dr Fleming says: "It may be mentioned that a one-horse engine, working ten hours per day, raises 19,799,360 pounds 1 foot high—this being the calculated amount of energy expended in ten hours if it could be all at once exercised. But this is probably much more than a horse could exert; a very hard day's work would in all likelihood not be more than 16,400,000 foot-pounds, which would be exercised by a horse pulling a load along at a walk for eight hours. Eight hours' slow walking, with a traction force of 100 lb., is equal to 8,436,571 foot-pounds *per diem*. Slow farm-work is equal to 11,211,000 foot-pounds a-day. With regard to fast work, the amount of foot-pounds raised is less, for the effort required is sudden, and the waste of tissue or force is consequently greater. The actual amount of work done is less, for the reason that the animal cannot sustain the effort, and owing to the greater waste incurred, more food is needed."

The amount of energy expended at work both at fast and slow pace must vary considerably, but Dr Fleming gives the following estimate as "fairly correct":—

	Foot-pounds.
A hard day's work for a horse at a walk would be . .	11,500,000
A moderate day's work, ditto .	8,500,000
A hard day's work for a horse at a trot of fast pace would be	7,233,000
A moderate day's work, ditto .	3,500,000

Rations for Degrees of Work.—The following table, showing the amount of food required by a horse under different conditions of labour — the proximate principles of the diet being stated—is given by Dr Fleming:—

Proximate Principles.	Moderate Work.		Active Work.		Severe Work.	
	lb.	oz.	lb.	oz.	lb.	oz.
Albuminoids . . .	1	4	1	8	2	0
Fats . . .	0	8½	0	10	0	12½
Carbohydrates . .	6	13	6	0	10	0
Salts	1	5	1	7	1	9
Total . .	9	14½	9	9	14	5½

It is necessary to explain that these are merely approximate quantities, and must not be followed blindly. In each individual case carefulness and judgment must be exercised; and the appetite, health, condition, and working powers of each animal duly considered.

Winter Feeding of Horses.

There is almost as much variety in the systems of feeding horses in winter as in the methods of the winter feeding of cattle.

Preparing Food for Horses. — As already stated, one great change has been introduced in the preparing of food for horses. On the best-managed farms all kinds of grain are bruised, and the larger portion of the hay and straw cut into chaff before being given to horses. As to the propriety of bruising grain there can be no question. Not an ounce of grain of any kind should be given to horses without being ground; for when given whole, a portion of the grain is liable to pass through the animals undigested. The husk of grain is so dense and difficult to dissolve, that if it should be given whole and escape being ground by the animal's teeth, the gastric juice acts feebly and slowly upon it, and will most likely be unable to dissolve it, so that a portion of the whole grain will pass through the animal unaltered.

As to the chaffing of hay and straw, there is some difference of opinion. But there is no doubt the chaffing both economises fodder and is advantageous to the horses, by assisting them to masticate their food. It should therefore be encouraged, for both these points are important.

Many who regularly pursue chaffing give their horses in addition small allowances of long hay or straw, which may be relished by the horses when they are not hard worked and have plenty of time to eat their food. The bruised grain and chaffed fodder are usually given together; and are of course mixed in varying proportions according to the work being performed at the time. Beans and peas should be merely cracked or split, and not ground into flour. Care should be taken to mix the various ingredients thoroughly, so that each animal may receive its due proportions of all the elements. The chaffed fodder and bruised grain may be conveniently mixed in a large iron vat or box, or in a wooden box lined with sheet-iron.

Cooked Food for Horses.—As to the cooking of food for horses there has been much discussion. As the standard article of food for draught-horses at hard work, raw bruised grain is generally considered preferable to boiled grain; but a night-feed once or twice, or even three times a-week, of boiled or steamed grain or bran, is found to be a useful and agreeable change. For horses at light work, cooking food may be commended on the score of economy, for a small allowance of cooked grain will render a large quantity of chaffed fodder palatable. For horses, old or young, whose teeth and digestive systems are weak or defective, cooked food is highly advantageous. Mouldy hay is made safer and more palatable by being steamed, and damaged grain should in all cases be cooked. Grain that is to be boiled or steamed for horses should not be bruised, but macerated with warm water. Horses will relish a sprinkling of salt on their cooked food. Be careful to give the cooked food to horses before it begins to ferment.

Fig. 151 is a common boiler for cooking food. The surface of a boiler is protected by coarse linen being rubbed by a trowel upon the plaster above the brickwork. The cloth prevents the breaking of the plaster in using the boiler. The proper way of setting a boiler is this: When the building has proceeded so far as to have formed the ash-pit, and received the grate and dumb-plate and furnace-door, to the height of the latter, let a circular basin be built of the form of and a few inches larger than the boiler, to contain the boiler itself; and let it be so contracted, as it comes nearer to its height, as to suspend the entire boiler within the basin by its ears; and let a flue be built from behind, or at one side of the basin, as the case may be,

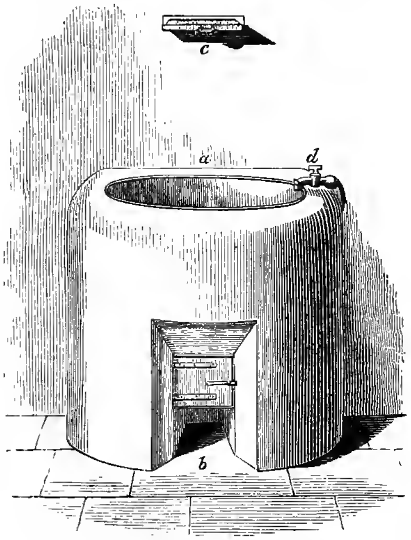


Fig. 151.—*Boiler and furnace.*

a Cast-iron boiler 3½ to 4 feet diameter.
b Furnace-grate.
c Damper or flue.
d Water-cock.

into the chimney. The advantage of this mode of setting is, that the heat of the fire is not confined to one part of the boiler, but is diffused over the whole of its under surface; and though the heat may not be so great at any one part, it cooks the contents more equally, and preserves the boiler from overheating and injury.

Hard Food for Horses.—It seemed at one time to be considered necessary that horses doing hard work should receive *hard meat.* Professor Dick described this as a very silly and erroneous idea. "For whatever may be the consistency of the food when taken into the stomach, it must, before the body can possibly derive any substantial support or benefit from it, be converted into *chyme*—a pultaceous mass; and this, as it passes onward from the stomach into the intestinal canal, is rendered still more fluid by the admixture of the secretions from the stomach, the liver, and the pancreas, when it becomes of a milky appearance, and is called *chyle*. It is then taken into the system by the lacteals, and in this *fluid*, this *soft* state —*and in this state only*—mixes with the blood, and passes through the circulating vessels for the nourishment of the system."[1]

Mashes for Horses.—In winter it is customary to give farm-horses a mash once or twice a-week. The mash generally consists of boiled barley, oats, or beans, mixed at times with bran and seasoned with salt, and an ounce each of sulphur and nitre are sometimes added. Raw potatoes or swedes are given one time and mash another, or the potatoes and swedes are boiled with either of the grains. The articles are prepared in the stable boiler-house in the afternoon, by the cattle-man or a field-worker, and put into tubs, in which it is carried to the stable by the men, and dealt out with a shovel, for supper at night, in the troughs used to carry the corn to the horses. It should not exceed milk-warmth. The corn put into the boiler is as much as when given raw, and in its preparation swells out to a considerable bulk. The horses are exceedingly fond of mash, and when the night arrives for its distribution, show unequivocal symptoms of impatience to receive it. The ingredients should be well mixed and well cooked.

Oats for Horses.—The quantity of raw bruised oats given to farm-horses, when at moderate work, is not less than (often more than) 3 lippies a-day, by measure, and not by weight; but taking horse-corn at 40 lb. per bushel, each feed will weigh 3¾ lb., the daily allowance amounting to 11¼ lb.; but the lippy measure — which is a fourth part of a peck—when horse-corn is dealt out, is not striked, but heaped, or at least hand-waved, so that the full allowance will weigh even more than this. As horses work only seven or eight hours a-day in winter, their feeding is lessened to perhaps 2 full feeds a-day, or 7½ lb., divided into three portions—namely, a full feed in the morning, ½ a feed at mid-day, and ½ a feed at night; and on the nights of mash the evening ½ feed of oats is not given raw, but in the mash.

Substitutes for Oats.—Some small farmers withdraw the corn altogether from their horses in the depth of winter, giving them mashes of some sort instead; whilst others give them only one feed a-day, divided at morning and noon, and a mash, or raw turnips or potatoes at night. One of the sorts of mash alluded to consists of barley or oat or wheat chaff, steeped for some hours in cold water in a large cistern made for the purpose, and a little light barley or oats sometimes put in, to give the appearance of corn. But a greater deception than such a mess, in lieu of corn, cannot be practised upon poor horses; for what support can be derived from chaff steeped in cold water? As well might the mess be mixed up at once in the manger. No doubt horses eat it, but only from hunger; and when obliged to live upon it, exhibit thin ribs, pot-bellies, and long hair—characteristics which bespeak poverty of condition.

Steamed Potatoes for Horses.—One season, as a mash, we tried steamed potatoes, with salt alone, of which the horses were excessively fond, and received three times a-week, and on which they became sleek in the skin, and fat, notwithstanding much heavy work. But in spring, when the long days' field-work was resumed, every one was affected by shortness of wind; and not only that, but profuse perspiration was induced, so that by the end of seed-time they had entirely lost their condition. Still potatoes are useful food for horses, and for animals doing light or moderate work they may with satisfactory results be given steamed or boiled, along with chaffed hay and straw, and a small allowance of oats. Potatoes intended for horses should be carefully washed, as dirty food is dangerous for them.

Overdoing Soft Food.—From what we have heard eminent veterinarians say, and from what has just been stated, it would seem quite easy to overdo mashing for horses. Such soft food is well adapted to the digestive organs of ruminating animals, but not for the single-stomached

[1] *Jour. of Agric.*, iii. 1033.

horse, and the kind of work he has to do. His muscular system being exercised to the utmost in field-labour in the spring, it should have nourishing, nitrogenous, flesh-forming food to supplement the great waste of muscular energy going on every day. It is therefore a bad preparation for spring-work to overload the horse with fat during the winter.

Mixed Food for Horses.—For horses as well as for cattle mixed foods are generally found most economical and satisfactory. Mr Gilbert Murray, Elvaston Castle, Derby, than whom there is no better authority, recommends the following—viz., 1 cwt. oats, 1 cwt. wheat, ½ cwt. white peas, and ¼ cwt. linseed—all ground and mixed together. He considers that 1 cwt. of this mixture will contain about 40 per cent more nutriment for horses than 1 cwt. of oats alone, and the cost in each case would be about the same. Mr Murray has also used for an ordinary agricultural horse at regular work on the farm, 13 lb. *per diem* of crushed oats, 3 lb. of bran, 6 lb. of raw swedes sliced, 14 lb. of cut chaff—two-thirds hay and one-third straw—and 10 lb. wheat-straw litter; the ground oats, bran, and chaff mixed together and macerated with water. This mixture should be prepared twelve hours before being used. He found this system admirably adapted for the winter months, the horses being healthy and standing their work well.

Among other forms of food mixtures used are these, the quantities mentioned being for one day: (1) 10 lb. of cut straw; 10 lb. of oats; 16 lb. of turnips. (2) 16 lb. of hay; 5 lb. of oats; 16 lb. of turnips. (3) 10 lb. of bruised oats; 20 lb. of hay; 12 lb. of cut straw. In the first two cases the turnips are pulped and mixed with the cut fodder twelve hours before being used.

A correspondent, who has the care of about 60 horses, writes as follows as to his system of feeding: "Our feeding at present is composed of the following ingredients,—viz., hay, maize, oats, and beans, mixed in the proportions of 4 cwt. hay, 3 cwt. maize, 2 cwt. oats, and 1 cwt. beans—the hay, of course, being chaffed and the grain bruised. Heavy farm and cart horses, doing full work, get as much of this mixture as they will eat, which is about 24 lb. each daily, with a little long hay twice a-day." [1]

English Methods.—Referring to the systems of feeding draught-horses in England, Mr John A. Clarke says: "As a rule, the old wastful system of giving the horses hay in racks, as well as the Lincolnshire practice of feeding on oat-sheaves, cut into chaff, has gone out of favour; and the best managers cut up hay and straw, and give their horses ground corn or crushed oats, sometimes bran or pollard, with a portion of pulped roots or green tares added to the dry food. In some districts the farm-horses are grazed on the pastures in summer; but the practice of keeping them in stables or yards the whole year round prevails in most tillage districts, and is extending." [2]

In some parts of England large quantities of Indian corn are used for horses; but on account of its moderate percentage of flesh-formers (albuminoids), and excess of heat-producers (carbohydrates), it is not quite so suitable as oats to form a leading ingredient in food-mixtures for draught-horses.

A Group of English Rations.—The prevailing customs of feeding draught-horses in England are shown in the following summary from replies sent by leading farmers to Mr H. F. Moore for his paper on the "Preparation of Food for Stock:" [3]

Mr H. Simmonds, Bearwood Farm, Wokingham—2 bushels of oats, ½ bushel split peas, with 2 trusses of hay and straw chaffed per week per head when in full active work.

Mr H. Straker, Riding Hill, Northumberland—when in full work, about 5 stones of crushed oats each per week, with long hay *ad libitum* and a bran-mash with a little boiled linseed in it, twice a-week during winter, the oats being reduced greatly when the weather stops work.

Mr J. Brockie, Carmarthenshire—as much as they can eat of long straw and uncut swedes, with 1½ bushel oats per week.

Mr John Watts, Falfield, Gloucester-

[1] *Farming World*, 1886, 276.
[2] *Jour. Royal Agric. Soc. Eng.*, xiv., sec. ser., 631.
[3] *Ibid.*, xxiv., sec. ser., 447.

shire — straw-chaff with some hay, and 2 bushels of crushed oats per week.

Mr John Treadwell, Upper Winchendon, Aylesbury—hay and straw chaff, with 1 bushel of ground maize, ½ bushel of oats, ½ peck of crushed malt per week.

Mr H. Woods, Merton Metford, Norfolk—1½ gallon oats and hay-chaff, 1 stone long hay, and occasionally 2 or 3 lb. of linseed-cake.

Mr T. H. Hutchinson, Manor House, Catterick, Yorkshire—chaffed oat-straw, ground oats, bran, a few roots, and 1 lb. linseed-cake.

Mr Gilbert Murray, Elvaston, Derby—young horses, 6 to 8 lb. per day of mixed meals (oats, wheat, white peas, and linseed all ground together), with cut hay and straw; the meal and chaff being mixed together, and saturated with water twelve to twenty-four hours before being used.

Ration for Hard-worked Horses.—From the beginning of October to end of March, hard-worked horses in Scotland are fed three times a-day. The morning feed in some cases, where high feeding is the rule, consists of from 5 to 7 lb. of bruised oats; the mid-day feed, 4 to 5 lb. of bruised oats, and 3 lb. crushed linseed-cake; in the evening from 5 to 7 lb. bruised oats, and as many raw swedish turnips, well cleaned, and given whole, as they will eat; oat-straw being given as fodder. After the end of March, when the straw gets dry, so that horses do not relish it, it may be well to substitute hay for straw. These are heavy allowances of oats, from 4 to 5 lb. at each meal being more general. In spring, when farm-horses are doing hard work for ten hours a-day, many Scotch farmers give full supplies of hay instead of straw, with about 1 lb. of linseed added to the 4, 5, or 6 lb. of bruised oats in the morning, and about 1 lb. of cracked beans, with two or three swedes, to the evening allowance of oats.[1]

Roots for Horses.—Swedes, either raw or cooked, are given largely to draught-horses. When the roots are cooked alone, from 50 to 60 lb. are put into the boiler or steaming-vat for each horse, and this gives about 35 to 45 lb. of cooked food, which should be prepared in time to allow it to become cool, but not cold, before being given to the horses in the evening. A little chaffed hay, perhaps not more than 1 lb. for each horse, is mixed with cooked roots, and some add about 1 lb. of ground oilcake, while others have about half a pound linseed for each animal cooked along with the roots. This warm food is given either in two meals—one when the horses come in from work in the evening, and the other at 8 P.M.—or in one meal at the latter hour.

But the most general plan is to give the turnips to horses raw and uncut, as the last meal for the night. Mangels are given in a similar way. Roots of all kinds should be thoroughly cleaned before being given to horses.

Carrots.—There is no kind of root equal to carrots for horses. They are especially suitable for hunting and other horses which are hard-worked. They are given raw and usually sliced. For ordinary farm-horses, however, they are generally beyond reach on account of their cost. Carrots are easily and successfully grown in the island of Guernsey; but Quayle states that they are not given to horses, on account of an allegation that "when on this food their *eyes* are injured."

Parsnips.—The same writer mentions a similar effect produced by the *parsnip* at a certain season of the year. "To horses," he says, "parsnips are frequently given, and have the property of making them sleek and fat; but in working they are observed to sweat profusely. If new, and cut sufficiently small, no other ill effect results — except, indeed, at one period of the year, towards the close of February, when the root begins to shoot; if then given, both horses and horned cattle are subject, on this food, to an inflammation in the eye, and epiphora or watery eye—in some subjects, perhaps, producing blindness."[2]

The boiling of carrots or parsnips might perhaps remove this dangerous tendency.

Furze for Horses.—Furze (whin or gorse) is relished by horses, and makes useful winter food for them. It is the young shoots of furze that are fed to

[1] *Farming World*, 1888, 505.

[2] Quayle's *Agric. Chan. Isl.*, 103.

horses, and they are best when bruised by the furze "masticator." (See fig. 118). In the absence of a "masticator," the furze is cut as fine as possible by a chaff-cutter, but this does not cut and bruise it so fine as is desirable. A hand furze-bruiser, which does its work wonderfully well, is represented in fig. 152. When fresh furze is crushed, it throws off a fine aromatic odour, which is much relished by horses. The furze is bruised every second or third day. It should not be allowed either to heat to any extent or to become dry. If it should get dry before being used, it would be well to sprinkle water over it by a garden watering-pan.

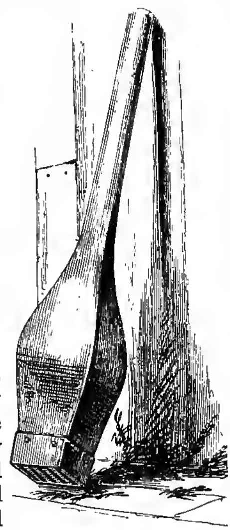


Fig. 152.—*Hand whin-bruiser.*

The Rev. W. R. Townsend, Aghada, County Cork, stated that having "been for fifty years and more feeding my horses and cows on furze, I can say from that long experience, that it is the cheapest and the best food for the autumn and winter months. I have had my horses, getting neither hay nor oats, in more beautiful condition (sleek as mice) than any of my neighbours', though they had costly grooms, the horses fed with the best hay, oats, and beans, and warmly clad. Mine were, perhaps, not as fit for the race-course or the hunting-field; but for road, riding, carriage-work, or work on the land, they were most fit, though fed only on chopped furze and steamed swede turnips." [1]

Draught-horses will eat from 20 to 25 lb. of crushed furze per day, but it will be as well to give smaller quantities, mixed with chaffed hay or straw and bruised oats. The furze will lend a delightful flavour to the feed, which will thereby be more than usually palatable to the horses. Furze tends to fatten horses rather than develop flesh and muscle, so that, for hard-working horses, an allowance of other food, such as bruised oats, should accompany it.

Furze for Broken-winded Horses.—Furze is specially suitable as fodder for broken-winded horses. Mr W. Hooper, Bandon, says: "I have been in the habit of giving furze as fodder to horses for the past fifteen years, and should be sorry to discontinue its use; for I find horses do better on it than on hay alone, to say nothing of the saving effected by it. It is not generally known what an astonishing effect furze has on a broken-winded horse. I have a mare which can do nothing but slow work (and that not without distress) when fed on hay, but as long as she is getting furze she can travel fast with ease." [2]

Feeding in a Clydesdale Stud.—In the valuable stud of pure-bred Clydesdale horses owned by Lords Arthur and Lionel Cecil of Orchardmains, Innerleithen, a very careful system of feeding is pursued. Turnips, bran, cut hay, beans, and barley are boiled and steamed, and of this mixture each horse when at work gets half an ordinary stable pailful every night at 6 P.M. Young horses and brood-mares get this once or twice a-day, according to the kind of pasture they may be going upon. The proportions of the boiled mixture are varied as may be suggested by the condition of the dung of the animals, a responsible man adding or withholding bran chiefly as may be thought advisable. It is considered that by chaffing and mixing the chaff with oats, a great saving of corn is effected, while the horses are kept in admirable health. During the five years the above mixture has been used, there has not been a single case of gripes in this large stud of upwards of 60 horses.

Feeding Young Horses. — Young growing horses are often stinted in food. No greater mistake could be made. They ought to be fed liberally and with as much care and punctuality as the hardest-worked horse on the farm. Let them have as much good hay or oat-straw as they can eat two or three times a-day.

[1] *Letters on Furze.*

[2] *Gorze, Furze, or Whins* (by J. Gillitt), 25.

"In addition to this, one-year-olds should have 3 lb., and two-year-olds 4 lb., gradually increasing as they get bigger to 5 lb.—crushed oats 3 parts, 1 part beans, and 1 part linseed, mixed, when they are housed at night, and before being put out in the morning. In wet stormy days, when they are out only half an hour or so for exercise, they should have their corn, &c., thrice, instead of twice a-day." [1]

This is liberal feeding, and less of the concentrated food, perhaps from 4 to 6 lb. per day, may suffice to keep the youngsters growing and in good condition. Many think it is desirable to give young horses once or twice a-week a warm mash, consisting of boiled roots, boiled linseed or linseed-meal, mixed with bran. Young horses will thrive admirably on 3 to 4 lb. of crushed oats, and 1 lb. of crushed linseed-cake per day, mixed with chaffed hay or straw. Mr R. O. Pringle considered that the value of linseed for young horses is not sufficiently appreciated.

The chief aim, of course, is to give to young horses such food as will most effectually promote the development of bone and muscle without forcing the animal into a very high condition. For this purpose, Dr Fleming says that "oats, crushed, should be the chief grain, and a small proportion of beans, split, mixed with these, the whole being scalded or boiled, if possible, and bran added to form a mash, is a good and appropriate feeding together with sound hay." [2] Mr Gilbert Murray says young horses can be successfully wintered on a mixture of cut hay or straw, and 3 lb. per day of mixed meals.

Importance of Careful Rearing.—Referring to the rearing of young horses, Dr Fleming says: "Nothing is more important for the future wellbeing of the foal than judicious rearing during its early years, as then its constitution is most impressionable, and its development receives an impetus which ensures good muscle and bone, with perfectly formed organs; or this is checked, and we have feebleness, insufficient growth, organs that are unsound or badly perform their functions, and a constitution that will not endure strain,—all depending upon careful or neglectful rearing. When half-starved and badly kept for the first two or three years of their lives, no amount of attention will afterwards compensate for the lost opportunity of promoting free growth and full development in the foals.

"Therefore it is that the wise breeder will see to it that foals and young horses have a plentiful supply of good and proper food, sufficent exercise, and pay attention to their feet, limbs, and body." [3]

Mr Frederick Street remarks that "foals require good and suitable dry food during the winter months. At no other period of life will they so well repay the outlay. Size will never afterwards be obtained, unless the foals are well grown when young."

Mr R. O. Pringle regarded starving young stock of all kinds as a most unwise proceeding, and especially so in the case of young horses intended for draught.

Young Horses not to be Pampered.—But while young horses should be fed liberally, they should not be forced in feeding, or pampered in any way. Keep them in good growing condition, full of natural flesh; and, without exposing them to excessive cold or wet, let them have plenty of exercise and fresh air, so that, as far as possible, their muscular and constitutional strength and hardiness may be developed.

Rations for Tramway Horses.—It may be interesting to note the daily rations given to their horses by tramway companies in the following towns:—

	Glasgow. lb.	Edinburgh. lb.	Birmingham. lb.	London, South. lb.	London Street. lb.	Liverpool. lb.	Dublin. lb.
Oats	6	8	10	7	3	...	3
Maize	11	4	6	7	12	12	14
Beans or peas	...	4	4	1	1	4	...
Hay	8½	14	12	11	11	14	12
Straw	1	2	...	3	...	...	...
Bran	0½	...	...	...	1	1	0½
Total lb.	27	32	32	29	28	31	29½

[1] *Farming World*, 1888, 505. [2] *The Practical Horse-Keeper*, 164. [3] *Ibid.*, 162.

In the case of Edinburgh, the straw consists of bean and oat straw mixed. Mr John Speir remarks that, although at first sight these rations may seem very different in composition, they are nevertheless, on close chemical examination, found to be very much alike. For instance, the albuminoid ratio in the Liverpool ration, with no oats, is 1 to 6.3, and the average percentage of fibre 15.3; while in the Birmingham ration, with 10 lb. of oats, the albuminoid ratio is 1 to 5.8, and the percentage of fibre 14.86.

Rations for Ponies.—Ponies, from 13 to 15 hands high, working at coal-pits, are allowed 20 lb. per day of a mixture of hay, Indian corn, oats, and bran, mixed in the proportion of 4 cwt. of hay, 3 cwt. of Indian corn, 2 cwt. of oats, and 1 cwt. of bran—the hay being chaffed, and the grain bruised. This is about as much as they would eat, and they are always in good working order. No long hay is given, but a feed of this mixture is steamed for them once a-week, with a few roots in their season.[1] Ponies which do little or no work of course require less food. They are often kept in good condition on hay and roots; in any case, from 4 to 6 lb. of bruised oats per day will be found sufficient.

Horses of all kinds are very fond of bread, oat-cakes especially, but this, however, is merely a "dainty" often given to pet animals, but not to be reckoned an article of food for horses. A drink of cold water with a few handfuls of oatmeal into it is very refreshing to horses.

Riding and Driving Horses.—Carriage-horses are often fed more highly than is necessary or is really beneficial for their health and usefulness. If their work is light, from 8 to 10 lb. of bruised grain and 12 to 14 lb. of chaffed hay *per diem* will be sufficient. When the work is heavier the grain must be increased, perhaps 2 or 3 or 4 lb. per day. Hunting-horses, and all riding-horses which are kept at hard work, should be liberally fed—horses over 15 hands, perhaps from 15 to 16 lb. of bruised oats per day, with 10 or 12 lb. of chaffed hay; the allowance of oats for smaller horses being reduced by 2 or 3 lb. per day. A few pounds of carrots—not more than 3 lb. per day—may occasionally be given with advantage. For hunters, Dr Fleming recommends the substitution of 2 lb. of split beans for 2 lb. of the allowance of oats.

Army horses usually receive 10 lb. of oats per day with 12 lb. of hay, and—for litter—8 lb. of straw. When on severe duty, or in camp, the allowance of oats is increased to from 10 to 14 lb. per day. The hay is given uncut.

Quantity of Food.—It is considered that, as a rule, an average-sized draught-horse will require about 29 lb. of food per day. Much less than that, even although it should be highly nutritious, will not be sufficient to maintain the animal in a healthy and vigorous condition. Reynolds states that such a horse, when moderately worked and well housed, will consume from 29 to 34 lb. per day, of which the hay and straw should constitute about two-fifths.

Bulk of Food.—It is undesirable, in ordinary cases, to attempt to feed horses mainly upon highly concentrated food. In order to enable the digestive organs to properly perform their functions, a certain considerable degree of bulk in the food is necessary. When horses are hard-worked, the morning and mid-day meals may advantageously be small in bulk—a feed of oats can be speedily eaten, and does not interfere with the breathing organs as does a bulky feed of hay or straw. But at night, in these cases, bulky food should be given.

Frequency of Feeding.—Horses should be fed at least three times a-day—before 6 in the morning, about mid-day (as soon as brought in from work), and in the evening. The exact hours will depend upon local circumstances as to the work being carried out. But it is very important that precise feeding hours should be arranged, and that these should be rigidly adhered to. Punctuality in feeding is a most important consideration.

Long fasts are detrimental to horses. The standard hours of farm-work seldom permit of more than three meals per day; but it would be far better for the horses if they could be fed four times a-day, at intervals of not more than four hours. Let the evening meal be the largest and bulkiest, as the horses have then plenty of time for thorough mastication. Long

[1] *Farming World*, 1886, 276.

fasts and rapid and heavy feeding often give rise to disorder of the digestive organs, and care should be taken to give the animals ample time to consume their food in comfort. Improper mastication, often caused by too hurried feeding, renders the process of digestion more difficult. At long spells of work, a feed of grain, even if it should be very small, given in a nose-bag will be found very beneficial. Do not give more food of any kind at a time than the animal is likely to consume, as if any were left it would become stale and unpalatable, and probably be wasted.

Littering Horses.

Straw as Litter.—Horses, especially if hard-worked, should have plenty of litter. Straw is the most largely used, and is the best of all kinds of litter. Wheat-straw, being stronger and tougher, is preferable to oat, or any other variety of straw, but in many parts of the country wheat-straw is not available. The stall should be thoroughly cleared out every morning, the wetter portions of the litter sent to the manure-pit with the dung; and the drier parts, which may be fit to be used for another night's bedding, retained in some convenient corner—if the weather is dry, spread out near the stable, and taken in again in the evening.

Litter which has been used should never, as is sometimes the case, be stored beneath or in front of the manger, as the ammonia is apt to rise and injure the eyes of the horse, as well as taint its food.

When litter which is too wet to be again used as bedding for horses, and not sufficiently made into manure, cannot be conveniently dried, it should be handed over to the cattle-man, who will be able to turn it to good account in the littering of cattle-courts.

Greedy horses sometimes eat the straw put below them for bedding, and are liable to injury thereby. It will help to prevent this if the litter which has been previously used be placed nearest the manger, and the fresh litter kept backwards.

From 8 to 14 lb. of straw are used as litter for each horse per day. With care, 8 to 10 lb. should be quite sufficient.

Peat-moss Litter.—The best substitute for straw as litter for horses yet introduced is "peat-moss litter"—peat-moss which has been broken and compressed by machinery till most of the moisture has passed away, leaving soft, spongy, fibry-looking vegetable matter. It makes cheap and comfortable bedding, absorbs and conserves the urine, and is a powerful deodoriser, keeping the stalls sweet and wholesome. It has a highly beneficial effect upon the feet of horses, keeping them cool, and encouraging the growth of strong tough hoofs. For animals with tender feet it is most beneficial. It is also valuable as manure, and its use should be commended on account of the saving of straw thus effected.

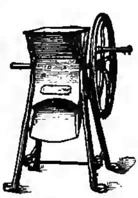


Fig. 153.—*Peat-breaker.*

Peat-moss litter is now a regular article of commerce. It is imported largely from Germany and other parts of the Continent, but may be had of native growth and manufacture. Peat-moss litter is rendered much more comfortable for horses by being put through a peat-breaker such as that shown in fig. 153, made by Bracher & Co., West-hill, Wincanton.

Other Varieties of Litter.—Many other substances are used as substitutes for straw in littering horses. Among these are sawdust, fine sand, spent tan, leaves of trees, and ferns. Sawdust is often used, but by itself it does not make comfortable or desirable litter. As a padding beneath a thin layer of straw it is very useful, comfortable, and economical, and may be resorted to where peat-moss litter cannot be procured at reasonable cost. Sawdust should be spread in a layer 2 or 3 inches deep, and raked daily; and the dung and wet particles removed and some fresh sawdust added. Then a thin cover of straw spread over this layer of sawdust at night will make a comfortable bed. At least once every week the stall should be thoroughly cleaned out, and an entirely fresh layer of sawdust laid down. Horses' feet are apt to get packed with the sawdust, and this should be picked out every morning, and also every evening when the horses have been in the house all day.

Fine dry sea-sand also makes fairly

comfortable litter. It is better to be covered by a thin layer of straw, as this keeps the sand from getting freely into the hair of the animals. Where ferns are plentiful, they may be cut and stored for use as litter in winter. Spent tan, about 6 inches deep, makes durable and useful litter. If the surface is carefully cleaned of the dung every morning, and the tan raked by an iron garden-rake, one layer will last over a month. Scatter a little gypsum over it now and again.

General Hints.

Exercise.—Horses that are not regularly at work should be exercised punctually every day, say, just after breakfast. In very cold weather in winter towards mid-day may be preferable. Unless idle horses have plenty of exercise given to them methodically, they are liable to contract "grease" in the legs, and become soft, flabby, and unfitted for active work. Horses that are entirely idle should have two hours' daily exercise.

Rest.—Farmers are often not so careful as they ought to be in providing quietness and comfort for hard-worked horses during hours of rest. In particular, during the two hours of mid-day rest horses should have as little disturbance as possible. As soon as they have been made comfortable in their stalls, and been fed, they should be left in perfect quietness. The stable-door should be shut, and no one let in to disturb the repose of the animals till their own attendants return to prepare for the work of the afternoon. Again, when the horses come in at night fatigued by a hard day's work, they should as soon as possible, after being fed and rubbed down, be left for quiet rest till supper-time.

Washing Horses' Legs. — Horses working on wet land are apt to have their legs so besmeared with mud that nothing but washing will clean them. In that case the legs should be washed at night, great care being taken to dry the legs thoroughly. Washing is in itself undesirable, and should be resorted to only when absolutely necessary.

Cracked and greasy heels are often caused by imperfect drying after washing or after exposure to wet and mud. Referring to this point, Dr Fleming gives a few words of warning which are well worthy of careful attention. He says: "It must, however, be regarded as essential to proper management, that under no pretext is a horse to be left for the night until all his legs have been thoroughly dried. Nor is this precept very difficult of execution; a handful or two of light wood sawdust, rubbed for a few minutes well into the hair, will absorb all the moisture from the most hirsute legs, affording not only a sense of comfort to the animal, but preventing those undesirable consequences engendered by continued application of cold and wet to the extremities." [1]

Clipping and Singeing.—For horses which have rank coats of hair and have fast trotting work to do, clipping or singeing is found advantageous. This is seldom practised with farm-horses;

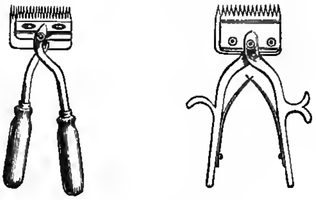


Fig. 154.—*Horse-clippers.*

and if they are well groomed there will be little need for any interference with the length of the coat. Clipping is most generally pursued with the ranker coats, and this is done speedily and efficiently by a clipper such as those (Clarke's) represented in fig. 154.

Shorter coats are singed, either oil or gas being used in the singeing-lamp, the latter being preferable.

Injurious to Clip Legs of Horses.—But while this system of clipping or singeing has its advantages, there is one practice often resorted to which is entirely mischievous and should be strictly forbidden, and that is clipping the hair from the legs of draught-horses. In condemnation of this practice we cannot do better than quote the words of Dr Fleming, who regards it as "highly pernicious," and adds: "Hair is the natural protector of the cuticle, and is especially required to warm and shield the delicate skin of the heels; its removal from these

[1] *The Practical Horse-Keeper*, 93.

situations is certain to induce a predisposition to *grease*, and other equally serious consequences. If the legs are muddy on return from labour, they should be dried as far as practicable, and the adherent clay subsequently removed with a hard brush. The application of the thinnest possible film of pure neat's-foot oil to the surface of the hair of the legs will prevent the adhesion of clay, but it should only be used when absolutely necessary. . . .

Protection to Skin from Wet.—"A predisposition to cracked heels is engendered by clipping the legs and pasterns in winter: this should never be done, if possible; but if necessary, then the skin should be protected from the action of wet and dirt by rubbing into it, before the horse leaves the stable, hard vaseline or zinc ointment. A very good protection against the action of icy cold water, or the salt slush which is so common on tramway lines in winter, is a mixture of one part of white-lead and three parts common oil, rubbed around the pasterns and the coronets by means of a brush." [1]

Method in Stable Management.—Method and punctuality contribute as much to successful stable management as to success in business. Let the stable rules be arranged on a well-thought-out, workable plan, such as will, in the most effective manner possible, contribute to the comfort and usefulness of the horses. And when the rules are laid down, see that they are rigidly adhered to. Irregularity in the feeding and general treatment of horses is most detrimental to their wellbeing. They delight in punctuality, order, and cleanliness. Among horses let all things be done quietly, kindly, and in order. They appreciate kindly treatment, and will repay such behaviour by confiding obedience. Good horsemen and good horses get warmly attached to each other. There is more of the "social element" about the horse, the greatest of all our quadruped friends, than the casual observer would be inclined to give him credit for.

The *diseases of horses* will be dealt with when the routine work of the year has been gone through.

SWINE IN WINTER.

Disadvantages of Feeding Pigs in Winter.—It has for a long time been the custom for farmers to fatten pigs during autumn and winter rather than during summer. This is a mistaken practice, for it is well established that a feeding-pig will make a considerably greater increase in condition from a given quantity of food fed to it in cool quarters during the summer months than in cold weather. Moreover, the average price of pork in the months of July, August, and September is higher than in the winter months.

Experiments have been carried out in the United States which have proved that in the very coldest weather fatting-pigs have actually made no increase in weight although fed on maize, one of our best heat-giving foods. An ingenious American has drawn up a table showing that if 3 lb. of corn be required to maintain the weight and condition of a pig when the day temperature is about 70° Fahr., 5 lb. will be needed when the thermometer stands at 20°, and 6¼ lb. when at zero; and as little as 2¼ lb. when 100°. According to this calculation, about 4 lb. more food is required for mere sustenance in the coldest of these temperatures than in the warmest.

It will also be found that, by better attention and a little more food, most of these pigs which now, as a rule, are not fattened off until the autumn, might just as easily be disposed of fat at more money per stone in harvest-time, when pork usually sells more readily and at a higher price than later in the season.

Early Maturity in Pigs.—In no other class of stock does "early maturity" pay the feeder better than with pigs. Young pork commands a readier sale and higher price than old. Then

[1] *The Practical Horse-Keeper*, 95, 96.

the saving of food is important. It is generally considered that a pig of 100 lb. weight requires about 3 lb. of corn per day simply to keep the animal machinery going — merely to supply animal heat and repair the natural waste in the body. It therefore follows, that if by judicious feeding and attention a pig can be made to realise as much at eight months old as one managed after the old-fashioned plan would at the age of twelve months, the gain in food alone must be substantial. And, in addition to this, there would be a saving in the cost of attendance and risk.

Attention to Pig-rearing. — There are thus several important circumstances which favour the feeding of pigs in summer and autumn rather than in winter. Economy in pig-feeding should have as careful consideration as economy in any of the more important operations of the farm, yet it is well known that, as a rule, farmers give but little thought to the management of pigs. Too often pigs are looked upon as little else than the scavengers of the farm. This is a great and unfortunate error, for with proper management pigs generally pay well. Indeed it may be doubted if any other variety of stock will give a better or quicker return for kind and judicious treatment and liberal feeding than may be obtained from a good class of pigs.

The pig assuredly deserves more attention from the general body of farmers than it has hitherto received. An important point, we have seen, in the profitable management of pigs is the season of the year in which the fattening is mainly carried out. Swine are more susceptible of cold than either cattle or sheep; and, upon the whole, it is clearly desirable that farmers should aim at fattening the majority of their pigs between March and October.

Litters of young pigs are troublesome and risky in winter, and are to be avoided except where the delicacy of roast sucking-pig is desired at the Christmas dinner. But although the feeding of pigs should be carried out mainly in the warmer months, there will always be less or more pig-feeding in winter—perhaps a few pigs of late litters to finish off, or it may be only two or three young porkers for home consumption during winter and spring. It may therefore be as well to deal here with the general question of feeding swine. For the information upon this subject we are mainly indebted to Mr Sanders Spencer, Holywell Manor, St Ives, who has made the profitable breeding and rearing of pigs a life-study.

Feeding Pigs.

In writing of the treatment of farrowing sows, attention will be given as to the best periods of the year for the arrival of young pigs. By dealing here with the whole subject of pig-feeding, we are able to follow the pig to maturity, whether for slaughter or for breeding purposes.

Feeding the Sow and her Litter.— It may be assumed that six is a fair number for a young sow or yilt, and ten to twelve for an aged sow, to rear at each litter. These numbers may be larger in the summer months, but it will be found most profitable not to attempt too much in pig-breeding any more than in most other things. From the time the piglets are three days to about four weeks old, the sow should be fed twice a-day with just about as much as she will clear up at once of thoroughly stirred slop, composed of three-fourth sharps, thirds, or randan, and one-fourth broad bran. By this time, or even before, the little pigs will begin to lick round the trough, and show signs of a desire to become less dependent on their mother for the necessaries of life. This natural want must be satisfied either by allowing the sow to have a run on the grass field or in the straw-yard for an hour or two, or, if the weather is too rough and cold, letting the little pigs into an adjoining place, and there feeding them with a little sharps, or oatmeal stirred with milk; or a small quantity of oats, peas, or wheat will be thankfully received and turned to good account by the now hungry "squeakers."

This system of feeding may be continued until the pigs are weaned, the only variations being a gradual addition to the food given to both sow and pigs, and the warming of the milk or water with which the food for the little pigs is mixed during the cold weather.

Weaning Pigs.—The little pigs will be best left on the sow in the summer months until they are six or seven weeks old, and in the winter months a week or two longer. The weaning should be effected gradually, by letting the sow remain away from the pigs a little longer time each day until the flow of milk gradually ceases, and the pigs think more of the arrival of the pail than of their mother. By adopting this plan the sow's milk will be no trouble, and the sow will desire to receive the attentions of the boar within two or three days after the pigs are weaned.

Castrating Pigs.—Those little pigs which are not required for breeding purposes should be attended to when they are about five or six weeks old. This is by no means a difficult operation, but it is better to employ a competent castrator, especially with the sow pigs, or, as they are variously termed, hilts, elts, yilts, yelts, gilts, or gelts.

Feeding Young Pigs.—After the pigs are weaned, their food should be very similar to that on which they had been previously fed, with the addition of a few more peas. As the pigs reach the age of three months, a proportion, amounting to one-sixth, of barley-meal may be added. This may be gradually increased until it becomes two-thirds of the food of a five-months-old pig.

Cocoa-nut Meal for Pigs. — We have of late years used a considerable quantity of cocoa-nut meal, and have found it a most economical food to use with the barley-meal. From experiments carried out at our wish, it was proved that not only was pork made at a less expense by the introduction of cocoa-nut meal to the extent of about one-eighth of the whole allowance of food, but the quality of the flesh was superior, and the appearance of the carcass much improved.

Cod-liver Oil for Pigs.—Owing to the high price charged until recently for cod-liver oil, its use for stock has been very slight; but it may now be procured at such a reasonable price as to come within the limit of profitable foods for young growing pigs, if not for those in the fattening stage. As to its use for fattening pigs we have had no experience, but we can recommend it with every confidence for newly weaned pigs and young stores. During this last winter (1887-88) we have given it to some two or three hundred young boars and gilts which were being reared for the spring trade, and the result was most satisfactory.

A Golden Rule in Pig-feeding.—If it be desired to rear and fatten pigs at a profit, one "golden rule" must not be lost sight of—*never allow the pigs to become poor*. Keep them ever in a progressive state, and if this is done properly, they will be fit for the butcher a month or two earlier than is the rule, while the pork will be of better quality, and the loss from disease will be reduced to a minimum. Should illness attack any of the pigs, they will thus be always fit for the knife, and realise pretty nearly their full value.

Variety of Food.—Variety of food is as beneficial and as welcome to pigs as to human beings. It may not be practicable to change the course of feeding to any great extent, but it will certainly be beneficial to give the fattening and even the growing pigs a *mixture* of meals.

Meals for Pigs.—Barley-meal has been proved to be the best single food for fattening pigs, and to a great extent it is necessary for the manufacture of a high quality of meat. Maize-meal may be used somewhat largely at the commencement of the fattening, but if used extensively at the latter stage, the pork is not so saleable. Instead of maize a small quantity of bean-meal, or even better still, pea-meal, may be given with great advantage. Upon this the older pigs will thrive well, and the pork prove firm and sweet in flavour. Oatmeal will generally be found too expensive for pig-feeding. It may, however, be profitably used if the pigs are required to be made ripe at an early age, and exceptionally high quality of London porket-pig desired. The use of some condiment with fattening pigs of a restless disposition will be found of great benefit.

Mr James Howard's Rations for Pigs.—Mr James Howard, of Clapham Park, Bedford, considers the following an excellent diet for fattening pigs: "Equal quantities of bean, maize, barley, and wheat meals. To three parts of this mixed meal, add one part of dan or sharps; if it is desired to push the pigs, a little linseed-cake or spiced food may be added; scald it and use it for young pigs.[1]

Ball-feeding for Show Pigs.—"For show pigs, and others, when getting ripe, the practice of stuffing, or ball-feeding, is an excellent plan, and attended with good results. The plan pursued is as follows: After each meal, mix, according to the number of pigs, a pailful or two of the mixed meal [above referred to] with skim or new milk, and roll it into balls the size of an egg; have a pail with a little milk in it, so that each ball may be dipped into it before being offered to the pigs. After a few meals, they will sit on their haunches, and be fed like so many children. Each pig, after his meal of the thinner food in the trough, will eat about a gallon of the food in the balls."[2]

Feeding Farrow Sows.—As food for farrow sows, or sows during pregnancy, Professor James Long says: "There is nothing better than pollard or sharps, or even bran may be used with good results, if it is of nice quality. If these meals are mixed with a quantity of waste and vegetable refuse from the garden, it will be found that the animals will thrive upon a very small quantity, for they require little food indeed for three months out of the four they are pregnant. During the fourth month, however, the feeding should be increased, as heavier claims are made upon their systems for the support of the coming family, and in order that they may not lose condition and strength, both of which will be very necessary after parturition. It is an unwise plan to feed in-pig or farrow sows upon dry meal or grain, as they put on too much flesh, which is most undesirable when they litter, although we have bred very respectable litters from exceedingly fat sows."[3]

Condimental Food for Pigs.—Some object to the use of condimental food for pigs; but our experience is that for fattening-pigs and for pigs that are newly weaned, some good well-manufactured stimulating food is of very great benefit, and is withal most profitable.

[1] *Jour. Royal Agric. Soc. Eng.*, xvii., sec. ser., 217.

[2] *Ibid.*

[3] *Book of the Pig*, 61.

Cooked Food for Pigs.—There has been considerable discussion as to whether or not the cooking or steaming of meal as food for pigs is an advantage. Some writers on pig management strongly recommend the practice; but Mr Sanders Spencer states that his experience is decidedly against it. He has given it fair trials, and in every case where the experiment has been fairly and thoroughly carried out, it has been found unprofitable to cook or steam the meal for the pigs. In very cold weather it is advisable to mix the meal with tepid water, so that the food is given to the pigs at about the temperature of new milk. But a better plan even than this is to feed the pigs on dry meal, and to give the water to them in a separate trough. The pigs may be much longer in eating their food in this way, but it will be more thoroughly masticated and mixed with saliva, so that it is more fully digested; and the pigs will then only consume as much water as nature and the weather render needful. There is certainly no need to warm the food in summer; but in winter there is an undoubted benefit in having the food warmed.

Experiments on this question have also been carefully carried out at different agricultural colleges in the United States of America, and in almost every case it was proved that the cooking of the food resulted in a considerable loss.

Upon many farms potatoes form a large part of the food of pigs. These should be steamed or boiled, with perhaps some meal and a few turnips.

Kitchen "Slops" for Pigs.—The "slops" of the kitchen are turned to good purpose as food for swine; but great care should be taken not to give pigs any liquid in which salt meat has been boiled or to which soda has been added. We have heard of several cases of death amongst pigs owing to their having been fed on such "slops" or boilings. These are usually given cold with other more solid food. The "pig's-pail" should always be at hand to receive food-refuse from the kitchen.

Skim-milk and "whey" are also extensively used as food for pigs. These, of course, do not require cooking.

Feeding Old Pigs Unprofitable.—

The fattening of old sows and boars is, as a rule, unprofitable. One cannot afford to convert good food into pork which sells at from 1½d. to 3d. per lb., and even this only when not made very fat. The importation of low-priced foreign meat, and the great reduction in the price of lard, has rendered the manufacture of inferior, or very fat, meat a losing game. And a word of caution here may not be out of place as to the making of the bacon pigs too heavy and too fat. The well-fed, meaty pigs of 150 lb. live weight, will realise much more per lb. than can ever be obtained for the over-fat pig of double the weight.

Green Food for Pigs.—Many pig-keepers seem to forget that the pig is naturally a graminivorous animal, and that in a state of nature it lives for a great portion of the year on grass, or the roots of certain plants, which it unearths by the aid of its long snout; whilst its chief food during the remainder of the season consists of beech-mast, acorns, chestnuts, or similar tree-seeds. Those who are generally most successful in the feeding of our domesticated animals are those who study most carefully the natural habits of the animals in their charge.

To make pig-feeding a complete success, it is imperative that a certain amount of green food should be supplied to those pigs which are confined in close quarters. It does not appear to matter much what this vegetable food consists of, whether it be grass, clover, lucerne, beet, mangels, swedes, turnips, cabbages, or kohl-rabi. All seem to have a beneficial effect on the health and progress of the pigs; whilst great numbers of pigs are fattened on cooked potatoes, and a little meal stirred with butter-milk or whey.

Pigs which are not allowed their liberty should also have an occasional supply of small coal, cinders, or even a lump of earth or mould. This will greatly tend to keep the pigs in health, and cause them to settle and thrive much better.

Exercise for Feeding-pigs.—It is sometimes found necessary to allow highly bred pigs a certain amount of exercise during the short time they are shut up in close quarters at the latter part of the fattening period. This difficulty, if it may be so termed, is not often experienced with the common-bred pig, whose spirit of unrest forces it to take a sufficient amount of exercise to keep the various organs of the body in good working order, and for the formation of that lean meat and muscle which is the natural result of a free use of the locomotive powers.

Keep Pigs Cleanly.—Pigs are accused of dirty habits, but the fact is otherwise. The accusation really applies more to their caretakers, who oblige them to be dirty, than to the animals themselves. When constrained to lie amongst dirt, and eat food fit only for the dunghill, and dealt out with a grudging hand, they can be in no other than a dirty state. Let them have room, choice of clean litter, and plenty of food, and they will keep their litter clean, place their droppings in one corner of the court, and preserve their bodies in a wholesome state. The pig-house or pig-yard should be cleaned as regularly as the cow-house, and kept in a fresh wholesome condition.

It is the duty of the cattle-man to supply the store-pigs with food, and clean out their court-yard; and this part of his duty should be conducted with as much regularity as feeding the cattle. Whatever food or drink is obtained from the farmhouse is usually brought to their court by the dairymaid.

Pigs in Cattle-courts.—Pigs often get the liberty of the large courts, amongst the cattle, where they make their litter in the open court when the weather is mild, and in the shed when cold. Though thus left at liberty, they should not be neglected of food, as is too often the case. They should be fed regularly, and in addition to other food many give them sliced turnips in troughs. Pigs, when not supplied with a sufficiency of food, will leap into the cattle-troughs and help themselves to turnips; but this dirty practice should not be tolerated, and it can arise only from their keeper neglecting to give them food.

A convenient pigs' trough, adapted for standing in the middle of a court, is represented in fig. 155. The divisions have a convexity on the upper edge, to prevent food being dashed from one compartment into the other. This trough stands upon the top of the litter, is not easily overturned—the cattle cannot hurt themselves upon it, while it is easily pushed about to the most convenient spot.

Rest for Feeding-pigs.—When pigs are fattening, they lie and rest and sleep a great deal, no other creature showing "love of ease" so strongly in all their doings; and, in truth, it is this indolence which is the best sign of their thriving condition. The opposite effects of activity and indolence on the condition of animals are thus graphically contrasted by Liebig. "Excess of carbon," says he, "in the form of fat, is never seen in the Bedouin or in the Arab of the desert, who exhibits with pride to the traveller his lean, muscular, sinewy limbs, altogether free from fat. But in prisons and jails it appears as a puffiness in the inmates, fed as they are on a poor and scanty diet; it appears in the sedentary females of oriental countries; and, finally, it is produced under the well-known conditions of the fattening of domestic animals;"[1] and amongst these last the pig may be instanced as the most illustrative.

Litter for Pigs.—Wheat-straw is best suited for this, especially for the breeding-

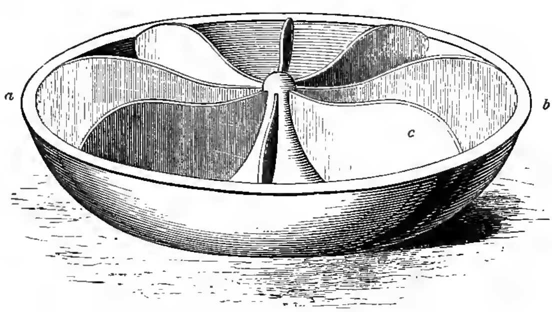


Fig. 155.—*Ring pigs' trough, to stand in a court*

a b Hollow hemispherical trough, 30 inches diameter.
c Eight subdivisions within it, 9 inches high, converging and meeting at a central pillar.

sow and her litter of young ones. In the cattle-courts, the pigs, of course, make litter of whatever is used for the cattle.

Nomenclature of Pigs.

The denominations of pigs are the following: When new-born, they are called *sucking pigs*, or simply *pigs;* and the male is a *boar pig*, the female *sow pig*, *hilt*, *elt*, *yilt*, *yelt*, or *gilt*. A castrated male, after it is weaned, is a *shot* or *hog*. Hog is the name mostly used by naturalists, and very frequently by writers on agriculture; but as it sounds so like the name given to young sheep (hogg), it is convenient to use the terms pig and swine for the sake of distinction. The term *hog* is derived from a Hebrew noun, signifying "to have narrow eyes," a feature exactly characteristic of the pig. A spayed female is a *cut sow pig* or *gelt*. As long as both sorts of cut pigs are small and young, they are *porkers*, *porklings*, or *London porket-pigs*. A female that has not been cut, and before it bears young, is an *open sow* or *hilt*, &c., until it has had one litter; and an entire male, after being weaned, is always a *boar* or *brawn*. A cut boar is a *brawner*. A female that has taken the boar is said to be *served* or *lined;* when bearing young she is an *in-pig* or *brood-sow;* and when she has brought forth pigs she has *littered* or *farrowed*, and her family of pigs at one birth form a *litter* or *farrow* of pigs.

[1] Liebig's *Ani. Chem.*, 89.

POULTRY IN WINTER.

Neglect of Poultry.—Farmers, as a rule, give little attention either to the breeding or the feeding of the domestic fowl. Indeed, the supposition that any farmer should devote a part of *his* time to the consideration of poultry, seems to be regarded by him as an unpardonable affront to his manhood. Women only, in his estimation, are fit for such a charge —and doubtless they are the best, and would do it well, were they not begrudged of every particle of good food they may bestow upon poultry. The consequence is, as might be expected, that at few farmsteads is it possible to find a fowl of any description in *good* condition—that is, such as it might be killed at the instant in a fit state for the table. The usual objection against feeding fowls is, that they do not pay—and no doubt the market price received for lean, stringy-fleshed, sinewy-legged fowls is far from remunerative; but whose fault is it they are sent to market in that state, but the rearer of them? and why should purchasers give a high price for fowls in such a condition?

That good prices are given for well-fed and prepared specimens is easily determined in any large town, even in this country; and the fact that in 1887 nearly 3½ million pounds sterling was paid by Great Britain to foreign countries (besides £1,600,000 to Ireland) for poultry and eggs, shows the importance of the industry.

Some excuse might be made for having lean fowls, were any difficulty experienced in feeding them: but there is none; and the idea of expense is a bugbear, and, like other fears, would vanish were fowls reared more in consonance with common-sense, instead of on the notion that they can never be ill off if at liberty to shift for themselves. Such a notion is founded on a grievous error in rearing any kind of live stock on a farm. Better keep no stock at all than rear them on such a principle. Fowls may be deemed a worthless stock, and they are so generally, but only on account of bad management and want of proper selection.

Apart from any consideration of profit, every farmer has it in his power, *at all times*, to have a well-fed fowl on his table; but he cannot have it while grudging the food required to feed it. He may rest assured that *good* poultry always at command would save him many a bill for meat, which must be settled in cash—and *cash* the farmer has only by sale at market of some commodity of the farm. Few farmers kill their own mutton—that is, keep fat sheep for their own use: lamb they do kill in the season; but as to beef, it is always purchased—so that their families depend greatly upon the produce of the poultry-yard and pigsty for their meat diet, and it is quite in their power to have these at all times in the highest perfection.

It must be owned, however, that rearing poultry, as regards breeds, and feeding them, have received marked attention on the home farms of proprietors in recent years. The admission of poultry into the show-yards of agricultural societies has tended to advance their improvement; and the pressure of adverse conditions, as well as the development of dairying, have led to attention being paid to poultry-keeping. It is to be hoped that this important species of live stock will soon confer credit on its rearers, as other species of stock have already done.

Chickens in Winter.—In winter chickens can be reared, but they need constant and regular attention, and unless this is carried out on an extensive scale, it is not to be recommended. But by means of a chicken-house winter breeding is possible and profitable. The best winter layers are the heavier breeds of fowls.

Varieties of Farm Poultry.

The ordinary fowls on a farm are:—The cock (*Phasianus gallus*); the turkey (*Meleagris gallopavo*); the goose (*Anas anser*); the duck (*Anas domestica*); and the pigeon (*Columba livia*), the white-backed or rock-dove, which was long confounded with the blue-backed dove (*Columba œnas*).

As hatchings of chickens are brought out from April to September, there will be broods of different ages in winter—some capable of laying their first eggs, and others mere chickens. The young cocks and older hens only are taken for domestic use, there being a natural reluctance to kill young hens, which will lay eggs largely in the following season. The hen-chickens or pullets most likely to become good layers should be preserved. The marks of a chicken likely to become a good hen are—a small head, bright eyes, tapering neck, full breast, straight back, plump ovoidal-shaped body, and clean—*i.e.*, unfeathered—legs. The criterion of a *fat* hen, when alive, is a plump breast, rump feeling thick, fat, firm, skin of the abdomen thick and fat, and fat under the wings. White flesh is always preferable.

A fowl is usually killed for marketing by dislocation of the neck on being overdrawn, and there the blood collects and coagulates. But for home consumption it is better to cut the throat, after first stunning the fowl by a blow on the head. If hung against a wall by the legs, the blood will flow freely.

Turkeys.—Turkeys, being hatched in May, will be full-grown in stature by winter, and, if they have been well fed in the interval, will then be ready for use. The varieties in common use are white, black, bronze, or mottled grey; and of these the white yields the fairest and most tender flesh. The criterion of a good turkey, when alive, is the great fulness of the muscles covering the breast-bone, thickness of the rump, and existence of fat under the wings—though the turkey does not yield much fat, its greatest property being abundance of tender white flesh. Young turkeys attain to great weights. We have had, year after year, young cocks weighing, at Christmas, 18 lb. each in their feathers, and young hens 15 lb. Norfolk and Cambridge have long been noted for their turkeys, where they are fed on buckwheat, and large droves are annually sent to the London market, while great numbers are sent from Ireland both to England and Scotland. Lately very fine turkeys have been sent shortly before Christmas from Canada. A turkey is deprived of life by cutting its throat, whereby it becomes completely bled. The barbarous practice of cutting out the tongue, and hanging by the feet to bleed slowly to death, for the alleged purpose of rendering the flesh white, has happily passed away.

Geese.—Geese, having been hatched in the early part of summer, will also, if well fed, be full grown and fit for use in winter. The criterion of a fat goose is plumpness of muscle over the breast, and thickness of rump, when alive; and, in addition, when dead and plucked, of a uniform covering of *white* fat under a fine skin on the breast. It is a good young goose that weighs in its feathers 12 lb. at Christmas. It is bled to death by an incision across the back of the head, which completely frees it of blood. Large flocks of geese are reared in Lincolnshire, and from thence driven to the London market, and vast numbers find their way from Ireland to England and Scotland. Geese have long been proverbially good watchers. An old gander will dispute the approach of beggars towards the kitchen-door as pertinaciously as a watch-dog.

Ducks. — Ducks, being also early hatched, are in fine condition in winter, if properly fed; and even ducklings soon become fit for use. A fat duck is very full in the breast, and should have a fine skin. It is deprived of life by chopping off the head with a cleaver, which completely drains the body of the blood. There is a great demand for ducklings in the spring, up to the end of May, and as a plump duckling can be secured at eight weeks old by proper feeding, they should be bred in February and March.

Catching Poultry.—Hens and turkeys are most easily caught on their roosts at night with a light, which seems to stupefy them; and geese and ducks may be caught at any hour in the outhouse they may be driven into.

Common Pigeons.—As young pigeons only are used, and pigeons do not hatch in winter, they require no other notice at present than regards their feeding. To give an idea of their gastronomic powers, it may be mentioned that of three rock-doves sent to Professor MacGillivray, the number of oat-seeds in the crop of one amounted to 1000 and odds, and the barley-seeds in that of another were 510. Remarking upon this, he says: "Supposing there may be 5000 wild pigeons in Shetland, or in Fetlar, which feed on grain for 6 months every year, and fill their crops once a-day, half of them with barley and half with oats, the number of seeds picked up by them would be 229,500,000 grains of barley, and 450,000,000 grains of oats—a quantity which would gladden many poor families in a season of scarcity. I am unable to estimate the number of bushels, and must leave the task to the curious."[1] We were curious enough to undertake the task, and found the result to be 422 bushels or 52 quarters 6 bushels of barley, and 786 bushels or 98 quarters 2 bushels of oats, or 151 quarters of grain in all. We ascertained the result by weight; and as the facts may be worth recording, we may mention that in an average of three drachms there were 75 grains of chevalier barley in each drachm, of a sample weighing 56½ lb. per bushel; and 97 grains of Siberian early oat in one drachm of a sample weighing 46 lb. per bushel. Of Chidham white wheat, a favourite food of the pigeon, weighing 65 lb. per bushel, there were 86 grains in the drachm.

Wood-pigeons.—Wood-pigeons destroy much young clover and braird of the cereal crops every spring. These birds have increased so amazingly that they have become a pest to the country. They are now destroyed in large numbers every year by farmers, chiefly by harrying their nests in the breeding seasons of seed-time and harvest.

Characteristics of Old Birds.—Farmers usually sell poultry alive, excepting on the Borders, where geese are killed and plucked for the sake of their feathers. Poulterers in towns kill and pluck every sort of fowl for sale—so that the purchaser can judge of the carcass. It is easy to judge of a plucked fowl, whether old or young, by the state of the *legs*. If a *hen's* spur is hard, scales on the legs rough, the under-bill stiff, and the comb thick and rough, she is old; while a young hen has only the rudiments of spurs, scales on the legs smooth, glossy, and fresh-coloured, whatever the colour; claws tender and short, under-bill soft, and comb thin and smooth. An old hen-*turkey* has rough scales on the legs, callosities on the soles of the feet, and long strong claws; a young one has none of these. When the feathers are on, an old turkey-cock has a long tuft on the breast, a young cock but a sprouting one; when feathers off, smooth scales on the legs, difference of size in the wattles of the neck and in the elastic snot upon the nose, decide the age. An old *goose*, when alive, is known by roughness of the legs, strength of the wings at the pinions, thickness and strength of the bill, and firmness and thickness of the feathers; and, when plucked, a young goose has smooth legs, weak pinions and bill, and fine skin. *Ducks* are distinguished by the same marks, but there is this difference, that a duckling's bill is much longer in proportion to the breadth of its head than that of an old duck. A young *pigeon* is easily recognised by its pale-coloured, smooth-scaled, tender feet, yellow long down interspersed among the feathers, and the soft under-bill. A pigeon that can fly has no down, and is too old for use. A general criterion of the young state of all kinds of poultry, is the yielding gristle at the lower end of the breast-bone or sternum. When hard as bone, the bird is old.

Poultry-houses.—When a permanent poultry-house is preferred, it may be divided into at least five apartments, included within a court-yard. The use of five apartments is, to devote one to hens and turkeys, which roost high; and where wooden roosts should be put up, as broad as the feet of the fowls which stand upon them. Geese and ducks should rest on the floor, and have a house for themselves. When obliged to rest below hens, they are dirtied by dung-droppings. Hatching-houses are requisite to accommodate both classes of birds to sit upon their eggs in separate nests. The fourth apartment is for laying fowls, containing nests to suit their nature. The fifth apartment is devoted to chickens. The largest apartment should be occupied by the most numerous body of hens and turkeys; and the egg-house should have access from the outside by an opening through the wall, at which a trap-ladder is affixed, to admit the laying hens.

There should be a sliding-shut in all

[1] MacGillivray's *Hist. Brit. Birds*, i. 285.

the outer doors, to give admittance to the birds disposed to rest at any time; and these shuts should be closed every night. The accommodation thus afforded will be occupied by its own class.

The usual practice is to put all kinds of fowls into the same apartment; and the small space thus occupied is even grudged, as if any place were good enough for poultry. In very cold weather, the apartment occupied by hens and turkeys should be kept warm by any expedient; but this can be done without artificial heat by attention to the ventilation, and will be most easily secured by placing the poultry-house near the byre or stables. Fowls thrive best in a mild temperature, and not great heat.

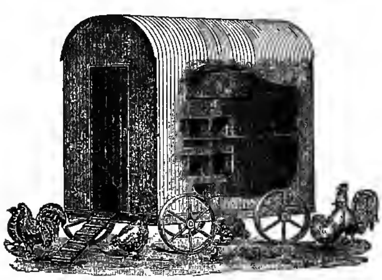


Fig. 156.—*Poultry-house on wheels.*

Movable Poultry-coops.—In a farm, the best plan is to have, in addition to a hatching-house, portable coops or houses, either on wheels or capable of being carried by a couple of men. A convenient iron poultry-house on wheels, made by the Redcliffe Crown Galvanised Iron Company, Bristol, is shown in fig. 156. A French portable poultry-house is represented in fig. 157. Shelter-coops of various patterns are shown in figs. 158, 159, 160, and 161. These can be scattered about, and moved as is thought desirable. In this way the fowls will be healthier, will cost very little for food, will do no harm to growing crops, and will manure the land. After harvest, such houses should be placed out on the stubbles.

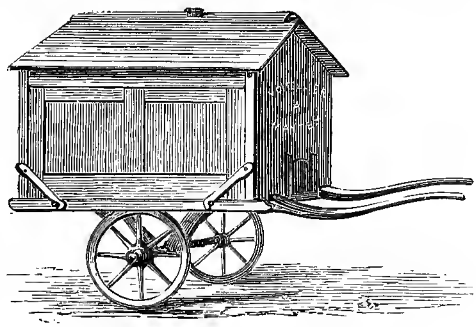


Fig. 157.—*Portable (French) poultry-house*

Pigeon-house.—A pigeon-house is a necessary apartment on a farm, and may be easily constructed. As pigeons are fond of heat at all seasons, a room in the gable in the horse boiler-house would suit well. A large pigeon-house is not required, as with ordinary care, pigeons being very prolific breeders, a sufficient number for the table may be obtained from a few pairs of breeding birds. We had a pigeon-house not exceeding 6 feet cube in the gable of the cow-byre, which yielded 150 pairs of pigeons every season. The flooring should be strong and close, and the three sides with the ceiling of roof lathed and plastered to retain heat.

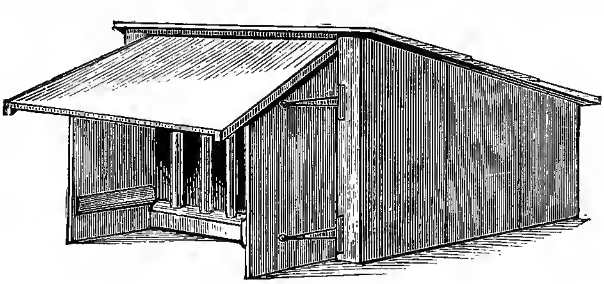


Fig. 158.—*Shelter-coop.*

A small door will suffice. The pigeon-holes in the gable should be of stone, and kept bright with white paint. The nest-cells should be of wood, 9 inches cube, placed round the walls.

Pigeons Hatching.—When pigeons receive artificial heat, they not only con-

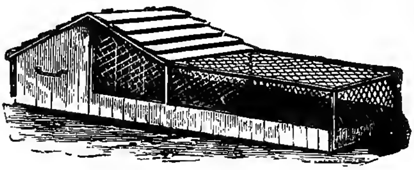


Fig. 159.—*Coop and run.*

tinue to hatch late in autumn, but will recommence early in spring. By a little management of keeping the house always pretty full of pigeons, to retain heat amongst themselves, they might hatch all the year, with the exception, perhaps, of two months in the depth of winter, in December and January. Pigeons, like other birds, are most prolific when not too old; and as old cocks tyrannise over the young, they should be destroyed as well as the oldest hens.

Catching Pigeons.—It is no easy matter to get hold of old pigeons to kill them in a *large* house, as they are always on the alert. The surest plan of securing them is to mark the birds you wish to destroy daily for some time, to recognise them readily. The old cocks are easily discerned by their froward manner,

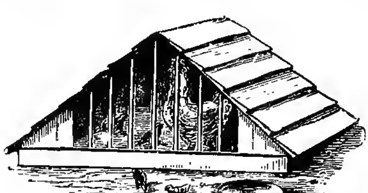


Fig. 160.—*Old-fashioned triangular coop.*

and interruption they give at the pigeon-holes to the entrance of others, though the old hens do not conduct themselves in that way.

The marks of old pigeons are rough scaly legs, callous soles of the feet, bright red scales on the legs, strong bill, strong wings, thick covering of feathers, and brilliancy of the play of colours upon the neck. These marks are conspicuous in winter, when *cocking* a pigeon-house, as it is termed, should be executed, as no young ones will then be deprived of their parents.

The quickest way of catching old ones is first to close up the entrance-holes from the outside, and then two persons to enter the pigeon-house gently, late at night, with a light. One takes special charge of the lantern, fig. 117; the other uses a light angler's landing-net for entrapping the pigeons, whether sitting or flying.

"Weeding" Pigeons.—Every bird caught should be examined and recognised, and every one exhibiting signs of old age should be destroyed, which can be done instantly by striking the back of the head forcibly against a wall. When *weeding* is being performed, it should be done effectually at the time,

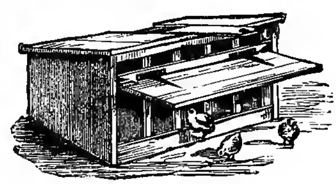


Fig. 161.—*Shelter-coop.*

and not repeated in the same season, as such repeated nocturnal visitations would intimidate the whole flock. Nor should it be done in the season of hatching, though done without fail every year; and the consequence will be, that the pigeon-house will be always stored with young prolific birds, which will receive no annoyance from old barren ones. In a small house the birds are easily captured at night, with the entrance-holes closed.

Daily Treatment of Poultry.—The daily treatment of fowls may be conducted in this manner: Some person should have special charge of them, and the dairymaid is perhaps the best qualified for it. As fowls are very early risers, she should go to the hen-house in the morning, and let out all the fowls, giving the hens and turkeys a feed of meal mixed stiffly with boiling water, and made into balls, either given in dishes or strewed along at some convenient and established place out of the way, where there is grass, from which they pick the food easily and cleanly. The ducks should get the same food. Geese thrive well upon sliced turnips, a little of which, sliced small, should be left by the cattle-man for the dairymaid at any of the stores, and given at a place apart from the hens in addition to the meal.

When stated places are thus established for feeding fowls at fixed hours, they will resort to them—at least the well-known call will bring the hour to their recollection, and collect them together on the spot in a few seconds; the regular administration of food being as essential for their welfare as that of other stock.

Ducks pick up a good deal of what falls about the stable and near the corn-barn door, as well as in the straw-barn; and geese will help themselves to the turnips that may chance to fall from the troughs of the cattle. They are also fond of raw potatoes.

After her own dinner, say, 1 o'clock P.M., the dairymaid takes a part of the potatoes that have been boiled at that time, and, while a little warm, gives them crumbled down from their skins, with some light corn, to the turkeys and hens. At this time of the day the spaces below the stathels of the stacks in the stack-yard form excellent dry sheltered places for laying down food, and the stack-yard is a very probable place for their resort after the morning meal, when it rains or snows.

In laying down food for the fowls, the pigeons should be remembered. Before sunset the fowls are all collected together by a call, and given a good feed of light corn, which in very cold or wet weather may have a little maize mixed with it. Care must be taken not to give more food than the birds will eat readily, as if left about it becomes offensive and injurious.

The floors of the different apartments should be littered with cut straw every day, sufficient to cover the dung, and cleaned out every week. Sawdust or sand, where easily obtained, forms an excellent covering for the floor of hen-houses; but peat-moss litter is best of all. Troughs of water should be placed in every apartment, supplied with fresh water, and cleaned out every day.

Regularity in Feeding Poultry.—This daily treatment will maintain fowls in a condition for using at any time; and it cannot be said to involve much expense, for the riddlings of potatoes and light corn may be regarded as the offal of the farm; but the truth is, food administered to these creatures at *irregular intervals*, though it be of the finest quality, will be comparatively thrown away, when compared to the good effects of food of even inferior quality given at *stated hours*. This plan contrasts favourably with that which gives large quantities of food in one spot, upon gravel or the road, at long intervals, in a clammy state—as also with that which permits fowls to shift for their food at the farmstead. Either way will never feed fowls; neither will food given in over-abundance at one time, and restricted at another, ever *fatten* them; nor can they obtain sufficient food at all times when made to shift for themselves, because of fowls, like other animals, some can forage most perseveringly, whilst others are indolent and careless of food when not placed before them.

A regular plan is essential, and when repeated daily, the condition of poultry must increase—it cannot decrease, the minimum quantity of food being sufficient to appease hunger; and they can never feel hunger when supplied with food at appointed times. Thus, in the long-run, more nutrition will be obtained from inferior food regularly administered than from richer given irregularly.

Rapid Fattening of Poultry.—Should it be desired, however, to have fowls always for immediate use, the following materials will render them *ripe* in a short time: boiled potatoes, mixed with barley-meal, warm, and light wheat, for hens; boiled potatoes, warm, and firm oatmeal porridge, warm, for turkeys; boiled potatoes, warm, and soaked oats, for geese; and boiled potatoes, warm, and boiled barley or rice, warm, for ducks.

These are the distinctive foods for the different kinds of poultry, which experience has proved best for them, and there are none better, if administered at regular times. Potatoes and porridge should be crumbled down and strewed about in small pieces upon grass. When potatoes are dear, cheap ingredients may be advantageously substituted. But *immediate* effects, even from superior food, should be expected only from fowls that have been regularly fed, as recommended above, up to the time the superior food is given. Let starved fowls receive the same ingredients, and a long time will elapse ere they show symptoms of improved condition, besides the risk they run, in the meantime, of receiving injury from surfeit and indigestion from cramming.

No doubt, superior feeding incurs cost, if persevered in throughout the season; but were only proper breeds of fowls cultivated, and were the shortness of time taken into consideration in which a pure breed will *ripen* on good food, a profit would actually be derived from poultry. That experiment has been attempted by few farmers, and most of the known instances of superior feeding, apart from the experiments by men of science or poultry fanciers, are derived from the establishments of noblemen, whose object is not so much to obtain profit, as that all fowls shall be large and well fed.

Other Foods for Poultry.—Other ingredients may be used for feeding fowls than those mentioned, such as buckwheat, rice, and Indian corn. Buckwheat is successfully grown in England, but not so in Scotland. It is said to feed poultry well, and is very largely used in France. It is excellent feeding for pheasants. Rice may be given either raw or boiled: in the raw state, fowls will pick it as readily as grain after feeding on boiled potatoes, and, when boiled, it will fatten without the aid of potatoes. It requires to be simmered rather than boiled, and can be bought undressed at a reasonable price. Fine barley, weighing 56 lb. per bushel, selling at 4s. per bushel, is nearly one penny per pound. Indian corn has come into very general use for poultry-feeding, and is one of the cheapest foods there is. It is very fattening, and should not be given to laying or breeding stock, except in very small quantities. It is usually cracked or crushed.

"From a desire to save expense," says Boswell, "the bran of wheat, and sometimes pollard, or middlings, are given to fowls; but these bruised skins, where little if any of the farina of wheat remains, appear to contain a very small portion of nourishment in proportion to the cost price. M. Reamur found by experiment that it is little or no saving to substitute bran for good grain in feeding poultry. Bran is not given dry, but mixed with water to the consistence of paste. Some people boil this; but it does not increase the bulk, except in a very trifling degree, and is therefore of small advantage. He found, also, that two measures of dry bran, mixed with water, were consumed by fowls in the same time that they would have eaten a single measure of boiled barley, equivalent to three-fifths of a measure of dry barley."[1] Bran, though not destitute of nutrition, is of little use to fowls as food, but may be the means of conveying nourishing food, in the shape of fat, broth, and other rich liquids from the kitchen, which they could not avail themselves of but by such an absorbent.

Fowls are very fond of bread, and of butcher-meat, cooked or raw, and they will pick a rough bone very clean. They are fond of chopped green vegetables, and of raw turnips. They display even carnivorous propensities, watching for a mouse at the taking down of a stack; the moment one attempts to escape, away they run, cocks and hens together, in full chase after it, mobbing and pecking it not only to death, but to pieces, and swallowing them.

Time and Place for Feeding.—From these particulars of feeding grown-up poultry, it follows that the food given to one and all of them should be at a fixed locality and at given times a-day—early in the morning, and in the afternoon before sunset, and at mid-day also, when the birds are unable to forage much. The hens should receive their food upon grass, at a fixed locality. Turkeys should also receive their food on grass anywhere. Geese, receiving cut turnips or corn, should have theirs in flat basins at any convenient place near water, separate from the hens and turkeys. Ducks should always receive their food near water, whether a rivulet, a lake, or horse-pond. The distribution of food upon grass for the gallinaceous tribe is most important, yet almost everywhere

[1] Boswell's *Poul.-Yard*, 54.

the food is given to them either on a road, whether in dust or dirt, or in deep dishes in large quantities, about which every description of fowl—geese, pigeons—fight for the mastery, the strongest, of course, obtaining the most. It is cruel to give ducks food away from water, without which they cannot easily swallow it.

The advantage of giving the food upon grass is, that it is kept clean, and so dispersed that each fowl has to pick its food up leisurely, and is thereby prevented swallowing it too hot or hastily in too large bits, which it is obliged to do when taken from a single point, as a dish, or from a heap on the bare ground, in a scramble with others. By this plan of feeding poultry the food is distributed to the different kinds according to their nature, and in such localities as are best suited to their respective habits. By following this plan the best results will usually be obtained.

Eggs in Winter.—By good management, both eggs and chickens may be obtained in winter. The young hens of the first broods in April will be old enough to lay eggs in winter. A few of these should be selected for the purpose; and as the period of laying approaches—which may be ascertained by their chanting a song and an increased redness of the comb—they should be sustained upon nutritious warm feeding, and warm housing at night. The feeding consists of warm potatoes, or warm Indian and barley meal, and firm oatmeal porridge, twice a-day—at morning when they are let out, and in the afternoon at 1 o'clock, with a few grains of oats—as much as they can eat in the short days. To give them peace in feeding upon this tempting fare, they should be fed by themselves in any quiet sheltered place. They should also have a good feed of grain about an hour before going to roost.

Their comfortable housing consists in directing them into the hatching-house betimes every afternoon, and therein making for them a number of comfortable nests of clean oat-straw to choose amongst, and, when each has taken to the one she selects for her own, leaving an old egg in it for a nest-egg. A little lime and gravel should be placed within reach—the gravel assisting the digestion, and the lime affording the calcareous covering for the egg.

Thus, three or four young hens will lay as many eggs every day; and though the eggs may not be as large as those of more matured fowls, being only pullets' eggs, still they will be fresh. It is no small luxury to enjoy a new-laid egg at breakfast every winter morning.

Young Broods in Winter.—With regard to young broods in winter, few people seem to take the trouble of setting hens on eggs so late in the season as to rear chickens in winter. Yet it may be done without difficulty, and with profit, if it is desired to sell young chickens early in the year, when prices are very high in large towns.

Some hens will secrete their nests in the fields, at a hedge-root, and bring out strong broods of chickens on the eve of winter; and in such an event, the little innocents should not be allowed to perish for want of care.

When a late brood is hatched or makes its appearance, it should be kept apart from the rest, in a warm and sheltered place; and no better place presents itself than in a corner of the cow boiler-house, fenced near the fire as a comfortable protection from external danger. From thence they should be let out for a while in the forenoon, to receive fresh air and bask in the sun, and returned to their nest long before sunset. In rain and in hard frost they should be confined to the house, as frost soon benumbs their legs; and whenever they lose the power of these, they inevitably droop and die. Their nests should be elevated some inches above the floor, to keep them above any draught of air, with a broad sloping base to afford the chickens an easy access to them; and every evening, a little of the cleanest and warmest of the straw, from under a cow in the adjoining byre, forms an excellent lining of the nests for the hens to brood upon.

Food should be given them from morning to evening every three hours. It may consist of warm boiled potatoes crumbled down, picks of oatmeal porridge, with oatmeal, rice, bruised peas, or barley, bits of hard-boiled eggs kept for the purpose, and a flat low dish of clean water. With variety of food, daily attention, and warm housing, they will get on well, and by spring be as plump as partridges, and as valuable as ortolans. The entire art consists of suitable food, shelter, medium temperature, fresh air, and well-timed attention. With these a large number of chickens may be reared in winter, without fail, at one time; and it is not worth the trouble of rearing a small number, although even a small number would realise a large sum, coupled with fresh eggs.

"Brooders."—When a roomy house or shed can be given, especially if the front facing the east and south can be fitted with glass, chickens can be easily reared by means of the "brooders" now sold. The floor should be covered with dry sand or earth, and the "brooder" placed thereon. A good "brooder" will hold from fifty to seventy-five chickens.

Table Poultry all the Year Round.—Such is the general way in which farmers may feed their poultry in winter. It is not an expensive mode in a pecuniary point of view, for it consists entirely of ordinary fare and regular attention; and therein depend the value and success of the plan. That the plan is valuable, and worthy of being followed, has been proved beyond doubt, as it supplies fowls of every kind in their respective seasons, in high condition—at any hour required—and without particular fattening up. Thus, a chicken, a young cock, a hen, may be at command throughout the year; a duckling in autumn; a goose or turkey from Michaelmas to March.

As with pigeons so with fowls; keep them always young, and they will not fail to be prolific and healthy. No greater mistake can be committed by a farmer, as regards poultry for his own table, than to maintain a large lot of old fowls of any description.

Pampered Fowls.—As to undue means for pampering fowls to fatness, Cobbett has truly said that "crammed fowls are very nasty things." Besides, the system is cruel, and for that reason is not to be commended. Liebig explains the rationale of this barbarous practice. "Experience," he says, "teaches us that in poultry the maximum of fat is obtained by tying the feet and by a medium temperature. These animals, in such circumstances, may be compared to a plant possessing in the highest degree the power of converting all food into parts of its own structure. The excess of the constituents of blood form flesh and other organised tissues, while that of starch, sugar, &c., is converted into fat. When animals are fed on food destitute of nitrogen, only parts of their structure increase in size. Thus, in a goose fattened in the method above alluded to, the liver becomes three or four times larger than in the same animal when well fed with free motion, while we cannot say that the organised structure of the liver is thereby increased. The liver of a goose fed in the ordinary way is *firm and elastic;* that of the imprisoned animal *soft and spongy.* The difference consists in a greater or less expansion of its cells, which are filled with fat." [1]

Still the system of pampering or cramming is so far useful; cramming is not merely fattening. The cruelties practised in France, and the system of liver enlargement, we emphatically condemn; but the system of "putting up" simply means restriction of elimination resultant upon exposure and exercise, and consequent development of flesh. A healthy farmyard fowl is not, as a rule, plump; but by keeping up in a pen within doors for a fortnight, and giving flesh-forming foods, its flesh can be increased, and made much more tender. Such a fowl is far and away superior to a bird killed without any such preparation.

Fattening Fowls.

By the term fattening is not meant mere laying on of an excessive quantity of fat or oil, but rather the addition of just so much fat as is necessary, and as much flesh as can be obtained. Fattening softens the flesh, in fact ripens it, and it is in this respect that the value consists.

For successful fattening two things are absolutely necessary: first, that the food supplied shall tend to the production of flesh; and, second, that the conditions under which the fowls are kept shall eliminate as little as possible of the oil or heat fuel.

[1] Liebig's *Ani. Chem.*, 94.

With regard to the food, it will be seen that the system of feeding ordinarily pursued will not answer for fattening. To that end we must give foods which are of a stimulating nature, having but a minor proportion of the fatty element in them. Therefore such grains as maize, rice, buckwheat, and barley should not be employed. They are, however, invaluable for fattening poultry, for in them the elements which go to make bone, and feathers, and muscle are not so strongly present as in some others. Buckwheat and barley are of themselves the least valuable of these four for fattening, but they have qualities of flavour which are most useful, and the deficiency in one direction can be overcome by the addition of a little fat.

French System.—In France some of the principal fatteners make buckwheat the chief article of food, whilst others use equal proportions of buckwheat and barley meals. Food for fattening poultry should always be given in the form of meal, as the digestion of soft food is much easier than of grain. Many of the French fatteners mix the meal with skim-milk. This has the effect of helping on the process. Milk has all the elements for the development of fat, and also makes the skin a good colour.

Little and Often.—It is desirable to give the food milk-warm, and the motto of the poultry fattener should be *little and often.* Regularity in feeding is an important matter, and food should not under any circumstances be allowed to stand over from one meal to the next.

Fattening Cages.—Fowls that are being fattened should be kept in cages in a somewhat dark room or loft, and it is desirable to see that the atmosphere of the place does not fall below temperate, for cold retards the process. The cage need not be more than 18 inches by 15 inches. They must be kept scrupulously clean, and nothing done to excite the birds. So fed and so kept for 14 to 20 days, will bring fowls into a splendid condition for the table.

Dressing Table Fowl.—In France, the preparation or dressing of the fowls after they are killed has been reduced to a science, it being there recognised that this has much to do with the appearance of the birds, both when offered for sale and when they are served up on the table. The birds are plucked immediately after they are killed, and then laid upon shaping boards, with their backs upwards. These boards are simply flat pieces of wood, about the same width as the fowls, having a block or pad at one end to support the rump, and one at the other end to support the neck. Thus the bird is kept perfectly level. Great care is taken to see that it is manipulated soon after it is killed, and before it is cold. The rib bones are bent in, and the knee pressed into the back; by this means the breast is forced inwards, and the legs fastened over it so as to keep the breast in its place. It is then laid back upwards upon the shaping board, with a wet linen fastened tightly over by means of tapes around the bottom board.

When kept in this way for twelve hours, it is then fit for anything, and there is no loose flabby flesh to repel the sight. It must not be omitted that when fastened down it is well soaked with cold water.

This shaping of the birds accounts for much of the great difference between French and English fowls. When the cook receives the bird she cuts the string which fastens the legs, and forces them down again. This brings out the meat on the breast without rising the bone, as the carver discovers when he commences operations.

Cramming.—Both in France and Britain there is much done in the direction of cramming, more, however, in the former country than the latter. Various methods are adopted, but the principle is the same—viz., that the fowls are forced to continue a given quantity of food *per diem*, the object of which is to add to the quantity of the flesh they carry ere being killed. In France the system may be said to have been perfected, as it is carried out on an extensive scale.

The process of cramming is performed in one of two ways, either by hand or by machine. In the former the food is made up into finger pieces, and after being dipped in milk, is forced down the throat of the fowl until its crop is full. When a machine is used, the mouth of the bird to be fed is placed over a nozzle provided for the purpose, and either by the pressure of the foot or a turn of a handle sufficient of the food is forced into it. The machine chiefly used in Surrey and Sussex uses firmly mixed food, but some of the French machines are made to hold liquid food, and these latter are more easily worked. At one time very large revolving cages, holding upwards of 200 fowls, were shown at the Paris *Mardi Cras* Exhibition, but these are expensive; and usually the birds are kept in small cages, from which they are removed to be fed.

Cramming simplifies the fattening process, and large numbers can be rapidly fed in this way in as short a time.

Nomenclature of Poultry.

The denominations of the common fowls of the farm are as follow: The male of the fowl is the *cock*, the female the *hen;* the young are *cockerel* or *pullet* (singular), *chickens* (plural), according to sex. A hen chicken before it begins to lay eggs is a *pullet*, and a castrated cock is a *capon.* A pullet deprived of her ovary is a *poularde.* Turkeys are likewise termed *cock* and *hen turkeys*, and the young of both sexes a *poult.* The male of the goose tribe is *gander*, the female *goose*, and the young of both sexes a *gosling.* A gosling fit for eating is a *green goose.* The male of the duck tribe is a *drake*, the female a *duck*, and the young of both sexes a *duckling. Cock* and *hen* pigeon, a young one of either a *young* pigeon. *Pea cock* and *pea hen* are the terms for the old male and female, and *pea fowls* for the young of both sexes.

Peacocks should be treated in the same manner as turkeys, and may be reared for the table.

Guinea-fowls, notwithstanding the delicacy of their eggs, should never be tolerated in a farmyard. They are objectionable both on account of the horrid grating noise they make, and the strong propensity they evince of constantly annoying and even killing the young of other fowl.

Feathers.

The feathers of the various sorts of fowls used, are either disposed of or converted into domestic use. The following directions on sweetening and managing feathers are given by a lady in the *Journal of Agriculture*, vol. x. p. 480, 481: "Every one is aware that the feathers of cocks and hens are very inferior to those of geese and ducks, for the purpose of filling beds and pillows; and consequently, it is scarcely necessary to mention that the former should be kept separate from those of the two latter fowls. As the birds are plucked, the large feathers should be selected and placed asunder. Paper-bags are the best recipients. The pinion feathers should be stripped from the quill, and added to the other feathers: and if great caution have not been used in plucking the birds, they should be carefully looked over, that no part of the skin has been torn and adhering to the base of the quills. The bags of feathers should be placed in the bread-oven on the day after it has been heated, and, after some hours, removed to a dry airy place; and this ought to be done every week. Notwithstanding every apparent caution shall have been used, the feathers are frequently found to be tainted, either from carelessness in plucking, or by neglecting to attend to them afterwards; and no *subsequent baking* or *picking* will be found available to restore them. In this case, the only method to render them sweet is to boil them, which is to be effected in the following manner: One or two large canvas or calico bags must be made, into which the feathers from the small paper-bags must be emptied and tied up; a washing-copper must be nearly filled with rain-water, and made *to boil.* The calico bags, then, one at a time, are to be dipped, and, by means of a stick, pushed about and squeezed and kneaded for the space of four or five minutes, then lifted out and taken out of doors; and being tied together and the openings kept secure, that no feathers may escape, they must be hung over a line, and left to drain and dry. Several times a-day the bags are to be shaken up and turned over; and as soon as the feathers appear to be light and drying, which will not be the case for nearly a week, the bags must be hung up during dry weather only, and taken in every night. In about a fortnight the feathers will become perfectly sweet and ready for use; and the water in which they were boiled will sufficiently indicate that this plan was not only necessary, but efficacious, in cleansing them from impurities which would else have rendered them useless."

Feathers are now efficaciously and quickly cleaned, and freed from all impurities, by the action of steam.

Feathers seem to have nearly the same properties as hair. According to Mr Hatchet, the quill is composed chiefly of coagulated albumen, but no traces of gelatin. Dr Scherer found feathers to contain 1.8 per cent of ash. The constituents of feathers are:—

Carbon	50.434 and 54.470	52.427
Hydrogen	7.110	7.213
Nitrogen	17.682	17.893
Oxygen	24.744	22.767

Feathers thus contain an atom less of oxygen than hair or horn.[1]

"*Feather dust*," says Mr Way, "appears to be principally the sweepings of the feather warehouses. Although apparently it consists of fragments of feathers, it contains so much dirt as greatly to reduce the value as manure. The percentage of nitrogen in this refuse was 6.22, and the price per ton £2, 10s., without carriage."[2]

Diseases of Poultry.

In regard to the diseases of fowls, it may be safely said that, if fowls are attended to in a systematic manner, with wholesome food prepared for them every day, and their roosting-place kept clean and airy, very little disease will affect them at any age.

Still there are many diseases which may in most cases be the result of connection with other birds. A purchased bird may often bring disease into a poultry-yard, and bought fowls ought therefore to be kept by themselves for a few days when brought home.

The following are the principal diseases affecting the respiratory organs:—

Catarrh.—*Cause*—Exposure, sudden changes in temperature. *Symptoms*—Sneezing, running at nostrils. *Treatment*—Warmth, nourishing food, homœopathic tincture of aconite or Spratt's Roup Paste. Cold in the head is a further development of catarrh. Treatment as before.

Bronchitis.—*Cause*—Cold settling in the chest. *Symptoms*—Cough and quick laboured breathing, feverishness. *Treatment*—Warm moist atmosphere, and any regular bronchitis remedy. Consumption and inflammation of the lungs frequently result from neglected cold, especially where there is an inherent weakness. When allowed to go thus far, treatment is seldom successful.

Roup. — This is a complication of diseases, and is very fatal. *Cause*—Impurity of blood, scrofulous deposits on the lungs or in the head, together with cold. *Symptoms* as in cold, or with swellings of the head and eyes, offensive breath, and congested nostrils. *Treatment*—Give sulphur or bark and iron in the soft food, and as medicine Spratt's Roup Paste, or homœopathic tincture of aconite, and wash the eyes, face, mouth, and nostrils with Condy's Fluid or solution of chlorinated soda.

Derangement of the digestive organs and other diseases are as follows:—

Indigestion. — *Cause* — Over or bad feeding. *Symptoms* — Bad appetite or mopishness. *Treatment*—A mild aperient, followed by a rhubarb pill, and plain food.

Diarrhœa.— *Cause* — Improper feeding, cold, or an irritant in the intestines. *Symptoms*—Looseness, the droppings being soft. *Treatment* — Powdered chalk mixed with boiled rice, or, if that fails, chlorodyne.

Liver Disease.—*Cause* — Over-feeding, too rich food; hereditary. *Symptoms* — Moping, irregular appetite, yellowish hue of comb, face, and wattles. *Treatment*—Give plain food only. For medicine, an aperient, followed by a couple of grains of calomel every other day, or homœopathic tincture of podophyllum.

Crop-bound.—*Cause* — Over-feeding and obstruction of the passages. *Symptoms*—Enlargement of the crop, which is filled with food. *Treatment*—Pour warm water into crop, or oil, and knead it to get away the food. If this fails, cut open the crop lengthwise, and remove the contents with egg-spoon, taking care

[1] Thomson's *Ani. Chem.*, 305, 306.
[2] *Jour. Royal Agric. Soc., Eng.*, xi. 766.

to see that the passages are clear. Wash out with a mild disinfectant, and then stitch up, sewing each skin separately.

Soft Crop.—This is an enlargement with water or air, which can usually be removed by kneading.

Egg-bound.—*Cause*—Obstruction in egg-passages, or too large egg, so that the hen is unable to lay. *Symptoms*—The hen is continually about the nest, and looks uncomfortable. On examination, the egg may be felt. *Treatment*—Oil the vent and parts around. If that fails, steam them. And finally, give a dose of warm treacle in which some chopped groundsel has been mixed. Cease forcing food, to restrain laying for a time.

Soft or Shell-less Eggs.—These may be due to want of shell-forming materials, or to undue forcing, and will disappear with removal of the cause.

Leg Weakness.—*Cause*—Damp, or too rapid growth in chickens. *Symptoms*—Inability of bird to walk; falling from apparent weakness of legs. *Treatment*—Rub with turpentine, and feed on bone-forming food; also give a good tonic.

Rheumatism, which is very similar, is usually found in old birds. Case the legs in flannel, which keep moist with turpentine.

Bumble Foot.—*Cause*—Cut on, or injury to, ball of foot. *Symptoms*—Limping. On examination, a corn or swelling is seen on foot. *Treatment*—If a corn, cut it out; if a small swelling, paint with iodine; if a large one, cut, and let out matter. Bandage to keep out dirt until better.

Scaly Legs.—*Cause* and *Symptoms*—(1) An insect; or (2) dryness, causing the scales to enlarge, and the leg to become offensive. *Treatment*—(1) Wash well, and rub in sulphur ointment; (2) rub in equal parts of zinc ointment and vaseline.

Diphtheria.—This has of late been rather frequent amongst poultry. Birds affected with it show the same symptoms as in the human subject. It is better to kill the birds at once and bury them in lime.

Lice.—As to vermin, fowls, like other animals, are affected with lice. The commou hen is infested by more than one pedicular parasite, but the most frequent is the *Lipeurus variabilis*, which has a narrow body, the head rounded in front, the general colour dirty white, smooth and shining, the margins with a black band, the abdomen having a brown interrupted strip down the middle. According to Mr Denny, it prefers the primary and secondary feathers of the wings, among the webs of which it moves about with great celerity. *Menopon pallidum* is almost equally common in poultry, running over the hands of those who are plucking their feathers, and difficult to brush off from the smoothness of their bodies. The peacock has a large and very singularly formed parasite of this nature, named *Goniodes falcicornis*. Another, not unlike the one just mentioned in general appearance, occurs plentifully on the turkey. Geese and ducks are infested by similar foes, particularly ducks, on which the *Docophorus icteroides*, a species common to the whole anserine tribe, is usually very abundant.[1]

To cure lice, which frequently result from a bad habit of body (and it is thus necessary to see that the health of the body is as it ought to be), wash the body with Sanitas fluid, and anoint the head, under the wings, and thighs with mercurial ointment, giving in the food flower of sulphur.

Goose Fat.

The useful properties of goose fat are worthy of notice. It is useful in anointing the udders of cows in spring, should they become hard, and it has the property of evaporating slowly. It also keeps a poultice moist until it should be renewed; and on account of this property it constitutes a good ingredient of grease for smearing the axles of cart-wheels. This fat may be *rendered* in the same manner as mutton-suet and lard, and kept in a jar covered with bladder. Goose fat "is colourless, and has a peculiar taste and smell, rather agreeable. If melted, it congeals at 80½° Fahr. into a granular mass, having the consistence of butter. When exposed to pressure between the folds of blotting paper at 28½°, it is resolved, according to Braconnot, into

[1] Denny's *Mono. Anopl. Brit.*

	Fusible at 111°. Goose fat.	Fusible at 126°. Duck fat.	Fusible at 113°. Turkey fat.
Stearin	32	28	26
Elain	68	72	74
	100	100	100"[1]

Professor Johnston says that the solid fat of the goose is the same as that of man, and of olive-oil and of butter, and is named *margarin;* and that the solid fat of the ox, the sheep, the horse, the pig, differs from that of man, and is known by the name of *stearin.* The elain or fluid part of fat is identical in all animals, and is exactly the same thing as the fluid part of olive-oil, of the oil of almonds, of many other fruits, and as the fluid part of butter; and it exists in a larger quantity in the fat of the pig than in that of the sheep, and hence it is that lard is always softer than suet.[2]

Poultry-farming.

It is often said that it is impossible to feed fowls with a profit. It seems strange that fowls should not make a return for their keep when the other animals on a farm do; yet modern experience tends to show that poultry-farming as such cannot be made to pay. The rock upon which the fair bark is shipwrecked is that the land becomes foul from the droppings, that disease coming into so large a flock ruins the enterprise, and that the fowls do not thrive so well when kept in small runs as upon a farm.

But in conjunction with other branches of agriculture or horticulture there can be no question as to poultry-rearing being profitable. The fowls will need but little special attention, they will occupy either arable or cultivated land without interference to other crops or stock; their produce will command an immediate and large return, and they will provide valuable manure for the land. If scattered about in the manner we have already indicated, they will also help to clean the land. Farmers could maintain in this way a considerable number of fowls; and cottagers might add greatly to their comforts by maintaining a moderate stock of poultry.

In this matter we might take an example from France. There are no purely poultry-farms in France, but the vast quantity of fowls and eggs produced are due to the multitude of peasant proprietors and small farmers there, all of whom keep a few fowls. There are, however, fattening establishments in the great poultry districts of Le Mans, La Fleche, Louhans, &c., which supply the Paris and other markets.

The *dung* of a single fowl is estimated in France at 1 franc. The feathers of a white fowl fetch 3 francs for dyeing to be made into flowers.

Imports of Eggs and Poultry.

The following are the import of eggs in certain years since 1865:—

1865	£928,247
1870	1,102,080
1875	2,559,860
1880	2,235,451
1885	2,929,085
1887	3,080,561

The following are the imports of poultry and game—including rabbits—in the same years:—

1865	£148,642
1870	158,482
1875	328,044
1880	421,645
1885	655,238
1887	721,049

CORN AT THE STEADING.

The providing of suitable means of stacking and threshing corn, storing straw, dressing and storing grain, are matters which demand careful consideration in furnishing a farm with the necessary equipments. These should be in keeping with the extent and character of the holding, and the purposes for which

[1] Thomson's *Ani. Chem.*, 138.

[2] Johnston's *Lect. Agric. Chem.*, 2d ed., 1011, 1012.

it is best adapted. Economy and convenience, combined with substantiality and efficiency, are the main principles to be kept in view in the providing of all farm equipments.

The Stackyard.

Careful consideration should be given to the preparation of the stackyard. It should lie close to the compartment which contains the threshing-machine, most probably on the north side of the steading. It is desirable to have the stackyard exposed to the north-east and west winds. The ground should be thoroughly under-drained and levelled.

Fencing the Stackyard.—The stackyard should be enclosed with a substantial stone-and-lime wall of 4½ feet in height. In too many instances it is entirely unenclosed, and left exposed to the trespass of any animal.

Forming into Ridges.—As most of the stacks must stand on the ground, the ground should receive that form which will allow the rain-water to run off and not injure their bottoms. This is done in some cases by forming the ground into ridges. The minimum breadth of these ridges may be determined in this way: The usual length of the straw of the grain crops can be conveniently packed in stacks of 15 feet diameter; and as 3 feet is little enough space to be left on the ground between the stacks, the ridges should not be of less than 18 feet in width.

Rick-stands.—It is preferable to have the stacks placed on stands of some sort, which will not only keep them off the ground, but in a great measure prevent vermin getting into the stacks. Fig. 162 represents a wooden stathel. If the wood of the framework were previously preserved by Burnett's process, it would last perhaps twenty years, even if made of any kind of home timber. Stack-stools, or *stathels*, or *staddels*, as they are variously called, are now most frequently made of cast-iron, and stands of this kind are neat and efficient; but of course rather expensive, and liable to be broken by accidental concussion from carts. Malleable-iron stathels would remove the objection of liability to fracture, but not that of expense. One point in favour of rick-stands is that they promote ventilation, which is often a matter of great importance.

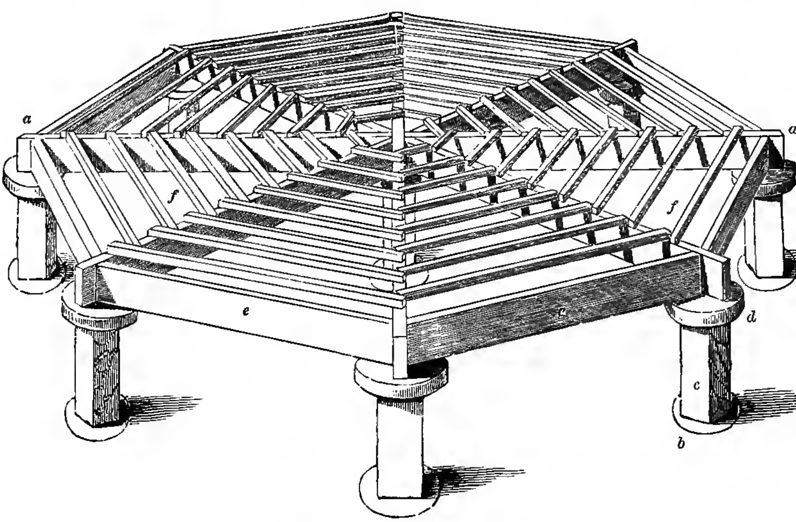


Fig. 162.—*Wooden rick-stand.*

a a Plank of Scots fir or larch, 15 feet in length.
b Stone flag sunk in the ground.
c Upright stone support, 18 inches high and 8 inches square, 8 in number, and one in the centre.
d Stone bonnet, at least 2 inches thick.
e e Bearers, 9 inches deep, 2 inches thick from bonnet to bonnet.
f f Fillets of wood, nailed up on the scantlings.

Stack Foundations.—Where stands are not provided, a foundation should be made for each stack of some material which will prevent the lowest layer of the corn from being damaged by contact with damp earth. A good plan is to have a circle formed of rough stones, about 12 to 18 inches high, the centre made up of broken stones and floored with flagstones. A still better foundation is obtained by building the outside circle with stone and lime, and filling the centre with broken stones, which are run in with concrete. Here, as should always be the case, the foundation is highest in the centre, so as to throw any moisture outwards. As a further barrier to vermin, the circle wall might be built projecting outwards towards the top, and made smooth with a coating of cement, so that rats and mice could not climb and get into the stack.

In hilly districts strong heather is used for this purpose, and it suits admirably. A rough layer of stones is perhaps the most general foundation, but this forms a capital nursery for mice. Some lay down a thick covering of coarse hay, which must be thoroughly dry.

Formation of Stacks.—As stacks containing corn in the straw are exposed to the weather in winter, they are so constructed as to resist rain and wind, and give protection to the corn. This is attained by placing the sheaves of corn towards the interior of a cylinder, while their butt-ends form its circumference, or towards the interior of a rectangle, with the butts to the outside. In either form the stacks must be firmly thatched with straw and rope. Unless there is provision made for thatch and rope, it not unfrequently happens that thatch is awanting, and part of the new crop is obliged to be threshed in a hurry to provide for it, and then where the threshing-machine is moved by horse-power, the new-built stacks remain uncovered while the horses are carrying part of the crop from the field.

Roofed Stackyards.—Were the stackyard covered in, farmers would be at liberty to make any form of stack they pleased, and be freed from providing thatching and ropes. The cost of this, however, would be great; and although it has been strongly recommended by some writers, a roofed stackyard is rarely seen.

Still roofs may now be thrown over a large stackyard much more easily, and at less expense than in former times, when the proposal was first urged upon farmers. A galvanised or corrugated iron roof or series of roofs could be erected at a comparatively moderate expense, which some contend would be repaid by dispensing with thatch and ropes for the stacks. Fig. 163 gives a representation of a galvanised or corrugated iron roof of 18 feet span. This is just the width a stack stands upon, and by erecting this side by side, and in length to any extent, any number of stacks would be under cover as desired. With this protection the stacks could be built round or rectangular, and in large mows as hay-stacks of the same kind of grain. They could be left open at the eaves at any height, without a head, and could be carried in dry to the machine in all weathers. A hay-stack could be built without a covering sheet, and a loaded cart of corn left until next morning. When the stacks were removed, such a shed would be most useful for clipping or bathing sheep, or for tying up oxen in summer upon forage.

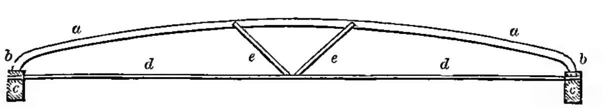


Fig. 163.—*Truss for a galvanised corrugated iron roof.*

a a Covered rib or rafter. *c c* Beams. *e e* Struts of wrought-iron.
b b Shoes bolted to the beams. *d d* Tie-rod.

A more expensive form of covering in a stackyard is represented in fig. 164, with roofs of galvanised iron, and cast-iron hollow pillars, 32 feet in height.

Ground-plan of Stackyards.—The ground-plan of a convenient stackyard is shown in fig. 165. This stackyard, it will be seen, is interspersed with roadways wide enough to permit of a horse and cart being turned round in them, so that any particular stack may be carted to the threshing-machine or elsewhere, without disturbing the other stacks.

In some cases a roadway runs round the stackyard, but this, of course, requires more space. When there are trees close to the wall of the stackyard, it is advisable to have as much space between the wall and the outer row of stacks as will prevent water from dripping on to the stacks from the trees.

Hay-barns.—That most useful institution, the modern hay-barn, is a modification of the scheme for covered stack-yards. Hay-barns constructed entirely of iron are now plentiful, and their value upon a farm is very great. Reference will be made to them in the chapter on hay-making.

English Barns.—A barn of vast dimensions, constructed principally of wood, is a characteristic feature of English farm-steadings. Some old English barns are marvels alike for their venerable age and

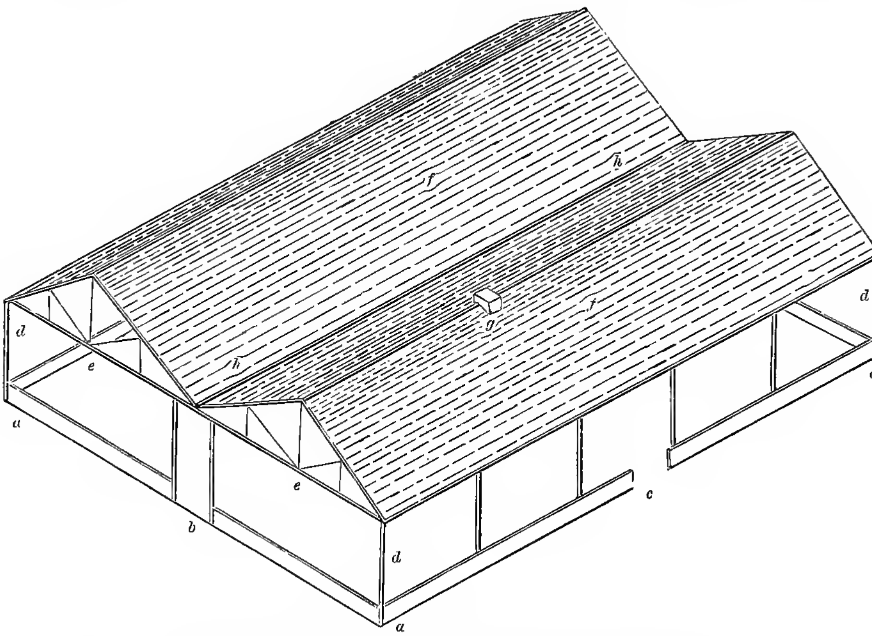


Fig. 164.—*Isometrical perspective of an iron-roof covered stackyard.*

a a Stackyard wall, 3½ feet high. *b* Cart entrance, 32 feet high, 12 feet wide. *c* Outlet to upper barn. *d d* Cast-iron hollow pillars, 32 feet high. *e e* Iron bracings supporting roof. *f f* Roof of galvanised iron. *g* Vent in any number. *h h* Valleys of roof, along which rain-water runs to hollow pillars.

great capacity. Unthreshed corn is often stored in these barns, and threshed as opportunity offers. In many parts of England large quantities of corn are stacked in sheds roofed with iron and other material.

THRESHING-MILL, STRAW-BARN, AND GRANARIES.

In steadings where there is a built-in threshing - machine, the compartment which contains it and the straw - barn and granaries are placed conveniently to each other, so that the labour of conveying the straw and the grain from the threshing-machine may be economised as far as possible. The building which contains the threshing-machine usually forms the centre of the back range of the steading, and often stretches out at right angles from the main wing of the steading into the stackyard, perhaps the length of the threshing-machine and the sheaf-barn, or compartment for holding the unthreshed corn. But the exact position of the threshing-machine will vary with local circumstances.

A common arrangement is to have the threshing-machine placed above the corn-barn, the building here being made exceptionally high on purpose. The sheaf-barn is sometimes large enough to hold a small-sized stack, but as a rule it is smaller, the corn being carted from the stack as the threshing proceeds.

Straw-barn.—The straw-barn is purposely made of the height of the upper barn, to contain a large quantity of straw, as it may be convenient in bad weather to thresh a considerable quantity of corn, when no outdoor work can be proceeded with, or when high prices induce farmers to take the corn to market.

There is another good reason for giving room in the straw-barn. All sorts of straw

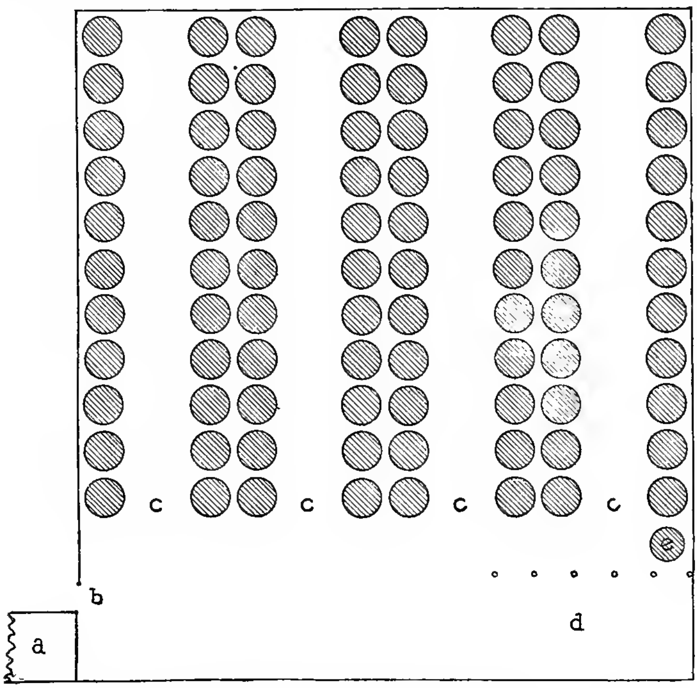


Fig. 165.—*Ground-plan of a stackyard.*

a End of house containing threshing-machine. *b* Gate. *c* Roadways between the rows of stacks. *d* Hay-shed or barn. *e* Hay-stack.

are not equally suited to every purpose, one sort being best suited for litter, and another for fodder. It is then desirable to have always both kinds in the barn, that the fodder-straw may not be wasted in litter, and the litter-straw given as fodder to the injury of the animals. Besides, the same sort of straw is not alike acceptable as fodder to every class of animals. Thus wheat-straw is a favourite fodder with horses, as well as oat-straw, whilst oat-straw only is acceptable to cattle. Barley-straw is used mainly for litter. It is not relished as food by stock in its whole state, but is useful food in pulped mixtures.

To give room to litter and fodder straw at the same time, it is necessary to have a high-roofed barn; and to give access to both sorts of straw, it is necessary to have a door in the straw-barn from each kind into each court. Thus four doors, two at each side near the two ends, are often found in a large straw-barn. Slit-like openings should be made in the side-walls, to admit air and promote ventilation through the straw. A skylight in the roof, at the end nearest the threshing-machine, is useful in giving light to those who take away and store up the straw from the threshing-machine when the doors are shut, which they should be whenever the wind happens to blow strongly against the straw from the machine.

Instead of dividing straw-barn doors into two vertical leaves, as is usually done, they should be divided horizontally into an upper and lower leaf, so that the lower may be kept shut against intruders, such as pigs, whilst the upper admits both light and air into the barn. One of the doors at each end should be furnished with a good stock-lock and key and thumb-latch, and the other two fastened with a wooden hand-bar from the inside.

Straw-barn Floor.—The floor of the straw-barn is seldom flagged or causewayed, though it is desirable it should be. Concrete is now largely used in barn floors, and it answers the purpose admirably. Whatever substance is employed, the floor should be made firm and dry, to prevent straw moulding. Mouldy straw at the bottom superinduces through the upper mass a disagreeable odour, and imparts a taste repugnant to every animal. That portion of the floor upon which the straw first alights on sliding down the straw-screen of the threshing-machine, should be strongly boarded, to resist the action of the forks when removing the straw. Blocks of wood, such as the roots of hardwood trees, trimmed and set on end causewaywise, into the ground, form a durable flooring for this purpose. Stone flagging would destroy the prongs of forks.

The straw-barn should communicate with the chaff-house, having an opening with a shutting door, to enable those who take away the straw to see whether the chaff accumulates too high against the end of the winnowing-machine.

Corn-barn.—This is the name usually given to the compartment underneath the sheaf-barn and threshing-machine. The corn as it is separated from the straw by the threshing-machine drops into this compartment, and before the threshing and dressing appliances were so admirably developed as they now are, the corn had to undergo subsequent dressing here by machines driven by hand-power. In the most improved modern threshing-machine the corn is almost perfectly dressed before it escapes from the machine, and is conveyed by elevators right away into the granary, where the corn is seen for the first time after its separation from the straw. Thus the corn-barn has lost much of its former importance.

The corn-barn, however, still exists, and in many cases has yet to be used for the old purposes of dressing and temporary storing of the threshed corn.

Door of the Corn-barn.—The door of a corn-barn is divided into upper and lower halves, and opens inwards. A more convenient method is to have it in a whole piece, and to fold back into a recess in the outer wall, over the top of which a plinth might project to throw off the rain. In this case the ribats and lintel of the doorway must be giblet-checked as deep as the thickness of the door, into which it should close flush, and be provided with a good lock and key and a thumb-latch. The object of making the door of this form is to avoid the inconvenience of opening into the barn. As to size, it should not be less in the opening than 7½ feet in height and 3½ feet in width. A light half-door can be hooked on, to prevent the intrusion of animals and the wind sweeping along the floor.

Floor of the Corn-barn.—The floor of the corn-barn is frequently made of clay, or of a composition of ashes and lime—asphalt or concrete would be better than either; but wood is best of all—sound hard red-wood Drahm battens, ploughed and feathered, and fastened down to strong joists with Scotch flooring-sprigs driven through the feather-edge. A wooden floor can be depended on being constantly dry in a corn-barn; and in a barn for the use of corn, a dry floor is indispensable. It has been suggested that a stone pavement, square-jointed, and laid on a bed of lime over 9 inches of broken stones—or asphalt, laid on a body of 6 inches of broken stones, covered with a bed of grout on the top of the stones—would make a dry and a more durable barn-floor than wood, and which will not rot. No doubt stone, asphalt, or concrete would be durable, and not liable to rot; but there are objections of a practical nature to these in a corn-barn, and it is certain that the best stone pavement is not proof against the undermining powers of the brown rat; whilst a wooden floor is durable enough, and certainly will not rot, if kept dry in the manner recommended, and illustrated in fig. 166.

Floors, which are perfectly vermin-proof, are now often made of concrete,

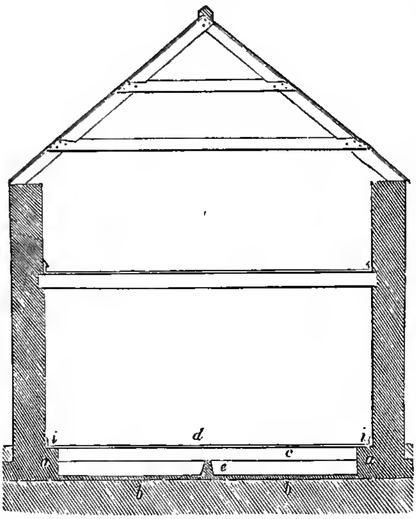


Fig. 166.—*Section of the corn-barn floor.*

a a 12-inch thick stone and lime sleepers.
b b Strong rough flags to support the sleepers.
c Wooden joists, 10 by 2½ inches, 16 inches apart, resting on ends on sleepers.
d Wooden floor, level with the door-sole.
i i Skifting-boards.
e Stone supports of floor.
f Upper barn, with roof of couples and slates.

and if care is taken to have the surface made as smooth as possible, is well suited for barns.

The objections to all stone pavements as a barn-floor are, that the wooden scoops for shovelling the corn pass very harshly over them—the iron nails in the shoes of the work-people wear them down, raise a dust upon them, and crush the grain—and they are hurtful to the bare hands and light implements, when used in taking up the corn from the floor. For true comfort in all these respects in a barn-floor, there is nothing like wood.

The walls of this barn should have hair-plaster, and the joists and flooring of its roof planed, to facilitate the removal of dust. The stairs to the granaries should enter from the corn-barn, and a strong plain-deal door with lock and key placed at the bottom or top of each. And there should be a bin to contain light corn for the fowls.

Hanging-doors in Steadings.—As hanging-doors on a giblet-check should be adopted in all cases in steadings where doors on outside walls are likely to meet with obstructions on opening inwards, the subject deserves illustration. Fig. 167 is the inside form of a strong door,

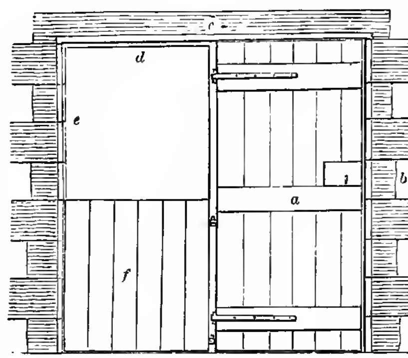


Fig. 167.—*Corn-barn door.*

a Inside of door.
b Recess in the wall.
c Lintel of doorway.
d Giblet-check in lintel.
e Giblet-check in ribats.
f Light movable door.

folded back into giblet-checks, mounted on crooks and bands.

Preservation of Wooden Floors.—The wooden floor of the corn-barn is liable to decay unless precautions are used to prevent it; but a much more common cause of its destruction is vermin—rats and mice. A most effectual method of preventing destruction either by vermin or damp is provided by supporting the floor as shown in fig. 166. The earth, in the first instance, is dug out of the barn to the depth of the foundation walls, which should be 2 feet below the door-soles. In the case of building a new steading, this can be done when the foundations of the walls are taken out. The ground is then spread over with a layer of sand, sufficient to preserve steadiness in the strong rough flags laid upon it pointed in good mortar. The building between the joists, to the level of the floor, should be done with squared rubble stones, and on no account should the mortar come in contact with the joists, as nothing destroys timber, by superinducing the dry-rot, more readily than the action of mortar. Vermin cannot possibly reach the floor but from the flags, which are nearly 2 feet under it, and the void freely admits the air, and affords room for cats or dogs to hunt the vermin.

Roofs of Steadings.—The roof, fig. 168, is very common for farm-steadings, and of strong construction, the balks or ties being notched into the couples or rafters, and its pitch above the walls is only 1 foot below the square. All roofs of steadings should be made of foreign timber, for strength and durability; but, unfortunately, on too many estates home timber is used, and one balk employed instead of two, the consequence of which is, that when the covering is of heavy grey or blue slates, the couples yield and the plane of the roof becomes depressed.

Truss-roofs.—Another form of roof has been adopted, in the *truss-roof*. In fig. 168 is a wooden king-post truss-roof. Fig. 169 is an iron king-post truss-roof. Modifications of these truss-roofs may be made thus: In fig. 168 the struts *e e* may meet at *f*, and an iron rod pass from *f* to the apex of the roof, and in fig. 169 an iron rod be placed from *f h* and *e i*. Roof, fig. 168, is of wood, fig. 169 of iron.

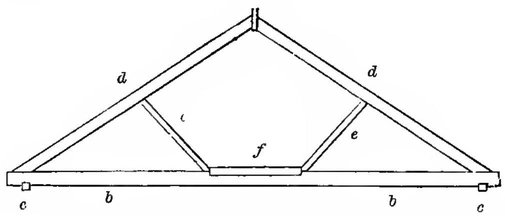


Fig. 168.—*Wooden king-post truss-roof.*

b b Tie-beam. *c c* Wall-plates. *d d* Rafters abutting on tie-beam, with span of 18 to 24 feet. *e e* Struts abutting on the straining-sill. *f* Straining-sill let into the tie-beam.

Upper Barn.—An upper barn, as frequently arranged, is represented in fig. 170. The position of the door *c* in this plan is not so convenient as could be desired. The sheaves should be so laid into the straw-barn as that when threshing is going on the women employed in supplying the feeder with loose sheaves should be able to lift them in exactly the reverse order from that in which they had been put in—that is, the last put in sheaves should be first threshed. In any other order it is difficult, and causes much delay to draw the sheaves out of the heap. It is more convenient, therefore, to have the sheaf-door situated so that the sheaves first put in may be placed furthest from, and the last put in nearest to, the feeding-bench of the threshing-machine.

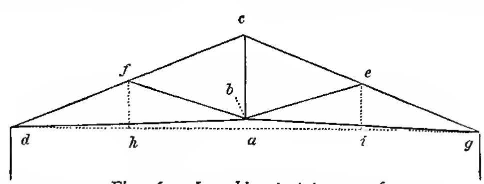


Fig. 169.—*Iron king-post truss-roof.*

d g Tie-rods, ¾ inch diameter. *a* to *b* Rise of tie-rods, 6 inches. *a* to *c* Rise of tie-rods, 4 feet. *b c* King-bolt, ⅝ inch diameter. *c d*, *c g* Rafters, bedded into shoes, secured to wall-plates. *b e*, *b f* Struts.

The sheaf-door may be in two upright leaves, to open outwards, one to fasten with a cat-band, the other with lock and key.

There should be a window in the wall, or a sky-light in the roof, immediately opposite or over the feeding-bench.

Conveying Sheaves to the Sheaf-barn.—Formerly it was the custom in some parts, where the sheaves were carried to the sheaf-barn from the stack by hand and not on carts, to have a *gangway* from the door of the upper barn. This was used as an inclined plane, upon which to wheel the corn-barrows, and formed a road for the carriers of sheaves from the stackyard. This road was at all times kept hard and smooth with small broken stones, and sufficiently strong to endure the action of barrow-wheels. To prevent the gangway affecting the corn-barn with dampness, it was supported on a semicircular arch of masonry from the wall.

This practice of carrying sheaves to the barn has now entirely disappeared. The general plan now is to employ carts in conveying the unthreshed corn from the stacks to the threshing-mill. Indeed, with the great speed accomplished by modern threshing-machines no other plan would, as a rule, be practicable.

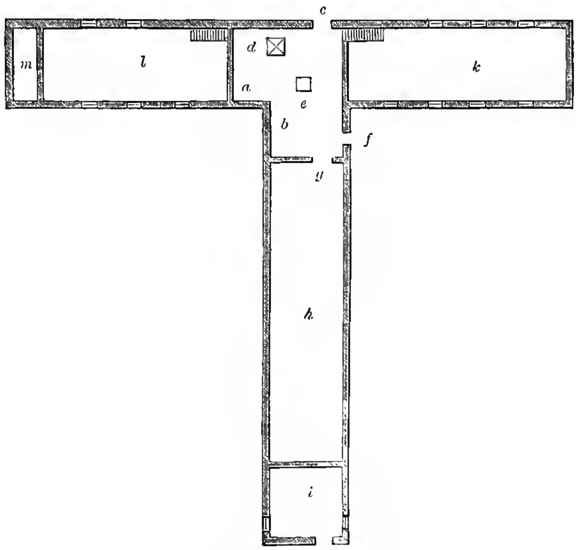


Fig. 170.—*Upper barn and granaries.*

a Upper barn.
b Site of threshing-mill.
c Door, 6 feet wide, for taking in sheaves of corn.
d Skylight.
e Hatch in floor, 3 feet by 3 feet.
f Bole for air.
g Opening from straw-barn, 4 feet by 3½.
h Straw-barn.
i Wool-room.
k Granary, 18 feet by 55.
l Granary, 18 feet by 47.
m Pigeon-house.

Granaries.—The roofs of the granaries in fig. 168 ascend to the slates. Their wooden floors should be made strong, to support a considerable weight of grain; their walls made smooth with plaster; and a high skifting-board should finish the flooring. The numerous windows should admit sufficient light and air; and a good way of affording both freely is shown in fig. 171, where the opening is 4½ feet in length and 3 feet in height. The shutters revolve by their ends on a round pin, in holes of the side-posts of the frame, and kept parallel by a bar attached by an eye of iron, moving stiff on an iron pin passing through both the eye and bar.

Another form is the "hit-and-miss" window, described on p. 392.

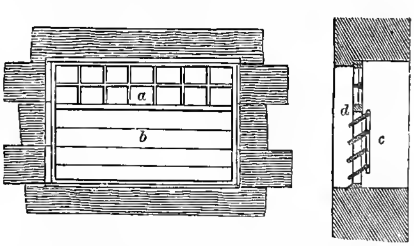


Fig. 171.—*Granary window and section of shutter.*

a Glazed sash 1 foot high, and two rows of panes.
b Venetian shutters.
c Section of shutters and bar.
d Side-posts of frame.

Precautions against Vermin.—Rats and mice being destructive and dirty vermin in steadings, and particularly so in granaries, means should be used in the construction of steadings to prevent their lodgment in any particular part. Many expedients have been tried to destroy them in granaries, such as putting up a smooth triangular board across each corner, near the top of the wall. The vermin come down any part of the walls to the corn at their leisure, but when disturbed run to the corners, up which they easily ascend, but are prevented gaining the top of the wall by the triangular boards, and on falling down, either on the corn or the floor, are there easily destroyed.

But preventive means, in this case, are much better than destructive. If at all possible the granaries should always be kept free of vermin, so that the grain may be saved and may remain sweet and clean. The best method of prevention is, to deprive vermin of convenient places to breed in above ground, and this may be accomplished in all farm-steads by building up the tops of all the walls by beam-filling between the legs of the couples with stone and mortar—taking care to keep the mortar from contact with the timber. These places form the favourite breeding-ground of vermin in farm-steads, and should therefore be filled up with stone and mortar. The top of every wall, whether of stables, cow-houses, hammels, or other houses, should be treated in this manner; for, if one place be left them to breed in, the young fry will find access to the granaries in some way. The tops of the walls of old as well as of new farm-steads should be treated in this manner, either from the inside, or, if necessary, by removing the slates or tiles until the alteration is effected.

Precaution is necessary in making beam-fillings, especially in new buildings, to leave a little space open *under* every couple face, to allow room for subsidence or bending of the couples after the slates are put on. Were the couples pinned firmly up with stone and lime, the stone would form hard points as fulcra, over which the couple, while subsiding with the load of slates upon it, would act as a lever, and might start the nails from the wall-plates, and push out the tops of the walls.

Rats and mice breed under ground besides on the tops of the walls, and find access into apartments through the floor. To prevent lodgment in those places also, it will be proper to lay the strongest flagging and causewaying upon a bed of mortar spread over a body of 9 inches of small broken stones, around the walls of every apartment on the ground-floor where any food for them may chance to fall, in the stables, byres, boiling-house, calves'-house, implement-house, hay-house, pig-sties, and hen-house, corn-barn, straw-barn, &c.

The best means of prevention in those places are, to make the foundation of the walls 2 feet deep, and fill up the space between the walls with broken stones. This of course would entail considerable outlay, yet some regard it as money well invested. A well-laid concrete floor will effectually resist rats, and this is not very costly.

THRESHING-MACHINES.

Great improvement has been effected in recent years upon threshing-machines. The old-fashioned forms of built-in threshing-machines, at one time so extensively used in Scotland, and some of which were illustrated and described in former editions of *The Book of the Farm*, are now rarely met with. Machines of a much more efficient character have taken their place. The portable threshing-machine is now largely used, and is growing in favour. Still a great many farmers, especially in Scotland, prefer to have a good modern threshing-machine, built in permanently in their steadings, to be always at their hand for use when desired.

These built-in machines now, as a rule, accomplish their work in a most admirable manner, threshing the grain at a rate formerly undreamt of, and in many cases not only at the same time dressing the grain so as to be fit for market, but conveying it into the granaries, which may be some considerable distance from the threshing-machine, and also carrying the straw to the remotest end of a long straw-barn — all this being done automatically, no human hand touching either grain or straw, after being fed into the drum, until each is deposited in its appointed quarters. These modern built-in threshing-machines are of many patterns, several of which may be said to be equally efficient.

Scotch Threshing-machine.—A section of the threshing-mill wing of a modern Scotch steading is represented in fig. 172 (p. 450), showing at a glance not only the position of the threshing-machine, but also the courses of the grain and the straw until the former is dressed and carried by elevators and oscillating spout into the granary, and the latter by shakers and a travelling web to the extreme end of the straw-barn.

The following is a working description of this machine, as erected by Mr R. G. Morton, Errol, Perthshire:—

The sheaves to be threshed are fed through the hopper A, the grain being driven from the husk by the drum B in its grated concave *cc'*, which is regulated for the different kinds and conditions of grain, by an instant and parallel acting set-gear D*d'*. A large portion of grain and chaff fall through *c*, while the remainder is discharged, at a tangent, amongst the straw by the centrifugal force of the drum against the reflecting board D', then dropping upon the shakers E. The straw is tossed forward to the straw-carriers by the action of cranks on shaft F, and the patent balance throw-gear G. The grain falling through the shaker and concave gratings is gathered by the inclined planes H*h*, and oscillating planes JJ' of first riddle K, which, by the current of air from first blast L, carries the chaff, short straws, &c., to chaff-room MM', while the good grain falls through K to plane N, from which it slides down to cross-spout *o*. The light grain, &c., blown over N, falls on plane P, over which it slides and falls into the current of air from second blast T, to be further cleaned as it falls into the light-grain compartment Y; while the good grain falls through a trap-door in spout *o*, from whence it slides down the inclined planes Q and R to oscillating plane S, and receives the current of air from second blast T, as it falls from *s* to second riddle *v*, the wind carrying all the lights over *v* into *y*. The remaining husks and dust are blown into chaff-room M. The good grain falls through *v* into oscillating spout *w*, which, with a perforated bottom for extracting the small seeds and sand, delivers the good grain to elevator ark X, to be carried up to the roof and discharged into vibrating inclined plane Z, passing over a series of sand, seed, and small grain extractors, and being delivered through the gable into the granary Z' for storage or bagging.

When the grain requires awning the trap-door in cross-spout *o* is closed, the grain passing over same to the patent pneumatic awner (shown by dotted lines at back of machine) and discharged into vertical tube, the air carrying the dust, &c., up same, while the grain falls down to the bottom of the tube and enters the machine by the port *aa*, and slides down the plane R to the oscillating plane S, to be winnowed and riddled as above.

The threshed straw as it leaves the shakers E at *e* 1 falls on the first section of straw-carriers *e* 2, to be delivered above the balks on to second section *e* 3, which in like manner delivers on *e* 4, which drops it into straw-barn at *e* 5, to be stored as at *e* 6 until full, when pinion 7 is caused to turn in rack 8. The frame and pulley 9 are drawn along with it, making an opening at 10, where the straw drops to the barn-floor, the operation being repeated at 11.

The whole parts of this machine are driven off drum-coupling, which is driven by "Morton's" direct-acting poncelet turbine, set in corn-room, designed for 34 feet fall, and 26 feet suction, with 130 cubic feet of water per minute, making 509 revolutions, and developing 11½ horse-power. The power required is 9 horse-power and 100 cubic feet water per minute.

The best of these modern machines often thresh and dress from 12 to 16 quarters of ordinary oats per hour. Much, of course, depends on the length of the straw and the wealth of grain in the crop. From 6 to 8 quarters per hour are common quantities.

By ingeniously constructed blasts worked in conjunction with the threshing-machine, the newly threshed and dressed grain is in some cases conveyed, or rather blown, into granaries situated at awkward angles from the threshing-machine, where one would scarcely consider it possible to have such work accomplished.

By extension or contraction of the

travelling-web the straw may be carried to the extreme end of the longest straw-barn, or, as already indicated, dropped at intermediate points as desired.

Saving of Labour.—A remarkable saving of labour is effected by these mechanical contrivances, and this, of course, is a point of great importance. The dressing-machines attached to the most improved threshing-mills are so effective as to dress the grain sufficiently well for ordinary purposes; and thus, when the grain is to be immediately sent to market, it may also be bagged—and not only bagged but also weighed automatically, as it issues from the spout at z′. To accomplish this automatic bagging and weighing, means are provided for hanging a bag upon or underneath the mouth of the spout, so as to catch the grain. The bag rests upon a portable weighing apparatus, upon which are placed weights equal to the weight which it is desired to have in each bag. As soon as the bag receives the proper quantity of grain, it of course presses down its side of the weighing machine, and in the act of thus descending it disengages a sluice, which thereupon shuts up the mouth of the spout. The attendant instantly removes the full bag, hangs on an empty one, and lifts the sluice, and

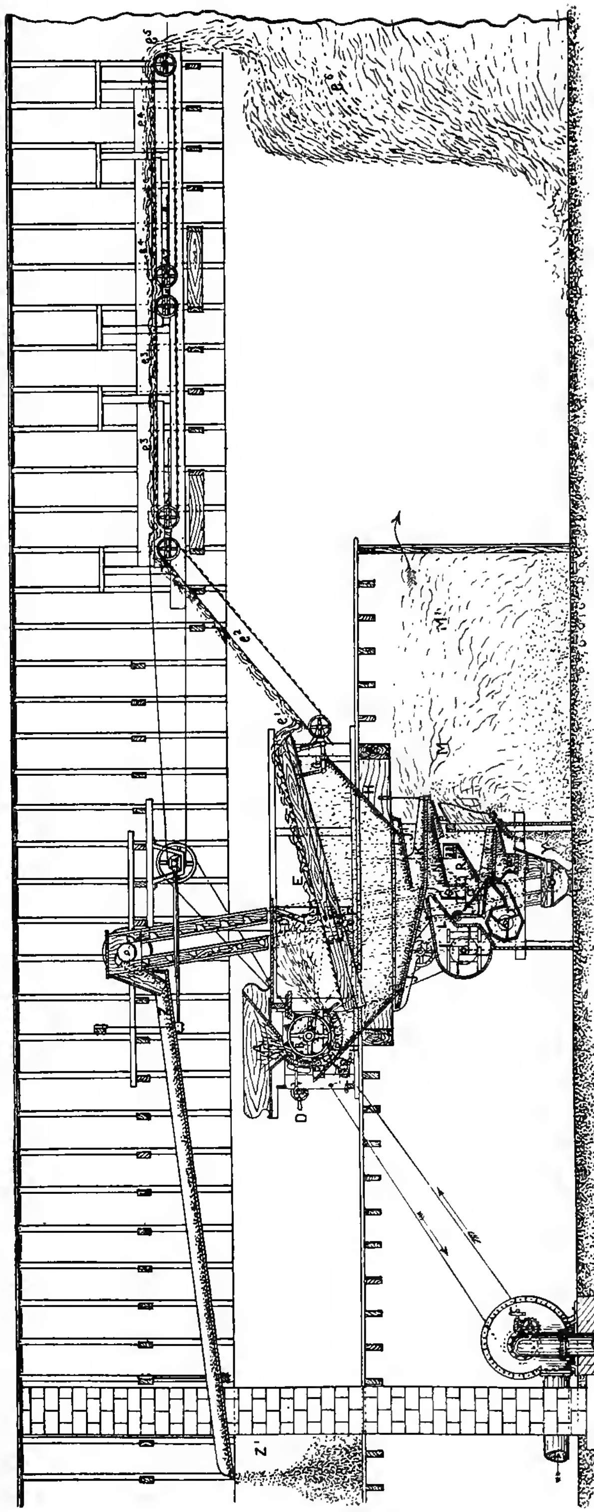


Fig. 172.—Modern Scotch threshing and dressing machine.

the operation goes on with admirable speed and precision.

It is only in exceptional cases that the automatic work is carried on to this ex-

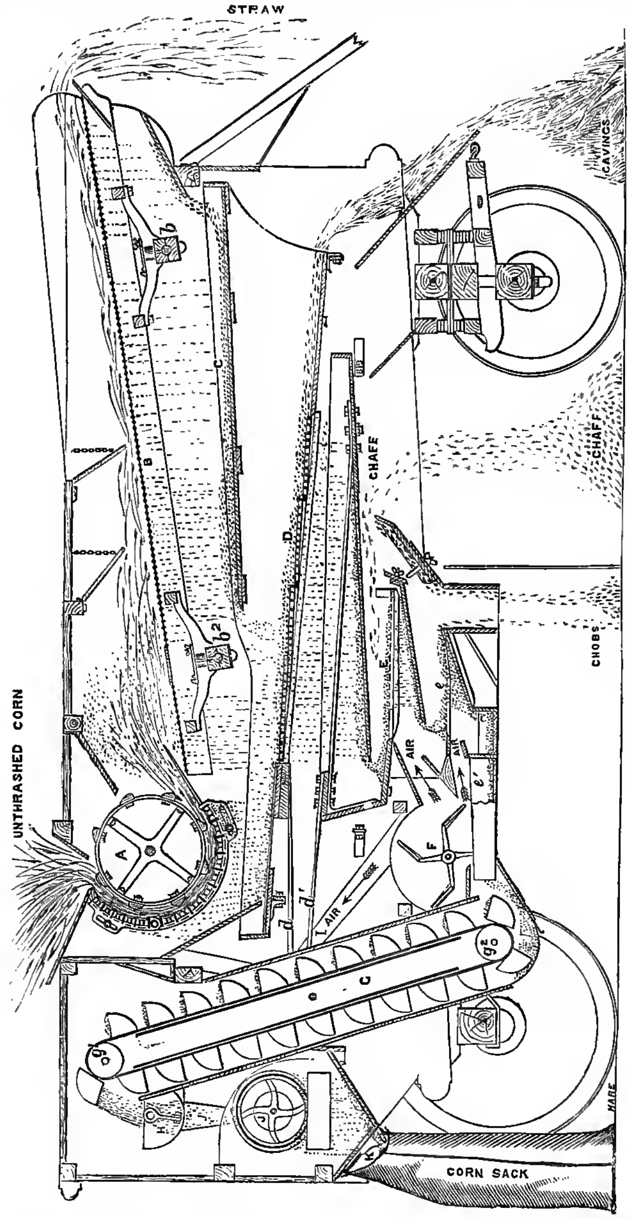


Fig. 173.—*Section of portable threshing-machine.*

tent, but the practicability, as well as the advantages of the plan, is obvious enough.

Portable Threshing-machines.—The portable form of threshing-machines prevails in England. As a rule, there is no threshing-machine of any kind at English farm-steadings. The threshing is done by travelling machines owned by companies or individuals, who may have several machines at work in different parts of the country at one time. This system is now also pursued to a large extent in Scotland, but not so extensively as in England.

Several leading firms of implement-makers have given much attention to the manufacture of portable threshing-machines, and now the farmer has ample choice of machines of the highest efficiency. These portable threshing-machines are usually worked by steam traction-engines, which also draw them from one place to another. In some cases portable steam-engines are employed in working the machines, but then horses have to be used in taking the machine from farm to farm.

In fig. 173—a longitudinal section of a modern portable threshing-machine, made by Marshall & Sons, Gainsborough—the operations of threshing, dressing, and bagging, all going on simultaneously, are shown very clearly. The working is seen so distinctly in the sketch, that no detailed description of the process is necessary. The machine is supposed to be working in the stackyard. The sacks of grain as they get filled have to be conveyed to the granary; but that is easily done.

The disposal of the straw entails more labour. It is usually formed into a large stack at the rear of the threshing-machine, and the conveyance of the straw from the shakers to this stack is, in most cases, accomplished by means of elevators, which can be lengthened and raised in the pitch as the stack increases in height. The working of this elevator is shown in fig. 174, which represents one of Clayton & Shuttleworth's portable threshing-machines at work in a stackyard.

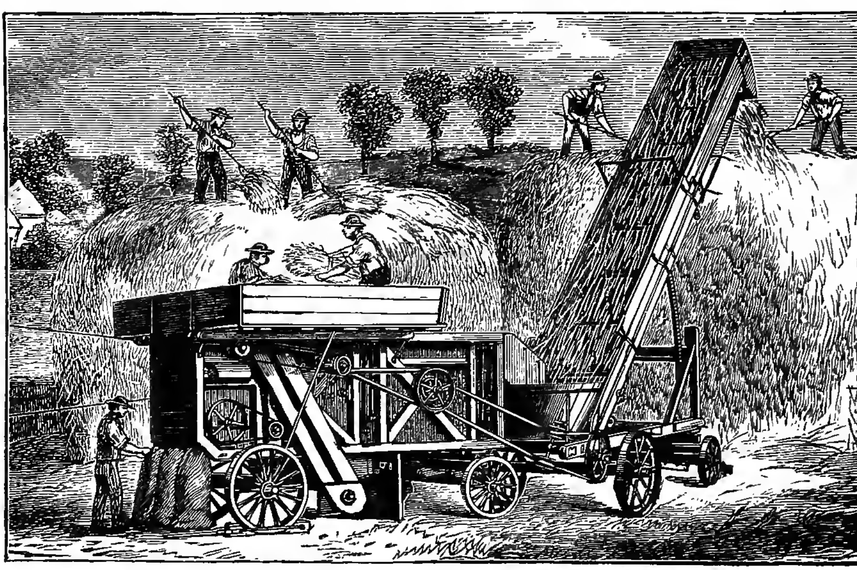


Fig. 174.—*Portable threshing-machine, showing straw-elevator.*

Hands required for Threshing-Machines.—The number of persons required to work these portable threshing-machines varies according to the operations performed and the speed of the machine. Ransome, Sims, & Jefferies, whose portable threshing-machine is represented in fig. 175, in process of being placed for work, point out that the economy of threshing must depend in a great measure on the proper distribution of the hands employed, and state that the force should consist of eleven men and boys, to be engaged as follows: "One to feed the machine; two to untie and hand the sheaves to the feeder; two on the corn-stack to pitch the sheaves on to the stage of the threshing-machine;

one to clear the straw away as it falls from the straw-shaker; two to stack the straw; one to clear away the chaff from underneath the machine, and occasionally to carry the chobs which fall from the chob-spout up to the stage, to be threshed again; one to remove the sacks at the back of the machine as they are filled; and one to drive the engine. The feeder,

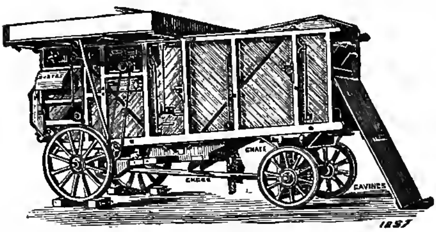


Fig. 175.—*Ransome's threshing-machine.*

on whom very much depends, should be an active man, and should have the control of all those stationed near the machine. He should endeavour to feed the drum as nearly as possible in a continuous stream, keeping the corn uniformly spread over the whole width. The two men or boys who untie the sheaves should stand on the stage of the threshing-machine, so that either is in a position to hand the feeder a sheaf with ease, but without obstructing the other. The men on the stack must keep the men or boys on the stage constantly and plentifully supplied with sheaves, which must be pitched on to the stage, so that the boys can reach them without leaving their position. The man who removes the straw from the end of the shaker should never allow it to accumulate so that it cannot fall freely. The man whose duty it is to clear away the chaff and cavings from underneath the machine must not allow these to accumulate so as to obstruct the free motion of the shoes; he must watch the skep or basket under the chob-spout, and as soon as it is full, empty its contents on to the stage, in a convenient position for the feeder to sweep the same, a little at a time, into the drum to be threshed over again. The man attending to the sacks must remove them before they get so full as to obstruct the free passage of the corn from the spouts, otherwise the clean corn may be thrown out at the screenings-spout; he will also have time between the removal of a full sack and the filling of another, to look round the machine, and give general attention to oiling the bearings."

When a large quantity is being threshed at one time, additional hands will be required to take away and stack the straw. It is better to cart the sheaves to the threshing-machine than to shift its position in the stackyard.

Safety-drums.—The frequency of serious accidents to those engaged in feeding threshing-machines led to the passing of an Act of Parliament providing that the drum and feeding-mouth of every threshing-machine must be sufficiently and securely fenced so far as practicable. Great ingenuity has been displayed by leading manufacturers in devising means for preventing these accidents, and now there are several patent safety-drums or drum-guards, most of which seem to render accidents by contact with the drum, if not absolutely impossible, at least extremely improbable. The guard used by R. Garrett & Sons consists of a simple cover, which always remains closed over the mouth of the machine—where the sheaves are admitted into the drum—until the feeder gets into the box in which he stands when feeding, and where it is considered he is beyond the risk of accident. When he gets into this box, his weight depresses the bottom of the box sufficiently to give movement to levers which thereby open the feeding-mouth.

In other machines protection is provided by having the feeding-board and a curved hood which half covers the drum-opening so arranged that if any undue pressure come upon either of them, the opening to the drum is instantly closed by an automatic flap falling over it. Marshall thus describes the action of his drum-guard: "In the front any undue pressure coming upon the feed-board releases a board underneath same, which instantly closes over the drum-mouth in a direction from the feed-board. To protect the drum from the back a hinged hood is provided, which, on any weight falling on it, drops over the mouth and closes it. This hood can readily be adjusted to overhang the drum-mouth more or less as may be desired, and is fitted with wrought-iron curved end plates sliding in grooves through the top of the machine; these end plates protect the drum at the sides whatever the position of the hood may be."

With these precautions a serious drum-accident now rarely happens.

Straw-trusser.—This is a most useful contrivance. It is attached to and worked in conjunction with a threshing-machine. The straw as it leaves the shakers of the threshing-machine is caught by the trusser, securely tied in convenient bundles—which may at will be varied in size—with stout twine, and thrown on the ground behind the machine, ready to be forked on to a stack or cart. This excellent machine, represented in fig. 176, made by J. & F. Howard, Bedford, will tie up the straw as fast as it leaves the most speedy threshing-machine, thus performing the work of five or six men.

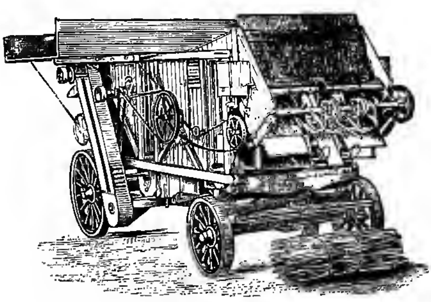


Fig. 176.—*Straw-trusser attached to threshing-machine.*

As is indicated in the illustration, the threshing-machine and trusser attached takes up very little more space than the threshing-machine by itself.

Hand Threshing-machines.—Several tiny threshing-machines are made for hand-power, and there are machines somewhat larger, but still, of course, of a comparatively small size, for one-horse or pony-gear. The "Tiny" threshing-machine made by G. W. Murray & Co., Banff, adapted for hand, pony, or horse power, is capable of threshing from 10 to 25 bushels of grain per hour. These little machines are extensively used on small holdings, where they are supplanting the "flail," which is now almost a thing of the past.

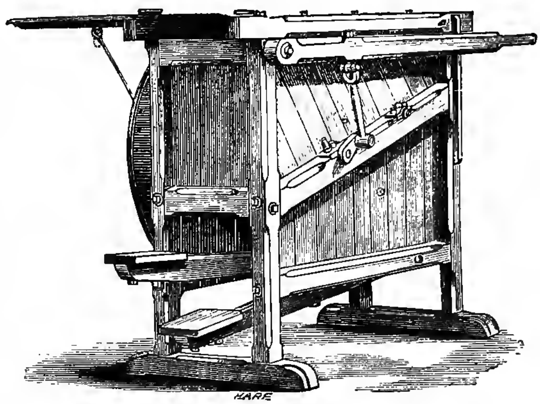


Fig. 177.—*Small threshing-machine.*

A very useful little threshing-machine, arranged for driving by hand and foot, or by other power, is made by Ben Reid & Co., Aberdeen, and illustrated in fig. 177.

MOTIVE POWER FOR THRESHING-MACHINES.

Steam is fast taking the place of horse-power in working threshing-machines. Where the supply is plentiful, water still holds its own, and will continue to do so, for it is the cheapest of all motors for the purpose. But the horse-wheel is gradually disappearing, and the windmill may be said to have gone.

Steam-power.

The steam-engine in its various forms, suitable for farm-work, has already been fully explained—see page 122—so that nothing more need be said in regard to it here. Steam-power possesses two important advantages: it is always at command and can be completely controlled. By the use of steam the threshing may proceed continuously as long as may be desired; while, except in the rare cases in which the force of running water is sufficient to drive the mill-wheel, the threshing for the time ceases with emptying of the "mill-dam." Experience has abundantly proved that threshing-machines dependent on water derived chiefly from the drainage of the surface of the ground, frequently suffer from a short supply in autumn, and late in spring or early in summer, thereby creating inconvenience for the want of straw in the end of autumn, and the want of seed or horse-corn in the end of spring. Wherever such casualties are likely to happen, it is better to adopt a steam-engine at once. Although coal should be distant and dear, for all that a steam-engine requires, a steam-engine should in these cases be chosen rather than horse-power.

The other advantage is also important. Water or horse power cannot be so nicely governed as steam, and, as a consequence with these powers, irregularities in feeding-in the grain or variations in the length of the straw are apt to make the motion of the corn-dressing appliances irregular, which, of course, causes imperfect dressing. This irregular working is to a large extent obviated by the use of steam-power.

It may perhaps be as well to point out that where steam is the power used for threshing, the engine-house should be placed as conveniently as possible for communication between the engine-driver and the person feeding the machine. As there can be but two propositions to make—to set on and to stop—one signal is sufficient, and a *bell* seems to be the most convenient medium of communication.

Water-power.

Still, wherever there is a sufficient fall and a reliable supply of water, it is desirable, for the sake of economy, that the latter should be utilised for threshing purposes. There are various methods by which water-power is made available for driving the threshing-machine, pulper, chaff-cutter, grist-mill, &c. The turbine is a comparatively modern invention, and a valuable contrivance it is. The water-wheels are usually of two kinds—*undershot* and *bucket* wheels.

Undershot Water-wheels. — The *undershot* or *open float-board* wheel can be advantageously employed only where the supply of water is considerable and the fall low. It therefore rarely answers for farm purposes, and need not be discussed.

Bucket Water-wheel.—A much more useful kind is the *bucket*-wheel, which may be *overshot* or *breast*, according to the height of the fall. It is this wheel that is adopted in all cases where water is scarce or valuable, and the fall amounts to 6 or 7 feet or more, though it is sometimes employed with even less fall than 6 feet.

Measuring the Water-supply.—When it is proposed to employ a stream of water for the purpose of power, the first step is to determine the *quantity delivered by the stream in a given time.* This, if the stream is not large, is easily accomplished by an actual measurement of the discharge, and is done by damming up the stream to a small height, say 1 or 2 feet, giving time to collect, so as to send the full discharge through a shoot, from which it is received into a vessel of any known capacity, the precise time that is required to fill it being carefully noted. This will give a correct measure of the water that could be delivered constantly for any purpose. If the water be in too small a quantity to be serviceable at all times, the result may found a calculation of the time required to fill a dam of such dimensions as might serve to drive a threshing-machine for any required number of hours.

If the discharge of the stream is more than could be received into any moderately-sized vessel, a near approximation may be made to the amount of discharge by the following method: Select a part of its course, where the bottom and sides are tolerably even, for a distance of 50 or 100 feet; ascertain the velocity with which it runs through this space, or any measured portion of it, by floating light substances on its surface in a calm day, noting the time required for the substance to pass over the length of the space. A section of the stream is then to be taken, to determine the number of superficial feet or inches of sectional area that is flowing along the channel, and this, multiplied into five-sixths of the velocity of the stream, will give a tolerable approximation to the true quantity of discharge—five-sixths of the surface velocity, at the middle of the stream, being very nearly the mean velocity of the entire section.

Supposing the substance floated upon the surface of the stream passed over a distance of 100 feet in 20 seconds, and that the stream is 3 feet broad, with an average depth of 4 inches—here the area of the section is exactly 1 foot, and the velocity being 100 feet in 20 seconds, gives 300 feet per minute, less one-sixth =250 feet, and this multiplied by the sectional area in feet, or 1 foot, is 250 cubic feet per minute for the discharge.

It is to be borne in mind that this is only an approximation, but it is simple, and from repeated experiments we have found it to come near the truth. For those who wish to enter more elaborately into the subject, we may here state a formula, derived from those of Sir John Leslie, for finding the mean velocity, and, having also the transverse section, for finding likewise the discharge of a stream or river.

Multiply the *constant* 1.6 into the hydraulic depth, and into the slope of the surface of the water per mile, the square root of the product will give the *mean velocity* of the stream in feet per second; and the root, multiplied by the section of the stream in square feet, is the discharge per second. The *hydraulic depth* is the transverse section of the stream in square feet, divided by the periphery of the stream, less the surface breadth.

Example.—If the surface breadth be 3 feet, the bottom breadth 2½ feet, and the slope of the sides each 9 inches, a transverse section of these dimensions will contain 2 square feet nearly, which, divided by the periphery, which is

$3+.75+.75+2.5=7$, the periphery,

then the area of the section = 2 feet;

and $2\div(7-3)=.5$ foot, or = 6 inches, the hydraulic depth.

And suppose the slope at the place of section to be 1½ inch on 100 feet, or 6.5 feet per mile, apply the formula—

$1.6\times.5\times6.5=2.3$ feet, the velocity per second nearly, and the delivery will be $2.3\times2=4.6$ cubic feet per second, which, multiplied by 60, gives 276 cubic feet per minute.

The next step is to ascertain the fall, by levelling, from the most convenient point at which the stream can be taken off, to the site where the water-wheel can be set down, and to that point in the continuation of the stream where the water can be discharged from the wheel, or what is called the outfall of the tail-race. If the water has to be conveyed to any considerable distance from the point where it is diverted from the stream to the wheel, a lade must be formed for it, which should have a fall of not less than 1½ inch in 100 feet, and this is to be deducted from the entire fall. Suppose, after this deduction, the clear fall be 12 feet, and that the water is to be received on a bucket-wheel whose power shall be equal to 4 horses.

The rule for finding the quantity of water required per minute to produce 4 horses' power is to multiply the *constant* 44,000 by the horse-power, and divide the product by the product obtained by multiplying the *constant*,—the weight of water per cubic foot by the height of the fall.

Example.—Multiply the *constant* . . .		44,000	
By the horse-power . .		4	
Which divide by the		)176000(234	cubic feet, the quantity
weight of water per cubic foot .	62.5	1500	of water required per
Multiplied by the height of the fall	12		minute to produce 4
		2600	horses' power.
	750.0	2250	
		3500	
		3000	

The formula is this— $\frac{44{,}000\times4}{62.5\times12}=234$ cubic feet.

The rule for finding the horse-power of any ascertained discharge of water will be found in p. 28.

Mill-dam.—If the stream does not produce this quantity, a dam must be formed by embanking or otherwise, to contain such quantity as will supply the wheel for three or six hours, or such period as may be thought necessary. The quantity required for the wheel here supposed, for three hours, would be 42,120 cubic feet; but suppose the stream to supply one-fourth part of this, the remainder, or 31,590 feet, must be provided for in a dam, which, to contain this, at a depth not exceeding 4 feet, would be 88 feet square. But the constant supply of water is often much smaller than here supposed, and in such cases the dam must be proportionally larger, and also to allow for evaporation.

Forming Mill-dam.—The *dam* may be formed either upon the course of the stream, by a stone weir thrown across it, and proper sluices formed at one side to lead off the water when required; or, what is much better, the stream may be diverted by a low weir into an intermediate dam, which may be formed by digging and embankments of earth, furnished with sluice and waste-weir, and from this the lade to the wheel should be formed. The small weir on the stream, while serving to divert the water, when required, through a sluice to the dam, would, in time of floods, pass the water over the weir, the regulating sluice being shut to prevent the flooding of the dam. This last method of forming the dam is generally the most economical and convenient, besides avoiding the risk which attends a heavy weir upon a stream that may be subject to floods. When water is collected from drains or springs, it is received into a dam formed in any convenient situation, which must also be furnished with a waste-weir, besides the ordinary sluice, to pass off flood-waters.

The position of the sluice in the dam should be so fixed as to prevent the *wrack* floating on the surface of the water finding its way into the sluice, and thence to the water-wheel. To avoid this inconvenience, the sluice should not be placed at the lowest point of the dam, where it most commonly is, but at one side, at which the water will pass into the lade, while the rubbish will float past to the lowest point.

Dimensions of the Bucket-wheel.—The water-wheel should be on the *bucket* principle, and, for a fall such as we have supposed, 12 feet, should not be less than 14 feet diameter; the water, therefore, would be received on the breast of the wheel. Its circumference, with a diameter of 14 feet, will be $3.1416 \times 14 = 44$ feet; its velocity, at 5 feet per second, is $44 \times 5 = 220$ feet a minute; and 234 cubic feet per minute of water spread over this gives a sectional area for the water laid upon the wheel of $\frac{234}{220} = 1.06$ feet; but as the bucket should not be more than half filled, this area is to be doubled $= 2.12$ feet; and as the breadth of the wheel may be restricted to 3 feet, then $\frac{2.12}{3} = .704$ foot, the depth of the shrouding, equal to 8½ inches nearly; and if the wheel is to have wooden soling, 1 inch should be added to this depth already found, making 9½ inches.

The Arc.—The *arc* in which the wheel is to be placed must have a width sufficient to receive the wheel with the toothed segments attached to the side of the shrouding. For a bucket-wheel it is not necessary that it be built in the arc of a circle, but simply a square chamber—one side of it being formed by the wall of the barn, the opposite side by a wall of solid masonry, at least 2½ feet thick: one end also is built up solid, while the opposite end, towards the tail-race, is either left entirely open, or, if the water is to be carried away by a tunnel, the water-way is arched over and the space above levelled in with earth. It is requisite that the walls of the wheel-arc should be built of square-dressed stone, having a breadth of bed not less than 12 inches, laid flush in mortar, and pointed with Roman cement.

Construction of the Wheel.—Fig. 178 is a *sectional elevation* of the wheel. The barn-wall, and the sole of the arc or chamber, are formed of solid ashler, having an increased slope immediately under the wheel, to clear it speedily of water. The shaft, the arms, and shrouding are of cast-iron, the buckets and sole being of wood; and to prevent risk of fracture, the arms are cast separately from the shrouding. The width of the wheel being 3 feet, the toothed segments 4 inches broad, and they being 1 inch clear of the shrouding, gives a breadth over all of 3 feet 5 inches, and when in the arc there should be at least 1 inch of clear space on each side, free of the wall. The length of the shaft depends upon how the motion is to be taken from the water-wheel. In the case of the wheel illustrated in the sketch it is taken off by the pinion shown on the left hand, in a line horizontal to the axis of the water-wheel.

The eye-flanges, 2 feet diameter, are separate castings, to which the arms are bolted; the flanges being first keyed firmly upon the shaft. The shrouding is cast in segments, and bolted to the arms and to each other at their joinings. On the inside of the shroud-plates are formed the grooves for securing the ends of the buckets and of the sole-boarding.

The form of the buckets should be such as to afford the greatest possible space for water at the greatest possible distance from the centre of the wheel, with sufficient space for the entrance of the water and displacement of the air. In discharging the water from the wheel also, the buckets should retain the water to the lowest possible point. These conditions are attained by making the pitch of the buckets, or their distance from lip to lip, 1½ times the depth of the shrouding; the depth of the front of the bucket inside, equal to the pitch; and the breadth of the bottom as great as can be attained consistently with free access of the water to the bucket immediately preceding; this breadth, inside, should not exceed two-fifths of the depth of the shrouding.

If there is the least danger of back-water — that is, of interruption to the discharge in the tail-race—it is a good plan to keep the bottom of the arc high at the up-water side. This gives the water discharging at the higher points a velocity greater than 5 feet per second, and assists in driving the water away from below the lowest discharging buckets.

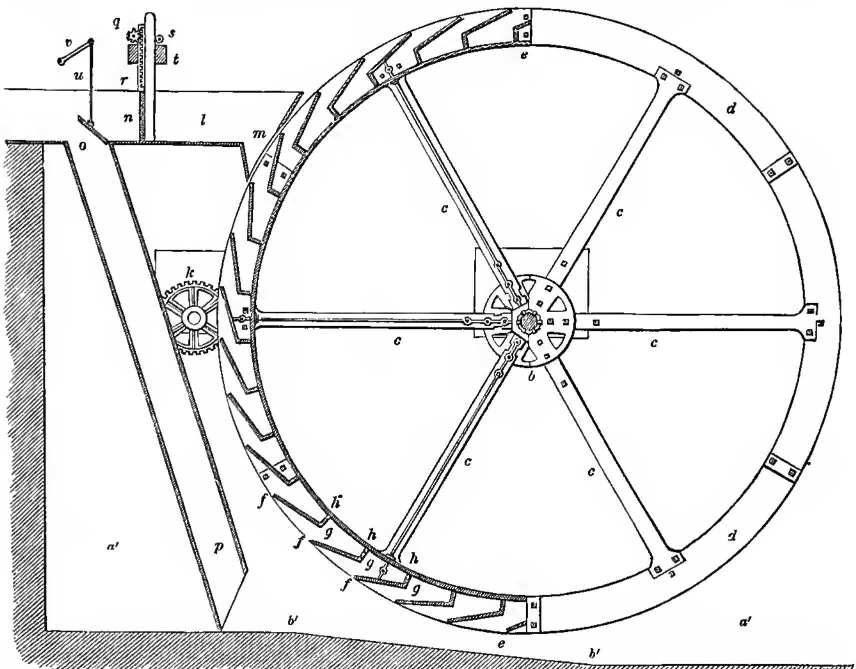


Fig. 178.—*Section and elevation of a bucket water-wheel.*

a′ a′ Barn-wall.
b′ b′ Sole of arc.
b Eye-flanges.
c Arms.
d d Shrouding.
e Groove for securing the buckets.
f f Pitch of the buckets.
f g Front of bucket.
g h Bottom of bucket.
k Pinion.
l Trough.
m Spout.
n Regulating-sluice.
q Pinion.
r Sluice-stem.
s Friction-roller.
t Cross-head.
o Trap-sluice.
o p Spout.
u Connecting rod.
v Crank-lever.

In the illustration one-half of the shrouding-plates are removed, the better to exhibit the position of the buckets. The *shrouding-plates* are bolted upon the buckets and soling by bolts passing from side to side; and in order to prevent resilience in the wheel, the arms are supported with diagonal braces. The toothed segments which operate on the pinion are bolted to the side of the shrouding through palms cast upon them for that purpose, and the true position of these segments requires that their pitch-lines should coincide with the circle of gyration of the wheel: when so placed, the resistance to the wheel's action is made to bear upon its parts, without any undue tendency to cross strains. For that reason, it is improper to place the pitch-line beyond the circle of gyration, which is frequently done, even upon the periphery of the water-wheel. The determination of the true place of the circle of gyration is too abstruse to be introduced here, nor is it necessary to be so minute in the small wheels, to which our attention is chiefly directed; suffice it to say, that the pitch-line of the segment wheel should fall between one-half and two-fifths of the breadth of the shrouding, from the extreme edge of the wheel.

Overshot or Breast?—An important point to decide is whether the wheel is to be worked on the overshot or breast method. Where the fall is ample but the supply of water small, or moderate, the overshot is the best; where the water is fairly plentiful and the fall not so great, the breast may be most suitable. But whether the water be delivered over the top of the wheel or on the breast—that is a little below the crown of the wheel as shown in the illustration—the water should be allowed to fall through such a space as will give it a velocity equal to that of the periphery of the wheel when in full work. Thus, if the wheel move at the rate of 5 feet per second, the water must fall upon it through a space of not less than .4 foot; for, by the laws of falling bodies, the velocities acquired are as the times and whole spaces fallen through to the squares of the time. Thus the velocity acquired in 1″ being 32 feet, a velocity of 5 feet will be acquired by falling .156″; for $32 : 1'' :: 5 : .156''$, and $1''^2 : 16 :: .156''^2 : .4$ foot, the fall to produce a velocity of 5 feet. But this being the minimum, the fall from the trough to the wheel may be made double this result, or about 10 inches.

So as to secure the proper filling of the buckets, the breast-wheel at 5 feet per second should have the pen-trough, with two or three guide-vanes set to turn the direction of the water into the bucket at a velocity of about 6 feet per second. This will also prevent the force of the water from opposing the wheel. For an overshot wheel at 6 feet per second at the periphery, it would be well to have the water entering the bucket at about 7 feet per second.

Trough and Sluices.—The trough which delivers the water upon the wheel should be at least 6 inches less in breadth than the wheel, to give space for the air escaping from the buckets, and to prevent the water dashing over at the sides; the trough and spout convey the water to the wheel. It is convenient to have a regulating sluice, that serves to give more or less water to the wheel; and this is worked by a small shaft passing to the inside of the upper barn. The shaft carries a pinion working the rack of the sluice-stem, a small friction-roller being placed in proper bearings on the cross-head of the sluice-frame; and this apparatus is worked inside the barn by means of a lever handle upon the shaft of the pinion. As a waste-sluice, the most convenient and simple, in a mill of this kind, is the trap-sluice, which is simply a board hinged in the sole of the trough, which in opening turns up towards the wheel. It is made to shut close down to the level of the sole, and when so shut the water passes freely over it to the wheel. The lifting of this sluice is effected by means of the connecting-rod and crank-lever, the latter being fixed upon another small shaft, which passes through the wall to the interior of the barn, where it is worked in the same manner as the lade-sluice. When it is found necessary to stop the wheel, the trap is lifted, and the whole supply of water falls through the shoot, leading it to the bottom of the wheel-arc, by which it runs off, until the sluice at the dam can be shut, which stops further supply.

Speed of the Wheel.—The wheel here described, if it moves at the rate of 5 feet per second, will make 6¾ revolutions per minute. The pinion-shaft will carry a spur-wheel, by which all the other parts of the machine can be put in motion. The rate of the spur-wheel depends on the relation of the water-wheel and its pinion. In the present case they are in the proportion of 8 to 1, and as the water-wheel takes 6¾ revolutions per minute, this, multiplied by 8, will give 54 to the spur-wheel.

The Turbine.—The turbine is much superior to the ordinary vertical wheels for utilising water-power, and it is rapidly taking their place. It is an ingenious and powerful water-engine, one of the many useful inventions we owe to the development of science. It is suitable for high or low falls, and, as a rule, can be fitted in at much less cost than the common vertical water-wheel. The power which the turbine generates can be applied very easily, and the "engine" can be worked at different degrees of its capacity, so that it may be adapted either to the working of the chaff-cutter, root-pulper, or grist-mill alone, or to the threshing-machine and all the smaller machines combined. The turbine makes the most both of the water and the fall. As its action is not impeded by back-water, the turbine may be placed on a level with the tail-race, and thus give the water before entering the turbine the full benefit of the entire available fall. Its small size is another advantage, and a small bed of masonry is all that is required for its foundation. Turbines revolve with such velocity—from 80 up to 1400 revolutions per minute—that the motion for driving machinery may be obtained direct from the wheel-shaft, thus saving intermediate gearing.

Various types of turbines are in use in this country and elsewhere. In some, those invented by Fourneyron for example, the water is admitted to the central part of the wheel, and passes out of the circumference; in others (Jonval & Fontaine), the flow of the water is in a direction parallel with the axis.

The Thomson Turbine.—Thomson's Vortex Turbine (made by Williamson Brothers) consists of a movable wheel with radiating vanes which revolves upon a pivot, and is surrounded by an annular case closed externally, but having towards its internal circumference four curved guide passages. The water is admitted by one or more pipes to this case, and issuing through the guide passages, acts against the vanes of the wheel, which is thus forced round at a rate proportionate to the height of the fall. The water, as it expands its force, passes out below at the centre of the case.

Professor Rankine ascribed the advantages of the Vortex or inward-flow turbine to the following points:—

1. Its discharging water near the centre of the wheel.

2. The action of centrifugal force in regulating the pressure of the water within the wheel.

3. The mode of varying the supply of water when required.

4. The action of centrifugal force in regulating the speed.

The nature of these advantages he described as follows:—

1. The advantage of discharging the water near the centre of the wheel is of the following kind: In every form of turbine a whirling motion is given to the particles of water before they begin to drive the wheel, and the efficiency of the turbine depends on the completeness with which that whirling motion is taken away from those particles during the action on the wheel. By discharging the water from a part of the wheel whose motion is comparatively slow, the practical fulfilment of that condition is rendered more easy and certain.

2. The action of centrifugal force in the regulation of the pressure within the wheel is of the following kind. It is favourable to economy of power that the effective pressure of the water immediately after entering the wheel should bear a certain definite proportion to the effective pressure in the supply-chamber, not differing much in any case from one-half. The centrifugal force of the water which whirls along with the vortex wheel tends to preserve at its circumference the very pressure which is most favourable to economy of power; and the centrifugal force of the two discs of water contained between the wheel and the two shields

or cover of the wheel-chamber prevents that pressure from making the water leak out between the wheel and the casing.

3. The action of centrifugal speed is as follows: Should the load be suddenly diminished, and the wheel begin to revolve too fast, the centrifugal force of the water whirling along with it increases and opposes the entrance of water from the supply-chamber; on the other hand, should the load be suddenly increased, and the wheel begin to revolve too slowly, the centrifugal force of the water whirling along with it diminishes, and allows more water to enter from the supply-chamber; and thus sudden variations of the load are prevented from causing excessive fluctuations of speed, the whirling water acting as a governor. In outward-flow turbines the centrifugal force of the water acts in a contrary way, and tends to increase the fluctuation of speed. In parallel-flow turbines it has no sensible action of any kind.

4. The advantage of the mode of varying the supply of water to the vortex wheel by means of movable guide-blades turning about their inner ends, is of special importance, and consists in this, that how small soever the supply of water may be, the passages through which it flows are always of a smooth and continuous form, and free from enlargements and from sudden contractions or throttlings, which causes of waste of power can never be wholly avoided when the supply is regulated by sluices or side-valves.

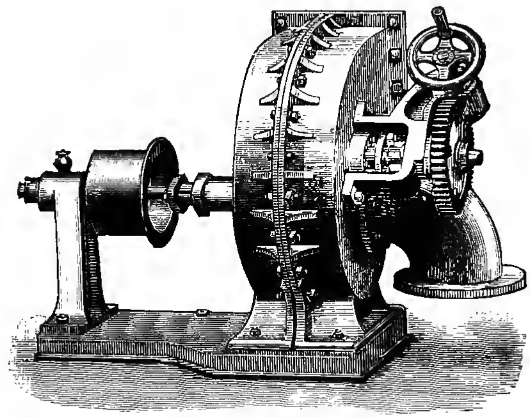


Fig. 179.—*Morton's turbine.*

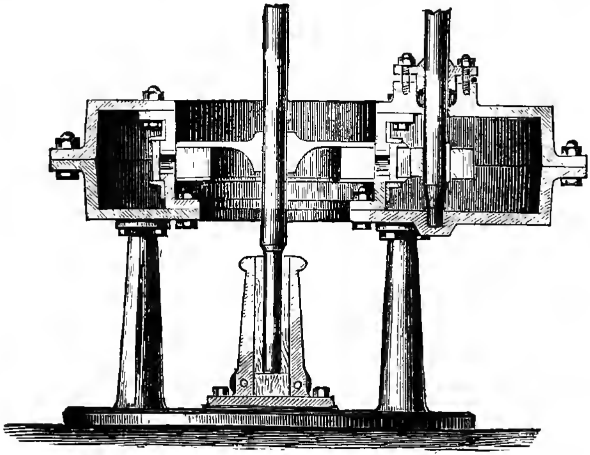


Fig. 180.—*Vertical section of horizontal turbine.*

This vortex turbine has come into extensive use, and has been applied to falls ranging from 3 to 400 feet.[1]

The Poncelet Turbine.—Mr R. G. Morton, Errol, whose turbine is illus-

[1] Scott's *Farm Engineering.*

trated in figs. 179 and 180, writes: "The poncelet turbine is a practically perfect poncelet wheel, in which the theoretical principles of perfection are fully carried out. An efficiency, obtained by experiments, of fully 60 per cent is claimed for the ordinary poncelet wheel. If this claim can be maintained, an efficiency of nearly 80 per cent may unquestionably be claimed for the poncelet turbine.

"The mechanism of the sluice of this turbine overcomes the well-known difficulty experienced in others when it is desired to work at less power, or when the water-supply is variable. In the poncelet turbine the variation is produced by totally closing or fully opening the sluice orifices in pairs, one of each pair being exactly opposite the other. By this means the efficiency is constant for all discharges, from the volume passing through a single pair of sluice orifices to the maximum."

Fig. 180 is a vertical section of the horizontal wheel, showing base and footstep, guide-vanes, regulating sluice and gear.

Horse-power.

As already indicated, horse-power for threshing purposes is gradually giving place to water or steam power—to the latter most largely. Still it is in use on many farms, and it demands brief notice.

Formerly there were two leading types of horse-wheels, known as *under-foot* and *over-head.* The under-foot was used chiefly where small powers are required, and the over-head on large farms where four horses and upwards were employed. But on nearly all large farms either the steam-engine or turbine water-wheel has taken the place of horse-power for threshing, so that the over-head horse-wheel is now rarely seen in use. It is therefore the under-foot horse-wheel that now prevails, and with it the horses draw by means of trace-chains and swing-tree. The horses usually worked singly, one at each lever or beam; but sometimes they are yoked in pairs, two horses at each lever. It is often found that horses accustomed to go together in the plough work most willingly in the horse-wheel when yoked side by side; and in this way also a greater force may, if desired at any time, be employed than with one horse to each lever or beam.

Horse-gear for one or two horses is now provided in great variety, and, as a rule, of a very convenient and serviceable description, easily fitted up or removed from one place to another. Only threshing-machines of small proportions can be worked by this form of horse-gear. Its most general function on the farm is to drive the chaff-cutter, turnip-cutter, cake-breaker, and grist-mill.

Driving Horses in Threshing.—To drive horses in a threshing-machine correctly, is a work which tests the natural temper of the driver more than most other operations. If he is a lazy or indifferent man, he at one time will look from him, and see the horses lagging as if coming to a stand-still; the next moment he will walk along with the horses; the nearest one then exerts himself beyond what he should. Or he will plant his back against the central shaft upon the platform within the wheel, which some threshing-machines have, but which should never be there, and at intervals will give a loud whoop with the voice, or a crack of the whip, which will make the horses nearest him push on with a start. Lagging causes the machine to take in the sheaves with difficulty, and at every start the sheaf will be drawn through suddenly, and escape the beaters. Now, a steady driver walks the course in an opposite direction to the horses, and he thus meets every horse quietly twice in every round of the course. Irregular action of the horses injures the more complicated parts of the machine, and makes bad work in the threshing and dressing of the corn.

THRESHING AND WINNOWING CORN.

The first preparation for *threshing* corn —that is, separating the grain from the straw by the threshing-machine — is taking in the stack to be threshed, and placing it in the upper or threshing barn.

Old-fashioned Corn-barrow Plan. —Formerly a common plan was to convey the sheaves from the stack to the sheaf-barn with a corn-barrow such as is illustrated in fig. 181. This method is scarcely ever pursued now except upon small holdings; yet it may be interesting to retain the description of the process which appeared in the third edition of this work.

The person appointed to superintend the barn-work forks down the stack to be conveyed into the barn. This is the steward, or the person who superintends the field-workers. The hedger does it when there is not much field-work in winter. Whoever undertakes the duty, he is assisted in it by 4 field-workers. When about to take in a stack, he provides himself with a ladder, and reaches its eaves with it; also a long small fork, employed to pitch sheaves at leading-time to the builder of stacks; and a strong clasp-knife, which most farm-servants carry. Standing on the ladder, he, in the first place, cuts away with the knife all the tyings of the straw-ropes at the eaves of the stack. On gaining the top, the ladder is taken away, and he cuts away as much of the ropes as he thinks will allow him to remove the covering with the fork. The covering is then pushed down to the ground, until the top of the stack is completely bared.

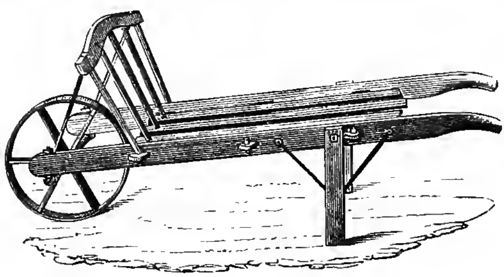


Fig. 181.—*Corn-barrow.*

On the side of the stack nearest the barn, a little of the covering is spread upon the ground by the field-workers, to keep the barn-sheet off the ground, and they unfold the sheet over the spread straw, close to the bottom of the stack. As many of the sheaves first thrown down from the top of the stack upon the sheet are taken by the women, and placed side by side, with the straw ends upon the edge of the sheet, along both its sides, as will keep the sheet from being blown up by the wind, or turned up by the feet.

Each barrow-load, as it arrives at the upper barn, is tilted upon the floor, and emptied at once, instead of the sheaves being lifted out of it one by one, the form of the barrow allowing this to be done. Two barrows, if the distance from the barn is not great, will bring in a stack of ordinary size in about 3 hours. The fourth worker remains in the upper barn, to pile up the sheaves as they are brought in into what are called *mows*—that is, the sheaves are placed in rows, parallel to each other, to a considerable height, with their butt ends outwards, the first row being piled against the wall.

In casting the stack, the steward takes up the sheaves in the reverse order in which the builder had laid them at harvest-time, beginning with those in the centre first, and then removing those around the circumference one by one. The fork thrust into the band will generally hit the centre of gravity of the sheaves, where they are most easily lifted, and swung towards the sheet. The sheaf is about the position it assumes on being pitched by a fork, the corn end always having a tendency to drop downwards.

When all the sheaves of the stack have been wheeled in, the steward takes a rake and clears the ground of loose straws of corn that may have been scattered from the stack to the barn, and puts them into the sheet, the four corners of which are then doubled in towards the middle, including within them the grain that had been shaken out by the shock given to the sheaves on being thrown down to the ground; and the sheet, with its contents, are carried by the women into the barn, and its contents emptied on the floor, near the feeding-board of the threshing-machine.

The sheet is then shaken, and spread out upon the stackyard wall, or other airy place, to dry before being folded up to be ready for use on a similar occasion.

The covering of the stack is carried away by the women to such parts of the courts and hammels as the cattle-man says require littering, in case it may become wetted with rain; and the ground is raked clean. The straw-ropes which bound down the covering of the stack should be cut *into short lengths* before being carried away in the litter, as *long* ropes are very troublesome to the men when filling their carts with dung on clearing out the courts.

Stacks should be carried into the barn in dry weather, though a drizzling or muggy day will do little harm to the straw. Damp straw passes through the threshing-mill not only with difficulty, but is apt to mould and contract a disagreeable smell in the straw-barn.

The *barn-sheet* is made of thin canvas, and should be about 12 feet square. It is useful not only for this, but many other purposes of the farm.

A very convenient form of *corn-barrow* is in fig. 181, the construction of which is obvious: it is 6 feet in length, and stands 2½ feet in height to the top of the bracket.

The sheaves are laid *across* the barrow in rows, with the corn and butt ends alternately, and they are kept from sliding off when wheeled by the slanting bracket supported by stays. In this way from 10 to 15 sheaves, according to bulk, may be wheeled away at once by a woman.

Carting Corn to be Threshed.—The almost universal plan now is to cart the unthreshed corn from the stack to the threshing-mill or machine. It is more expeditious than the time-honoured barrow-plan, and saves manual labour, which is more costly now than when the antiquated plan just described prevailed. The corn is usually carted to the sheaf-barn as the threshing proceeds; but in many places where there is sufficient sheaf-barn accommodation, a stack is stored there at some convenient time and threshed out at another time, or at intervals, according to circumstances.

In many cases where the threshing-machine is fed from the ground-floor, or where a cart-way can be made up to the level of the sheaf-barn on the first floor, the sheaf-door is made wide enough to admit the load of straw, which is deposited there by a tip-cart without any further handling. Where the sheaf-door is not wide enough to admit the load, the sheaves are usually forked off the cart into the barn. Where the floor of the sheaf-barn is level with the ground outside, the load of sheaves may be tipped at the door and carried or forked in. This is an expeditious plan when only one cart is employed in taking in the stack; but it has this drawback, that the tipping is apt to shake out grain from the straw.

Ladders.—Ladders are most useful about a farm-steading. They are best formed of tapering Norway pine spars, sawn up the middle. A useful form of ladder for farm purposes is in fig. 182, where the rounded form of the Norway spar, divided in two, is placed out-

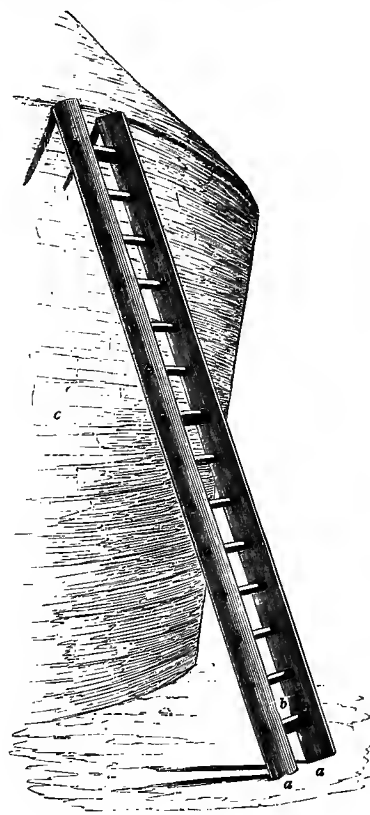


Fig. 182.—*Ladder*, 15 *feet long*.
a a Spars of ladder. c Stack.
b Steps of ladder.

most, though it is as often placed inmost. Those spars are connected together by steps of clean ash, pushed through auger-made holes in the spars, and rendered firm by means of wedges driven into the outside ends of the steps. The steps are 9 inches apart, and 16 inches long at the bottom, and 13 inches at the top, in a ladder of 15 feet in length, which is the most useful size for use in a stackyard. To prevent the ladder from falling to pieces in consequence of the shrinking of the round steps, a small rod of iron is passed through both spars, having a head at one end and a screw and nut at the other, *under* the upper, middle, and lower steps, the head end keeping its hold firmly while the screw end is rendered tight by the nut. When well finished and painted, such a ladder will last many years. A couple of ladders 10 feet, a couple of 15 feet, and one of 24 feet long, will suffice for all the purposes of a farm, as also for the repairs of the steading and houses.

Some dexterity is required to set a long ladder on end, as also to carry it from one place to another. To place it in a perpendicular position, its lower or heavy end is placed against any object that will prevent its slipping upon the ground; and on its light end being elevated arm's-length above the head, the position is kept good by another person taking one of the steps between the prongs of a long fork, by which the ladder is farther elevated, and the first person then pushes arm's-length, simultaneously, against one step after another, until the perpendicular position is gained.

A long ladder is carried a short distance in this way: Set the perpendicular edge of the ladder against the right shoulder, and then take hold of a step with the right hand, and raise the ladder steadily by it a little from the ground, while, to retain the perpendicular position, grasp a step above the head firmly with the left hand, and then walk steadily forward. Some can carry it steadily by grasping one step with both hands, with the edge leaning against the shoulder; and some even are so powerful in the arms as to carry a ladder by the steps at arm's-length before them, with one arm above and another below the head.

A ladder may be moved on the ground a short distance, while standing in a perpendicular position, by holding a spar in each hand at arm's-length, and then moving first one foot of the ladder in advance, and then the other, till the spot is gained.

A long ladder is brought down from the perpendicular to the horizontal position, by placing it against any object which will resist its foot slipping on the ground, and one person with the hands stretched above the head upon the spars: the ladder will approach the horizontal position the further he steps back, while the higher part is supported by another person with a long fork. When not in use, ladders should be hung along the stackyard wall, or some other handy stone or close wooden fence; and careful farmers will have slanting boards fixed above the ladders in roof-like fashion to protect them from rain-water, just as the projecting part of a roof at the "easing" prevents the roof-water running down the outside of the walls of a building.

Long ladders are more frequently destroyed by being brought to the ground in a careless manner, and by being blown down by the wind while resting against a stack, than by fair use.

Preparing for Threshing.—Before setting on the threshing-machine, its several parts required to be *oiled.* Fine machinery-oil should be employed for this purpose, though too often a coarse dirty oil is used. It should be put for use into a small tin flask, having a long narrow spout (fig. 183) to reach any

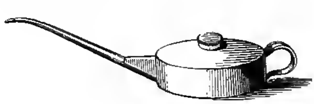


Fig. 183.—*Oil-can.*

gudgeon behind a wheel. It is important that the machine should be thoroughly oiled, and it should therefore be carried out with great care, and by one acquainted with the construction of the machine.

When steam is employed as the motive power, the fire should be kindled by the engine-man in time to get up the steam by the moment it is wanted. From half an hour to an hour may be required for this purpose, according to the state of the atmosphere.

When water is the power, the sluice of the supply-dam should be drawn up to the proper height, to allow the water time to reach the mill-wheel sluice when it is wanted.

When the power is of horses, the horses are yoked in the wheel by their respective drivers, immediately after leaving the stable at the appointed hour of yoking; and while one of the men is left in charge of driving the horses, the other men go to the straw-barn to take away the straw from the shakers of the mill with straw-forks, fig. 150, and fork it in mows across the breadth of the barn, which mows may be tramped down by a woman in narrow breadths—that is, where the straw is not carried away automatically, as in fig. 172.

Every preparation ought to be completed before the machine is started by the order of the person who is to feed the machine, and who should be a careful man of experience. The power should be applied gently at first, and no sheaf should be presented until the machine has acquired its proper momentum—the *threshing motion*, as it is termed.

Care in Feeding.—The capacity of the modern threshing-machines compels the feeder to be active at his work. The efficiency of the threshing, however, is not now so much dependent upon the care and skill of the feeder as was the case with the old-fashioned machines formerly in use. With the improved high-speed drums, the best modern machines make a perfect separation of the grain and the straw even with unskilled feeding, yet it is desirable that this important piece of work should be executed carefully.

It may therefore be useful to read the following directions given in previous editions to feeders of machines with slow drum-movement.

When the machine has attained proper speed, the feeder takes a portion only of a sheaf in both his hands, and, letting its corn-end fall before him on the feeding-in board, spreads it with a disengaging motion across the width of the board. His great care is, that no more is fed in than the mill can thrash easily; that none of the corn is presented sideways, or with the straw end foremost. He thus proceeds with a small quantity of corn for a few minutes, until he ascertains the capacity of the mill for work at the particular time, which is much affected by many circumstances, and then the requisite quantity is fed in. The ascertainment of the capacity of the mill is necessary every time the mill is used; for however well acquainted the feeder-in may be with it generally, and whatever power may be employed, it is not alike effective under all circumstances. For example, the water may flow quicker or slower; the horses move slower or faster, duller or brisker; and the steam be more or less easily raised, and retain its elasticity longer or shorter one day than in another.

The state of the atmosphere has a great influence on all these conditions. If water is flowing *freely into* the supply-dam while the threshing is going on, it will come more quickly towards the wheel, and consequently maintain the threshing pace of the mill for a longer time than when it flows from a full dam until it is emptied, when the power becomes less by degrees. So with horses: the state of the weather will oppress them one day, and they will work with languor and irregularity, do what the driver can to induce them; while on another day they will work with an active pace throughout the yoking. Little of this variation will, of course, be felt with steam.

Fig. 184 represents the feeding process in a threshing-mill of the olden type.

Irregular Driving.—There are certain circumstances which greatly affect the action of the machine in the *foulness* of its threshing. One depends—where horse-power is used—on the *driving of the horses*, in which a considerable difference is felt by the feeder when one man keeps the horses at a regular pace, whilst another drives them by fits and starts. The regular motion is attained by the driver walking round the course in *the contrary direction to the horses*, in which he meets every horse twice in the course of a revolution, and which keeps the horses upon their mettle, every horse expecting to be spoken to when he meets the driver. The irregular motion is produced by his walking in the *same direction* with the horses, when the horse next him makes the greatest exertion until he outstrips the man, when he slackens his pace; and then the horse following him, on coming up to the man, exerts himself until he also passes him; and so on in succession, one horse after another. The man always walks slower than the horses; and when he gives a crack of the whip the horses give a start, and strain the machine; but immediately after this they relapse into the irregular motion, caused as above described. In such a style of driving, a willing horse is sure to get more to do, and a lazy one less than he should, as horse-wheels are usually constructed. The gangway, which is sometimes made for the driver to walk on within the stays of the wheel, serves only to encourage in him carelessness and indolence.

The horses receive a breathing of 15 or 20 minutes at mid-yoking in the mill.

Removing Straw.—The straw, as it is threshed, is mowed up in the straw-barn, and the mowing is done in this manner—that is, where it is not carried away automatically, as shown in fig. 172, or trussed as in fig. 176. Two persons are required to take away the straw when the threshing-machine is in motion. The straw, as it falls from the shakers, is taken up in forkfuls, and carried to the part of the straw-barn where it is intended to be mowed up, and where a field-worker is ready to receive it and mow it up. The mowing consists of spreading the straw in a line, across the end or along one side of the straw-barn, in breadths or mows of 5 or 6 feet, and trampling it firmly with the feet; and when one mow has reached such a height as the roofing of the barn will easily allow, another one is made upon the floor beside it, and so on in succession, one

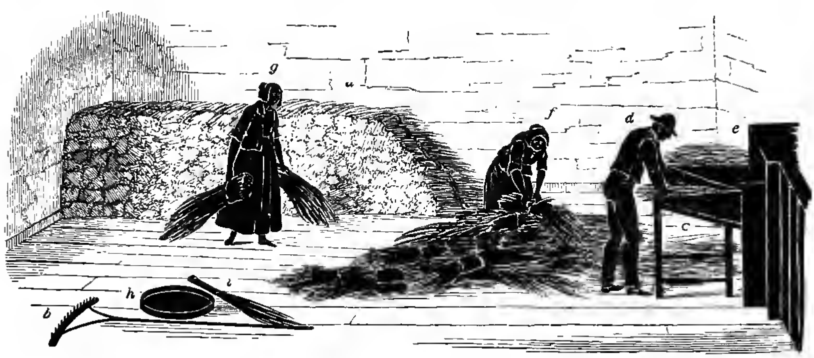


Fig. 184.—*Feeding in sheaves into the threshing-machine of the olden type.*

a Sheaves mowed up from the stackyard.
b Rake.
c Refuse on floor.
d Feeder-in of corn.
e Feeding-in board.
f Field-worker loosening sheaves.
g Field-worker bringing forward sheaves from the mow.
h Wecht.
i Broom.

mow after another, in parallel order, until the stack is threshed or the barn filled.

Mows of Straw.—The advantage of putting up straw in the barn in mows in preference to building it over a large portion of the barn-floor, is—that a mow receives the straw in forkfuls, which require to be only spread a very little before being trampled firm; whereas over a broad space the forkfuls would have to be carried to the farthest end and sides—a task which no single field-worker could do as fast as the men fork it. And moreover, when the straw is to be used, each mow is easily removed by force of the arms alone, whereas straw is very difficult to be pulled asunder when built up and trampled in broad spaces.

Carrying Straw to the Courts.—When a stack of litter-straw is being threshed, the cattle-man may be saved a good deal of trouble by the men or the women who are taking away the straw carrying the litter to the courts and hammels, should these require to be littered. In this case the straw is carried in back-loads from the shakers in short ropes, one end of which is hooked on to the bottom of the straw-screen, and the other end is held in one hand of the person who is to carry the load, while the other hand guides the straw into the rope. Those who carry assist each other on with the load in the barn. The carriers litter one court after another methodically, and not at random, in which they are assisted and directed by the cattle-man, and by the field-worker who would have had to mow the straw in the barn.

Straw-screen.—For the convenience of this process, as well as many others, it is better to have the end of the straw-screen, or straw-rack as it is sometimes called, cut off about 3 feet above the floor of the straw-barn, than to allow it to slope down to the floor, because, when so prolonged, its end is apt to be injured by the prongs of the forks when removing the straw; and it interferes with the bundling of straw directly from the mill, either for litter, fodder, or thatching stacks. In some machines there is no straw-screen at all, the straw falling on the floor direct from the shakers, which in modern improved machines do their work most efficiently.

Dressing Corn.

In former times the threshing and dressing of grain were distinct operations performed at different times. Now they may be said to be but two parts of one operation. The modern threshing-machine of the most improved type is so admirably equipped as to efficiently clean and dress the grain, as well as separate it from the straw; also "hummelling" or

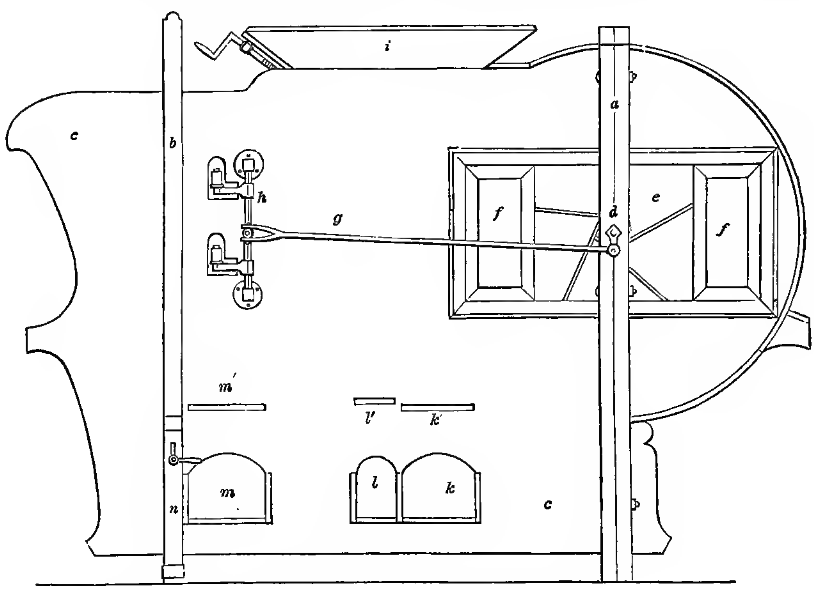


Fig. 185.—*Elevation of the dressing-fanner.*

a Fore-framing, made in halves.
b Back-frame, made single.
c c Side-boarding.
d Crank on fan-spindle.
e Arms of fans.
f f Sliding-panels on air-port.
g Connecting-rod.
h Bell-crank spindle.
i Hopper for undressed corn.
k l m Spouts for first, second, and light grain.
k' l' m' Sliders upon spouts for the opposite side.
n Slot-bar for adjusting the fanner to the floor.

"beating" the barley, and, as has already been explained, conveying the grain to the granary, and the straw to the extreme end of the straw-barn—all this in one continuous operation.

Still there are many farms on which the threshing-machines only partially dress the grain, and not a few indeed, mostly of small size, where the threshing-machines do little or nothing except separate the grain and the straw. Most probably another decade or two will see these latter cases reduced to rare instances; but that day has not quite arrived, and in the meantime it may be interesting to many, and useful to not a few, to present here the greater portion of the detailed information given in former editions as to the dressing of grain.

Corn-dressing Machines.—Some idea may, in the first place, be given of the machines employed in dressing corn. They are often named *blowers* or *fanners*, because they blow away the filth from the corn by means of fans. When cleaning-fanners are fixed to one spot, and are connected with elevators, they are generally of large dimensions, and of more complicated construction than when made to be moved about in the barn. Fig. 185 is the *elevation* of a fixed fanner, long used in the country, but now considerably improved upon. It is 6 feet 9 inches in length, 4 feet 9 inches in height, and 1 foot 9 inches in breadth. Fig. 186 is a *longitudinal section* of the same fanner, the letters of which partly correspond with those in fig. 185. The proportions of the wheel and pinion are 4½ to 1, the fan making from 212 to 220 revolutions per minute. The full complement of riddles for the riddle-frame is 6, of which 2 only can be employed at one time. Their meshes are—for wheat 5 in the inch, for barley 4 in the inch, and for oats 3 in the inch. The slap-riddles are three-quarter inch, and 1 inch in the meshes. The sieves

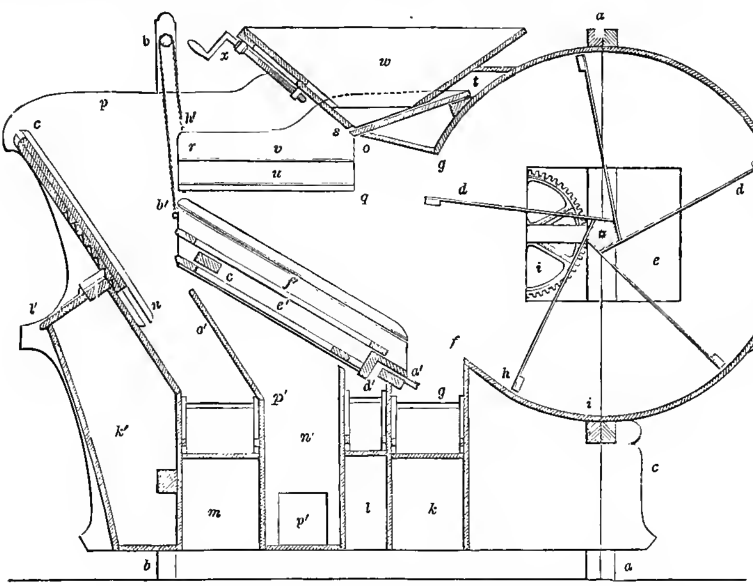


Fig. 186.—*Longitudinal section of the dressing-fanner, with riddles and sieves.*

a Fore-framing, in halves.
b Back-framing, single.
c c Side-boarding.
d d Arms of fans.
e Air-port of fans.
f g Space for discharge of air.
g o Funnel-board for the air.
s t Shoe.
q r s Riddle-frame.
u v Riddles, upper and lower.
w Hopper for corn.
s Sluice.
x Screw-winch to regulate feed.
a' b' Sieve-frame.
e' f' Sieves, upper and lower.
b' h' Chains supporting riddle-frame.
b Stretcher-rod across fanners.
i Toothed wheel acting on a pinion on fan-spindle, and moved by winch-handle.
k' Locker for spare riddles.
l' Lid of locker.
c n Slider for catching light corn.

are made of wire-cloth; the upper one has 9 meshes in the inch, the lower 7 meshes. When this fanner is in operation, the blast is sent through the funnel, its chief force being directed upon that end of the riddles; and as the grain falls from the hopper upon that end of the riddles, the lighter chaff is immediately blown off beyond the point of the slider, the remainder, with the grain, will be passing through the riddles towards the sieve; and during this stage, any remains of chaff are blown off, and the light grain and seeds are blown beyond the sieve-frame; the blast not having power to carry them over the slider, they fall down between it and the sieve-frame, and are discharged at the *lights* spout; at the same time, the heavy grain and seeds fall upon the upper sieve, when all the plump full-sized grains roll down over this sieve, and are delivered at the *firsts* spout; these grains, together with other seeds whose specific gravity exceeds the foot of the lower sieve, into the chamber of the *seconds* spout. The smaller seeds, such as those of *sinapis* and others, being too small to be retained even upon this sieve, fall through it, and are received into a chamber, from which they are removed at convenience through an aperture which is closed by a sliding shutter. Fig. 187 is a *transverse section* of the dressing-fanner.

The finishing-fanner or *duster* is a fanner of simpler construction than fig. 185, although as regards the blast it is constructed on the same principle. Fig. 188 is a *transverse section* of the finishing-fanner, fig. 189 is an *elevation*, and fig. 190 is a *longitudinal section*. The framework is similar to fig. 185, but its overall dimensions are smaller, the extreme length being 5 feet 8 inches, the height 8 feet 8 inches, and the width, as before, 1 foot 9 inches. In operating with this fanner, the grain is taken from the hopper by the revolution of the feeding-roller; and as it falls perpendicularly in a thin sheet, is intercepted by the blast under the most favourable circumstances. All such chaff and dust as yet remain amongst it are blown over the sliders; the light grain that may have remained is separated over the sole, and falls down the spout; the remainder runs down the sole, and in passing over the sieve, should any small seeds yet remain, they are intercepted, and fall through it, while the best corn passes on, and is delivered at the end spout.

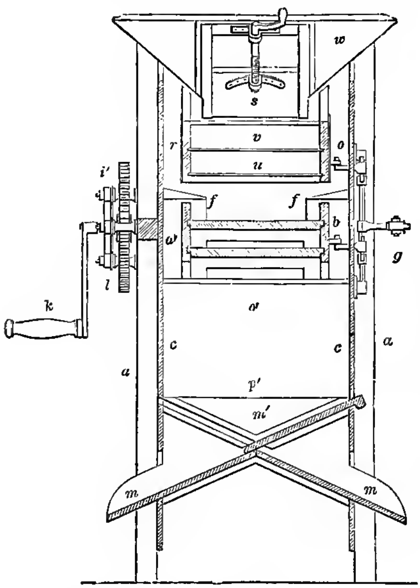


Fig. 187.—*Transverse section of the dressing-fanner.*

a a The frames.
c c Side-boardings.
m m Light spouts.
m' Sliders to change direction of discharge.
o' p' Sloping division.
a' b Sieve-frames with sieves.
f f Flaunch-boards.
r o Riddle-frames.
u v Riddles.
w Hopper.
s Sluice.
g End of connecting-rod.
b o Attachments of riddle-frames with bell-crank.
i' Toothed wheel.
k Winch-handle.
l Framework.

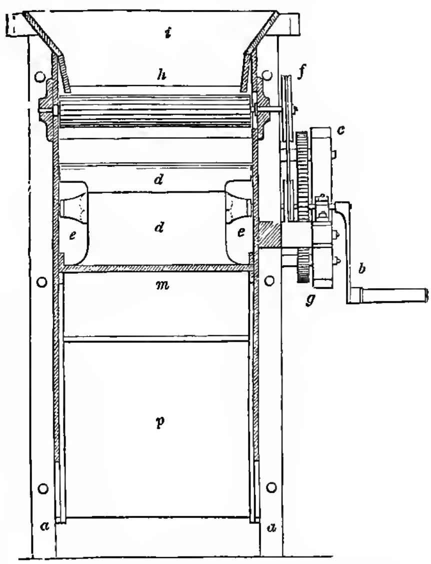


Fig. 188.—*Transverse section of the finishing-fanner or duster.*

a a Frames.
b Winch-handle.
c Wheel-framing.
g Wheel.
f Pulley of feeding-roller.
h Feeding-roller.
i Hopper.
m The sole.
p Division under the sole.
d d Arms of fans.
e e Axle of fans.

Modern Winnowers.—The modern winnowers, worked in conjunction with the threshing-machine, are, as a rule, built upon similar principles to those on which the machines just illustrated were constructed, but many improvements have been introduced which enhance their efficiency. The blowing, finishing, and dusting—that is, the blowing away of the chaff, the separating of the light grain from the heavy, and the removal of sand and dust—are now all performed

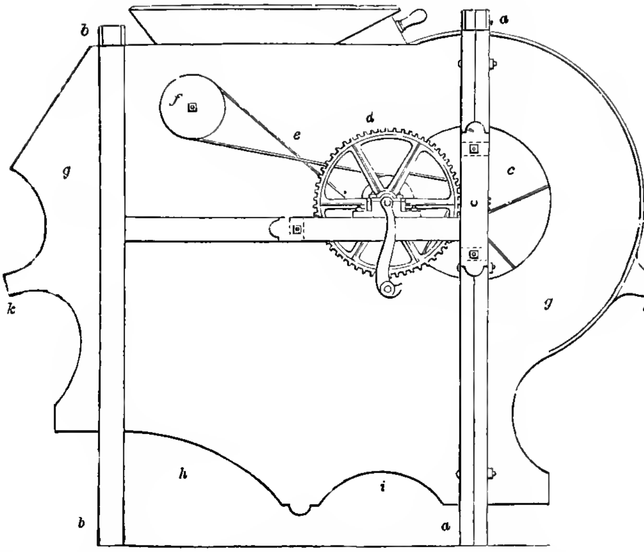


Fig. 189.—*Elevation of the finishing-fanner or duster.*

a a Frame, in halves.
b b Frame, single.
c Air-port.
d Wheel and pinion.
e Cross-belt between wheel and pulley.
f Pulley on axle of feeding-roller.
g g Side-boarding.
h i Boarding cut away to give access to light corn and seeds.
k l Handles to carry the fanner.

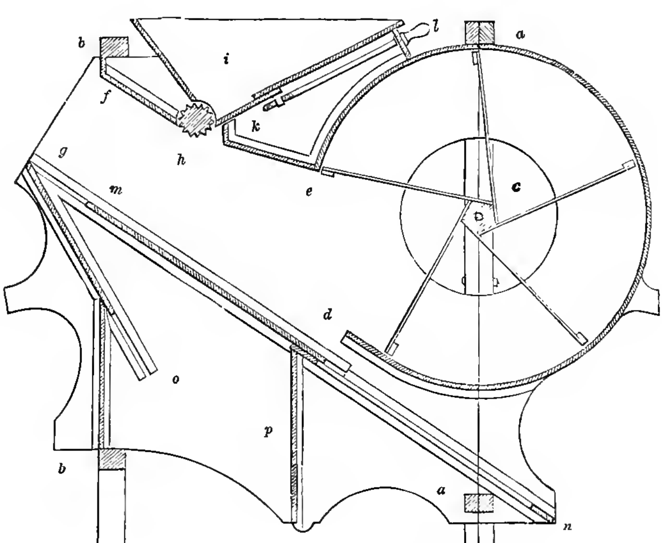


Fig. 190.—*Longitudinal section of the finishing-fanner or duster.*

a a, b b Cross-rails of the frames.
c Air-port.
d e f g Open funnel for the air.
h Feeding-roller.
i Hopper.
k Slider of hopper.
l Adjusting-screw.
m d Solid sole of funnel.
d n Wire-sieve for good corn.
n End spout.
m d, g o Slides up and down for chaff and light corn.
p Division between light corn and seeds.

by one machine—a machine of which there are numerous patterns, made by various firms, many of them very ingenious, and nearly all very efficient.

It is necessary to have at all farms at least one detached corn-dresser, as even with modern threshing and finishing machines it is usually desirable to put once through a winnower, before sending to market, grain which may have lain in the granary for a little time. Indeed, the majority of farmers still put the grain once through a separate winnower after leaving the threshing-machine. In some cases arrangements are made whereby the grain as it leaves the elevator, raising it from the threshing-machine as at z' in fig. 172, falls into the hopper of a winnower, which is worked by hand, and which remains in the granary to give the grain its finishing touches.

In fig. 191 a representation is given of an improved corn-dressing machine, with apparatus attached, for bagging and weighing the grain automatically, made by T. Corbett, Shrewsbury. The elevator is worked by a strap from the driving-wheel spindle of winnower, and raises the grain by conducting tins, as it passes from the machine, into a hopper, sufficiently high to apply a bag at full length. Under the spout is an ordinary weighing-machine, to which a cord passes from a catch applied in the elevator spout, so that when the bag (which is placed on the weighing-machine) has its proper weight, the descent of the machine disengages the catch, and the slide falls instantly, and thereby prevents a further discharge. The hopper is sufficiently large to receive the grain while the attendant is moving the bag and applying another, by which arrangement the laborious work of filling the bag from the machine is dispensed with, and at the same time a saving of two men is effected. The grain may be elevated at the rate of from 60 to 80 bushels per hour, with wonderfully little difference in the power required to work the winnower.

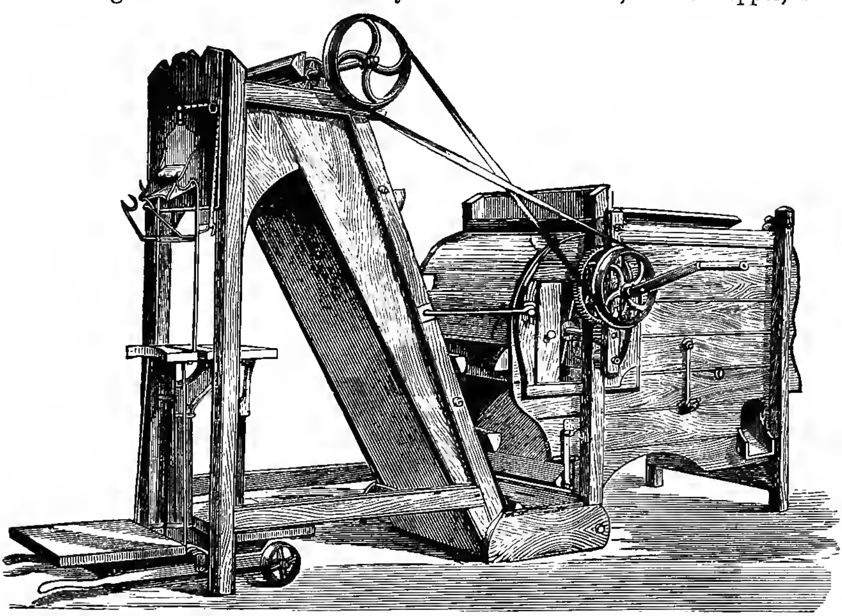


Fig. 191.—*Combined winnower and bagging-machine.*

Many of the improved modern winnowing-machines are so constructed that by change of riddles, screens, &c., all kinds of grass as well as grain seeds can be cleaned by them. Notwithstanding their more varied accomplishments, the modern corn-dressing machines are easier to work than the simple and less efficient but clumsier machines of former times.

Corn-screens.—Screens of various

patterns are often used in addition to winnowers in dressing and finishing grain. By these screens sand and dust are thoroughly removed, and small seeds are separated from those of the proper size. Screening is specially serviceable in dressing barley for malting purposes, uniformity of the size of the grain being an element of some importance in the manufacture of malt. Some of these screens are made on the flat, and others on the rotary, principle.

Barn Implements.—There is less use now than formerly for such appliances as riddles, *wechts* or *maunds*, and shovels, in the corn-barn. In former times hand-riddles played an important part in the

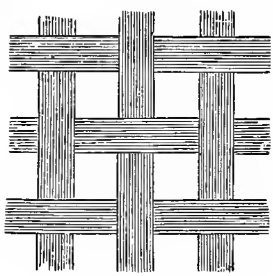


Fig. 192.—*Old wooden wheat-riddle.*

cleaning of grain, but they have been almost entirely supplanted by improvements in the threshing and dressing machines. The riddling of the corn was heavy and tedious work; and altogether

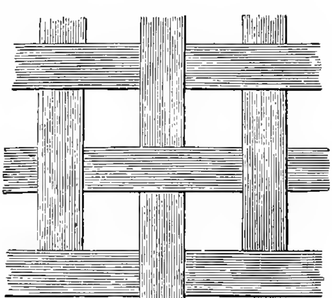


Fig. 193.—*Old wooden barley-riddle.*

there are few branches of farm-work in which there has been greater saving of manual labour through the introduction of improved mechanical contrivances than in the threshing, dressing, and handling of grain.

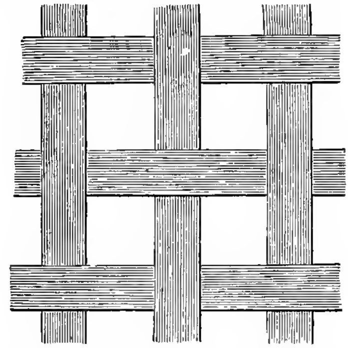


Fig. 194.—*Old wooden oat-riddle.*

Riddles.—Although they are now little used, it may be interesting to pre-

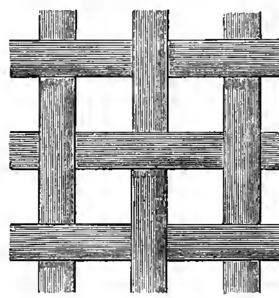


Fig. 195.—*Old wooden bean-riddle.*

serve here some of the illustrations of the barn implements in use in former

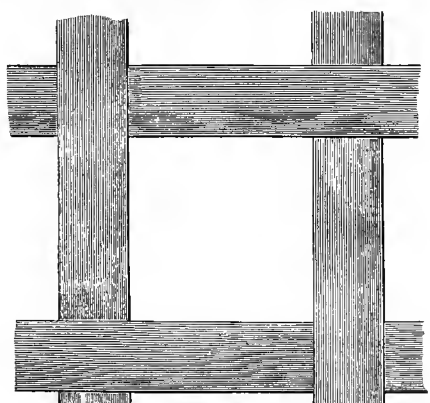


Fig. 196.—*Old wooden riddle for the roughs of wheat and corn*

times, and illustrated in previous editions of this work. See figs. 192 to 196. In earlier times riddles were, as a rule, made of wood, but latterly wire came to be extensively used. In the illustrations the meshes are shown at full size, and

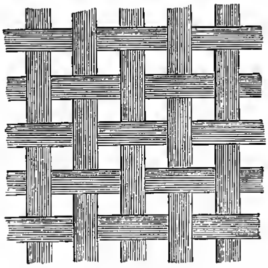


Fig. 197.—*Wooden sieve.*

the diameter of the riddle was usually about 23 or 24 inches. The mesh for wheat was ¼ inch square, for barley and beans $\frac{5}{16}$ inch, and for oats ⅜ inch; while for riddling the roughs of wheat and oats a riddle with meshes of 1 inch square was employed.

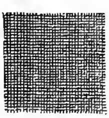


Fig. 198.—*Iron-wire sieve.*

Sieves.—The use of the sieves was to sift out dust, earth, and small seeds from corn. The wooden sieve, fig. 197, had meshes of ⅛ inch square, and the iron-wire sieve, fig. 198, 64 meshes to the square inch, including the thickness of the wire. Fig. 199 is a triangular-meshed iron-wire sieve, with an oak rim.

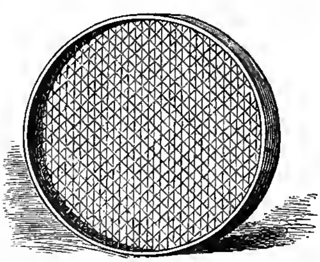


Fig. 199.—*Triangular-meshed iron-wire sieve.*

Barn Wechts or Baskets.—A form of *wecht* or *maund* long in use for taking up corn from the bin or floor, is represented in fig. 200, made either of withes or of skin, attached to a rim of wood. A young calf's skin with the hair on, or sheep's skin without the wool, tacked to the rim in a wet state, after becoming dry and hard, makes a better and more durable wecht than wood. Baskets of close and beautiful wicker-work, such as fig. 201, have been used in barns in parts of England instead of wechts.

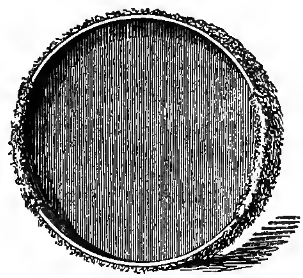


Fig. 200.—*Wecht of skin.*

The articles for lifting the loose corn, either for pouring into the bushel, the bag, or the winnower, are now usually made of wood, almost square, with a deep frame at three sides; and these are much more expeditious than the older forms.

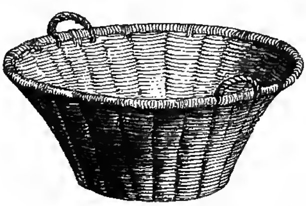


Fig. 201.—*Corn-basket of wicker-work.*

Barn-stool.—A strong four-legged *stool*, 2½ feet long, 9 inches broad, and 9 inches high, fig. 202, made of ash, is useful in a barn, to allow the women to reach the hopper of the fanner easily. For want of a stool the inverted bushel is taken to stand upon, much to its in-

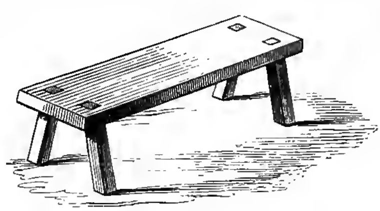


Fig. 202.—*Barn-stool.*

jury. There is, of course, much less need for this homely article than in former times, yet it may still at times be useful, and will not add much to the outlay for barn machinery.

Barn-hoe.—A *wooden hoe*, fig. 203, 7 inches long and 4 inches deep in the blade, fixed to a shaft 9 inches long, made of plane-tree, is better than the hands to fill wechts with corn from the floor.

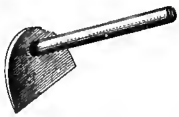


Fig. 203.—*Barn wooden hoe.*

Corn-shovels.—A couple of wooden *scoops* or shovels, such as fig. 204, to shovel up the corn in heaps, and to turn it over, are indispensable implements in a corn-barn. The scoop is 3 feet 3 inches in height, with a head like a common spade; a helve 18 inches in length, and the blade 14 inches wide and 16 inches long. The blade, helve, and handle are of one piece of wood, of plane-tree, the belly of the blade being a little hollowed out, and its back thinned away to the sides and face. Sometimes scoops are made longer, with a handle of a separate piece of ash, but they are clumsy implements when made of more than one piece of wood. A wooden scoop does not injure a floor so much as an iron spade, and better retains the corn upon its face in the act of shovelling.

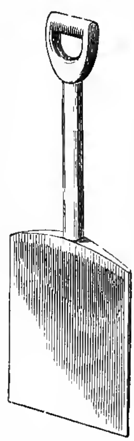


Fig. 204.—*Wooden corn-scoop.*

Barn-brooms.—Excellent brooms for the corn-barn and granaries are made of stems of the broom plant (*Genista scoparia*), about 3 feet in length, simply tied together with twine at one end, and used without a handle. The broom is also in the best state when fresh, and becomes too brittle when dry. When long straight stems of the common ling (*Calluna vulgaris*) can be procured, they make both good and durable brooms. A hard birch-broom is required to clear the dirt from between the stones of a causeway, while the softer broom answers best for the barn-floor. Hair brooms do not answer, as bristles have not strength to clear away the heavier dust often generated in barns. Perhaps brooms of whalebone or of coir would do.

An open coir *mat* in a corn-barn is useful in cleaning the feet of the workers when coming into the barn.

Nails or pins of wood should be driven at convenient places in the walls and partitions of the barn, to hang the riddles, wechts (or baskets), and sieves upon.

Winnowing in Olden Times.—Dressing corn in the olden times, when the threshing-machines and flails left the grain and the chaff together, was a very tedious process, taking a great deal of time from the farm hands. A scene such as that depicted in fig. 205 was quite common up till 1860, and even later in certain parts of the country; but now,

Fig. 205.—*Winnowing corn in olden times.*

a Fanner.
b Driver.
c Woman feeding the hopper.
d Woman taking up corn.
e e Women riddlers.
f Corn-basket.
g Wooden shovel.
h Besom.
i Light corn.
k Chaff.

happily, very little work of this kind has to be done.

Care in Dressing Corn.—The farmer will find it advantageous to see that his grain is perfectly dressed before sending it to the market or using it for seed. Most likely he will find it necessary to put it once through a winnower after it leaves the threshing-machine and fanners attached. If this after-dressing does not leave a clean uniform sample, it becomes evident that a turn of the screen would be useful. In former times the hand-sieve was made to perform the function now much more expeditiously and efficiently accomplished by the screen.

Measuring Grain.—Corn is now invariably measured by the imperial bushel, fig. 206. It is of cooper-work, made

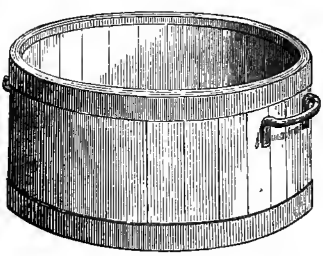


Fig. 206.—*Imperial bushel of a convenient form.*

of oak and hooped with iron; and, according to the Weights and Measures Act, must be stamped by competent authority before it can be legally used. Having been declared the standard measure of capacity in the country for dry measure, it forms the basis of all contracts dependent on measures of capacity when otherwise indefinitely expressed (5th Geo. IV. c. 74, sec. 15). The bushel must contain just 2218.19 cubic inches, though its form may vary. The form represented in this figure is somewhat broader at the base than at the top, and furnished with two fixed handles. It is not too broad for the mouth of an ordinary half-quarter sack, nor too deep to compress the grain too much; and its two handles are placed pretty high, so that it may be carried full without the risk of overturning.

Some bushels are made inconveniently broad for a sack, made shallow that the corn may not be compressed in them. Others are so spread at top as to render them unsteady. Some have no handles, and must be lifted in the arms; whilst others have only one handle, sometimes jointed, and sometimes too low. These different structures of bushels are inconvenient when much corn has to be measured up in a short time.

In connection with the bushel is the *strike* for sweeping off the superfluous corn above the edge of the bushel. It is made of two forms; one a flat piece of wood, the other a roller (fig. 207). The

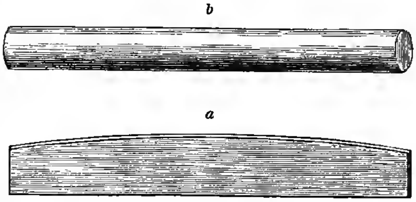


Fig. 207.—*Corn-strikes.*
a Flat corn-strike. *b* Cylindrical corn-strike.

Weights and Measures Act prescribes that the strike shall be round, of light wood, 2 inches in diameter; but he who drew up the Act must have had little experience of using one. If the object of striking corn in a bushel be to separate one stratum of grains from another, the *sharp* edge of the flat strike is best fitted for the purpose. A cylinder, passed in a continuous motion over a bushel, must push down some of the grains in front under it; and if it is *rolled* across the bushel, it must press down still more grains, and *make* the bushel hold more corn than it should contain. On striking wheat, the flat strike is drawn straight across the bushel; the grains, being nearly round, settle themselves easily to the forward motion of the strike; but with barley and oats, peas and beans, their grains not being round, the strike should be moved across the bushel with a zigzag motion. The strike should be made of seasoned wood, and plane-tree is the best.

Bagging Grain.—As already indicated, a great deal of grain is now run into bags or sacks right from the threshing and finishing machine, or from a detached dressing-machine; but in former times the universal practice was as represented in fig. 208.

Some care is required in measuring

corn. The bushel should be filled at once, because two separate basketfuls will put more corn into it than two at once. The basketfuls should be poured into the bushel from a small height, the higher fall compressing more grains into the bushel. The women are purposely shown in fig. 208 pouring the corn from too great a height into the bushel. The bushel should be striked immediately

Fig. 208.—*Measuring up corn in the corn-barn.*

a Measurer of corn.
b Bushel.
c c Women filling bushel.
d d Women holding the sack.
e Sack being filled.
f Sack-barrow.
g Filled sacks.
h Empty sacks.
i Heap of corn.
k Wooden shovel.
l Besom.

after it is filled. The corn raised in the centre of the bushel by the pouring should be levelled lightly with a wave of the fingers of the left hand, not lower than the edge of the bushel farthest from the heap, and sweeping the edge clear of corn, the strike is applied to make the superfluous corn fall off near the heap.

As proof how much grain sinks in a bushel, a space round the rim will be seen the moment the bushel is touched to be emptied; and with a smart stroke

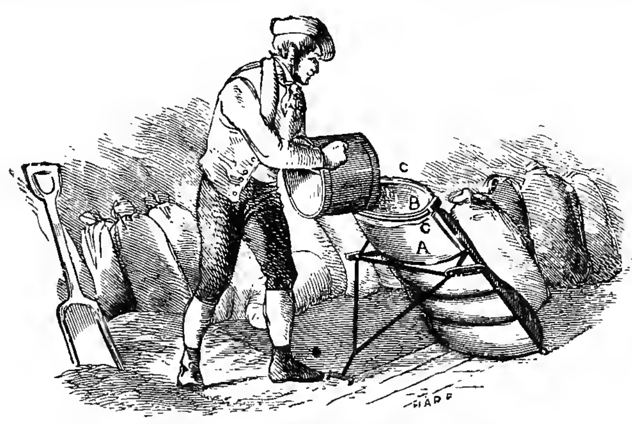


Fig. 209.—*Bagging grain with sack-holder.*

of the strike the grain will subside a considerable space.

It is much easier for a man to carry a firmly filled sack than one loosely filled. A filled sack is under command; in a slack one, the corn is apt to shift, and change the centre of gavity of the load.

Formerly, the almost universal custom was to put exactly four bushels into each bag and ascertain the weight of the grain by weighing two or three bushels taken from the body of the heap of grain. Now, grain is more frequently bagged and sold by weight than by measurement, the quantity sometimes reduced or measured, according to whether it is unusually heavy or exceptionally light, to bring it to the standard weight of four bushels. The standard weights of the different kinds of grain vary throughout the country—oats from 38 to 42, barley about 54, and wheat 60 or 62 lb., per bushel.

A useful arrangement by Richmond & Chandler for saving labour in bagging grain is represented in fig. 209.

Hummellers.—Wheat and oats are dressed clean by the winnower; but it is otherwise, at times, with barley. When barley has not been thoroughly ripened, the awns are broken off at a distance from the grain by the threshing-machine; and as the part left must be got rid of before the corn can be clean dressed, a *hummeller* is used for the purpose. Improved modern threshing-machines are provided with hummellers, so that barley as well as oats and wheat is threshed and dressed at the one operation. The hummellers in use are of various patterns; and besides those worked in conjunction with threshing-machines, there are hummellers which work separately. The hand-hummellers are now seldom used, except on small holdings. A very simple form of hand-hummeller is shown in fig. 210. It consists of a square frame of iron, 12 inches each way, 2 inches in depth, and ⅛ inch thick. Bars of similar dimensions are riveted into the sides of the frame, and crossing each other, form compartments of from 1½ to 2 inches square. A branched iron stem is riveted to the frame below and at top, and forms a socket into which a wooden helve is fixed, having a cross-head by which it is held in the hand. Such hummellers are also made with parallel bars only, in which case they are less expensive but much less effective. It is used with a mincing motion on a thin layer of barley on the floor.

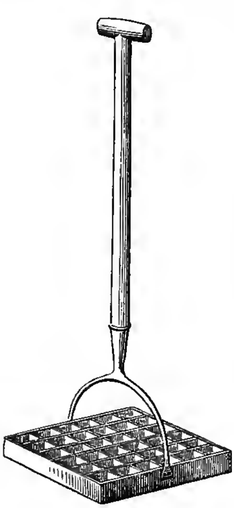


Fig. 210.—*Simple hand-hummeller.*

Arranging Sacks of Corn.—To make sacks stand so that each may be taken away with ease from a number, the first one should be set in a corner, with one shoulder against one wall, and the other shoulder against the other wall, fig. 211; and every other sack in the same row will stand with the left shoulder against the wall, and the right shoulder against the side of the sack set down before it. In the second row, the first sack will have its right shoulder against the wall, and its left shoulder in the hollow between the first two sacks of the first row; and so on, with the second and third sacks, row after row. In short, the sacks stand shoulder to shoulder instead of side to side.

Now, the utility of this arrangement is, that the sacks are as closely set together as they can. As each sack is removed in the reversed order from that in which it was placed, it presents its broad side to the barrow to be wheeled away, or to be lifted upon a man's back.

The figure shows the difference between tight and slovenly sacking of corn, in the crease at the bottom of the third sack of the second row, and the projections of its corners. The first in this row is a well-filled sack.

Filled sacks wheeled aside should have their mouths flat-folded. On tying sacks, which they must be when intended to be sent away by cart, the tying should be made as near the corn as possible, so as to keep the sack firm.

Lifting Sacks of Corn.—There are four modes of lifting a sack to a man's back. One is, for the man to bow his head low down in front of the sack, bending his left arm behind his back, across his loins, and his right hand upon his right knee. Two persons assist in raising the sack, by standing face to face, one on each side of it, bowing down and clasping hands across the sack near its bottom, below the carrier's head, and thrusting the fingers of the other hands into its corners. Each lifter then presses his shoulder against the edge of the sack, and with a combined action upwards, which the carrier seconds by raising his body up, the bottom of the sack is placed uppermost, and the tied mouth downmost, the sack resting upon the back of the carrier. The lifters leaving hold, the carrier keeps the sack steady on his back, with his left arm across its mouth.

Another plan is, for the carrier to lay hold of the top of the shoulder of the sack with both hands and crossed arms. His two assistants do as directed before; and while they lift the sack between

Fig. 211.—*Filled sacks on the barn-floor properly arranged.*

a First sack set in a corner.
b c Second and third sacks in the first row.
d First sack in second row set in the hollow between *a* and *b*.
e f Second and third sacks of second row.
g h Bottom of ill-filled sack.
d Well-filled sack.
d e f Sacks with folded mouths.
a b c Sacks with tied mouths.

them, the carrier quickly turns his back round to the sack and receives it there, retaining a firm hold of all the parts he had at first.

A third plan is for the assistants to lift the sack upon another one, and the carrier lowers his back down against the side of the sack, laying hold of its shoulders over his own shoulders, when he is assisted in rising up straight with it on his back. A fourth plan, and by far the easiest, is with a sack-lifter, of which there are different patterns. A simple form of sack-lifter is shown in fig. 212, which consists of two pieces of ash, 3 feet 9 inches long, terminating at both ends in the form of handles, and united together, at 15 inches apart, by three cross-bars of wood tenoned and mortised into the handles. A thin boarding is placed over the bars for the sacks to stand upon. On using it, the sack is lifted upon the board; two assistants, taking hold of the handles, lift it up simultaneously, while the carrier turns his back to the load to receive it.

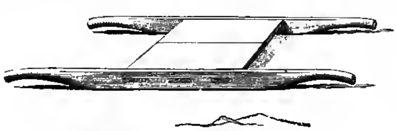


Fig. 212.—*Sack-lifter.*

An improved and very convenient sack-lifter is shown in fig. 213. This is a combined sack-barrow and sack-lifter, made by Clayton & Shuttleworth. The barrow is pushed below the sack in the usual way, and then, by the handle shown, the bag is screwed up sufficiently high to enable a man to take it easily on to his back.

The more upright a man walks with a

loaded sack on his back, with a short firm step, the less will he feel the weight of the load.

A filled sack is kneed forward from one spot to another by placing both knees against one side of the sack, while

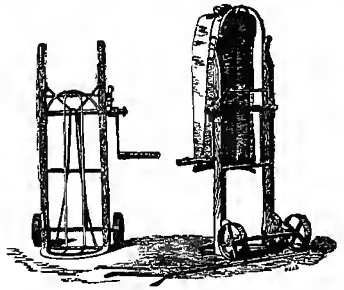


Fig. 213.—*Combined sack-barrow and lifter.*

embracing the other side with both arms, and lifting it slightly from the ground, while pushing it forward a space with the knees, and thus space after space is attained.

Loading a Cart with Sacks.—In regard to loading a cart with filled sacks, the general principle is to place all the mouths of the sacks within the body of the cart, that should any of the tyings give way, the corn will not be spilled upon the ground. The mode of loading a double-horse cart so is shown in Plate I., which is intended to represent the general method of conveying grain to market prior to the introduction of railways. Two sacks are laid flat on the bottom of the cart, with the mouths next the horse. Two are placed with their bottoms on the front; two on the tail-board, with their bottoms in the rear; other two on edge above these four; and one behind, on its side, with the mouths of all three pointing inwards. From 54 to 60 bushels, in 6-bushel sacks, used to be carried by two horses, as in the plate, according to the distance; but now half-quarter sacks and single-horse carts are employed, the loads are placed in a different form, according to the length of journey, and whether the horses return home loaded or empty. About 36 bushels of wheat, 40 of barley, and 54 of oats, each quantity making about 1 ton weight, is considered a good load for a double cart in the country in a journey of some miles; and a single one will take a proportionate quantity of 15 cwt. The carters in towns take much heavier loads of corn than those in the country.

Corn-sacks.—The *sacks* for corn require attention to keep them serviceable. They are usually made of tow yarn, manufactured, tweeled, or plain. Every sackful of corn, before it is put into the cart, is tied at the mouth with a piece of soft cord. The ties should be fastened to the seam of the sack. Every sack should be marked with the initials of the owner's name, or the name of the farm, or with both. The letters are best painted on with a brush, rubbing the paint upon open letters cut through a plate of zinc.

When sacks become wetted with rain they should be shaken and hung up to dry; and if dirtied with mud, they should be washed and dried. If the air in winter, when sacks are most used, cannot dry them in time to prevent mouldiness, they should be dried before a fire. Where steam is used for threshing, sacks may be dried in the boiler-house. An airy place to keep sacks is across the granary, over ropes suspended between the legs of the couples.

Holes will break through sacks, by wear and tear, or mice. The best thread for darning even canvas sacks is strong worsted. When a sack is much torn, it is used to patch others with. The person who has the charge of threshing and cleaning the corn has also the charge of the sacks, and must be accountable for their number.

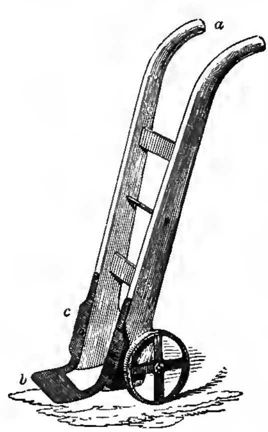


Fig. 214.—*Sack-barrow.*
a Handle. *b* Shelf.
c Shields over wheels.

Sack-barrow.—Sacks, filled, are most easily removed to any part of the barn by a sack-barrow, fig. 214—see also fig. 213. The height of the barrow in fig. 214 is 3½ feet, and breadth across the wheels 1½ foot.

The body consists of two stilts of ash-wood, connected together in the centre with two bars of wood and one iron bolt with head, screw, and nut. The lower ends are united by a shield of iron on each, terminating at a high angle in an iron shelf for receiving the bottom of a sack. Two iron wheels, connected by an iron axle, support the load in motion, and are so placed in reference to the shelf, as that the body shall stand a little inclined back off the perpendicular. The frame may be painted or left plain.

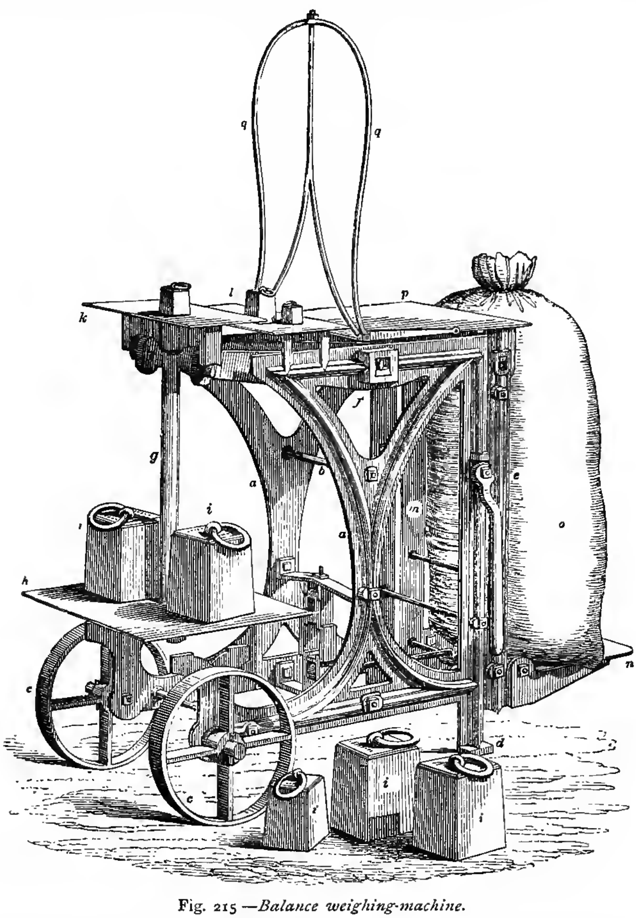


Fig. 215.—*Balance weighing-machine.*

a a Cast-iron framework.
b Cross-stretcher bolts.
c c Wheels.
d Feet.
e Folding handles.
f Double beam of cast-iron.
g Pillar.
h Shelf-plate.
i i Weights.
k Top scale.
l Dead-plate for small weights.
m Framing.
n Shelf for sacks.
p Upper shelf or scale.
q q Light frame for supporting sacks when placed on the upper scale.

The mode of using the sack-barrow is this: When the full sack is standing by itself, the person to remove it stands behind the wheels, and taking a hold of the handle with the right hand, and pushing off the mouth of the sack at arm's length with the left, shoves the shelf, with the foot between the bottom of the sack and the floor, and then pulls the sack towards him upon the body of the barrow. When the sacks are as in fig. 211, lying a little off, the shelf is pushed under the sack, and held firm there by the foot upon the axle; the sack is pulled by the left hand upon the body of the barrow. The iron shields *c*, fig. 214, over the wheels, save their rubbing against the sacks. The load is most easily wheeled away when the barrow is in a nearly upright position.

Weighing-machines.—A weighing-machine is an important article of barn furniture, and various forms of it are resorted to. The common beam and scales is the most correct of all the instruments of the class; but it is defective, as being less convenient for the purposes of the barn than several others that are partially employed. Steelyards of various forms are also used.

A weighing-machine on the balance principle, which combines every convenience for the setting on and removal of the bags of corn, with accuracy and neatness of construction, is shown in fig. 215. The beam is double, with steel centres, the two bars forming the beam-stand, and are connected by a diagonal truss. The one end of the double beam supports a cross-head suspended on the end centres of the beam, and to which is attached a pillar, to the lower end of which is attached the shelf-plate or scale upon which the principal weights are placed. The cross-head carries also the top scale, upon which the smaller weights are placed, and a dead-plate is fixed on the frame-work on which the small weights stand ready for use. The opposite ends of the beam carry a frame, to the lower end of which the shelf is jointed, upon which bags about to be weighed are placed. To the upper end of the frame is also attached, by a strong bracket, a scale, upon which a bag may be placed and weighed with equal accuracy, while it is supported by the light frame. The object of the top and bottom weighing-shelves is to suit the placement, or the removal of the bag, either from or to a man's back by the top shelf, or from or to the corn-barrow by the lower shelf.

When the machine is not in use, the lower shelf is folded up against the back of the frame, and the light frame folds down over the folded-up lower shelf, reducing the machine to a very compact state.

In weighing with this machine, from its being on the principle of the balance, the amount of weights required is equal to the absolute weight of the body that is being weighed, and the true weight is determined when the scales coincide in one level line with the dead-plate. In constructing this machine, the bottom of the pillar and of the frame is provided with a horizontal connecting-rod, which preserves their parallelism, and, consequently, the correct indications of the beam.

Fig. 216 is a perspective view of a portable lever weighing-machine, extensively used. When the lever of the standard is up, as in the figure, any weight placed on the platform does not affect the balance-beam; but on pulling it down, it puts the platform in connection with the beam. Weights are then put on the weight-plate connected by a rod with the extremity of the balance-beam, these weights representing cwts. and

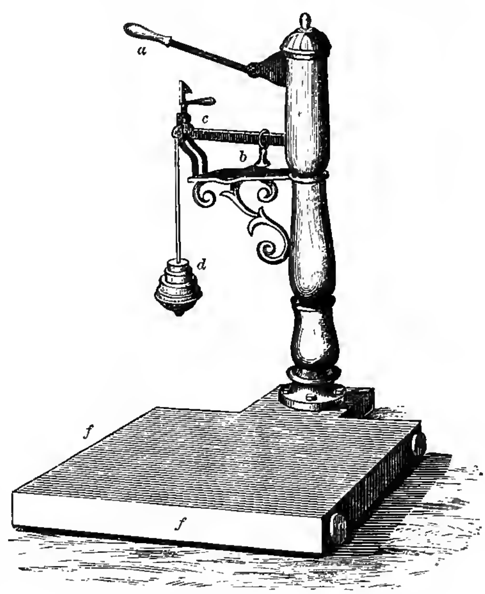


Fig. 216.—*Portable weighing-machine.*

a Lever. *c* Balance. *d* Weight-plate. *b* Sliding-weight. *f f* Platform. *e* Standard.

imperial stones. The balance-beam is divided into parts, each showing a pound, from 1 to 14 lb. After bringing this beam nearly to the balance-level, the sliding-weight is moved along it till the balance is accurately obtained. The weights on the weight-plate shows the number of cwts. and stones, and the sliding-weight indicates on the scale of the beam the number of pounds beyond the cwts. and stones. The article to be weighed is placed on the platform.

VARIETIES OF CORN.

Wheat, like all true cereals and grasses, belongs to the natural order *Gramineæ*. In treating of the plants cultivated on a farm, systematic writers on agriculture describe their characters in minute botanical phraseology. This is right when different species of plants have to be distinguished from each other. When mere varieties and sub-varieties are numerous, they should be described in a more easily understood if less scientific method, so that others besides botanists may easily distinguish them.

Wheat.

Professor Low enumerates 11 different subdivisions of wheat[1] which are cultivated, and doubtless possess distinct botanical characteristics, but these are not likely to be appreciated by farmers. Mr Lawson has described 83 varieties of wheat;[2] Colonel le Couteur mentions having in his possession, in 1836, no fewer than 150 varieties.[3] To acquire a knowledge of all these varieties through botanical terms would puzzle any farmer. If he wishes to have a precise knowledge of them, he must study botany.

Simple Classification.—It is thus desirable that a method should be established for easily recognising the different kinds of corn by the external characters of the ear and grain. Colonel le Couteur has given a classification of *wheat* involving this principle, and adduces a similar reason for attempting it, when he says,—"No one has done so, as a branch of agriculture, in those plain terms which may be intelligible, not to the botanist or scientific reader only, but to the great mass of farmers." And the principal object he considers should be held in view, in establishing such a classification, is the nature and qualities of each variety for making bread. In prosecuting this idea of a classification, Colonel le Couteur divides all the varieties of wheat into two classes—namely, *beardless* and *bearded*. In so far he imitates the modern botanist, who divides the cultivated varieties of wheat into the two divisions of *barbatum* and *imberbe*, signifying the above conditions. But, unfortunately for the stability of this classification, that distinction is not immutable, for some bearded wheats lose their beards on cultivation, and some beardless ones are apt to become bearded when cultivated on poor soils and exposed situations.

Some other cereals indicate a tendency to similar sporting, for the potato-oat assumes a beard when sown a long time on the same ground in a poor state.

Colonel le Couteur subdivided beardless wheat into white, red, yellow, and liver-coloured, smooth-chaffed, and velvet-chaffed; and the bearded he divided under the same colours. Some varieties of wheat are, no doubt, decidedly downy on the chaff; but others, again, are so very little so, that it is difficult to distinguish them from some of the roughest varieties of smooth-chaffed; and it is known that the same wheat will be differently affected in this respect by the soil upon which it grows. A sharp soil renders the chaff and straw smoother and harder than a deaf one, and the deaf soil has a tendency to produce soft and downy chaff and straw. Downiness is thus not a more permanent character than the beard for establishing the denominations of the great divisions of wheat.

Conjoining the characters of the grain and ear of wheat seems unnecessary, inasmuch as the character of either separately cannot positively indicate the state of the other, and both characters are not required to indicate the superior properties of any variety of wheat for making bread. A miller at once distinguishes the *grain* which will afford the

[1] Low's *Ele. Prac. Agric.*, 229.
[2] Lawson's *Agric. Man.*, 29.
[3] Le Couteur *On Wheat*, ii., Dedi.; and 77.

best bread; and neither he nor any farmer could indicate such a property from the *ear* of any wheat.

Colour of Wheat.—Colonel le Couteur assumed that a liver-coloured wheat was a distinctive colour. We never remember to have seen a wheat of a liver-brown colour. All the colours of wheat, we think, may be classed under two primary colours, *yellow* and *red*—for even the whitest has a tinge of yellow—and every dark colour is tinged with red; and as *white* and *red* are the terms by which the colours of wheat have been longest known, these should be retained. The sub-tints of yellow and red might be easily designated.

Classification by the Ear.—Were we to classify both the plant and grains of wheat by *natural marks*, we would make two classifications, one by the ear and the other by the grain, so that each might be known by its own characteristics. In this way confusion would be avoided in describing the ear and the grain. The farmer who grows the wheat plant, and sells it in the grain, should be acquainted with both; but the miller who purchases the grain need know nothing of the ear.

The ears of three classes of wheat are represented in fig. 217, which shows the ears half the natural size. The first, *a*, is a *close* or *compact* eared wheat, which is occasioned by the spikelets being set near each other on the rachis; and this construction makes *the chaff short and broad.* The second class of ears is *b*, the spikelets being of *medium* length and breadth, and placed just as close upon the rachis as to screen it from view; this ear is not so broad, but longer than *a*; the *chaff* is of *medium length and breadth.* The spikelets of *c* are set *open*, or as far asunder as to permit the rachis to be easily seen between them; this ear being about the same length as *b*, but much narrower, *the chaff long and narrow.* There is no chance of confounding these three structures of the ears of wheat.

These three classes of varieties constitute the *Triticum sativum imberbe* of botanists,—that is, all the beardless cultivated wheats. Formerly they were divided by botanists into *Triticum hybernum* or winter wheat, and *Triticum æstivum* or summer wheat; but experience has proved that the summer wheat may be sown in winter, and the winter wheat sown in spring, and both come to perfection. Paxton says that Triticum is derived from "*tritum*, rubbed—in allusion to its being originally rubbed down to make it eatable."[1]

In *d*, fig. 217, is represented a bearded wheat, which shows the appearance the beard gives to the ear. The bearded wheats are generally distinguished by the *long shape* of the *chaff* and the open

Fig. 217.—*Classification of wheat by the ear.*

position of the spikelets, and therefore fall under the third class *c*. But cultivation has not only the effect of decreasing the strength of the beard, but of setting the spikelets closer together, as in the white Tuscany wheat. Bearded wheat constitutes the second division of cultivated wheat of the botanists, under the title of *Triticum sativum barbatum.* The term bearded has been used synonymously with spring wheat,

[1] Paxton's *Bot. Dic. Tritic.* See also Hooker's *Brit. Flo.*, 20, edition of 1831.

but erroneously, as beardless wheat is as fit for sowing in spring as bearded, and the bearded for sowing in winter.

Classifying by the Grains.—Classified by the grain, wheat may again be grouped under three heads. The first class is shown in fig. 218, where the grains are *small*, *short*, *round*, and *plump*, with the bosom, the median line, distinctly marked, and well filled up. Fine *white* wheat belongs to this class, and is enclosed in *short*, *round*, *thin*, and generally *white chaff*, which, when ripe, becomes so expanded as to endanger the grain falling out. Very few *red* wheats belong to this class. In reference to the ear, this class is found in *short-chaffed* and broad spikelets, which are generally compact, as *a*, fig. 217.

Fig. 218.—*Short, round, plump form, and small size of wheat.*

The second class is in fig. 219, where the grains are *long and of medium size*, longer and larger than the grains of fig. 218. The *chaff* is also *medium sized*. In reference to the ear, it is of the *medium* standard, in respect to breadth and closeness of spikelets, as *b*, fig. 217, though *medium-sized grain* is *not* confined to this sort of ear; and is found in the *compact* ear, as well as in the *open* ear. Most *red* wheat belongs to this class of grain, though many of the *white medium-sized* also belong to it. This grain is the Caucasian red wheat, whose ear is bearded, and belongs to the open-spiked class *c*, fig. 217.

Fig. 219.—*Long medium-sized form of wheat.*

The median line is strongly marked, and the ends are sharp.

In fig. 220 is the third form of grain, which is *large and long*. Its *chaff* is *long*, and in reference to the ear, the spikelets are generally open. The median line is not distinctly marked. The ends of the grain are pointed but not sharp, and the skin is rather coarse. The germ and radicle are boldly marked.

Fig. 220.—*Large size and long form of wheat.*

These three sorts of wheat are of the natural size, and indicate the forms of the principal varieties found in our markets.

Relation of Ear and Grain.—It will be seen from what has been stated, that no inevitable relation exists between the *ear* and *grain*; that the compact ear does not always produce round grain nor white wheat; that in the medium ear is not always found medium-sized grain; and that the open ear does not always produce large long grain.

Still, there exist coincidents which connect the *chaff* with the *grain*. For example, *length* of *chaff* indicates *length* of *grain*, upon whatever sort of ear it may be found; and, generally, the *colour* of the chaff determines *that* of the grain; and as the open spikelet bears long chaff, long chaff covers grain of coarser quality than the chaff of the compact ear.

On desiring, therefore, to determine the sort of *grain* any number of *ears* of different kinds of wheat contain, the *form* and *colour* of the *chaff* determine the point, and not whether the ear carries compact, medium, or open, bearded or beardless, woolly or smooth spikelets.

Vilmorin's Classification.—M. Henry Vilmorin, in his beautiful work[1] on wheat, adopts the following arrangement:—

Triticum sativum .	Soft wheat.
T. turgidum .	Plump "
T. durum .	Hard "
T. polonicum .	Polish "
T. Spelta .	Spelt.
T. amyleum .	Starchy wheat.
T. monococcum .	One-grained "

The most important of these, *T. sativum*, he subdivides according as the variety is awned or unawned, the ear white or red, smooth or downy, and the grain itself white or red. Familiar forms of *T. sativum* are Chidham, Hunter, Trump, Talavera, Hickling, Hallett, Dantzic, Shireff, Browick.

Judging Wheat.—But the classification is unimportant to the farmer, compared to the mode of *judging* wheat, to ascertain the external characters which best indicate the purposes for which the corn may be best employed, in the particular condition of the sample. The purposes are, for seed and for making

[1] *Les meilleurs blés.*

into flour—whether the flour is to be employed in bread, in confections, or starch.

In its *best* condition, all wheat, whether red or white, small or large, long or round, should appear plump within its skin. The skin should be fine and smooth. The colour should be bright and uniform. The grains should be of the same size and form, and perfect. With all these properties wheat is fitted for every purpose.

Wheat for Flour.—When wheat is quite opaque, it is in the best state for yielding the finest flour. Such flour, from white wheat, confectioners use for pastry, and it contains the largest amount of starch, but it is too dear for the starch-maker. When wheat is translucent, hard, and flinty, it is suited to the baker, as affording flour that rises freely with yeast, having much gluten in it. For bread of finest quality a mixture of the two conditions of flour is best suited.

Some sorts of wheat naturally possess *both* these properties, and are great favourites with millers. Generally speaking, the purest-coloured white wheat indicates most opacity, and yields the finest flour; and red wheat is most flinty, and yields the strongest flour: translucent red wheat will yield stronger flour than translucent white wheat, and yet red wheat never realises so high a price in the market as white—partly because it contains more bran, makes darker-coloured bread, and yields less starch.

Wheat varying with Soil.—Mr Powles says, in his translation of Kick's treatise: "Wheat varies very much according to the soil and country in which it is grown. Among the best kinds of wheat are the Hungarian and the Banater, though they frequently show a flinty appearance in cross-section. This is not the case with wheats grown in more northern countries. Their grain, which shows in cross-section a uniform white colour, gives better flour, and is called soft or white wheat, whereas that which shows a mottled or flinty cross-section takes the name of hard wheat, and gives less and inferior flour. A fine, clear, glistening exterior and oval form, are a sign of good quality with old wheat, which has been kept for many years in the granary; the recovery of its original colour and lustre after washing and slow drying indicates good quality."[1]

Weight of Wheat.—The weight of wheat varies, according to the state of the season, from 55 lb. to 66 lb. per imperial bushel; the 55 lb. being very light, and produced in a wet late season on inferior land—the heavy being very heavy, and produced in a hot season on the best soil. An average weight for wheat is 62 to 63 lb. per bushel. The average weight of all the wheat sold in the Edinburgh market in the thirteen years up to 1880 was 62.2 lb. per bushel.[2]

"A plump, rounded, white, smooth grain, without wrinkles, gives the heaviest weight per bushel. Wheat grain is heavier than water, its specific gravity ranging from 1.29 to 1.41."[3]

"High specific gravity is, above all, an indication of good quality. Wheat which weighs 50 to 60 lb. per imperial bushel is considered good—that is, rich in flour. The grains should be equal-sized, large, and full. In rare cases the weight rises to 66 lb. per imperial bushel."[4]

Number of Grains in a Bushel.—Of Chidham white wheat, weighing 65 lb. per bushel, 86 grains were found to weigh one drachm, so that the bushel should contain 715,520 grains. At 63 lb. to the bushel, and 87 grains to the drachm—the most common case—the bushel should contain 701,568 grains.

Wheat for Seed.—For seed, the root-end of the grain should be distinctly prominent, and the stem-end slightly hairy. When either end is rubbed off, the grain is deprived of its vitality. Kiln-drying also destroys vitality. Wheat unfit for seed may be detected in various ways. If it has been in sea-water, although not enlarged by moisture, it never loses the saline taste. When washed in fresh water and dried in a kiln, the washing gives it a bleached appearance, and the kiln-drying is detected by smell or taste. When shealed, the ends are rubbed down. When heated in the sack, it tastes bitter. When heated in the stack, it has a high colour. When long in the granary, it is

[1] *Kick's Flour Manufacture.*
[2] *A Bushel of Corn*, A. S. Wilson, p. 35.
[3] Church's *Food.*
[4] Powles's *Kick's Flour Manufacture.*

dull and dirty, and has a musty smell. When attacked by weevils and other insects in the granary, which breed within its shell and eat the kernel, the shells are light, and have holes in them. Germinated, swollen, burst, bruised, smutted grains, and the presence of other kinds of corn and seeds, are easily detected by the eye.

Preserving Wheat in Granaries.—Difference of opinion exists in regard to the best mode of preserving wheat in granaries. The usual practice is to shovel the heap over from the bottom every few weeks, according to the dryness or dampness of the air, or heat or coldness of the atmosphere. In this mode of treatment a free ventilation of air is requisite in the granary, and the worst state of the atmosphere for the grain is when it is *moist* and *warm*. Extreme heat or extreme cold are preservatives of corn.

The practice of others is not to turn it over at all, but to keep it in the dark in thick masses, reaching from the floor to the ceiling. No doubt, if air could be excluded from a granary, the corn would be preserved in it without trouble; and a good plan of excluding the air seems to be, to heap the grain as close together as possible. When kept long in heap without turning, it retains its colour with the fresh tint, which is also secured by keeping it in the dark.

Ancient Practice in Storing.—The ancients preserved grain many years, to serve for food in years of famine. Joseph, in Egypt, preserved wheat for seven years in the stores; in Sicily, Spain, and the northern parts of Africa, pits were formed in the ground to preserve it; and the Romans took great pains in constructing granaries, which kept wheat for 50 and millet for 100 years.[1]

Storing *v.* Immediate Selling.—The practice of storing grain in farm granaries is not now pursued to so large an extent as formerly; yet it is often found necessary or desirable for the farmer to store a moderate quantity for a limited time. As to this point a cautious and experienced farmer says:—

"As regards the farmer, the question of preserving wheat in granaries should little affect him, the best way of keeping wheat being in the straw in the stack; and when the stacks are threshed, that the straw may be used, he should dispose of his wheat immediately, and take the current market prices. During the currency of a lease, this is the safest practice for securing him an average price; and it saves much trouble in looking after the corn, much vexation when it becomes injured, and much disappointment when the price falls below its expected amount. Loss is likely to be the fate of farmers who speculate in corn of their own growth; and when they become merchants besides, they are likely to become involved in the intricacies of foreign trade, and feel the effects of their thoughtlessness."

Production of an Acre of Wheat.—A crop of wheat, yielding 30 bushels per acre, weighing 1800 lb., affords of nutritive matter, 270 lb. of husk or woody fibre; 990 lb. of starch, sugar, &c.; 180 to 340 lb. of gluten, &c.; 36 to 72 lb. of oil or fat; and 36 lb. of saline matter.[2]

Lawes and Gilbert found at Rothamsted that the average quantities of total mineral constitutents (ash) yielded per acre per annum, over sixteen years on three plots, differently manured, on which wheat was continuously grown, were the following:—

	In grain. lb.	In straw. lb.	Total. lb.
By farmyard manure	36.3	201.1	237.4
Without manure .	16.6	89.5	106.1
With ammonia salts alone . . .	23.0	119.2	142.2

Kernel and Husk.—Mr A. S. Wilson found that of the grain of wheat about 95.59 per cent consisted of kernel, and 4.41 per cent of husk.

Origin of Wheat.—"It is a very remarkable circumstance," observes Lindley, "that the native country of wheat, oats, barley, and rye should be entirely unknown; for although oats and barley were found by General Chesney, apparently wild, on the banks of the Euphrates, it is doubtful whether they were not the remains of cultivation. This has led to an opinion, on the part of some persons, that all our cereal plants are arti-

[1] Dickson's *Hus. Anc.*, ii. 426.

[2] *Origine des Plantes cultivées.*

ficial productions, obtained accidentally, but retaining their habits, which have become fixed in the course of ages.[1]

Antiquity of Wheat Cultivation.—A. de Candolle[2] observes that the cultivation of wheat is prehistoric in the Old World. Very ancient Egyptian monuments, older than the invasion of the shepherds, and the Hebrew Scriptures, show this cultivation already established; and when the Egyptians or Greeks speak of its origin, they attribute it to mythical personages—Isis, Ceres, Triptolemus. The earliest lake-dwellers of western Switzerland cultivated a small-grained wheat, which Heer has described under the name of *Triticum vulgare antiquorum.* The first lake-dwellings of Robenhausen were at least contemporaneous with the Trojan war, and perhaps earlier. The Chinese grew wheat 2700 B.C. It is remarkable that wheat has been twice asserted to be indigenous in Mesopotamia, at an interval of twenty-three centuries, —once by Berosus, and once by Olivier in our own day. The Euphrates valley lying nearly in the middle of the belt of cultivation which formerly extended from China to the Canaries, it is infinitely probable that it was the principal habitation of the species in very early prehistoric times. The area may have extended towards Syria, as the climate is very similar; but to the east and west of Western Asia wheat has probably never existed but as a cultivated plant, anterior, it is true, to all known civilisation.

Limits of Wheat Culture.—Only the lower-lying parts of the United Kingdom are well suited for wheat cultivation, yet in recent years wheat has been grown to a greater or lesser extent in every county in England and Wales; and also in every Scotch county, excepting Selkirk and the Orkney and Shetland islands. In former times it was not so widely grown.

"Wheat is cultivated in Scotland to the vicinity of Inverness (lat. 58°); in Norway to Drontheim (lat. 64°); in Sweden to the parallel of lat. 62°; in western Russia to the environs of St Petersburg (lat. 60° 15′); while in central Russia the polar limits of cultivation appear to coincide with the parallel of 59° or 60°. Wheat is here almost an exclusive cultivation, especially in a zone which is limited between the latitude of Tchernigov, lat. 51°, and Ecaterinoslav, lat. 48°. In America the polar limits of wheat are not known, on account of the absence of cultivation in the northern regions. The physical conditions of these limits are, in the different countries where cultivation has been carried to the utmost extent, as follows:—

	Lat.	Mean temperature, Fahr. Year.	Winter.	Summer.
Scotland (Ross-shire)	58°	46°	35°	57°
Norway (Drontheim)	64	40	25	59
Sweden . . .	62	40	25	59
Russia (St Petersburg)	60 15′	38	16	61

This table shows how little influence winter cold has in arresting the progress of agriculture towards the north; and this is confirmed in the interior of Russia, where Moscow is much within the limits of wheat. The spring-sown wheat escapes the cold of winter, and wheat sown in autumn is protected during winter by a thick covering of snow. The farther we advance to the north, the more deep and enduring is the covering. The temperature of air, during the severe season, can therefore have no direct action on plants which are annual, or at least herbaceous, and buried under the snow. The isothermal curve of 57° 2′, which appears to be the minimum temperature requisite for the cultivation of wheat, passes in North America through the uninhabited regions of Canada. At Cumberland House, which is situated in the middle of the continent of North America, in lat. 54° N., long. 102° 20′ W., the officers of the Hudson's Bay Company have established a prosperous agriculture. Captain Franklin found fields of barley, wheat, and even maize (Indian corn), growing here, notwithstanding the extraordinary severity of the winter. The polar limits of the cultivation of wheat are the more important, since, during a part of their course, they coincide with the northern limits of those fruit-trees which yield cider; and in some parts also with the limits of the oak. Agriculture and forests, therefore, both undergo a sudden and remarkable change of appearance on approaching the

[1] Johnston's *Lect. Agric. Chem.*, 2d ed., 928.
[2] Lindley's *Veget. King.*, 112.

isothere of 57° 2′. In middle and western Europe, wheat (*Triticum vulgare*) is cultivated chiefly in the zone between lat. 36° and 50°; farther north, rye (*Secale cereale*) is generally preferred. To the south of this zone, new combinations of heat, with humidity, and the addition of many other cultures, sensibly diminish the importance of this precious cereal. The isocheimal curve of 68° or 69°, which appears to be the extreme limit of the possible cultivation of wheat towards the equator, oscillates between lat. 20° and 25°. The cultivation of wheat is very productive in Chili, and in the united state of Rio de la Plata. On the plateau of southern Peru, Meyer saw most luxurious crops of wheat at a height of 8500 feet, and at the foot of the volcano of Arequipo, at a height of 10,600 feet. Near the lake of Tabicaca (12,795 feet high), where a constant spring-heat prevails, wheat and rye do not ripen, because the necessary summer-heat is wanting; but Meyer saw oats ripen in the vicinity of the lake."[1]

Barley.

The botanical position of *barley* is the genus *Hordeum*, of the natural order of *Gramineæ*. Professor Low divides the cultivated barleys into two distinctions,—namely, the 2-rowed and the 6-rowed, and these comprehend the ordinary, the naked, and the sprat or battledore forms.[2] Lawson describes 20 varieties of barley.[3]

Classifying by the Ear.—The natural classification of barley by the ear is obviously into three kinds—4-rowed, 6-rowed, and 2-rowed. Fig. 221 represents the three forms, where *a* is the 4-rowed, or bere or bigg, *c* the 6-rowed, and *b* the 2-rowed, which figures give the ear in half its natural size. Of these the bere or bigg was cultivated until a recent period, but the 2-rowed has almost entirely supplanted it, and become the most commonly cultivated variety, the 6-rowed being rather an object of curiosity than culture.

Classifying by the Grain.—In classifying barley by the *grain* we find there are just two kinds, *bere* or *bigg*, and *barley;* and though both are awned, they are sufficiently marked to constitute distinct varieties.

Fig. 221.

4-rowed bere or bigg. *6-rowed barley.* *2-rowed barley.*

In the bere, fig. 222, the median line of the bosom is so traced as to give the grain a twisted form, by which one of its sides is larger than the other, and the lengthened point is from where the awn was broken off. The figure gives the grain of the natural size.

Fig. 222.—*Scotch bere or bigg.*

In barley, fig. 223, the median line passes straight, and divides the grain into two equal sides, short and plump, with a crenulated skin. The grain here is of the natural size. The bigg was long cultivated in Scotland, along with a 2-rowed variety named common or Scotch barley; but several English varieties are now cultivated which show a brighter and fairer colour, plumper and shorter grain,

Fig. 223.—*English barley.*

[1] Johnston's *Phys. Atl.*—Phytol., Map No. 2.
[2] Low's *Elc. Prac. Agric.*, 244.
[3] Lawson's *Agric. Man.*, 33.

quicker in malting, though less hardy and prolific, than the common barley.

A variety known as *awnless* barley is now cultivated. When it becomes fully ripe the awns fall off, hence its name.

Judging Barley.—The crenulated skin is a good criterion of malting; and as most of the barley is converted into beer or spirits, both requiring malt to produce them of the finest quality, it is not surprising that English Chevalier barley should realise the highest price. In judging good barley it should break soft between the teeth, and show a white fracture, and be wrinkled in the bosom. When it breaks hard it is flinty, and will not malt well.

As to grinding barley, "the indications of good flour-producing qualities in barley are these: a fine pale-yellow colour, roundish rather than long form, and a high specific weight. Long, pointed, and flat grains yield less flour, and of a bluish tint. According to Neumann, barley one year old will yield flour whiter than fresh barley."[1]

Yield and Weight of Barley.—A good crop of barley yields a return of from 48 to 60 bushels per acre. Good barley weighs from 54 lb. to 59 lb. per bushel. A crop of 60 bushels per acre will yield of straw about 176 stones of 14 lb. to the stone, or $1\frac{1}{10}$ ton, and the weight of the grain of that crop, at 56 lb. per bushel, will be $1\frac{1}{2}$ ton. Mr A. S. Wilson states that the average weight of all the barley sold in the Edinburgh market in the thirteen years ending with 1880 was 54.93 lb. per bushel, the range being from 46 to 60 lb.[2]

Grains in a Bushel.—It takes of bigg 111 grains to weigh one drachm; of 6-rowed barley, 93; and of Chevalier barley, 75 grains; of which, with the weight per bushel of 57 lb., the number of grains of Chevalier barley in a bushel will be 547,200.

About 90 per cent of the grain of barley consists of kernel, and 10 per cent of husk.

Utilisation of Barley.—By far the largest proportion of the best barley is converted into *malt* for making malt liquor and spirits. Barley is also used for distillation in the raw state.

Pot and pearl barley are made from barley for culinary purposes. Both meal and flour are manufactured from barley for making unleavened bread, which is eaten by the labouring class in some parts of the country.

Of the states of barley the soft is best adapted for making into malt and meal, and the flinty into pot barley. It was supposed that flinty barley contained the most gluten or nitrogen; but Professor Johnston showed that it contains less than the soft barley, in the proportion of 8.03 to 10.93.

Barley-meal.—"The meal so highly commended by the Greeks was prepared from barley. . . . It was not until after the Romans had learnt to cultivate wheat, and to make bread, that they gave barley to the cattle. They made barley-meal into balls, which they put down the throats of their horses and asses, after the manner of fattening fowls, which was said to make them strong and lusty. Barley continued to be the food of the poor, who were not able to procure better provision; and in the Roman camp, as Vegetius has informed us, soldiers who had been guilty of any offence were fed with barley instead of bread corn."[3]

Malting.—The malting of barley is noticed, in connection with the use of malt as food for stock, in pages 248-252.

Limits of Barley Culture.—"Barley is cultivated farther north than any of the other grains: fields of it are seen in the northern extremity, in the Orkney Islands, and in Shetland (lat. 61° N.), and even at the Faröe Islands (lat. 61° to 62° 15′ N.) Iceland (lat. 63° 30′ to 66° N.) does not produce it, although an industrious population have made every exertion to acquire some species of cereal. In Western Lapland the limit of barley is under lat. 70° near Cape North, the northern extremity of Europe. In Russia, on the shores of the White Sea, it is between the parallels of 67° and 68° on the western side, and about 66° on the eastern side, beyond Archangel; in central Siberia, between lat. 58° and 59°; such is the sinuous curve which limits the cultivation of barley, and consequently that of all the cereals.

[1] *Kick's Flour Manufacture.*

[2] *A Bushel of Corn.*

[3] Phillips's *Hist. Culti. Veget.*, i. 50.

"A little farther north, all employment of vegetables ceases, at least as an important object of nourishment—the people live on the product of their cattle, as in the high Alps, or by hunting and fishing, according to locality.

"But beyond the limits of barley there occurs a narrow and indeterminate zone, in which certain early potatoes are cultivated, and where the snow does not cover the ground for a sufficient length of time to prevent the raising of some lichens, some fruits, barks, or wild roots, fit for the nourishment of man. As the introduction of the potato is, in comparison to barley, recent in these regions, it almost everywhere forms the limit between the agricultural and the pastoral or nomad life.

"From the importance of the cultivation of barley in the north, it is evident that wherever the human species has attained the first stage of civilisation, the attempt will have been made to advance it as far as possible towards the pole. If, then, it is limited by a sinuous curve as already explained, it is because circumstances of a purely physical nature oppose to it an insurmountable barrier.

"A mean temperature of 46° 4′ during summer seems to be, for our continent, the only indispensable condition for the cultivation of barley; in the islands of the Atlantic Ocean, a summer temperature of three or four degrees higher appears to be necessary for its success. Iceland indeed, where this grain cannot be cultivated, presents in its southern districts, at Reikavik, a mean temperature of 37° 4′ for the year—24° for the winter, and 49° 4′ for the summer. It appears that here considerable rains are the means of preventing the cultivation of cereals.

"Thus the limit of barley in the countries where its cultivation is of the most importance, varies between 46° 4′ and 49° of mean temperature, during summer. In the continental regions 46° 4′ is sufficient; but in the islands the excessive humidity requires to be compensated by a little heat in summer.

"Barley is cultivated as an alimentary plant as far as the northern limit of rye and oats. Farther north it loses its importance, and is very little cultivated. Between the tropics this cereal does not succeed in the plains, because it suffers from heat more than any of the other cultivated grains." [1]

Oats.

The oat-plant belongs to the natural order of *Gramineæ*, genus *Avena*. Its ordinary botanical name is *Avena sativa*, or cultivated oat. The term oat is of obscure origin. Paxton conjectures it to have been derived from the Celtic *etan*, to eat.[2]

There are a great number of varieties of this cereal cultivated in this country. Lawson describes thirty-eight.[3]

Fig. 224.—*Potato oat.*

Classification by the Grain.—The natural classification of the oat by the grain consists only of two forms—one plump and short and beardless, as fig. 224, the potato oat, smooth-skinned, shining, having the base well marked, and the germ-end short and pointed.

The other form is in fig. 225, long and thin, and having a tendency to produce a beard, the white Siberian early oat. It is cultivated in the poorer soils and higher districts, resists the force of the wind, and yields a grain well adapted for the support of farm-horses.

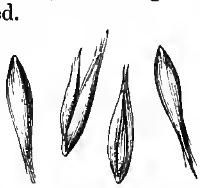


Fig. 225.—*White Siberian early oat.*

The straw is fine and pliable, and makes an excellent dry fodder for cattle and horses, the saccharine matter in the joints being very sensible to the taste. It comes early to maturity, and hence its name.

Mr A. S. Wilson divides oats into three groups, which he designates as the *Oviform*, *Coniform*, and *Fusiform*. In the first he places the short round oats approaching the form of an egg, the potato oat and Scots barley oat being types of this class. The *Coniform* embrace the oats of medium length in proportion to their thickness, as the sandy oat. The long oats, such as the Tartarian and Arkangel oats, comprise the *Fusiform*.[4]

[1] Johnston's *Phys. Atl.*—Phytol., Map No. 2.
[2] Paxton's *Bot. Dict.*, art. Avena.
[3] Lawson's *Agric. Man.*, 44.
[4] *A Bushel of Corn.*

Classification by the Ear.—The natural classification of the oat by the ear is obvious. One kind, fig. 226, has its branches spreading equally on all sides, shortening gradually towards the top of the spike in a conical form, and the panicles are beardless. This is the potato oat. While the ear is yet recent, the branches are erect; but as the seeds advance towards maturity, and become full and heavy, they assume a dependent form. By this change, the air and light have free access to the ripening grain, while the rain washes off the eggs or larvæ of insects that would otherwise prey upon the young seed. This variety is extensively cultivated in Scotland on account of the fine and nourishing quality of its meal, which is largely consumed by the people—unfortunately not so largely now as in former times. It is cultivated in the richer soils of the low country.

Fig. 226.—*Spike of potato oat.*

The plant of the potato oat is tender, and the grain is apt to be shaken out by the wind. The straw is long and strong, inclining too much to reediness to make good fodder. It is late in coming to maturity. Its peculiar name of the potato oat is said by one writer to have been derived from the circumstance of the first plants having been discovered growing accidentally on a heap of manure, in company with several potato-plants, the growth of which was equally accidental;[1] while another writer says plants of it were first found in 1789 in Cumberland, growing in a field of potatoes. The ear in the figure was taken from the stack, none being at the time available in the field, where it would have been more regular and beautiful.

[1] Rhind's *Hist. Veget. King.*, 218.

The white Siberian oat, fig. 225, has an ear of this description.—The other kind of ear has its panicles shorter, nearly of equal length all on the same side of the rachis, and bearded. Fig. 227, a head of Tartarian oat, taken from the stack, shows this form of ear. The seeds of this form also assume the pendant position. It is of such a hardy nature as to thrive in soils and climates where other oats could not be raised. This variety derives its name, most probably, from Tartary. It is much cultivated in England, and only to a limited extent in Scotland. It is a coarse grain, more suitable for animal food than for making into meal. The grain is dark-coloured, awny; the straw coarse, harsh, brittle, and rather short.

Fig. 227.—*Spike of Tartarian oat.*

Yield and Weight of Oats.—The *crop* of oats varies from 30 to 80 bushels per imperial acre, according to kind, soil, and situation, 40 to 48 being very general. Oats vary in weight from 33 lb. to 48 lb. per bushel. The average of all the oats sold in the Edinburgh market during the thirteen years ending with 1880, was 42.22 lb. per bushel. Whiteness, of a silvery hue, and plumpness, aro the criteria of a good sample. A crop of potato oats, yielding 60 bushels to the acre, at 47 lb. per bushel, weighs of grain 1 tou 5 cwt. 20 lb., and yields of straw 1 ton 5 cwt. 16 lb., in the neighbourhood of a large town; or, in other words, yields 8 kemples of 40 windlings each, and each windling 9 lb. in weight. A crop of Hopetoun oats, of no more than 60 bushels to the imperial acre, grown near Edinburgh, yielded 2 tons 18 cwt. 16 lb. of straw.

Grains in the Bushel.—The potato oat, 47 lb. per bushel, gave 134 grains to one drachm; the Siberian early oat of 46 lb. gave 109 grains: and the white Tartarian oat, 42 lb., gave 136 grains; so that these kinds respectively afford 806,144, 651,792, and 731,136 grains of oats per bushel.

Kernel and Husk.—Mr A. S. Wilson gives the proportions of kernel and husk in the various kinds of oats as follows: *Oviform*—kernel 76.34, husk 23.66 per cent; *Coniform*—kernel 76.07, husk 23.93; and *Fusiform*—kernel, 73.23, and husk 26.77 per cent. Average of all kinds—kernel, 75.21, and husk 24.79 per cent.[1]

Oatmeal.—For human food the oat is manufactured into *meal*, not into flour. Oats are always kiln-dried before being ground, in order the more readily to get quit of the thick husk in which the grain is enveloped. After the husk has been separated by a fanner, the grain, then called groats, is ground by the stones closer set, and yields the meal. The meal is then passed through sieves, to separate the thin husk from the meal. The meal is made into two states: one *fine*, which is the state best adapted for making into oat-cake or bannocks; and the other is coarser or *rounder* ground, which is best adapted for making the common food of the country people—porridge; *Scotticè*, parritch. A difference of custom prevails in respect to using these two different states of oatmeal, the fine meal being best liked for all purposes in the northern, and the round meal for porridge in the southern counties.

There is, unfortunately, too good reason to fear that this wholesome article is losing its position as the "common food" of the country people of Scotland. Meat, fish, and milk food are now consumed much more largely by the rural classes of Scotland than in former times; and the "cheap loaf" is fast supplanting the more substantial oat-cake.

A sharp soil produces the finest cake-meal, and clay land the best meal for boiling. Of meal from the varieties of the oat cultivated, that of the common Angus oat is the most thrifty for a poor man, though its yield in meal is less in proportion to the bulk of corn.

Oatmeal has long been and is still the principal food of the Scottish ploughman. In several districts of the country he lives upon it three times a-day, consuming 14 lb. every week. And a stouter and more healthy man cannot be seen. It was considered a rather anomalous circumstance to find men thriving as well on oatmeal as on wheat bread and butcher-meat; but the anomaly has been cleared up by the investigations of chemistry. By analysis, the oat contains fully 7 per cent of oil or fat, and 17 per cent of avenin—a protein compound, as the gluten of wheat is—making together 24 per cent of really nutritive matter, capable of supporting the loss incurred by labour of the muscular portion of the body. All vegetables contain fat, and the largest proportion of vegetable fats contain the elaic and margaric acids, mixed with a small proportion of the stearic. The elaic is always in a fluid state, and the margaric and stearic in a solid; and of the latter two, the margaric is much less, and the stearic acid very much greater, in animal fat than in those of plants. It is by the dissipation of this oil or fat by heat, in baking, that the agreeable odour of the oat-cake is at once recognised on approaching the humble cottage of the labouring man.

Yield of Meal.—In regard to the *yield of meal* from any given quantity of oats, when they give half their weight of meal they are said to give *even meal*. Supposing a boll of oats of 6 bushels to weigh 16 stones, it should give 8 stones or 16 pecks of meal, and, of course, 8 stones of refuse, to yield even meal. But the finer class of oats give more meal in proportion to weight than this—some nearly 9 stones and others as much as 12 stones per boll. The market value of oats

[1] *A Bushel of Corn.*

is therefore often estimated by the meal they are supposed to yield, and in discovering this property in the sample millers become very expert.

Composition of Oatmeal.—The following figures show the percentage composition of fresh Scotch oatmeal:—

Water	5.0
Fibrin and its allies	16.1
Starch and its allies	63.0
Fat	10.1
Cellulose and lignose	3.7
Mineral matter	2.1
	100.0

One hundred pounds of oats (weighing 45½ lb. to the bushel) commonly yield the following proportion of products:—

	lb.
Oatmeal	60
Husks	26
Water	12
Loss	2

Kick,[1] quoting the mean of many analyses, gives for oats the following percentage composition:—

Starch	56
Gluten	12
Cellulose	12
Salts	3
Water	17
	100

Oats as Food for Stock.—Oats are now used much more extensively than formerly as food for horses, cattle, and sheep. Indeed this is now their chief function. For this purpose they are usually crushed flat.

Antiquity of Oat Culture.—"We find no mention made of oats in Scripture," says Phillips, "which expressly states that Solomon's horses and dromedaries were fed with barley;" but "the use of oats as a provender for horses appears to have been known in Rome as early as the Christian era, as we find that that capricious and profligate tyrant, Caligula, fed "Incitatus," his favourite horse, with *gilt oats* out of a golden cup." Oats are mixed with barley in the distillation of spirits from raw grain; and "the Muscovites make an ale or drink of oats, which is of so hot a nature, and so strong, that it intoxicates sooner than the richest wine."[2]

Origin of the Oat.—As all the varieties of oats are cultivated, and none have been discovered in a truly wild state, it is very probable that they are all derived from a single prehistoric form, a native of eastern temperate Europe and of Tartary (A. de Candolle).

Limits of Oat Culture.—"The oat (*Avena sativa*) is cultivated extensively in Scotland, to the extreme north point, in lat. 58° 40′. In Norway its culture extends to lat. 56°; in Sweden to lat. 63° 30′. In Russia, its polar limits appear to correspond with those of rye. Whilst, in general, oats are cultivated for the feeding of horses, in Scotland and in Lancashire they form a considerable portion of the usual food of the people. This is also the case in some countries of Germany, especially in the south of Westphalia, where the inhabitants of the 'Sauerlands' live on oaten bread. South of the parallel of Paris oats are little cultivated; in Spain and Portugal they are scarcely known; yet they are cultivated with considerable advantage in Bengal to the parallel of lat. 25° N."[3]

Rye.

Rye, botanically, occupies the genus *Secale* of the order *Gramineæ*. It is the *Secale cereale* of the botanists, so called, it is said, from *á secando*, to cut, as opposed to leguminous plants, whose fruits used to be gathered by the hand.

A spike of rye, fig. 228, is not unlike a hungry bearded wheat. There is only one known species of rye, which is said to be a native of Candia, and was known in Egypt 3300 years ago. But several varieties are raised as food, four of which are described by Lawson.[4]

A. de Candolle adduces historical and philological data to show that the species probably had its origin in the countries north of the Danube, and that its cultivation is hardly earlier than the Christian era in the Roman Empire, but perhaps more ancient in Russia and Tartary.

[1] *Flour Manufacture.*

[2] Phillips's *Hist. Culti. Veget.*, ii. 9.

[3] Johnston's *Phys. Atl.*—Phytol., Map No. 2.

[4] Lawson's *Agric. Man.*, 31.

The grains of rye are long and narrow, not unlike shelled oats or groats, but more flinty in appearance. They are in fig. 229, of the natural size.

Rye is not much cultivated in this country, and in Scotland only a patch here and there is to be seen. It is extensively cultivated on the Continent, on all soils, and forms the principal article of food of the labouring classes.

"Closely resembling the wheat berry is that of rye. Its appearance is well known as naked, rather long, very tapering off at the lower end, curved or slightly keeled at the back, with a furrow at the front, and with hairs at the upper end. It is of a greyish-brown colour, and slightly wrinkled." [1]

Fig. 228.—*Ear of rye.*

Yield and Weight of Rye.—The produce of rye is about 25 bushels per acre, and the weight of the grain is from 52 to 57 lb. per bushel. The number of grains in 1 drachm being 165, at 55 lb., the bushel should contain 1,161,600 grains.

In a crop of 25 bushels to the acre, weighing 1300 lb., the nutritive matter derived from rye consists of 130 lb. to 260 lb. of husk or woody fibre; 780 lb. of starch, sugar, &c.; 130 to 230 lb. of gluten, &c.; 40 to 50 lb. of oil or fat; and 26 lb. of saline matter.

Fig. 229.—*Grains of rye.*

Limits of Rye Culture.—"Rye (*Secale cereale*) is cultivated in Scandinavia, on the western side to the parallel of lat. 67° N., and on the eastern side to lat. 65° or 66° N. In Russia, the polar limit of rye is indicated by the parallel of the city of Jarensk, in the government of Wologda, lat. 62° 30′. . . . It is as common in Russia, Germany, and some parts of France, as it is rare in the British Islands. Rye-bread still forms the principal sustenance of at least one-third of the population of Europe; it is the characteristic grain of middle and northern Europe; in the southern countries it is seldom cultivated." [2]

Rye is much used in the distillation of gin in Holland. Rye-bread is heavy, dark-coloured, and sweet; but when allowed to ferment, becomes sour.

Rye-flour.—In Russia, 100 lb. of rye-flour, containing 16 per cent of water, yield from 150 lb. to 160 lb. of bread. There, horses get it on a journey, in lieu of corn. The following is an analysis of rye-flour, showing the percentage composition:—

Water	13.0
Fibrin and allied bodies	10.5
Starch and allied bodies	71.0
Fat	1.6
Cellulose	2.3
Mineral matter	1.6
	100.0

Beans.

Beans are classed with a very different tribe of plants from the cereals which we have been considering. They belong to the natural order *Leguminosæ*, because they bear their fruit in legumes or pods. Their ordinary systematic name is *Faba vulgaris;* but the bean is also known as *Vicia Faba.*

The common bean is divided into two classes, according to the mode of culture to which it is subjected; that is, the field or the garden. Those cultivated in the field are called *Faba vulgaris arvensis*, or, as Loudon calls them, *Faba vulgaris equina*, because they are cultivated chiefly for the use of horses, and are usually termed horse-beans. Some farmers attempt to raise a few varieties of the garden-bean in the field, but without success. All beans have butterfly or papilionaceous flowers.

Field-bean.—Lawson has described 8 varieties of the field-bean. The variety in common field-culture is thus well described by him: "In length the seed is from a half to five-eighths of an inch, by three-eighths in breadth, generally slightly or rather irregularly compressed and wrinkled on the sides, and frequently a little hollowed or flattened at the end; of a whitish or light-brown

[1] *Kick's Flour Manufacture.*

[2] Johnston's *Phys. Atl.*—Phytol., Map No. 2.

colour, occasionally interspersed with darker blotches, particularly towards the extremities; colour of the eye black; straw from 3 to 5 feet in length. There is, perhaps, no other grain over the shape and colour of which the climate, soil, and culture exert so much influence as the bean. Thus, in a dry warm summer and harvest, the sample is always more plump and white in colour than in a wet and cold season; and these more so in a strong rich soil than in a light, and more so in a drilled crop than in one sown broadcast."[1]

Fig. 230.—*Horse-beans.*

Fig. 230 represents the horse-bean of its natural size.

Leguminous Plants.—"The leguminous order," observes Lindley, "is not only among the most extensive that are known, but also are of the most important to man, whether we consider the beauty of the numerous species, which are amongst the gayest-coloured and most graceful plants of any region, or their applicability to a thousand useful purposes.

"The cercis, which renders the gardens of Turkey resplendent with its myriads of purple flowers; the acacia, not less valued for airy foliage and elegant blossoms than for its hard and durable wood; the braziletto, logwood, and rosewoods of commerce; the laburnum; the classical cytisus; the furze and the broom, both the pride of the otherwise dreary heaths of Europe; the bean, the pea, the vetch, the clover, the trefoil, the lucerne, all staple articles of culture by the farmer, are so many leguminous species. The gums, Arabic and Senegal, kino, senna, tragacanth, and various other drugs, not to mention indigo, the most useful of all dyes, are products of other species; and these may be taken as a general indication of the purposes to which leguminous plants may be applied. There is this, however, to be borne in mind, in regarding the qualities of the order in a general point of view—viz., that, upon the whole, it must be considered poisonous, and that those species which are used for food by man and animals are exceptions to the general rule; the deleterious juices of the order not being in such instances sufficiently concentrated to prove injurious, and being in fact replaced, to a considerable extent, by either sugar or starch."[2]

Yield and Weight of Beans.—The produce of the bean crop varies from 20 to 40 bushels per imperial acre, the prolificness of the crop palpably depending on the nature of the season. The average weight may be stated at 66 lb. per bushel. It requires only 5 beans to weigh 1 drachm, so that a bushel contains only 42,240 beans. Beans have been known to yield 2 tons of straw or haulm per acre.[3] A crop of 40 bushels, at 66 lb. per bushel, gives 1 ton 3 cwt. 64 lb. per acre.

Consumption of Beans.—Beans are given to the horse, whole, boiled, raw, or bruised. They are given to cattle in the state of meal, but can be ground into fine flour, which is used at times to adulterate the flour of wheat. Its presence is easily detected by the peculiar smell arising from the flour on warm water being poured upon it.

"There are several varieties of the bean in use as horse-corn, but I do not know that one is better than another. The small plump bean is preferred to the large shrivelled kind. Whichever be used, the bean should be old, sweet, and sound; not mouldy, nor eaten by insects. New beans are indigestible and flatulent; they produce colic and founder very readily. They should be at least a year old."[4]

Ancient Superstitions regarding Beans.—"The ancients entertained some curious notions in regard to the bean. The Egyptian priests held it a crime to look at beans, judging the very sight unclean. But the bean was not everywhere thus contemned, for Columella notices them in his time as food for peasants, and for them only—

'And herbs they mix with beans for vulgar fare.'

The Roman husbandmen had a religious

[1] Lawson's *Agric. Man.*, 62.

[2] Lindley's *Veget. King.*, 546, 547.

[3] *Brit. Husb.*, ii. 215.

[4] Stewart's *Stab. Eco.*, 205, 206.

ceremony respecting beans somewhat remarkable: When they sowed corn of any kind, they took care to bring some beans from the field for good-luck's sake, superstitiously thinking that by such means their corn would return home again to them. The Romans carried their superstition still farther, for they thought that beans, mixed with goods offered for sale at the ports, would infallibly bring good-luck to the seller." The Romans used beans more rationally, when they were employed "in gathering the votes of the people, and for electing the magistrates. A *white* bean signified absolution, and a *black* one condemnation. From this practice, we imagine, was derived the plan of *black-balling* obnoxious persons." [1] It would appear, from what Dickson states, that the *faba* of the Romans—a name, by the way, said to be derived from *Haba*, a town of Etruria, where the bean was cultivated—is the same as the small bean of our fields." [2]

Peas.

The *pea* occupies a similar position to the bean in both the natural and artificial systems of botany. The plant is cultivated both in the field and in the garden, and in the latter place to great extent and variety. The *natural* distinction betwixt the field and the garden pea is founded in the flower, the field pea always having a red-coloured, and the garden almost always a white one; at least the exceptions to this mark of distinction are few.

The botanical name of the pea is *Pisum sativum*, the cultivated pea; and those varieties cultivated in the field are called in addition *arvense*, and those in the garden *hortense*. The name is said to have been given to it by the Greeks, from a town called Pisa, in Elis, in the neighbourhood of which this pulse was cultivated to great extent: Paxton derives the name from the Celtic word *pis*, the pea, whence the Latin *pisum*. [3]

Lawson has described 9 varieties of the field-pea. Of these a late and an early variety are cultivated. The late kind, called the *common grey field-pea* or *cold-seed*, is suited for strong land in low situations; and the early, the *partridge*, *grey maple*, or *Marlborough pea*, adapted to light soils and late situations, is superseding the old grey Hastings, or *hot-seed* pea.

The grey pea is described as having "its pod semicylindrical, long, and well filled, often containing from 6 to 8 peas. The ripened straw indicates 3 varieties—one spotted with a bluish-green ground, one light blue, and one bluish-green without spots." The partridge pea has its "pods broad, and occasionally in pairs, containing from 5 to 7 peas of a medium size, roundish, and yellowish-brown speckled, with light-coloured eyes. The ripe straw is thick and soft-like, leaves large and broad, and average height 4 feet." [4]

Fig 231 is the partridge field-pea of the natural size.

Fig. 231.—*Partridge field-pea.*

Produce of Peas.—The produce of the pea crop is either in abundance or almost a failure. In warm weather, with occasional showers, the crop may amount to 48 bushels, and in cold and wet it may not reach 12 bushels the acre. The grain weighs 64 lb. the bushel, and affords 13 grains to 1 drachm; consequently a bushel contains 106,496 peas.

Consumption of Peas.—The pea was formerly much cultivated in this country in the field, and even used as food, both in broth and in bread, *pease bannocks* having been a favourite food of the labouring class: but, since the extended culture of the potato, its general use has greatly diminished. It is now chiefly given to horses, and also split for domestic purposes, for making pea-soup—a favourite dish with families in winter. Its flour is used to adulterate that of the wheat, and is easily detected by the peculiar smell which it gives out with hot water. Peasemeal in brose is administered in some cases of dyspepsia. Pea-pudding is eaten as an excellent accompaniment to pickled pork. Pea and barley bread is eaten on the Borders by the peasantry. It was customary in the

[1] Phillips's *Hist. of Cult. Veget.*, i. 67, 68.
[2] Dickson's *Husb. Anc.*, ii. 182.
[3] Paxton's *Bot. Dict.*, art. Pisum.
[4] Lawson's *Agric. Man.*, 70.

country to burn peas in the sheaf, and mix them with butter for supper, under the name of *carlins*. In some towns, where ancient customs still linger, roasted peas are sold in winter in the hucksters' stalls. Pigeons are excessively fond of the pea, and it has been alleged that they can devour their own weight of them every day.

Wheat-straw.

Wheat-straw is generally long, often upwards of 6 feet in length, and it is always strong, whatever its length. Of the two sorts of wheat, white and red, the straw of the white is softer, more easily broken by the threshing-mill, and decomposed in the dunghill. Red wheat-straw is tough, and is used for stuffing horse-collars. The strength and length of wheat-straw render it useful in thatching, whether houses or stacks. It is yet much employed in England for thatching houses, and perhaps the most beautifully thatched roofs are in the county Devon, whilst excellent examples of this art may be seen in Wiltshire.

Since the general use of slates in Scotland, thatching houses with straw has fallen into desuetude. Wheat-straw makes the best thatching for corn-stacks, its length and straightness insuring safety, neatness, and despatch, which, in the busy period of securing the fruits of the earth, is valuable. It forms an admirable bottoming to the littering of every court and hammel of the steading. As litter, wheat-straw possesses superior qualities, and few gentlemen's stables are without it.

It is not so well suited for fodder, its hardness and length being unfavourable to mastication; yet farm-horses are fond of it when it is fresh.

If wheat-straw were cut in short lengths, say of 4 inches, it would make not only more economical litter than long straw for stables and courts, but the manure from it would be better made and would more equally decompose in the soil.

Upholsterers use wheat-straw as stuffing in mattresses for beds, under the name of *paillasse;* but such a mattress is a miserable substitute for crisp, curled, elastic horse-hair.

Ash of Wheat-straw.—The ash of wheat-straw contains the following ingredients:—

	Berthier.	Boussingault.	Fromberg.
Potash	10.86	9.56	15.52
Soda	...	0.31	...
Lime	5.36	8.83	4.58
Magnesia	...	5.19	2.45
Oxide of iron	2.32	1.04	1.56
Phosphoric acid	1.12	3.22	2.92
Sulphuric acid	0.44	1.04	10.59
Chlorine	2.82	0.62	1.56
Silica	77.08	70.19	60.58
	100.00	100.00	99.76
Percentage of ash	4.40	7.00	

In Fromberg's analysis silica is deficient, and sulphuric acid abundant.

The following figures show the mean results of analyses of the ash of wheat-straw, grown under ten different conditions as to manuring, during two consecutive periods of ten years each, by Sir J. B. Lawes and Dr Gilbert, at Rothamsted:—

	10 years. 1852-61.	10 years. 1862-71.
Pure ash	55.6	55.6
Ferric oxide	0.32	0.22
Lime	2.86	3.50
Magnesia	0.81	1.03
Potash	11.19	10.46
Soda	0.23	0.34
Phosphoric acid	1.75	1.77
Sulphuric acid	2.42	2.25
Chlorine	1.95	2.17
Silica	34.48	34.28

These figures show the quantity of each ash-constituent per 1000 dry substance of straw.

Wheat-chaff.—The chaff of wheat is not relished by any stock, and is strewn upon the dunghill. It ferments with great heat, and would make a valuable ingredient in maintaining heat around the frames of forcing-pits. The odour arising from wheat-straw and chaff newly threshed is glutinous.

Barley-straw.

Barley-straw is soft, has a clammy feel, and its odour, with its chaff, when newly threshed, is heavy and malt-like. In its long state it is relished by no sort of stock as fodder; on the contrary, it is deleterious to horses, engendering grease in the heels. It is thus mainly used as litter, and is much inferior to wheat-straw for cleanliness, durability, or comfort. It does not make a good thatch for stacks, being too soft and difficult to assort in lengths, apt to let through the rain, and rot. Cut into chaff, it is now used largely in pulped mixtures for cattle.

Ash.—The ash of barley-straw contains these ingredients:—

	Boussingault.	Sprengel.
Potash	9.20	3.43
Soda	0.30	0.92
Lime	8.50	10.57
Magnesia	5.00	1.45
Oxide of iron and a little oxide of manganese	1.00	0.65
Alumina	...	2.78
Phosphoric acid	3.10	3.06
Sulphuric acid	1.00	2.25
Chlorine	0.60	1.33
Silica	67.60	73.56
	96.30	100.00
Percentage of ash	7.00	5.24

Strength of Straw.—"There exists a popular notion that strength of straw is dependent on a high percentage of silica; but direct analytical results clearly show that the proportion of silica is, as a rule, lower, not higher, in the straw of the better-grown and better-ripened crop—a result quite inconsistent with the usually accepted view, that high quality and stiffness of straw depend on a high amount of silica. In fact, high proportion of silica means a relatively low proportion of organic substance produced. Nor can there be any doubt that strength of straw depends on the favourable development of the woody substance; and the more this is attained the more will the accumulated silica be, so to speak, diluted—in other words, show a lower proportion to the organic substance." [1]

Barley-chaff.—Barley-chaff is relished by cattle of all ages, and, rough as the awns are, they do not injure the mouth in mastication. It soon heats in the chaff-house, and, if not removed in the course of two or three days—dependent on the state of the air—decomposition will rapidly ensue. Both barley-straw and chaff seem to contain some active principle of fermentation.

[1] Fream, *The Rothamsted Experiments on Wheat, Barley, &c.*

Oat-straw.

Oat-straw is used mostly as fodder, being too valuable for litter. It makes a sweet soft fodder, and, when newly threshed, its odour is refreshing.

Of the different sorts, that of the common oats is preferred, being softer, sweeter, and more like hay than that of the potato oat. When oats are cut a little green, the straw is much improved as fodder; and it has been recommended to be cut green and dried, and used like hay, under the name of *oat-hay*.[2]

In Holland, oat-straw is built in the hay-stack, and both oat-straw and hay are cut together and given as fodder to horses and cows.

Ash.—The composition of the ash of oat-straw is as follows:—

	Levi. Kurhess.	Boussingault. Alsace.
Potash	12.18	26.09
Soda	14.69	4.69
Lime	7.29	8.84
Magnesia	4.58	2.98
Oxide of iron	1.41	2.24
Phosphoric acid	1.94	3.19
Sulphuric acid	2.15	4.37
Chlorine	1.50	5.00
Silica	54.25	42.60
	99.99	100.00
Percentage of ash		5.10

Oat-chaff.—Oat-chaff is not much relished by cattle. Being very clean and elastic, it is used by hinds' wives to fill the tickings of beds, after being riddled. It is apt to get into the eyes of young stock in the courts.

Chaff as a Foot-warmer.—The chaff of all the cereals is an admirable conserver of heat. Poachers in Scotland, when sitting out in winter nights in wait for ground-game, have effectually kept their feet from getting cold by letting them lie in a bag containing dry chaff. A bag of chaff may not be a convenient, but it is certainly a most effective foot-warmer.

Rye-straw.

Rye-straw is small, hard, and wiry, quite unfit for fodder, and would be an unmanageable litter in a stable, though useful in a court, in laying a durable bottoming for the dunghill. It makes

[2] *Trans. High. Agric. Soc.*, xiv. 148.

excellent thatch for stacks. It is much sought for by saddlers for stuffing collars of posting and coach horses. It is also in great request by brickmakers. Bottles of Rhine wine are packed in rye-straw.

Rye-straw is sometimes three or four times as heavy as the grain, which is a remarkable feature in this straw.

The plaiting of rye-straw into hats was practised as long ago as the time of the ancient Britons. Bee-hives and *ruskies*—baskets for supplying the sowers with seed—are beautifully and lightly made of rye-straw.

The ash of rye-straw contains these ingredients:—

	Will and Fresenius.
Potash	17.36
Soda	0.31
Lime	9.06
Magnesia	2.41
Oxide of iron	1.36
Phosphoric acid	3.82
Sulphuric acid	0.83
Chlorine	0.46
Silica	64.50
	100.11
Percentage of ash, about	40.00

Bean and Pea Straw.

Pea and bean straw, or haulm, are difficult in some seasons to preserve, but, when properly preserved, no kind of straw is so greatly relished as fodder by every kind of stock. An ox will eat pea-straw as greedily as he will hay; and a horse will champ bean-straw with more gusto than ill-made rye-grass hay. Sheep enjoy pea-straw much. The product of the pulse crops is considered much too valuable to be given as litter.

According to Sprengel, the ash of bean and pea straw contains the following ingredients:—

	Field-bean.	Field-pea.
Potash	53.08	4.73
Soda	1.60	...
Lime	19.99	54.91
Magnesia	6.69	6.88
Alumina	0.32	1.21
Oxide of iron	0.22	0.40
Oxide of manganese	0.16	0.15
Phosphoric acid	7.24	4.83
Sulphuric acid	1.09	6.77
Chlorine	2.56	0.09
Silica	7.05	20.03
	100.00	100.00

Percentage of ash, from 4½ to 6.

Young cattle are very fond of bean-*chaff*, and, with turnips, thrive well upon it. Cows also relish it much.

Ash of Straw.—100 lb. of the *ash* of the above sorts of straw gave the following weights of these constituents:—

Constituents.	Wheat-straw.	Barley-straw.	Oat-straw.	Rye-straw.	Bean-straw.	Pea-straw.
	lb.	lb.	lb.	lb.	lb.	lb.
Potash	0½	3½	15	1	53½	4¾
Soda	0¾	1	a trace	0½	1½	..
Lime	7	10½	2¾	6	20	54¾
Magnesia	1	1½	0½	0½	6½	6¾
Alumina	2¾	3	a trace	} 1	0¼	{ 1¼
Oxide of iron	..	..	..			0½
Oxide of manganese	..	0½	a trace	..	0¼	0¼
Sulphuric acid	1	2	1½	6	1	6¾
Phosphoric acid	5	3	0¼	2	7¼	4¾
Chlorine	1	1½	a trace	0¾	2¾	0¼
Silica	81	73½	80	82¼	7	20
	100	100	100	100	100	100

On comparing these numbers, one cannot fail to remark the large proportion of potash in bean-straw; the trace of soda in all the straws except the bean; the large proportion of lime in pea-straw compared with bean-straw; the large proportion of silica in wheat and oat-straw compared with pea-straw and bean-straw; and the large proportion of phosphoric acid in bean-straw compared with oat-straw.

Straw as Food or Litter.—Of the cereal straws that of oats is most relished by stock, that of barley least. Barley-straw should therefore be the first used for litter, and then wheat-straw, and if the supply of these is not sufficient, then oat-straw may have to be used. The use of straw as food for stock is fully considered in the chapter in this volume dealing with foods. So also is that of the different kinds of corn.

The *colour* of fodder affects the dung of the various animals; thus, pea and bean straw and chaff make the dung quite black, wheat-straw gives a bleached appearance to the dung of horses, and oat-straw a brownish hue to all dung.

Yield of Straw.—The value of straw may be estimated from the quantity usually yielded by the acre, and the price which it realises. Arthur Young estimated the straw yielded by the different crops—but rejecting the weaker soils—at 1 ton 7 cwt., or 3024 lb. per English acre. Mr Middleton estimated the different crops in these proportions:—

	cwt.		lb.	
Wheat straw . .	31	or	3472	per acre.
Barley " . .	20		2440	"
Oat " . .	25		2800	"
Bean " . .	25		2800	"
Pea " . .	25		2800	"
Average rather more than	25		2862	

or 1 ton 5 cwt. 62 lb. per English acre. In the immediate vicinity of Edinburgh, the produce, both in Scotch and imperial measures, per acre, has been found to be as follows:—

			Stones		lb.		ton	cwt.	lb.
Wheat straw,	9	kemples of 16 st. of 22 lb.	= 144	or	3168	or	1	8	32
Barley "	7	" " "	= 112		2464		1	2	0
Oat "	8	" " "	= 128		2816		1	5	16
Average	8	" " "	= 128		2816		1	5	16

or 1 ton 5 cwt. 16 lb. per Scotch, or 1 ton 0 cwt. 3 lb. per imperial, acre.

Ancient Uses of Straw.—The Romans used straw as litter, as well as fodder, for cattle and sheep. They considered millet-straw as the best for cattle, then barley-straw, then wheat-straw. This arrangement is rather against our ideas of the comparative qualities of barley and wheat straw; but the hot climate of Italy may have rendered the quality of barley-straw better, by making it drier and more crisp, and the wheat-straw too hard and dry. The haulm of pulse was considered best for sheep. They sometimes bruised straw on stones before using it as litter, which is analogous to having it cut with the straw-cutter. Where straw is scarce, they recommend the gathering of fern, leaves, &c., which is a practice that may be beneficially followed in this country, where opportunity occurs. Varro says, "It is the opinion of some that straw is called *stramentum*, because it is strawed before the cattle."[1]

An Ancient Threshing-machine.—This "advertisement anent the threshing-machine" appeared in the *Caledonian Mercury* of August 26, 1735: "Whereas many have wrote from the country to their friends in town about the price of the threshing-machines, the following prices are here inserted, for which the machines will be furnished (with the privilege of using them during the patent) by Andrew Good, wright in Edinburgh, whose house and shop are in the College Wynd—viz., to those who have water-mills already, one which will thresh as much as 4 men, costs £30 sterling. . . . One which threshes as much as 6 men, £45; 8 men, £60; and so on, reckoning £7, 10s. for each man's labour that the machine does, which is but about the expense of a servant for one year, whereas the patent is for 14 years. One man is sufficient to put in the corn to any one of 'em and take away the straw. . . . About 6 per cent of the grain which is lost by the ordinary method of threshing may be saved by this machine. . . . One of the machines may be seen in said wright's yard in the College Wynd."

TREATMENT OF FARMYARD MANURE.

Losses from Want of Care.—Farmers as a rule are not nearly so careful in the treatment of farmyard manure as they ought to be. It would be impossible to estimate the loss entailed annually by want of proper attention to both solid and liquid manure, but it is well known to be enormous. The loss arises mainly of course by the washing away of valuable elements of plant-food in rain-water, by the escape of volatile ammonia, and by what is known as "fire-fang." The dung-heap with its rich store of costly plant-food is too often left to look after itself. The heart may be burning out of it by "fire-fang," or its life-blood, so to speak, passing away in a black streamlet, or disappearing in the

[1] Dickson's *Husb. Anc.*, ii. 407.

atmosphere—all for want of thoughtfulness and thrift, and a little timely work on the part of the farmer and his men.

But this is not all. Over and above these there are losses of a negative kind, on account of which the amount of manure made upon many farms is much less than it might otherwise be. Some careful farmers lose no opportunity of adding to the manure-heap any sort of waste material, earthy or vegetable, which is capable of there becoming useful manure. They thus not only conserve what is already in the heap, but sensibly increase its bulk and value; while there is the further pleasing advantage in this careful system that where it is pursued the steadings are kept clean and tidy, the roadways and foot-paths in and around it dry, comfortable, and free from mud and loose straw or other litter. Others again never seem to think that any effort should be made to assist the live stock in adding to the contents of the dung-pit. Those who are thus neglectful not only lose useful manure, but also have the thoroughfares in and around their steading constantly in an untidy and uncomfortable condition.

From all points of view, therefore, the treatment of farmyard manure is a subject that demands and will amply repay the most careful consideration and attention.

Forming Dunghills.

Carting out Manure.—The carting of dung to dunghills in the fields in winter is not now pursued so largely as in former times. Better provision, in covered courts and prepared dung-pits, is now made for storing the dung at the steading. The winter carting of dung of course lessens spring work, which is an important consideration. The fertilising value of the dung, however, can be most effectually conserved by retaining the dung in the court or dung-pit at the steading till it can be spread on the land.

In some cases the dung, towards the close of winter, will have accumulated so high in the cattle-courts, as to become nearly level with the feeding-troughs, thereby making them inconveniently low for the cattle. To avoid such inconvenience it is still the custom in many parts to have the dung removed, and formed into dunghills in the fields intended to be manured in the ensuing season. The most convenient and proper time to do this is when the frost, snow, or rain prevents the ploughing of the land.

Different kinds of Dung for Different Crops.—In carting out manure at this time care is taken to have the dung placed upon or convenient to whichever field or division of field it is to be applied. Some farmers have considered it desirable to keep the different kinds of dung separate, so that each may be used for the crop for which it is best adapted. It is well enough known that the different sorts of farmyard manure—stable, cow, and pig—are not equally suitable for all kinds of crops.

Suppose that carrots are to be raised on a field of light land, then the land should be dunged in the autumn with a large proportion of cow-manure, or mixed manure; because if the manure be very nitrogenous, like stable-manure, the land light, and the rainfall heavy, a large portion of the nitrates will be washed into the drains or subsoil, while if cow-manure be used, it being less soluble, little is wasted. Then when potatoes are desired to be raised on heavy soil, which is not their natural one, horse-litter should be used. But with the choice of several kinds of cheap and efficient artificial manure, the advantages of keeping the different sorts of dung separate are now of less importance than formerly.

Mixing Dung.—The better plan is to have all the kinds of dung mixed together as they are taken away from the various classes of stock. Thus, the horse-manure should be daily and systematically spread over the cattle-dung in the cattle-court or manure-pit. If horse-dung is left by itself in a heap, it will speedily get injured by "fire-fang." Then, it is also well to have the manure made by cows and store cattle mixed with the richer manure made by cattle which are being fattened.

Position of the Dunghills.—Another matter which deserves consideration before courts are begun to be cleared in winter, is the position the dunghills should occupy in the field. This point is determined partly by the form which the surface of the field presents, and partly from the point of access to the field. It should be a general rule that the dunghill should be placed in the field where the horses will have the advantage of going downhill with the loads from it when the manure is applied to the land. Wherever practicable, this rule should never be violated, as facilities afforded to labour in the busy season are of great advantage.

If the field has a uniformly sloping surface, the dunghill should be placed at the highest side; but the access to the field may only be at the lowest side, and it may be impracticable to reach the highest side by any road. In such an untoward case the loads should be taken to the highest side, up a ridge of the field, and frosty weather chosen to form the dunghill in it, as the cart-wheels and horses' feet will then have firm ground to move on. The loss of time thus incurred by the distant travel will not be much felt in winter. But if it be impracticable to lead dung there, on account of the soft state of the land or steepness of the ascent, the only alternative is to form the dunghill at the side nearest the access.

When the field has a round-backed form, the dunghill may be placed on the top of the height, to allow the load to go downhill on both sides—in all cases certainly where the manure is to be put out in heaps, with a heap in every third drill, each heap about three or four yards apart. But when the manure is to be thrown from the cart in graipfuls as the horse moves along the drill—which is by far the most expeditious method—some consider it a better plan to have the dunghill at the lowest end of the field, so that as the cart goes up the hill, it always becomes lighter until it arrives at the top, by which time the cart will be empty. This is the best system to pursue, where the land is flat enough at the entrance of the drills to allow a horse to draw easily a full-loaded cart. If this cannot be done, it is better, as already suggested, to empty downhill.

To form a proper site for a dunghill, a head-ridge should be formed along the crest of the height when the stubble is ploughed. In a level field, it is immaterial which side the dunghill occupies.

The precise spot which a dunghill should occupy in a field is thus not a matter of indifference. We have seen a dunghill placed in the very centre of a field which it was entirely to manure. From this point the carts must either go across every ridge between the one which is being manured and the dunghill, or go direct to a head-ridge, and thence along it to the ridge to be manured. This latter alternative must be adopted if the dung is to be deposited in drills; and if not followed, the drills prepared for the dung will be much cut up by the passage of the carts across them—a practice never to be allowed when neat work is desired.

The proper position for the dunghill is on a head-ridge, or at the end of a side-ridge of the field. Some prefer the end of a side-ridge, because the length of a dunghill upon a head-ridge prevents the ends of the ridges opposite to it being ploughed or drilled to their proper length. The dunghill on a side-ridge only prevents that single ridge being ploughed to the last.

When a large field requires two dunghills, the one first to be used should be placed *along the end of a ridge* at such a distance from the far side of the field as that the ridge occupied by the dunghill may be ploughed when the manuring reaches it. The second dunghill should be on the nearest side-ridge. The first dunghill should be first used, for the farthest side of the field.

Should the weather be fresh and the ground soft, one dunghill may be made on the side-ridge nearest the gateway, and made large enough to manure the whole field. A large dunghill in one place will doubtless take more time to manure the field at the busy season than two dunghills at different places; but, in soft weather and soil, it is better to incur a little future inconvenience in good weather, and on firm soil, than make the horses drag half-loads axle-deep along a soft head-ridge.

The main objects to be kept in view, in selecting the sites of dunghills in the field, is to ensure that the loads in the busy season will not only have a passage downhill, but that the dung will be situated at the shortest distance from the place where it is wanted, and that the ploughed or drilled land may not be injured by cart-wheels and horses' feet.

When it is considered desirable to go through a part of the prepared land on the way from the dunghill to the drills, it is a good plan to draw six or eight drills for a road, following as easy an incline as possible. This prevents the treading of the surface-soil by the horses and carts.

Fields to be Manured.—The fields in which dunghills are usually formed are those in which, in the ensuing season, are to grow the green crops. The potatoes coming first in order, the land for them should first have its manure carried out and formed into a dunghill, that is, if it is decided to cart the manure into dunghills. The mangels and turnips come next. All the dunghills should be respectively of such a size as to manure with a given quantity the extent of land to be occupied by the particular crop.

Loss of Time in Carting Dung.—Few would believe the care required in laying straw in a court, except those who have experienced the trouble and loss of time incurred in removing dung from it, when the straw had been carelessly laid down. The courts are usually cleared during frost, when time is regarded of less value—the plough being rendered useless; but notwithstanding this common feeling, a loss of time at this season may cause a serious loss of it in a future operation.

For example: The hard state of the ground may favour the carriage of manure to a distant field, to gain which most of the time is spent upon the road. Suppose frost continued as long as to allow time to carry as much manure as would serve the whole field, provided ordinary diligence were used on the road, and no interruption occurred in the courts. Suppose, further, on manuring the field in summer, there was found to be less manure in the dunghill, by a small quantity, than was wanted, and that half a day, or, at most, a whole day's driving in winter, from the steading, would have supplied the requisite quantity, it is clear that one day's driving could have been accomplished in frost at much less loss of time than at the season when the manure is wanted. Any sacrifice of time *must* be made on the instant, or the field will be deprived of its due proportion of manure.

This is no hypothetical case; it has occurred in every farmer's experience. Now, what was the primary cause of this dilemma? Either too much time had been spent upon the road in driving the manure, or interruption had been experienced in the courts. To which of these two causes ought the waste of time to be probably attributed? With regard to driving, farm-horses get into so regular a pace upon the farm-road, at all times, that little loss or gain of time can be calculated on their speed. Besides, when a number of carts are employed at any work, each cart must keep its turn, otherwise it will be overtaken or left behind by one of the other carts.

Careless Strewing of Litter in Courts.—The probability is, the loss of time was incurred in the courts, and the reason was this: The usual way of taking the wet litter from the work-horse stable is to roll as much of it together with a graip as a man can lift, and throw it into a barrow, in which it is wheeled into a cattle-court, emptied on any spot to get quit of it in the shortest time, and left in heaps to be trampled down by the cattle. Bundles of thatchings of stacks, not always dry, are carried into the court, and put down anywhere and partially spread. Long straw-ropes from the stackyard are pulled along the court.

In doing all this—at intervals of time—it seldom enters the head of any one to do what would facilitate the lifting of the dung-straw afterwards, when the court is being cleared of its contents. When that time arrives, and before the litter has become short by fermentation, the difficulty attending its removal is then experienced. A lump of long damp straw is seized by one part of a graip, while the other part of it goes into a coiled-up heap of straw-rope, which cannot be torn asunder without much exertion on the part of the ploughman, pulling it this way and that. Another graip encounters a long straw-rope, which, after much tugging, is broken or pulled out, and thrown upon the cart with its end dangling down.

In short, not a single graipful is easily raised, and the work is not expedited when a heap of chaff intervenes and evades the thrust of the graip. Add to this the few hands generally sent to assist the ploughmen to fill the carts, and some idea may be formed of the waste of time incurred at this necessary work. The men are not intentionally idle, and when they are put to it, they work very hard; and yet, in such circumstances, they show but small result from unwonted exertion.

How Litter should be Spread in Courts.—Thus, much time is uselessly thrown away which would have been saved had the litter been spread judiciously over the surface of the dung-heap, and had the straw-ropes from the stackyard been cut into short pieces. Free from such unnecessary obstructions, a whole day more of driving of dung might have been obtained ere frost gave way, which would have avoided the dilemma experienced at the manuring of the field.

The effectual way of preventing delay in carrying out dung to the dunghill in the field is at first to put down the litter so as to be easily lifted afterwards, and to afford as much assistance at filling the carts in the court as to detain the horses for the shortest time.

The litter should be laid down at first, and continued to be so, in this manner. The bare ground in the empty court should be covered evenly with straw, and the future layers of litter should be spread thinly, beginning at the end of the court furthest from the gate. The litter should be spread with the slope of its lower part towards the gate, and carried gradually forward every day until it reaches the gate; and every kind of litter, whether from the work-horse stable, the stackyard, or straw-barn, should be intermixed and treated in the same manner.

The straw-ropes should be cut into small pieces and thrown about, and the chaff not fit for fodder sprinkled, and not laid in heaps. Thus layer above layer is scattered, until the whole season's manure is made.

Another very important reason why litter should be evenly and carefully spread over courts or heaps of dung, will be explained in speaking of "firefang" in farmyard manure.

Chaffing Litter.—An effective method of avoiding the losses arising from the uneven spreading of long litter on manure-heaps and in courts, is to have the litter cut short by a litter-cutter. The advantages claimed for this process are well set forth by Mr H. Howman, on page 231.

Emptying Courts of Dung.—When the time has arrived for emptying the courts, the process is *begun at the gate* through which the loaded carts are to pass, and the dung lifted from there will come up in sloping layers, having an inclination to the top of the dung-heap, not in entire layers of the whole depth of the dung-heap, but in successive small detached layers, one beside the other, and succeeding one after the other, from the gate to the farther end of the court. The empty carts enter the court by another gate, if there be one, and, without turning, take up their position where the loaded cart was before, and has just passed through the gate appointed for it.

When there is only one gate to a court, and the court not very large, and the lot of beasts obliged to be kept in it, for want of room to put them elsewhere, one cart, on starting work for the day or yoking, may have to wait on the outside until the other has been loaded and gone away.

When the court is large, it may be possible to load two or three carts at one time.

On dropping work at mid-day, it will save time, at starting again after dinner, to fill a cart and allow it to stand loaded, without the horses, until the time for yoking, when the horses are put to, and it forms the first load to start for the field—the work being so arranged that only one cart is at the court at one time.

On clearing a court, or any part of it, it should be *cleared to the ground;* because the manure made from a dung-heap that has been simultaneously formed, will be more uniform in its texture than that made from a heap composed entirely of new dry straw on the top, or of old and wet straw at the bottom. Indeed so important is this point of having the old and the fresh dung mixed, that to ensure it many farmers turn over the entire dung-heap before it is carted out.

Besides, it is much better for the

future comfort of the cattle that the court receive a fresh dry littering from the bottom, than that the wet bottoming should remain.

Turning Dung.—But this turning should not take place except within eight or ten days before the dung is to be applied to the land. The turning sets up a rapid fermentation, and if this fermentation is allowed to go too far, the dung will be seriously injured.

Cattle sometimes are injured by a cart or horse when the court is emptying; and, to avoid the risk, they should be confined in the shed as long as the people are at work in the court.

Art in forming a Dunghill.—To form a dunghill in the field requires some art. A dunghill having a breadth of 15 feet, and of four or five times that length, and of proportionate height, will contain as much manure as should be taken from one spot in manuring a field quickly. Suppose that 15 feet is fixed upon for the width, the first carts should lay their loads down at the nearest end of the future dunghill, in a row across the whole width, and these loads should not be spread thin. Thus, load after load is laid down in succession upon the ground, maintaining the fixed breadth, and passing over the loads previously laid down. On frosted ground the bottoming is easily formed.

After the *bottom* of the dunghill has been formed of the desired breadth and length, a gradual slope upwards is made from the near end and carried to the highest level near the farthest extremity, from which also a slope descends to the end. Thus layer after layer is laid on until the full height of the dunghill has been reached, the dung in the meanwhile being trampled down by the carts and horses. The slope towards both ends facilitates the passage of the carts in going on and coming off the dunghill.

Every cart-load laid down above the bottom stratum is spread around, to mix the different kinds of dung together, in order to give a uniform texture to the whole heap of manure. To effect this purpose the better, a field-worker should be employed to spread the loads on the dunghill as they are laid down, ploughmen being apt to spread it too little, and the field-worker will save the time of both men and horses. It is essential to have the whole dunghill equally compressed, with a view to making the manure of similar texture throughout.

If the manure is being carted from a dungstead at the farm, containing a large proportion of manure from the cow-byres, it may be too soft to enable the carts to go on it as recommended above. In such a case a row of carts should be emptied across the bottom of the proposed dung-heap, the rest of the manure being thrown from the carts by the graips on to the top of what was emptied up, until it reach the desired height, perhaps 3 to 4½ feet.

After the dunghill is completed, the scattered portions of dung along the sides and the thin extreme ends should be thrown upon the top and trampled down, and the entire top brought to a gentle ridge, like a house-top, so that heavy rains may be run off, instead of soaking down through the whole mass. Such a finishing to a dunghill is very generally neglected.

Preventing Fermentation.—The object aimed at by the compression of the dunghill by the loaded carts, is to prevent immediate fermentation. So long as the temperature continues at its average degree in winter of 45°, there is little chance of much activity of heat in the interior of a dunghill; but towards spring, when the temperature rises, it will show symptoms of action. Even then, a temperature of 65° is required to commence the second stage of fermentation. The first fermentation only evaporates the water, the destruction of fibre commencing with the second stage of fermentation.

Covering Dunghills.—Covering a dunghill in the field with a thick layer of earth, with a view to exclude the air and check fermentation, is unnecessary in the coldest months of winter, though of service in spring to a dunghill which is not to be immediately turned, and useful in winter to throw off rain. In some cases loose sheets of corrugated iron are used to carry rain-water off dunghills.

A dunghill, made up in a loose manner at once in graipfuls from each cart-load, gives, in effect, the dung a turning, and although covered with earth, it soon becomes fermented enough for an early crop, such as beans; but if it is not to be used until an advanced period of the season, when the temperature will have risen considerably, loose dung will ferment too rapidly. A new-made dunghill should thus be covered with earth or not, according to the use to be made of it.

Dung-spade.—The dung in hammels and courts is often so much compressed as almost to resist the entrance of the graip. To enable it to be easily lifted, therefore, it may in this case be cut in narrow parallel divisions with the *dung-spade*, fig. 232. This consists of a heart-shaped blade of steel, thinned to a sharp edge along both faces; and its cross-head, or helve, is fastened to it with nails into a split socket. The height of the spade is 3 feet, length of the cross-head 18 inches, length of the helve 18 inches, length of the blade 16 inches, and its breadth 10 inches. It is sharpened with a scythe-stone.

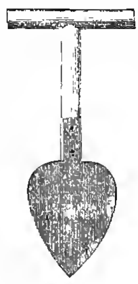


Fig. 232.—*Dung-spade.*

In using this spade, it is raised with both hands by the cross-head, and its point thrust with force into the dung-heap, up to the head of the blade at least, making a rut across the dunghill by a repetition of thrusts. The blade is heart-shaped, not squared like a common spade, because, when cutting the dung-heap to a greater depth than the length of the blade, its rounded ears escape catching the dung on the blade being drawn up.

Another instrument for cutting dung is like the common hay-knife, and used in like manner, but is not so efficient an implement as the spade. The common spade used in cutting surface-drains, well sharpened, is used by many farmers for cutting dung.

Manure-court.—It is the practice of many farmers to keep the dung from the cow-byres in a loose state in a dung-court, enclosed with a strong wall 3 or 4 feet in height, into which the dung is wheeled as it comes from the byre, a plank being used as a roadway for the barrow to ascend, the dung being allowed to accumulate here till required on the land. It does not need any more turning, and soon gets in a state fit for potatoes or turnips. This plan saves the trouble of turning the dung, and if a roof were provided to the pit, loss by washing would be prevented.

Is Winter Carting-out Injurious to the Dung.—As to the influence which the carting out of dung to heaps in the field in winter has upon the manure there is some difference of opinion. Some contend that the carting process entails loss by volatile ammonia passing away in the atmosphere, and by rain-water washing away valuable ingredients. The danger of this, however, is reduced to a minimum, if not altogether removed, by proper care in forming and finishing the dunghill. If the dunghill be well packed in the field and finished off on the top —by being raised in a ridge along the centre and covered with a smooth layer of earth—so as to keep out rain-water, there will be little risk of loss.

Upon the whole, therefore, the carting of at least a certain quantity of the dung to the fields in the slack months of winter has several points to commend it. With proper care it may be done with safety to the manure, and there is great advantage in the saving which is effected in the carting in the busy spring-time.

Field - sheds for Manure.—To protect the dunghills it has been suggested that permanent sheds might be erected at convenient points in the various fields, to which the dung could be carted in winter as usual. The great expense involved renders this plan impracticable, except, perhaps, in a few rare instances. In the third edition of this work the following sketch was given of a shed for manure, which might answer in any part of the fence of a single field, or in the point of section of two fences in the corners where four fields meet. Fig. 233 is such a place, where there is a shed, 80 feet long and 12½ feet broad, over walls, standing either E. and W., or N. and S., whichever is most convenient for the dung to be brought from the steading to the corners of the four fields, where are the midden-stances, 18 feet wide each, upon which the dung is first put when taken out of the courts early in winter, but if towards the end of winter it should be put into the shed at once.

As most of the dung experiences much warmth from a high temperature of the atmosphere before it is ploughed into the ground, a plantation, 12 feet in width, of spruce or Scots fir, around the midden-

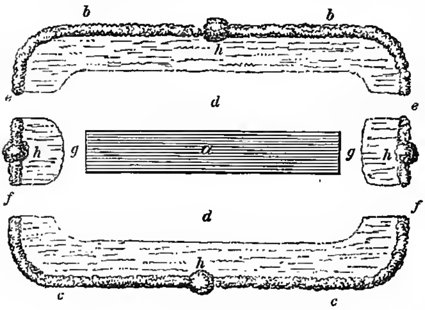


Fig. 233.—*Dung-pit for four fields.*

a Shed.
b b Fences of 2 fields.
c c Fences of 2 other fields.
h Points where the fences of 4 fields come.
d d Midden-stances.
e e Outlets to 2 fields from their midden-stance.
f f Outlets to 2 other fields from their midden-stance.
g g Passage at the ends of the shed.

stances, would be a screen from the sun or a protection to the outside of the midden from heavy rains from any quarter in winter.

There are four slip-gates, 10 feet wide, for taking the dung in and out to the four fields. The midden-stances should be firmly causewayed or macadamised. Such an arrangement, shed, stances, and fences, would occupy a space of 134 feet long by 84½ feet broad, or about a quarter of an acre. The fences of the four fields meet those of the midden-stances at four points. There is a passage for carts at both ends of the shed.

Winter Industry lessens Spring Work.—We have dwelt the longer on the subject of clearing the courts of dung for the making of dunghills in the fields in winter with the view of enforcing the fact that farm-servants are apt to believe that work may be done at leisure during a stormy period in winter, on the supposition that time is of less value at that season than at any other. We have seen, on the other hand, that time uselessly spent in winter on one thing may cause much trouble and delay on another thing in the busy season of spring. Let, then, everything done in winter tend to facilitate and expedite whatever has to be done in the ensuing busy season; and for that intent, few things require more attention than the judicious distribution of litter in the courtyards.

Dunghills Injurious to Drains.—A rather curious and entirely unlooked-for effect took place from the oozings of dunghills in two fields on the estate of Pumpherston, near Midcalder, in the county of Edinburgh, in March 1848. Tile-drains that had been made in the autumn preceding were found to be choked in spring, and bursting out water. On opening them, the tiles within a limited space were completely filled with a peculiar substance. The subsoil in one field was gravelly, and the drains 3 feet deep; that of the other, clay, with drains of 20 inches deep. In both cases the drains leading from a dunghill were only so affected, and the conclusion arrived at was, that the oozings from the dunghills had induced the growth of the substance found in the tiles. The substance was of a dirty grey colour, slimy, tenacious, some pieces of it resembling fragments of skin, but appearing to consist, when pulled asunder, of minute fibres, too fine to be easily observed by the unassisted eye. It had an extremely offensive, putrid, animal odour, and was impregnated with a good deal of earthy matter, which long washing with water could not entirely separate. It was pronounced by Dr Greville to be a plant — the *Conferva bombycina* — the filaments of which are extremely fine, and act as a cobweb in catching and retaining minute insects, larvæ, and floating atoms of inorganic matter in water. These plants grow rapidly, and as rapidly pass into putrescence.[1]

The moral of this is that no dunghill should be formed above tile-drains, for although in this case the alarming state of the drains was but of short duration, more permanent injury might be experienced from stronger materials. Anyhow, it is safer to avoid such inconveniences by placing dunghills beyond the reach of drains, and also making the sites of dunghills impervious to liquids. A side-ridge

[1] *Trans. High. Agric. Soc.*, July 1848, 278, 279.

of a field is the safest place, and, when the dung is put into a pit, it is quite out of the way of doing harm. Drains of 4 feet deep would probably have been less injured, if at all, in being beyond the reach of oozing.

Covered Manure-pits.

Fermentation in Dung.—The important questions relating to fermentation in farmyard manure—its causes and effects, and how it may be regulated—have, from time to time, given rise to much interesting and intelligent discussion.

As pointed out on page 231, Dr John Voelcker considers that the fermentation which takes place in dung does no injury—that is, if anything like ordinary care is bestowed upon the "making" of the manure. He explains that the gases generated by fermentation in the centre of the heap get cooled and fixed as they penetrate the colder surface-layers of the dung; so that if care is taken to have the dung spread evenly, and tramped firmly—still more particularly if it is kept moist in the surface-layers—there will be little or no loss by fermentation.

Mr Rowlandson, of Bootle village, near Liverpool, writing in the *Journal of Agriculture* for Oct. 1845, said: "The fermentation of manure-heaps depending upon the presence of heat, moisture, and the atmosphere, the skilful farmer will avail himself of the means in his power to promote or retard fermentation, by dispensing with or admitting one or other of these agents, as the case may require. This is done in several ways. The free admission of the atmosphere is one of the principal causes of excess of fermentation; and Boussingault, although he does not state this to be the *cause*, admits that 'it is of much importance that the heap be pretty solid, in order to prevent too great a rise of temperature, and too rapid a fermentation, which is always injurious. At Bechelbronn, our dung-heap is so firmly trodden down in the course of its accumulation by the feet of the workmen, that a loaded waggon, drawn by four horses, can be taken across it without very great difficulty.'

"Notwithstanding this opinion of a man of science, many writers have asserted that tramping down manure is injurious. Each party is right according to circumstances. If a manure-heap is wanted for immediate use, a free admission of the atmosphere is necessary, to promote rapid fermentation; but this is done at the expense of a considerable escape of its volatile contents. On the other hand, if intended to lie for some months, as is frequently the case, pressure, and consequent absence of a current of atmospheric air, will retard fermentation.

The Manure-pit.—"By restricting the admission of air, we have a direct command over the fermentation of the manure-heap; and this restriction can be attained only by placing the manure in pits. The usual shape of a manure-heap is that of a cube or parallelopipedon, each being a figure of six sides, five of which are exposed to the influence of the atmosphere, the bottom only not being surrounded by it. By the pit we shall completely reverse the order, one side, the top, only being exposed to the atmosphere; and that is also the side, from the altered circumstances of the heap, into which the air will have the greatest difficulty in penetrating. In fact, from the absence of draught from the sides, fresh volumes of air will only penetrate the top by means of pressure. . . .

"Another advantage to be derived by using pits is, that in winter the caloric arising from the fermentation of the heap could not be dissipated so speedily, but would be diffused through the heap more equally than it is under the present system, when surrounded by a cold, perhaps a frosty, atmosphere. It is so well known that manure-heaps formed in winter do not ferment equally, or scarcely at all, that it has given rise to the axiom, that one load of manure formed in summer is worth two formed in winter.

Oozing of Liquid from Heaps.—"The amount of my observation is, that in heaps, as usually formed, with free access to the atmosphere, a larger amount of humic acid, soluble in alkalies, is formed than when the manure is placed in pits, and access of the atmosphere is limited. In the latter case, some humic acid is formed; in both cases, the humic acid is in the same state as that which is found in barren mosses, as I have determined by repeated experiments. The humic acid has a strong affinity to combine with the alkalies, potash, soda, and ammonia in manure-heaps, and this forms the brown-coloured solution which is observed running from them after rain. It is perfectly obvious, therefore, that every drop of the brown-coloured liquid which oozes from the manure-heap contains, in combination, one or other of the above-named alkalies, two of which, potash and ammonia, are of so much importance as fertilisers. The mode I have suggested of placing the manure in pits may be said to remedy this evil, as, at all events, it will prevent the liquid from running away."

It will be observed that these latter remarks apply to the dung-heap in a state of fermentation. When not fermenting, the dung-heap, in winter, parts with very little liquid; and if the top of dunghills in the field were finished off and covered with sheets of iron or with earth made smooth on the surface as already explained, little or no rain could get into the heap.

Manure-pits at Steadings.—Although the proposal to erect manure-sheds in the fields cannot be said to have come into practice, permanent manure-pits with substantial roofs have been constructed at many farm-steadings. This covered pit is situated as conveniently as possible to the cattle-courts and byres, and is sometimes round or oval, but as a rule square or oblong. Corrugated iron roofing is frequently used for this, and in some cases the side walls are not carried close up to—about 4 or 5 feet high, or 3 or 4 feet from—the edge of the roof, which therefore rests on pillars. The manure is conveyed into this pit in carts or barrows daily, or at intervals, as may be considered best, or as may be most suitable to local circumstances.

But a preferable plan—except in northern districts, where the winter is long and idle and the spring short and busy—is to have the dimensions of the covered courts sufficient to admit of the whole season's dung being allowed to remain under the cattle until it is required upon the land.

Flooring of Manure-pits.—It is desirable that the bottom of the manure-pit should be made water-tight, so as to prevent the urine from passing into the earth. A layer of clay pounded firmly makes a good bottom and is very often adopted. Concrete is very effective, but may be more costly. What should be done with any excess of urine will be explained presently.

Extra Value of Covered-court Dung.—There is less winter carting of manure to the fields now than formerly. With the extended introduction of covered courts, the practice of keeping almost all the season's manure under the cattle till required for the land has gained in favour. Upon very many farms the dimensions of the covered courts are now so extensive as to easily admit of this; and important advantages are claimed for the system. The spring work is of course increased by having the manure to cart from the steading, but it is contended—and the contention is supported by many eminent practical farmers, as well as by men of science—that this extra work in spring is far more than counterbalanced by the greater value imparted to the dung by its continuous good treatment under cover.

It is unnecessary here again to discuss fully the relative properties of manure made in covered courts and in open yards. The subject has already been dealt with in pages 226-232. As to the respective and relative merits and influences of dung which has been turned, and lying for a time in a dunghill in the open field, and dung taken direct from below the cattle in the covered court, there is some difference of opinion. It has in several cases been found in practice that the latter was the more efficacious for potatoes, and there is perhaps a preponderance of testimony in favour of carting direct from the covered court.

The Art of "Making" Manure.

Well-made Dung.—It is of course important that the manure should be "well made"—a term sufficiently understood by farmers. It should be even in texture, with no lumps of fresh straw or of litter of any kind. Well-rotted dung will exert its influence more rapidly than rank fresh dung, and this is often a point of importance. Too often farmyard manure is estimated merely by its bulk. There could be no greater mistake. Far more important is the question of quality. The mechanical influence which bulky farmyard manure exerts in opening up a close soil is certainly of considerable moment. The chief function of the dung, however, is the supplying of plant-food. Its value is dependent mainly upon the amount of plant-food it is capable of providing; and in the estimating of this, it is the character rather than the mere bulk of the dung that has to be considered. One load of short, rich, well-rotted dung may be worth two of rank fresh dung in which there may be a good deal of straw but very slightly decomposed. There is little use of filling drills of rank fresh straw, in which it should be remembered there is little manurial value.

The Art.—There is therefore some art in having dung "well made." It lies mainly in this: Litter the court so as to provide every part of it with just as much litter as the animals can turn into well-soaked firmly packed manure. Spread the litter frequently, and in thin layers, taking care above everything that no dry bundles of straw can get buried in any part of the heap of dung. Depend upon it such dry bundles will become veritable volcanoes, burning up the valuable fertilising materials around them. If stable-dung is taken into the court, spread it evenly over the manure. If left in a heap by itself, it will be liable to injury by "fire-fang." The dung which is taken from the cow or other house in which there may be stalled cattle should also be carefully spread over the court, the wetter portions being thrown on the drier parts of the manure already in the court.

It is also desirable, as already indicated, to have the dung from cows and store cattle mixed with that made by fattening cattle. The last will, of course, be richer than the two former, and it is well to have the dung-heap of uniform quality.

How the Urine may be Utilised.—Then, in the event of the farmer desiring as much straw as possible converted into manure, the cattle may be considerably assisted in this by having such of the liquid manure as finds its way into the manure-tank periodically pumped on to the mass of solid dung, the drier parts getting the largest share of the liquid. Where the supply of litter is sufficient, this is perhaps the best way of utilising liquid manure. By this method both the quantity and the quality of the dung may be greatly enhanced. Where litter is scarce, the animals may be able to moisten and make thoroughly all the material placed beneath them, without any aid from the liquid-manure tank. In that case, as will be presently explained, other uses will be found for the contents of the tank.

Injury from "Washing."—An argument used against covered courts is that the dung made in them is apt to be too dry. In open courts the rainfall no doubt helps the urine of the animals to make the litter *wet*, but the *wetness* which comes from the influence of rainfall may not be altogether beneficial. Indeed it has been well established by scientific investigation that dung is more liable to suffer injury by having its fertilising elements washed out of it by rainfall than by either evaporation or "fire-fang." The late Dr A. Voelcker investigated this matter fully, and he found that the loss by washing sometimes amounted to as much as two-thirds of the whole fertilising value of the manure.

It is therefore desirable to note, that while moisture is essential to the successful making of manure, great damage may be done by having the dung exposed to washing. In open courts more harm is often done by the collected rainwater from roofs being allowed, through defective water-spouts at the eaves, to rush upon the dung with considerable force, than by the direct rainfall upon the area of the dung-heap. Indeed, if all the small quantity of rain which usually falls during winter would only distribute itself pretty evenly over the season, and descend in nice gentle showers, its influence upon the dung-heap might be all for good—that is, if the neglectful farmer would only give up his careless ways and insist upon the water-spouts doing their duty. But winter rain is wilful, and too often falls in such torrents as to be perilous to the unprotected manure-heap.

It is thus, upon the whole, a good thing to have a roof over the manure, whether it be kept in the cattle-court or in a pit by itself. Do not attempt to convert more litter into manure than the animals, with the assistance of their own urine, can moisten and tread into "well-made" dung. Little reliance can be placed upon moisture from extraneous sources; and dung that contains any considerable quantity of straw merely rotted by rain-water cannot possess very high manurial value.

Mischief from Defective Water-spouts.—Incidental reference has been made to the neglect of water-spouts. Now this is a point seemingly small enough, yet of great importance. For be it remembered that through the absence of efficient spouts around the eaves to catch and carry away the water as it falls from the roof, the benefit of the roof over the manure may, as far as concerns rainfall, be almost entirely nullified. We have occasionally—even where substantial roofing had been thrown over the courts—seen the rain-water from the roofs allowed to rush upon the dung with all its concentrated force, thus doing much more harm than the same amount of rain would have done had it fallen directly and universally upon the manure. And all this mischief arose through neglect to repair a few feet of a decayed water-spout. Decayed water-spouts around the eaves of the cattle-court are like great holes in the farmer's purse, through which hard-earned coin steals imperceptibly away. For the sake of the manure we would rather have an entirely open court than the best covered court in the universe and no water-spouts to carry the rush of rain-water away from the dung-heap.

"Fire-fang" in Manure.—Much loss, all of which is preventible, is sustained through "fire-fang" in manure. Horse-dung is most liable to it, but it occurs in other kinds of manure where great neglect prevails. When stable-dung is thrown into a heap, and allowed to become dry, it will ferment in the centre, and if left undisturbed, will rapidly pass into the most rampant stage of "fire-fang," which results in great destruction of plant-food. Bundles of dry straw, buried amongst cow-dung, may also become centres of "fire-fang," doing harm where it is little expected.

Now all this mischief is quite easily prevented. *If* the dung, as it is removed daily from the stable and cattle-houses, were spread evenly over the heap in layers, and well packed — tramped with cattle, perhaps, in covered courts—and moistened by having the liquid manure from the tanks pumped over it once a-week, *there would be no fire-fanged dung upon the farm.* It is a simple cure, but quite effective. By careful and constant attention to this simple method, enormous loss which now takes place every year would be entirely saved. Cutting litter into short lengths helps greatly in avoiding "fire-fang" and in making first-class manure. This is well pointed out by Mr Howman, whose remarks are quoted on page 231.

Different kinds of Dung.

Horse and Cow Dung Compared.—The dung from a cow-byre put in a covered pit, direct from the byre, will probably remain a long time, after the arrival of warm temperature, unsusceptible of fermentation; and perhaps it is from this property that cow-dung has received the character of being a *cold* manure; whereas horse-dung easily ferments, and goes rapidly through the stages of destructive fermentation, termed "fire-fanging," and is said to be a *hot* manure. Both dungs mixed form a valuable manure. The hot nature of horse-dung, and its rapidity of fermentation, are supposed partly to arise from its containing more nitrogenous matter than cow-dung; but, according to the analyses by Boussingault, it would seem that it is only as long as the dung is fresh that that supposition is well founded. The analyses are:—

	Fresh dung. Cow.	Fresh dung. Horse.	Dry dung. Cow.	Dry dung. Horse.
Water	90.60	75.31	...	...
Nitrogen	0.22	0.54	2.3	2.2
Saline matter	1.13	4.02	12.0	16.3

"From these analyses," remarks Professor Johnston, "it appears that, though recent cow-dung contains more water than horse-dung, yet the dry matter of the former is richer in nitrogen than that of the latter. Were this generally the case, it ought, one would suppose, after becoming a little drier, to ferment, or be as warm as horse-dung. However this may be, the two circumstances—that the nitrogen of the food is discharged chiefly in the urine, and that the cow voids a much larger quantity of urine than the horse—incline me to believe that cow-dung must *generally* contain less nitrogen than that of the horse, and that this is really the cause of its greater coldness. The correctness of this opinion can only be tested by a series of careful analyses. At the same time it is proper to add, that the peculiar state of combination in which the nitrogen exists in two bodies, supposing the proportion in both to be the same, may modify very much the rapidity of the decomposition they respectively undergo in the same circumstances.

"Though fermenting with such apparent slowness, fresh cow-dung undergoes in forty days a loss of one-fifth of its solid matter (Gazzeri). Though this result was observed in Italy, yet there is sufficient loss in our climate also to make it worth the while of an economical farmer to get his cow-dung early in heaps, and to shelter it as much as possible from the sun and air. Even when fed on the same food, the dung of the horse should be richer than that of the cow, because of the large quantity of urine the latter animal is in the habit of voiding. In the short period of twenty-four hours, horse-dung heats, and begins to suffer by fermentation. If left in a heap for two or three weeks, scarcely seven-tenths of its original weight will remain. Hence the propriety of early removing it from the stable, and of mixing it as soon as possible with some other material by which the volatile substances given off (much ammonia) may be absorbed and arrested."

Pigs' Dung.—"Pigs' dung is still colder and less fermentable than that of the cow. . . . A specimen examined by Boussingault was found to contain per cent :—

	Recent.	Dry.
Water . . .	81.00	...
Nitrogen . .	0.63	3.37

being richer in nitrogen even than horse-dung." Our experience determines pigs' dung to be hot, and excellent; and this was also the opinion of the ancients, as the Quintilli remarked, that "the dung of hogs, being of superior goodness, is improper for corn-fields on account of its abundant heat, for it instantly burns corn grounds."[1]

Sheep's Dung.—"Sheep's dung is a rich dry manure, which ferments more readily than that of the cow, but less so than that of the horse. Boussingault found a specimen to consist of :—

	Recent.	Dry.
Water .	63.0	...
Nitrogen . .	1.11	1.99

The food of the sheep is more finely masticated than that of the cow, and its dung contains a little less water, and is richer in nitrogen; hence, probably, its more rapid fermentation."[2]

Heat from various kinds of Dung.—The following are the results of Jacquin's experiments on the heat given out by dung of various kinds, and its duration :—

Sheep-dung	lasts 4 months,	giving out a heat from	141° to 158°
Horse	" 6 "	" "	122° " 140°
Cattle	" 8 "	" "	95° " 113°
Tanner-bark	" 6 "	" "	95° " 104°
Tree-leaves	" 12 "	" "	95° " 104°

Pigeon-dung increases the heat of other dung.

Quantities of Dung from Stock.—The following quantities of dung have been obtained from horses and oxen from given quantities of food in a given time :—

A horse produces ¾ of the weight of food he consumes in manure.

A horse makes 12 tons of manure in a year, of superior quality to that of oxen.

An ox fed on turnips or mangel, with 24 lb. or 28 lb. of straw, gives 150 lb. of dung and urine a-day in winter.

An ox fed on turnips, corn, and hay, in seven months in winter produces 12 tons

[1] Owen's *Geoponika*, i. 68.

[2] Johnston's *Lec. Agric. Chem.*, 2d edition, 821, 822.

of manure, and in summer 7 tons more. With just enough straw to keep it clean, an ox will make 1 ton each month; all extra litter going to increase that quantity.

An ox fed in a box produces 11 cubic yards of manure in four months, or 33 cubic yards in a year.

An ox's dung is better than a cow's.

LIQUID MANURE.

Its Composition and Character.

The liquid manure of the farm consists of impure and diluted urine, comprising the oozings from manure-heaps and farmyards, the wash from byres, stables, and piggeries, and the whole surface-drainings of a farm-steading, assumed to meet and mingle in one common stream or reservoir. In this sense, pure urine does not form ordinary liquid manure; but as it constitutes the source and the basis of the chief ingredients that impart to liquid manure its high fertilising properties, it is proper, in the first place, in order clearly to understand the character of the latter, to examine in some detail the composition of the urine of the different animals of the farm.

The following analyses by Stoeckhardt shows the

Composition of Urine of different Animals.

	Sheep. (Fed with hay.)	Swine. (Meagre diet, chiefly potatoes.)	Horses. (Hay and oats.)	Cows. (Hay and potatoes.)
	Per cent.	Per cent.	Per cent.	Per cent.
Water	86.5	97.5	89.0	92.0
Solid matter	13.5	2.5	11.0	8.0
Ashes	3.6	1.0	3.0	2.0
Organic matter	9.9	1.5	8.0	6.0
Nitrogen	1.4	0.3	1.2	0.8
Phosphoric acid	0.05	0.12	...	...
Alkalies	2.0	0.2	1.4	1.4
Lime and magnesia	0.6	0.05	0.15	0.15
Sulphuric acid	0.4	0.05	0.15	0.15
Salt	0.25	0.5	0.1	0.1
Silica	trace	trace	0.025	0.01

Complex Character of Excreta.—The solid and fluid excrements of animals form a very complicated mixture, as may be seen from the following enumeration by Sprengel; but this renders them the more valuable a manure for vegetables:—

1. Vegetable or woody fibre.
2. Wax and resin.
3. Chlorophyll, or the green substance of leaves, partly decomposed.
4. Deposited humus.
5. A fatty and oily substance.
6. Mucus.
7. A peculiar brown colouring matter, in the solid excrement of oxen.
8. Vegetable albumen (hardened).
9. Animal gelatine.
10. Animal fibre.
11. Salivary matter.
12. Osmazone. } Originating in the urinary passages.
13. Hippuric acid. }
14. Uric acid. } Originating in the urinary passages.
15. Lactic acid. }
16. Benzoic acid. }
17. Urea. }
18. Bilious matter.
19. Bilious resin.
20. Picromel.
21. Oxides of iron and manganese, derived from vegetables.
22. Earths—silica, lime, alumina, magnesia.
23. Salts, consisting of mineral acids and bases, derived from plants and water.
24. Common salt.
25. Carburetted hydrogen. } Products of the fermentation and putrefaction of the food in the bodies of animals.
26. Phosphoretted hydrogen. }
27. Sulphuretted hydrogen. }
28. Ammonia. }
29. Hydrogen. }

Numerous as these substances are, it was Sprengel's opinion that many more might be discovered by carefully conducted chemical analyses.

Conditions influencing Excreta.—The value of animal excrements as manure depends very much upon the age of the animals, their kind, their mode of employment, the kind and quantity of food they eat, and the nature of the water they drink. Thus: age has effect, for the excrements of a full-grown animal are much better than those of young animals. The state of the animal has an effect, the manure from oxen being much better than that from cows, a great proportion of the substance of whose food goes to the production of milk; and in like manner, the manure of the wether is better than that of the ewe. The kind of food has an effect; for poor and scanty food cannot supply so rich manure as nourishing and abundant food. The manner in which the animals are treated has an effect; working cattle afford better manure than fattening oxen, because the latter abstract from the food, to support their increasing flesh and fat, the same materials as go to produce milk in cows. The water drunk has an effect; an ox that drinks 80 lb. of water a-day will pass more urine than a cow which drinks the same quantity, because a large proportion of the water she drinks goes to the formation of milk. Boussingault found that a cow which drank 132 lb. of water a-day passed 18 lb. of urine, and gave 19 lb. of milk; an ox that drank the same quantity gave 40 lb. of urine; a horse that drinks 35 lb. a-day passes 3 lb. of urine—no more than a man, which fact seems remarkable; but when we consider the much greater extent of surface over the body of a horse, compared to that of a man, the insensible perspiration of the horse, it is seen, must carry off a large proportion of the liquid food; whereas a man drinks daily only one-tenth more than the urine he passes.

Fresh and Stale Urine.—A comparison of the composition of *cows' urine* fresh, and after it has been kept a month, will show the change that takes place in it by exposure to the air:—

		Cows' urine. Fresh.	Cows' urine. A month old.	
Water in 100,000 parts by weight		92,624	95,442	
Urea, along with some resinous colouring matter		4,000	1,000	
Albumen		10	...	
Mucus		190	40	
Benzoic acid (hippuric acid)	combined with potash, soda, and ammonia, forming salts	90	250	
Lactic acid		516	500	
Carbonic acid		256	165	
Acetic acid		...	1	
Ammonia		205	487	occurring partly in an uncombined state.
Potash		664	664	
Soda		554	554	
Sulphuric acid	combined with soda, lime, and magnesia, forming salts	405	338	
Phosphoric acid		70	26	
Chlorine		272	272	
Lime		65	2	
Magnesia		36	22	
Alumina		2	0	
Oxide of iron		4	1	
Oxide of manganese		1	...	
Silica		36	5	
Sulphuretted hydrogen		...	1	
Sediment, consisting of phosphate, and carbonate of lime, and magnesia, alumina, silica, and oxide of iron and of manganese		...	180	
		100,000	100,000	

Decomposition of Urine.—In winter, urine scarcely contains half the quantity of urea stated in the first column, and is then, of course, of less value; and when it has been putrefying for a month, it contains more than as much again of ammonia as urine in a fresh state. The ammonia is derived from the decomposition of the urea, and the other organic bodies containing nitrogen. The caustic ammonia remains partly dissolved in the water, and is the substance through which urine not properly putrefied is so apt to injure plants.

If exposed long to the atmosphere, the caustic ammonia absorbs from it carbonic acid, becomes mild, and the urine may then be employed without danger as a manure for vegetation. But on urine being thus exposed to the air, part of it will escape in the form of gas, unless some substance is added to the putrefying urine to neutralise the ammonia—to *fix* it, as it is usually termed.

Fixing Ammonia.—This fixing of the ammonia is often done by adding water to it, which, of equal bulk to the urine, enables the diluted mass to retain four times as much ammonia—that is, in every 100,000 lb. of diluted urine, 1135 lb. more of ammonia is retained.

Another simple substance for fixing the ammonia is black vegetable mould, which supplies humic acid, and every 90 lb. of it saturates 10 lb. of ammonia; but as the best earth contains only 45 per cent of humic acid, 200 lb. of earth will be required to fix every 10 lb. of ammonia.

Gypsum is now extensively used for this purpose. It may also be effected by adding sulphuric acid, at the rate of a gill of the acid to every 18 or 20 gallons of the liquid manure. This is preferable to water, as it lessens carting.

Changes through Decomposition.—It is rather important to trace the change in liquid manure occasioned by keeping. Fresh urine of cattle has a yellow colour, occasioned by a small quantity of resinous colouring matter; but on standing exposed to the air, the yellow assumes a brown, and at length a black colour, attributable to the formation of humic acid. In winter, urine does not possess a trace of ammonia, whereas it does in summer, thereby indicating the decomposition of urea by heat in the body before the emission of the urine.

The above table shows that exposure of urine for a month to the air has the same effect of decomposing the urea as heat has in the body; and four weeks are not sufficient time to decompose all the urea, as still 0.6 remains. When exposed for three months and longer, urine loses its carbonate of ammonia, which is evaporable as well as the crude ammonia itself.

In short, a six months' urine contains not a trace of its original urea, mucus, and albumen, and new acid combinations take place, such as the lactate, humate, sulphate, acetate of ammonia.

Urine is supposed to be in a ripe state after it has putrefied in summer for five or six weeks, and in winter for eight or nine, though no absolute rule can be laid down on this point, so much depending on the evaporation of the air. The chemical rule for knowing the ripeness of urine is when it contains neither urea nor caustic ammonia, and this can be ascertained only by chemical investigation.

After exposure to the air a year and half, urine contains no organic remains, and only salts and mineral bodies dissolved in water.

Specific Gravity of Urine.—The specific gravity of the urine of the horse, according to Fourcroy and Vanquelin, varied from 1.03 to 1.05; according to Prout, 1.029; and to Boussingault, 1.064.[1]

Composition of its Saline and Mineral Ingredients.—The saline and mineral ingredients of the urine of the horse, ox, sheep, and pig, consist of the following substances:—

	Horse.	Ox.	Sheep.	Pig.
Carbonate of lime	21.75	1.07	0.82	..
" magnesia	11.26	6.93	0.46	..
" potash	33.12	77.28	..	12.1
" soda	15.16	..	45.25	..
Chloride of sodium	6.27	0.30	32.01	53.1
" potassium	..	..	12.00	little
Sulphate of soda	11.03	..	7.72	7.0
" potash	..	13.30	2.98	..
Phosphate of soda	..	..	..	19.0
" lime	..	..	0.70	
" magnesia	..	..		8.8
Silica	0.52	0.35	1.06	
Oxide of iron and loss	0.79	0.77	..	

The conclusion Professor Johnston comes to, in reference to the contents of this last table, is, that "the fermenting urine of our domesticated animals cannot afford phosphoric acid, which must be

[1] Thomson's *Ani. Chem.*, 493.

conveyed to the soil by the solid excrements."[1]

Valuable Character of Liquid Manure.—The analyses given show clearly whence urine derives its great manurial value. If we take the average composition of the urine of the four kinds of animals, we find that thirty-five parts of the total solids in the urine contain 3.7 parts of nitrogen, or rather more than 10 per cent of the most costly substance that is purchased by farmers for manurial purposes. Three cwts. of the solids of urine contain approximately as much nitrogen as two cwts. of commercial nitrate of soda, or one and a half cwt. of sulphate of ammonia.

The mineral ingredients in urine must not be overlooked. In thirty-five parts of total solids, there are five parts alkalies, about one part each of salt, lime, and magnesia, and some phosphoric acid. Probably all these ingredients have some manurial value, and this is enhanced materially by the very fine state of division in which they exist.

Variation in its Composition.—Ordinary liquid manure, however, cannot be regarded as having a composition or value precisely identical with that of any of the kinds of urine mentioned. It has indeed in the main a similar character, and its high fertilising qualities are due to the same causes. But it is a less concentrated manure, and part of the substances in it which assist in raising its analytical standard of apparent merit, are present in combinations less readily available for the use of plants, less immediate in their effects, and therefore in some degree of less intrinsic worth. It is necessarily liable to considerable variation of quality, according to the circumstances attending its production and management. The urine itself, as the analyses quoted have made manifest, alters in character with the species of animal producing it, and in some measure it also varies with the nature of the food with which the animal has been supplied.

But the liquid manure varies still more, according to the proportions in which each species of animal has contributed to it, and according to the nature and amount of the extraneous substances with which it has become commingled. As a rule it consists most largely of the urine of cows or other cattle, with a less quantity from horses and pigs, mixed with drainings from the yards and middens or manure-heaps, and with some parts of earth and solid excrements.

Drainings from Yards and Dung-heaps.—Where the yards are entirely uncovered and exposed to the whole rainfall, the drainings from yards and manure-heaps form by far the bulkier portion of the liquid manure. The composition of this part of the mixture differs greatly from that of the original urine, not only because it is more or less diluted with rain-water, but also because of the chemical changes that have occurred during the time occupied in its passage through the bulky mass of solid litter and manure, and because it contains some of the products of the decompositions that have taken place, as well in the solid as in the liquid excrements.

It is obvious therefore that, in most cases, ordinary liquid manure must differ very greatly from pure urine, and that the analyses we have examined of the latter can be serviceable only in that they enable us to see clearly what are the ingredients contained in liquid manure that are of use as fertilising agents, though they must by no means be accepted as showing precisely the forms and combinations in which these ingredients ultimately exist, nor as indicating their relative proportions to its whole volume.

Johnston on Liquid Manure.—"The drainage of dung-heaps," says Professor Johnston—"the usual liquid manure of our farmyards—differs in composition according to circumstances. When the *urine* of cattle is *mixed* with it in *considerable quantity*, it is found to contain a portion of the constituents, not only of the solid and liquid excretions of the stock, but also of the straw and other vegetable matter which have fermented along with it. It varies in strength, however, very much with the quantity of rain or other water with which it is mixed, or which falls upon the dung-heaps from which it flows." The composition of two specimens of such liquid is as follows:—

[1] Johnston's *Lect. Agric. Chem.*, 2d ed., 811.

	Drainings of Cow-dung washed by rain.	Drainings of Farmyard manure watered with cows' urine.
An imperial gallon contained—	Grains.	Grains.
Ammonia	9.60	21.30
Solid organic matter	200.80	77.60
Solid inorganic matter or ash	268.80	518.40
	479.20	617.30
Inorganic matter in a gallon consisted of—		
Alkaline salts	207.80	420.40
Phosphate of lime and magnesia, coloured with a little phosphate of iron	25.10	44.50
Carbonate of lime	18.20	31.10
Carbonate of magnesia and loss	4.30	3.40
Silica and a little albumen	13.40	19.00
	268.80	518.40

From these facts Professor Johnston concludes, "that the liquid which flows from a dung-heap *watered with urine* is greatly richer in ammonia and in saline matter than that which flows from the solid excrements newly washed by the rain; that the liquid in both cases contains a considerable proportion of phosphate of lime. This does not exist in cows' urine alone. In both cases it has been washed out of the solid dung; and both contain also an appreciable quantity of silica not existing in urine. This is derived from the straw of the fermenting farmyard dung, or from the grass which has passed through the digestive organs of the cow. As fermenting manure can yield in a soluble state every mineral ingredient which a plant requires, the liquid that runs from the farmyard ought to be no less carefully preserved than the pure urine of our cattle." [1]

Average Composition of Liquid Manure.—It would be impossible to state with absolute accuracy the percentage of useful substances, or even of total solids present in liquid manure, because the conditions hardly permit the selection of an average sample. It will not, however, be far wrong to accept Wolff's analysis as being fairly representative. He gives the average percentage composition as follows:—

Water	98.20
Organic matter	0.70
Ash ingredients	1.10
Nitrogen	0.15
Potash	0.49
Phosphoric acid	0.01
Lime	0.03
Magnesia	0.04

Liquid Manure Acts quickly.—The value of nitrogen in manures depends not only on its quantity, but also on the particular combination in which it occurs. An insoluble or slowly soluble form will give a less immediate return, and is consequently of less value, than one in which the nitrogen acts more rapidly on plants. In this respect urine takes a high position among manures. Its nitrogen, as uric acid, hippuric acid, &c., is entirely contained in solution. It is capable of being more readily and more widely distributed through the soil than it is even in ammonia compounds, and it is at once available for the use of plants. Hence, urine is universally recognised in practice to be a "forcing" or quickly acting manure. It produces its full effects on the first crop to which it is applied, and its nitrogen is thus fully equal in value to that of the most expensive nitrogenous manures that are offered in the market.

The fact that the valuable ingredients of liquid manure are contained in solution in a large volume of water adds distinctly to the certainty and uniformity of their action, on such soils at least as are suitable for the reception of large quantities of liquid applications. Indeed the most striking characteristic of liquid manure, and that to which it owes its special differences from all other forms of manure, is the enormous bulk

[1] Johnston's *Lect. Agric. Chem.*, 2d ed., 812.

of water in which its valuable constituents are contained. It is necessary at this point to consider more particularly the effects produced by this special feature. They are of a twofold and contradictory character.

Advantages of the Liquid Form.—Except when employed in a fresh or undiluted form, burning effects seldom follow the application of liquid manure. It causes, besides, the most perfect distribution of the manure; for the water, in its slow circulation through the whole body of the soil and subsoil, conveys its valuable materials into every pore into which the tender rootlets of plants can penetrate. The important constituents of the manure, instead of being left in unequal lumps spread irregularly on the surface, or scattered in drills, from which they only become, slowly and with difficulty, diffused through the soil,—as may be the case with dry manures in dry seasons,—are deposited in the most minute state of subdivision through all parts of the soil.

Indeed it is strictly accurate to say of many artificial manures, that they never can become so completely distributed through the soil, or so thoroughly mingled with its particles, as are the same substances when abstracted by each little grain of earth from the liquid manure percolating in a sluggish flow through its pores, and carrying its cargo of enriching materials into those deeper layers of soil which are untouched by the common operations of tillage, but which are nevertheless laid under contribution by the deeper searching roots of plants.

Utility of the Water.—It is not to be overlooked that the mere water contained in liquid manure, which constitutes by far the greater portion of its bulk, is not without a very considerable utility in those circumstances of soil and crop when its employment can be regarded as at all advisable. It is obvious enough that in years of drought its influence must be beneficial to a degree quite beyond its usual merits, and in such a season the application of the water itself is simply invaluable. But independently of specially dry years, the water in the liquid manure in its passage through the soil produces effects that in suitable cases are of considerable importance. It promotes processes of oxidation, assists in the dissolution and redistribution of soil constituents, brings with it some further supply of useful minerals, and contributes in itself a condition absolutely essential to a luxuriant plant-growth. Such are the beneficial effects produced by the water in the liquid manure.

Still it is right to remind farmers that if the watering of farm crops is once begun, it must be systematically and persistently pursued till rain takes its place. Unless this is done, the latter state of these crops will be worse than the first.

Disadvantages of Excess of Water.—But the large quantity of mere water in liquid manure must also be considered in another aspect, that has a very important bearing on the whole problem of economical liquid manuring.

Dry artificial manures have this notable practical advantage, that they can be conveyed great distances, and can be applied to crops at an expenditure which is relatively low in proportion to the amount of really valuable ingredients supplied.

But it is quite otherwise with liquid manure. The enormous bulk of water adds so much to the cost of handling as entirely to control the whole system and mode of using it. If we accept Wolff's average analysis, already given, we find that for two tons of solid substances added to our soils in liquid manure, we have to deal in no case with less probably than about 100 tons of water, and in many cases much more. It is clear that the mere conveyance of a material of this weight and bulk must be undertaken in the face of such obstacles as to confine the area of its availableness within a very limited distance from the place of its production, and to make the question of its value turn chiefly on the readiness and cheapness with which it can be applied. Assuming even that the initial difficulty of spreading such a volume of liquid over a wide extent of land has been successfully overcome, it still remains to be decided how far its superior efficacy repays the greater cost involved in its application.

But before proceeding to consider the profitable utilisation of liquid manure, something may be said as to how it is to be conserved at farm-steadings.

Neglect of Liquid Manure.—The general body of farmers are not nearly so careful as they ought to be in the preservation of liquid manure. This neglect has been commented on by writers on agriculture for generations; and while it is readily acknowledged that great improvement has taken place in the management of liquid manure, it must at the same time be urged that, in many cases, the subject does not receive that amount of attention which it so well deserves.

The loss through leakage from dung-heaps in the field is not, as a rule, very serious—that is, if the dung-heaps have been properly formed, with a covering of earth, or some other material, to prevent rain-water getting into the dung to carry away its own rich juice. But at the steadings, the losses which arise from want of attention to liquid manure are often enormous—such as would greatly surprise the negligent farmers themselves if only they had the actual amounts of the losses "figured out" to them.

Often have we seen cattle-dung lying in heaps for weeks and weeks—perhaps even for months—as thrown from the cattle-byre, in such form as to press out its liquid contents rather than conserve them; a rich brown liquid oozing out freely at all sides, and passing away into utter uselessness.

Rainfall and Loss of Liquid Manure.—The heaviest losses in liquid manure occur where the rain-water from the roofs of the adjoining buildings and the open heavens is allowed to rush on to the dung-heap in the yard, and pass through it and go where it may without let or hindrance. It may sink into a porous soil, or find its way into a passing stream, carrying with it a great deal of the very richest of the ingredients of the manure. And be it remembered that wherever there is free access and free exit, so to speak, to the rain-water to and from the dung-heap, *robbery* of the dung is inevitable. We have already seen (p. 231) that dung is very susceptible of damage by washing—in fact, that two-thirds of the total manurial value of a dung-heap may be carried away by rain-water passing through it as we have indicated.

Preventing Loss in Liquid Manure.—Now it will readily occur to one that useful measures may be taken in two ways to prevent these losses. In the first place, by efficient water-spouts and roofed courts or dung-pits the rain-water may be prevented from reaching the dung. In the second place, arrangements may be made whereby any liquid escaping from the dung may be directed into some safe receptacle for preservation until it can be advantageously utilised. Already at various points, in treating of covered courts (pp. 226-232), and of farmyard dung (pp. 501-514), we have referred to the various ways of covering cattle-courts and dung-pits, and to the advantages arising therefrom.

Liquid-manure Tanks.—Here we need, therefore, consider only the second of these measures whereby the loss of liquid manure may be averted—that is, the means whereby it may be preserved for useful application. There are various methods by which this may be done—the liquid-manure tank being the most general. Liquid-manure tanks of many sizes and designs are in use. The formation of drains and tanks for liquid manure, as they exist on many farms, is described on pages 223 and 224. In the cases there referred to it was not intended that any of the liquid should be returned to the dung, so that the tanks were not placed close to the dung-pit. Modern experience, however, inclines more and more towards placing the tanks so that when desirable the liquid (as will be presently explained) may be pumped out of them on to the manure, or into a liquid-manure cart when it is to be carried away. It is also desirable, on the score of expense, to have the tank near the cattle-court, and thus avoid unnecessary outlay on drains to conduct the liquid manure.

There are several circumstances to be taken into consideration before proceeding to construct a tank for liquid manure. When a tank is made deep, such as a well, the building of the lower part will require to be particularly strong, and, of course, will be so much the more expensive in construction. A tank should therefore be shallow, not deeper than 4 or 5 feet below the sole of the drains which bring the liquid manure. It is very desirable to have the tank covered, for the sake of protection against accidents. The most durable covering is an arch; and to keep the cost of that within bounds, the tank should be narrow, not exceeding 6 feet. The desired capacity of a tank will thus be attainable by extending its length.

A tank should neither let in nor let out liquid. To prevent its letting in water, a drain should be formed where there is the least appearance of it in oozings or a spring; and to prevent the liquid getting out, a puddling of clay should be used, where the subsoil does not consist of tenacious boulder-clay. The clay for puddling should be well pugged, or beaten into the consistency of putty. A fall of from 6 inches to a foot is required along the floor, according to its length; and a roomy man-hole should be made in the arch of the roof, at each end of the tank, and at the deepest end a third opening for the pump.

Liquid-manure Pump.—The *pump* used in tanks is generally the chain one, in which an endless chain passes from the bottom of the tank to the height to which it is desired to raise the urine, where it passes over a pulley, constructed so as to firmly hold the chain. On the chain, every 15 or 18 inches apart, are fixed circular discs about 2 inches in diameter. The up-going side of the endless chain is inside an iron pipe, the diameter of which is slightly greater than that of the discs. To the pulley is affixed a crank-handle, which when turned at an ordinary speed, carries the water up the tube to the desired height. This class of pump works best with lifts under 12 feet; over that it is heavy to work. Loose straws or mud do not in any way interfere with its proper working, and it lasts for many years without any renewal.

Dispensing with Pumps.—If the configuration of the land will permit of such, tanks should always be emptied by a pipe direct from the bottom to some place on a lower level, but high enough to run into a cart. Much labour is thereby saved, and not a little time. Cast-iron pipes are the best for the purpose, as fireclay ones can rarely be made tight enough at the joints to bear the requisite pressure.

Size of Tank required.—To know the *size* of tank required for any particular case, an allowance of 1000 gallons for every cow on a dairy farm will suffice, and that number of gallons occupies 162 cubic feet. When enlarged tanks are desired, it is better, because cheaper, to have parallel rows of narrow tanks contiguous to each other, than to extend the breadth or length, or increase the depth. In a series of parallel tanks, the common walls support the arches on both sides. A tank of 72 feet in length, 6 feet wide inside, and 6 feet deep below the soles of the drains, contains about 2600 cubic feet.

A Mid-Lothian System.—A simple and convenient mode of collecting the liquid manure of a dairy farm—of from 130 to 170 acres, with a stock of cows from 14 to 24, with young beasts and horses—has long been practised in Mid-Lothian. Drains are formed from the byres and stables into one main drain, the mouth of which is elevated as high above the ground below it as to admit a liquid-manure barrel—a common butt, mounted on its cart—to stand under it, and receive the liquid direct into the bung-hole; and as the barrel becomes full, it is carried away, and its contents emptied on the field. The barrel contains 150 gallons, and is usually filled three times a-week. When there is an excess of liquid, in consequence of much rain, it is allowed to run into the dunghills below the drain, and after saturating them it flows into an open shallow tank, from which it irrigates at pleasure a drained moss laid down to perpetual grass. A common butt, of 150 gallons, sunk into the ground, forms a good tank for a labourer's cottage, and, retaining all liquid refuse, affords a ready means of manuring a portion of the garden.

Incorporating the Liquid with the Dung.—We may say at once that we think the best way of utilising liquid manure is incorporation with the solid manure, and that therefore the liquid manure which finds its way into the tanks should in the first place be used in saturating the drier portions of the dung-heap—that is, in so far as it can be readily absorbed and held by the solid material.

Where this practice prevails, a convenient arrangement is to have in each court a tank into which any liquid that escapes from the dung finds its way—a tank sunk in at the lowest point in the court, with access for the liquid manure through a grating. A pump rises up from the tank, and once every week the cattle-man pumps the liquid back over the dung, directing it by movable spouts of various lengths on to the drier parts of the dung-heap. This is a capital plan both for the solid and the liquid manure, and by it the maximum quantity of first-class dung may be made.

Of course the extent to which this plan may be advantageously carried out will depend largely upon the supply of litter. If there should be plenty of litter, the whole of the liquid manure may be fully and most profitably utilised in this way—that is, where the liquid manure is not increased to excess by rain-water. On the other hand, where litter is scarce and the dung therefore short in texture, it may not be able to absorb nearly all the liquid manure.

Utilisation of Surplus Liquid.—There will thus in many cases be more liquid manure than can be advantageously absorbed by the dung. This indeed will rarely happen where the cattle-courts are roofed and any extraneous water prevented from reaching the dung, but it will very often occur where the greater part of the cattle-court or dung-pits is uncovered. Now the profitable preservation and utilisation of this *surplus* liquid manure are the two most important points in connection with what is generally known as the liquid-manure question.

In reference to this economical utilisation of liquid manure, some remarks well worthy of careful attention were made by Mr R. P. Wright, Lecturer on Agriculture in the Technical College, Glasgow, in a paper in the *Farming World Year-Book*, 1889, from which we have made copious extracts.

Noteworthy Attempts.—Mr Wright says: "It is not surprising that the problem of the economical utilisation of a manure possessing such high qualities as have been described, and which is regarded by many as the most valuable of all manures, should have engaged the attention of some of the most enterprising agriculturists of this century, and that numerous attempts should have been made to overcome the difficulties attending its practical application.

"Perhaps the most widely known investigator into this question was the late Mr Mechi of Tiptree Hall; and further attempts, modelled on the practice recommended by him, were made at Myrie Mill and Kinning Park, in South Ayrshire. The efforts made on these farms to secure the complete and effective distribution of the liquid manure by means of elaborate arrangements of pipes, conduits, hydrants, and other machinery, were continued over a series of years, and have furnished sufficiently conclusive proof that the thorough distribution and utilisation of the whole quantity of liquid manure produced on a farm is perfectly possible, and they have further shown that the expectations entertained of the effects of the liquid dressings have been in no degree exaggerated, and that by judicious applications crops of wonderful luxuriance can be successfully grown.

Outlay greater than the Return.—"But the ultimate collapse of these systems of farming has just as completely demonstrated that, however remarkable the results obtained from the use of liquid manure, the return is not sufficient to defray the expenditure. Mr Mechi, indeed, is said to have maintained to the last that his practice was profitable; but it is now almost universally held that the bulk of material to be disposed of in liquid manure wholly rules the economy of its use, and that with the low average prices of the farm crops for which it is best suited, no method of utilising it can be profitable unless the outlay involved be reduced to a very low point. Any costly process of treatment must be looked on as unlikely to yield a satisfactory remuneration.

Suitable for Exceptional Crops.—"It must not be forgotten, however, that this objection does not hold good when the liquid manure is employed for crops of relatively high value. Expensive methods of application may be justifiable for the production of certain market-gardening crops, or even some common farm crops grown in a district of high markets; but for ordinary farm practice it may be fairly concluded that only such modes of utilising liquid manure are commendable as involve the minimum of expenditure."

Application by Cart.—In discussing the various methods of applying manure, which have been found most successful and been most largely adopted, Mr Wright says: "Perhaps the best known and most widely adopted practice is to collect the liquid manure in a central tank or reservoir, to pump the liquid at intervals into a specially constructed manure-cart, and by its means to spread the liquid over the land. The initial expense is confined to the provision of a tank, of a pump, and of a manure-distributor; and the amount will vary according to the dimensions and extent of building needed, and the size of the pump and distributor. The after-cost is limited to the charge made for the man and horse required for the conveyance of the manure to the fields; and this may properly be estimated at a low rate, as such work can be done, in part at least, at odd intervals of time.

"Although this plan of utilising the manure is pretty common in some districts of the country, it cannot be regarded as a very satisfactory one. The first expense is not inconsiderable, and the manner of applying the manure does not warrant the expectation of the most favourable results. The operations of pumping and carting such large quantities of liquid are slow, cumbrous, and troublesome, and in the press of other farm-work the dressings are apt to be given at irregular intervals, and perhaps at unsuitable times. Very often the liquid so applied is not sufficiently diluted, when it is liable to injure and destroy the vegetation. There is a constant temptation to use the manure in a strongly concentrated form, because any addition of water entails some additional difficulty, and the greater the dilution the heavier becomes the subsequent labour of pumping, carting, and spreading.

"For these reasons, while this practice prevails somewhat widely, it has never obtained a very great popularity among farmers. Many of them, however, hold decidedly the opinion that, whatever be its other drawbacks, it has the crowning merit of being thoroughly profitable, and of far more than repaying the cost of application."

Fig. 111 illustrates the process of filling a liquid-manure cart by a pump fixed in the tank. Fig. 234 represents a

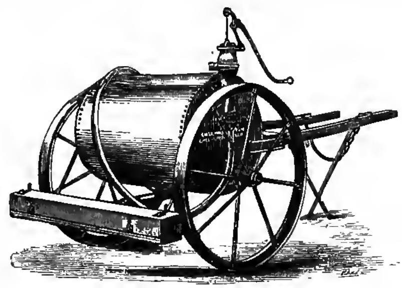


Fig. 234.—*Liquid-manure cart.*

liquid-manure cart (Coleman & Morton, Chelmsford), which has attached to itself a pump and pipe with which to raise the liquid out of the tank. A new and ingenious form of liquid-manure cart, in-

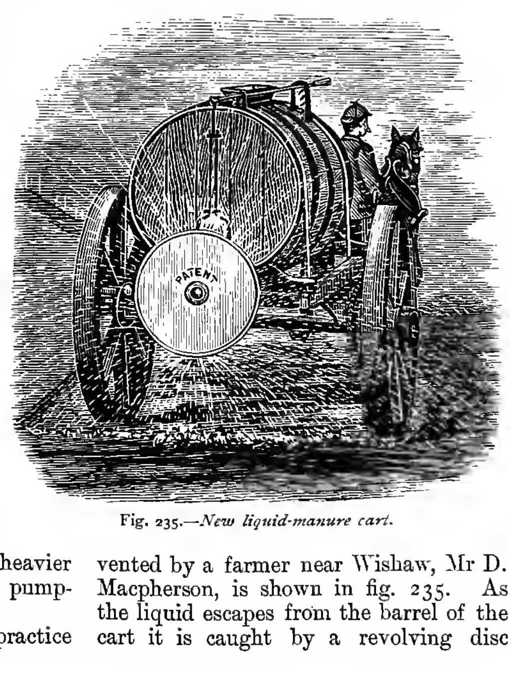


Fig. 235.—*New liquid-manure cart.*

vented by a farmer near Wishaw, Mr D. Macpherson, is shown in fig. 235. As the liquid escapes from the barrel of the cart it is caught by a revolving disc (driven by a chain from the axle of the cart) with several equidistant flanges, and is sent over the ground in an even spray as shown in the figure. The trials we have witnessed with this ingenious yet simple contrivance have been very successful, and it is just possible that the invention may be found capable of more extended use than the inventor had originally in view—for instance, in watering field crops at critical periods, notably newly sown turnips in severe drought. It spreads the liquid evenly, and takes a breadth of about 30 feet at a time.

Water-carts. — The *water-cart* has been very long in use for the conveyance of water, when the supply of that necessary element for household use has been distant from the steading. A modern water-cart, with iron cylinder for the water, is represented in fig. 234. But the old form still prevails, consisting of the naked bed-frame of a cart mounted on wheels, and surmounted with a cask of a capacity suited to the demands of the establishment. The cask is furnished with a funnel, inserted in or attached immediately over the bung-hole; and it is likewise furnished with a spigot, or with a stop-cock, inserted into that end of the cask which hangs over the back of the cart. When the water-cart has been drawn to the fountain or the pond from which water is to be conveyed, it is filled either by means of a pump, raised so high as to deliver the water which it lifts into the funnel of the cask, or the water is lifted with the hand by means of a *scoop*, having a helve of sufficient length to enable the workman to reach the pond on the one hand and the funnel on the other. The scoop best adapted to this purpose is a small wooden pitcher, fig. 236, about 8 inches in depth and 10 inches in diameter, the helve passing through its sides in an oblique direction, and a little above its centre of gravity.

Fig. 236.—*Scoop for filling a water-barrel.*

Liquid manure can be conveyed into a barrel by means of such a scoop as well as water. The *liquid-manure cart* differs very little from the water-cart, except in its being provided with the distributing apparatus in place of the spigot; but in large establishments the cask is superseded by a covered *rectangular cistern or tank*, which takes the place of a common cart-body. For a *liquid-manure cart*, a cask of 120 or 140 gallons contents will be found more economical in first cost than a rectangular tank; and as these machines can be only occasionally in operation, they will, if not very carefully attended to, become leaky while standing unoccupied. In this respect the cask will have a manifest advantage over the tank, for the tightening of a cask is an operation the most simple, by the act of driving up the hoops; while in the case of the tank becoming leaky, no means of that kind can be resorted to, and the alternative is, either soaking it in water till the wood has imbibed as much of the fluid as will expand its substance and close the leaks, or the vessel must be tightened by some more expensive process.

For the more easy means of filling the cask, it is suspended between the shafts of the cart, and this position requires the bending of the axle to nearly a semicircle. The cart is a mere skeleton, consisting of the shafts, which for this purpose may be made of red pine, their length being about 14 feet. They are connected by a fore and hind bar, placed at such distance as will just admit the length of the cask, while the width between the shafts is suited to the diameter of it. The axle is bent downward to nearly a semicircle to receive the cask, and its length will of course be greater than the common cart-axle; even the distance between the caddy-bolts, in a straight line, will be usually greater, but this will depend on the diameter of the cask. A pair of common broad cart-wheels are fitted to the axle. The cask is suspended on two straps of hoop-iron, the ends of which are bolted to the shafts, and the same bolts pass also through the ends of two lighter straps which pass *over* and secure the cask firmly in its place.

The funnel or hopper is usually fixed upon the top of the cask over the bung-hole, or it may be inserted therein by means of an attached pipe. The distributor may be made of sheet-copper, of cast-iron or malleable iron, or even of wood; the copper will be found the most durable, and it should be at least one-twentieth of an inch in thickness. The next best is the patent malleable-iron tube; cast-iron, though sometimes used, is not to be recommended; neither is wood desirable, from its liability to choke. The distributor should consist of a strong rectangular trough of sound wood, 7 feet or so in length, and 6 inches wide, and 6 inches deep. The discharge-pipe should be bent down at right angles, so as to deliver the contents into the trough. Along the bottom of the trough are holes to let the urine away. Immediately under the discharge-pipe these holes should not be over ¾ or ⅞ of an inch in diameter, but they should gradually increase up to 1½ inch as the ends are reached. This is necessary to prevent the holes filling up with straws and sludge, while the force of the urine at the outlet keeps the smaller holes there clear. The distributing trough is generally hung from the hind trams by two iron hooks, into which it slides. It is never permanently fixed; and when in use is better taken off every time the cart is emptied, and left as a mark where to begin next time — be it the same day, or next week, or month.

A stop-cock is frequently put upon the stem to regulate the discharge—and for this purpose it is very beneficial, serving in a great measure to regulate the quantity per acre; but for the entire setting off or on of the supply, the stem opens into a small chamber inside the cask, which chamber is closed by a flap-valve heavily loaded. This valve, when closed, stops the discharge; and when lifted, the fluid has a free passage to the distributor. The opening of the valve is effected by a small chain attached to the flap, rising to the top of the cask, where it passes over a small roller, and onward to the fore part of the cart on the nigh side, where it hangs at hand for the carter to set off or on at pleasure. Fig. 237 is a section of part of the cask, showing the chamber and valve, which is the common leather flap or clack valve, well loaded with lead, and the chain attached to the valve passing over a roller.

When the liquid-manure cart is furnished with a *tank*, the latter can with equal facility be placed low for the convenience of filling: thus the axle may be cranked, as in the Liverpool dray-cart, the tank resting on the cranked

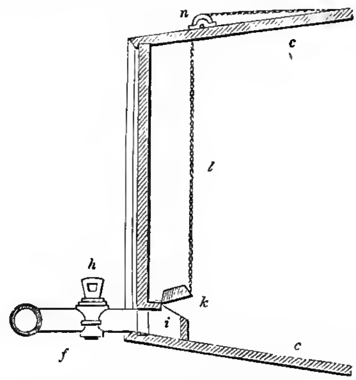


Fig. 237.—*Apparatus for discharging liquid manure.*

f Stem of distributor. *h* Stop-cock. *i* Chamber. *k* Valve. *c c* Part of cask. *l* Chain attached to the valve. *m* Roller.

part of the axle; or the axle may remain straight, and the tank suspended below the axle. Such a tank may be conveniently built to contain a ton of the liquid, or about 220 gallons; and the distributing apparatus is the same as for the cask.

The distributor, as made by Mr Crosskill of Beverley, swings upon a stud. This is a great improvement on the former construction, inasmuch as the distributor always remains in a level position, whatever may be the inclination of the ground upon which the cart has to pass over, and therefore always distributes the liquid uniformly; whereas, in a fixed distributor, the liquid is discharged with the greater force, and of course in greater quantity, on the lowest side, for the time being, of the uneven ground.

Making Compost with Liquid Manure.—In many cases the surplus liquid manure, instead of being collected into a tank is directed by a channel—in some cases open, in others covered, as it always should be—into a compost-pit. On many farms this pit is merely a convenient hollow near the steading, but where there is a good deal of surplus liquid manure it will be profitable to have a properly constructed reservoir. This pit is made a receptacle for dry rubbish, earthy or vegetable matter, such as withered weeds, waste straw, brackens, dried scrapings from open drains and roadways, or any similar material capable of absorbing the liquid manure and then forming useful dressing for land. The liquid manure runs into this pit, and converts the dry rubbish into valuable compost.

Referring to this system Mr R. P. Wright, in the paper quoted above, says: "The liquid manure from a steading running regularly day by day on to such a body of dry material gradually works into it, till ultimately the waste becomes so much enriched by the constant deposition of the valuable ingredients contained in the liquid slowly percolating through its mass, as to be converted into a manure, not inferior in its character and qualities to ordinary farmyard manure, and requiring a similar after treatment and management.

Advantages of the Compost System.—"This system appears to possess many valuable features, and to be preferable to that previously described. It allows of the utilisation of quantities of organic material, which otherwise might have been got rid of by burning or some other equally profitless method. It gives the farmer the command of what is practically an additional supply of farmyard manure. It is capable of being adopted on farms in any situation, and it permits the application of the fertilising substances of the manure to a greater variety of crops than can be conveniently or beneficially treated with any manure in a liquid form.

"It is a cheap method, as reservoirs may be dispensed with entirely, or may be of the crudest kind, while the expense of forming conducting channels is trivial. It is particularly suitable where the liquid manure is of a strongly concentrated character, and it is free from any of the drawbacks that attend the direct use of the liquid in such a condition.

Amount of Carting.—"The only objection that can be taken to this practice is on the ground of the amount of carting required. It is to be remembered, however, that the carting of large quantities of dry rubbish is a comparatively easy matter, owing to its light weight; and, on the other hand, the manure produced would be worthless indeed, did it not more than handsomely repay the labour of conveying it out again to the fields."

Forming a Compost Reservoir.—The receptacle for the liquid-manure compost need not be costly or elaborate. It should be water-tight at the bottom and sides. Concrete or masonry would be most substantial, but it might be formed merely of earth with a coating of clay pounded into the sides and bottom. It may be from 2½ to 3 feet deep, and at one end should slope up to the level of the ground, so as to provide easy access and egress for carts.

Irrigation with Liquid Manure.—Where the configuration of the land and the system of cropping are suitable, and a stream of water available, this is an excellent method of utilising liquid manure. The liquid as it escapes from the steading is conducted into a small stream, which is controlled for the purpose, and which is then employed in irrigating an adjoining meadow. Mr R. P. Wright says: "This practice is less known than it ought to be. In those districts in which it is carried on, its benefits are well understood and thoroughly appreciated. It combines at once all the advantages of water irrigation with those of ordinary manuring. It secures the employment of the liquid manure in its most highly diluted and most effective and favourable form, while the water from the stream may itself contain no inconsiderable portion of fertilising ingredients. It allows the manure to be used on the crop, grass or hay, for which it is best suited, and on which it will give the largest increase.

"The fullest fertilising effects are obtained from this system, because there are no hindrances in the way of the most regular and periodical applications of the manure, and because the thickly matting roots of the grasses do not permit the escape to the drains of any of the valuable substances. It is the cheapest of methods, as there is no expense further than cutting the small channels and water-courses, and keeping them in repair. No horse labour is required, and only a very slight attention is necessary to keep the whole system in good and regular working order."

As will be readily understood, the circumstances necessary for the success of this method of irrigation are of rare occurrence, but wherever they do exist they should be taken advantage of; for Mr Wright adds, "I have never yet met a farmer who had given it a trial who has not had reason to be perfectly satisfied with the results."

An Irish Example.—We have seen this system of irrigation with liquid manure pursued with capital results upon Mr Richard Barter's farm, St Ann's Hill, County Cork. The liquid manure from his large herd of dairy cows, in the first place, flows over the dung-heap, and the portion which escapes therefrom is carried by a passing stream over a sloping stretch of meadow-land lying in front of the steading. The water from the drained land, at a higher level than the steading, is as far as possible utilised for this purpose, as well as for irrigation by itself.

Preventing Loss of Ammonia.—Wherever liquid manure collects there is risk of loss by evaporation of its ammonia. This, however, may be prevented by sprinkling gypsum over the liquid in the tank, or on the liquid manure wherever it may be collected or exposed. Mr Richard Barter has the gypsum-box kept constantly in a corner in his cow-byre, and immediately after the byre is cleansed, a little of the gypsum is sprinkled over the fresh dung, and on the spaces behind the cattle. The gypsum "fixes" the ammonia, and thus prevents its evaporation. This practice is a most commendable one. It causes little extra labour, and may save considerable loss of the most costly of all manurial ingredients. The gypsum-box should be at every steading, and its contents should be used with unfailing regularity, not only for the liquid-manure tanks but also for the dung-heap itself.

The Problem solved in Sussex.—Professor Wrightson makes favourable reference to an ingenious method adopted by Mr Livesey, C.E., in his beautifully constructed cow-house at the Mayfield Dairy, Rotherfield, Sussex. So as to avoid the necessity of litter, and to effectually conserve both the solid and liquid manure, Mr Livesey had a gutter, 2 feet wide and 5 inches deep, made behind the cows. This gutter is nearly filled with dry earth *sprinkled over with gypsum*, and this porous matter receives both the solid and liquid excrements of the animals. Guide-rails are laid in the passage behind the gutter, and the soil is daily removed and collected in a shed adjoining. Mr Livesey regards the material thus collected as, weight for weight, three times the value of ordinary farmyard manure made in his district.[1]

This system must, of course, involve a good deal of extra labour, but such advantages as are claimed for it would most probably far outweigh the increased expense. The practice, it will be observed, not only utilises the whole of the liquid manure in a most effective manner, but also renders litter unnecessary, which is in itself a point of great importance.

Fresh Urine injurious to Vegetation.—If urine is applied to grass-land or to growing crops while the urea is undecomposed, or the ammonia is in a caustic state, it will destroy vegetation. When intended for direct application to crops, the liquid should therefore be allowed to "ripen" for some time—perhaps four or five weeks in summer, and eight or nine in winter; or by the addition of a little sulphuric acid, the caustic ammonia may be turned into a neutral salt—sulphate of ammonia—and if thus prepared, liquid manure may at any time be applied with safety. Read in this connection what is said as to the composition of fresh and stale urine, and the changes the liquid manure undergoes by keeping, pp. 515, 516. But fresh urine may safely be applied to the ploughed soil at any time, in as far as the soil is concerned, although it is better received by the soil in some states than in others.

Time for Application.—Early spring is considered the best season for applying the liquid manure, not only because it is then most abundant, but the ground, being all ploughed, is then also in the best state for imbibing it: and if applied to the soil just as it has flowed into the tank, much trouble will afterwards be saved in driving out the water, which must be put

[1] *Agric. Gazette*, 1888, p. 464.

amongst it to save the ammonia, and which in fact is better saved by the humus of the soil. Formerly winter was considered the best time for applying liquid manure; but the Rothamsted investigations as to the loss of nitrates through drain-water from land not covered with any crop, have shown that this was an error. See "Accumulation and Exhaustion of Fertility" in soils, on pp. 60, 61. Frozen ground will not take in liquid manure, neither will very dry ground take it in easily.

Advantage of Incorporating with the Dung.—As Sprengel states, "it will be obvious to every one that the urine-tanks are no such excellent arrangements as they are frequently represented to be; and that it is in many cases more profitable to pour the urine over the dung in the dung-pit, or to supply as much straw that the whole of the urine may be absorbed, for then the humic acid arising from the solid excrements will be combined with the ammonia formed at the same time from the urea," &c.

There is this aditional advantage, that the urine, as the most efficient portion of animal excrement, being mixed with the dung, may be distributed more equally over the ground—that no manure-barrels, &c., are required—and that there is no necessity to bestow labour on the preparation of the urine; for the urine, if any, which is not taken up by the dung, may always be most profitably pumped back upon it again.[1]

Town Sewage.—Although the utilisation of town sewage has some relation to that of the liquid manure of the farm, it will be convenient to discuss that wider and more intricate subject by itself.

Construction of Liquid-manure Tanks.

The following general remarks by Mr Slight as to the construction of tanks for liquid manure may be perused with interest:—

"The *cistern* for collecting liquid manure in the farm-stead is apparently simple in its construction, being merely a covered pond or a well; yet serious errors are frequently committed in its formation. The first and most important consideration for the formation of the cistern, is the effect of hydrostatic pressure; inattention to this has caused the failure of many such cisterns. The liquid we have here to deal with, like all other fluids, acts on the bottom and sides of the vessel or body that contains it with a pressure directly in proportion to the depth at which the fluid stands, without reference to either length or breadth; that is to say, suppose a cistern, whose bottom is 12 inches square, and its depth 10 feet, filled with water, every square inch in the bottom will suffer a pressure equal to the height of a column of water whose base is 1 inch square and 10 feet or 120 inches in height. The weight of such a column will be 4½ lb. nearly, and this would be exerted on every square inch on the bottom, or the whole pressure on the bottom would be 625 lb., the weight of 10 cubic feet of water.

Pressure of Fluids.—"There is a natural law that governs the pressure of fluids, which shows us that they press *equally in all directions*, downward, horizontally, and even upwards, the last arising from the general statical law, that '*action and reaction are equal, and in opposite directions.*' It follows, from these hydrostatical laws, that the lowermost portion of *each side* of our supposed cistern will suffer a pressure from the water equal to that which acts upon the bottom — hence, taking the lowermost inch in the height of the sides of this cistern, it will be pressed with a force of 52½ lb. or thereby, or 4½ lb. on the square inch, and each of the four sides will suffer the same pressure.

"Suppose, now, that the cistern is elongated in one direction to any number of feet, and again filled to the depth of 10 feet, the pressure on each square foot of the bottom remains the same as before, and so on in like manner does it remain the same upon the sides; for the pressure is not altered in any direction, although the proportion of the cistern has been changed.

Depth the Chief Element.—"Keeping this in view, it will be seen that length and breadth produce no effect on the pressures that a fluid exerts against the vessel or body that retains it; and that, in calculating the resistance to sustain such pressures, *depth* is the only

[1] *Jour. Royal Agric. Soc. Eng.*, i., 455-480.

element requiring to be taken into account. It is also to be kept in view, that pressure on the bottom or sides is directly as the depth: thus, if our supposed cistern were reduced to 5 feet in depth, the pressure on the bottom would only be one-half, or 2¼ lb. on each square inch.

Pit or Well Form.—"The conclusion to be drawn from these remarks is, that a cistern in the form of a pit or well should be always avoided, unless it can be formed in a natural bed of impervious clay. When such a substratum can be attained a pit may be adopted, but not otherwise. If such has been found, and the pit dug out, it should be lined with brick, or with stone built in mortar, the bottom being first lined with the same material. When the building approaches to the surface, the wall can be gradually reduced in diameter to a small compass, leaving only an opening of 2 to 3 feet square, which is covered in at small expense; and the saving in this last item is the only apparent advantage that seems to attend the practice of pit cisterns.

Disadvantage of Deep Tanks.—"Deep cisterns are liable to another inconvenience — of their becoming recipients of spring or of drainage water; and it is sometimes more difficult to keep such water *out* than to keep the proper liquid *in*—for if springs and their origin lay at considerable heights, their hydrostatic pressure may be so great as to render the prevention of access to their products a process of great difficulty.

Shallow Tanks. — "A *cistern* of moderate depth, not exceeding 4 feet below the outfall of the drains, may be constructed in any situation, whether in gravel or in clay, and its length can be extended so as to afford any required capacity; the breadth being restricted to that for which materials for covering it can be most easily obtained, which may be from 3 to 4 feet, or, if arched, it may be 6 feet. Whatever be the stratum in which such a cistern is to be formed (unless it be perfectly impervious clay), it should be puddled to the thickness of at least 1 foot with the best clay that can be procured. For this purpose, the earthy matters are to be dug out to a depth of 1½ foot lower than the intended sole, and to a width of 4 feet more than that proposed for the cistern. Two or three thin layers of the prepared clay are then to be compactly laid over the whole breadth of the excavation, and beaten firmly together at all points, making up the depth to 1 foot, and the surface of it brought to a uniform level. Upon this the side-walls are to be founded, and these may be of brick 9 inches in thickness, or of flat-bedded rubble-stone 14 inches. The wall should be built in successive courses of about 1 foot in height, the whole being bedded in mortar; and as each course is completed, the puddle is to be carefully laid and beaten in behind, in layers of 6 inches or thereby—the first layer being properly incorporated with the foundation-puddle, and each succeeding layer with the one immediately preceding it.

"To prevent the side-walls from being pushed inward by the pressure of the puddle or of the bank, tie-walls of brick or of stone should be formed at every 5 feet of the length of the cistern. These may be 9 inches of brick or 14 inches of stone, and they must have conduits formed at the level of the sole, to allow the liquid to run towards the pump.

"The sole should be laid all over with brick set on edge, or with strong pavement jointed—the whole having a slight declivity towards one end, where a small well-hole of 9 inches in depth is to be formed to receive the bottom of the pump. The brick or pavement, as the case may be, is to be bedded on the puddle, and grouted flush in the joints with mortar; and when the walls and sole are built up, they should then be pointed in every joint with Roman cement.

Covering Tanks. — "The covering may be effected with strong pavement, of length sufficient to rest on the side-walls, laid and jointed with mortar; or with rough *found*-stones, where such can be procured; and if neither can conveniently be found, a beam of cast or malleable iron may be laid along the middle of the cistern resting on the tie-walls, and, with this bearer, stones of half the length will be sufficient to form a cover. A thin layer of clay may be laid over the stone covers, and upon that a coat of gravel.

Preventing Accidents. — "To prevent accident, it is always desirable to construct the cistern in a situation where it will be as little as possible exposed to the transit of carts; and this may be always obtained at a small additional expense of covered drain to convey the manure from the dunghills to the cistern. The best and most secure plan, no doubt, though the most expensive, is to cover the cistern with an arch of stone or brick."

CLAYING LANDS.

Benefits of Claying.—This is a practice often followed by excellent results. Where the surface-soil consists chiefly of shifting sand or of soft mossy matter, its agricultural value may be improved by spreading and mixing with it a layer of clay, chalk, or marl. This admixture binds the sandy material and increases its cropping capabilities. The clay or marl is usually dug from the layer below the soil with which it is to be mixed. The cost of carting the clay from any considerable distance would be so great as to render the operation unprofitable. Chalk, however, is often conveyed long distances for the purpose of being mixed with soil.

Professor Wrightson says that thirty or forty yards of clay per acre has a wonderful effect in binding sands together; and mentions that in some counties, as in Norfolk, marling is thoroughly appreciated. Marl or clay pits are opened in the fields, and from forty to sixty cart-loads are applied per acre. The lower chalk is the best material for chalking. Large quantities of chalk are carried upon the Thames in barges for application to the heavy soils of the London clay, and to the heavy marine clays which extend still nearer to the Essex coast.[1]

Clay Pits.—This process of claying the soil, which may conveniently fill in work for several days in winter, is in some cases conducted in this manner: Within the four sides of the field to be clayed, fig. 238, two lines of pits are set out, the clay of which is to be taken. The space between the pits depends on the depth the clay lies from the surface. If to the clay is deep, the distance between the pits is 12 yards; if shallow, it is extended to 20 yards, and varying between these two extremes. When the distance has been determined on, it is marked by a plough making a furrow in each line of pits. The width of the pits depends also on the depth of the clay; if it is 2 feet deep to the clay, the width is

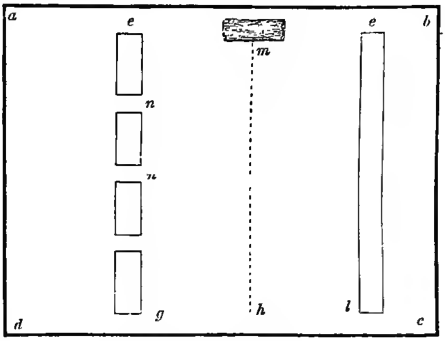


Fig. 238.—*Claying of soil.*

a b c d Four sides of a field.
e e Lines of pits out of which the clay is taken.
g to *l* Distance, 12 yards.
m Where the first surface-soil is laid down.
n n Spaces of ground left untouched between the pits.
m h Half-way between the lines of pits.

3 feet 3 inches, but if 6 feet and upwards, the width is 4 feet.

A pit is dug in the first line, which should be begun near the upper fence. At half-way between the lines of pits, the surface-soil taken out of the first pit is laid down. The pits are made 9 feet in length. Should the clay be far down, the sides of the pit should be supported by planks, or framework of wood, to prevent the earth falling in, and to protect the lives of the men working in them. Lives have been lost through neglect of this precaution.

[1] *Prin. of Agric. Prac.*, p. 113.

Spreading the Clay.—The clay as it is dug out is taken up with a fork or spade by a man or boy, and thrown equally over the space on both sides of the pit in which the men are working. Two good spits of the spade generally afford the requisite quantity of clay. After one pit has been sufficiently dug out, another is formed along the line, spaces of the ground being left untouched between the pits, of sufficient strength to support the sides from curving in.

The upper soil of the second pit is put into the first pit, to fill it up as far as it will go, and the clay is taken out of the second pit and spread upon the surface, in the same manner as that out of the first pit; and so on, from pit to pit, until all the pits in the line are dug.

When the first pit in the second line is begun, its surface-soil is wheeled to fill up the last pit of the first line; and when all the pits have been dug out in the second line, the surface-soil taken out of the first pit of the first line is wheeled to fill up the last pit of the second line.

In this manner, with every two rows of pits is the entire field spread over with the clay. The pits are levelled up afterwards with the adjoining soil by the plough. A little frost does the clay good by pulverising it, and makes it more ready to mix with the soil; but it is better to plough the clay in soon than allow it to become too hard either by drought or frost.

If the clay had to be carted upon it thus, the claying of land would be attended with much trouble and expense.

To cover an acre of soil with only one inch deep would require 180 cubic yards of clay.

Is Claying injurious to Sheep.—Mr Henry Woods, in his essay on sheep, asks, "Does clayed land materially affect the health of the ewe? I know the prevalent opinion is that it does, and probably it may; but I say that it is also very much within the control of the flock-master himself. I believe that with the care and intelligence which a person may bring to bear upon the matter, it may be very much controlled; and I will give you some practical experience on this point. I have been told, time after time, that the Waterloo Farm would kill any sheep—no matter whether they were hoggets or ewes, or any other sort of sheep, they could not live upon it; and still more unhealthy would it be if it was clayed. And as to ewes, the man would be mad who would attempt to keep them. Now that farm has been clayed very heavily; it has been clayed, marled, and chalked. All those three materials, which are held to be injurious, have been applied; and what has been the result? Not that all the sheep died, but this has occurred: From Michaelmas 1861 to Michaelmas 1862, the last year we had the farm, and consequently at a time when we had to feed off turnips grown from artificial manures or clayed land, there were on the farm 306 ewes, 340 hoggets, 100 shearlings, and we had 352 lambs. Between 1861 and 1862 our loss comprised the following: 5 hoggets, 10 ewes, 3 shearlings, and 3 lambs—total 21, lost out of 1098 sheep, including lambs, and not a single case of abortion. . . .

"Through the kindness and fairness of our excellent tenant, Mr Bunting, I am enabled to give you the result of his experience for 1863. He had 300 ewes on his farm last year, and he had not a single case of abortion; his loss of ewes only 5. I think that is a certain proof that, under judicious management, with proper feeding, the virulence of clayed land may be very much mitigated.

"This year we have 220 ewe-hoggets feeding upon clayed land, clayed at the rate of something like 100 loads per acre; they are in the same field they have been ever since Michaelmas. I state it as a fact, that never since those ewe-lambs have been fed on those turnips has one of them ailed anything; and they have very much improved in condition and appearance, and have been very much admired. They have, in addition to ground white turnips, ½ lb. of cake per sheep per day, and we give them a little long hay in racks. I must tell you that the land used to be light blowing sand, but I hope its blowing is stopped now."[1]

Mixing Soils.—The opposite process to that described above may also, in certain cases, be carried out with advantage. That is, where the surface-soil consists chiefly of stiff adhesive clay, its texture and usefulness may be increased by the admixture of a quantity of sand.

[1] Wood's *Breed. and Manag. Sheep.*, 21-30.

Professor Wrightson says: "The mixing and moving of soils may sometimes be carried out with benefit. Wherever clay or sandy soils exist in close proximity, an interchange may be effected with good results, although the effect of clay upon sandy soils will always be more apparent than the reverse operation of adding sand to clay.

Top-dressing bare Heights.—"The carting of soil on to bare brows is a work that may profitably occupy horses during winter. The tendency for soils to slip down hillsides, and gradually accumulate at the bottom of slopes, is well known. Every tillage operation tends to effect this result, and in process of time the upper portion of hill becomes denuded of soil, while there may be an excess of soil at the bottom. The restoration of this soil to the upper portion of the field is a beneficial act."[1]

While the detailed treatment of the work of winter may fittingly enough terminate here with volume i., there are some operations not yet noticed which receive a share of the farmer's attention in the course of the winter months.

Wheat-sowing.—Wheat-sowing, especially in late seasons, forms a considerable portion of the field-work in earlier part of winter. This, however, is a continuation of work begun in autumn, and may be more appropriately described in dealing with the operations of the autumn.

Forming Compost.—Similar remarks apply to the forming of composts—a subject which deserves more attention than is generally given to it. Every farm should have its compost-heap, and large additions should be made to it in winter. It should be remembered that by well-matured compost a substantial addition may be secured to the supply of manure made on the farm.

Although winter is not the season to expect a quick fermentation to arise among the materials composing a compost dunghill—or *midden*, as it is technically called in Scotland, being the corresponding phrase to the English *mixen*—it is a favourable time for collecting materials from convenient places, and mixing them in proper proportions. There are many materials which may be collected at the commencement of winter—as quicken or couch-grass of the fields, obtained while preparing the land for the green crops of last year; dry potato-haulms, scourings of ditches, weeds destroyed during summer; leaves fallen in autumn; moss or turf available; and every vegetable matter whatsoever.

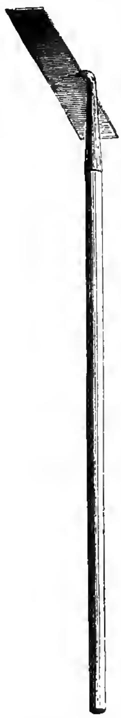


Fig. 239.—*Mud-hoe, harle, or claut.*

Immediately after a rainy day, when the land is in such a state of wetness as to prevent work being done upon it, and the horses have nothing particular to do, two or three of the men should each take a *mud-hoe* or *harle*, fig. 239, and rake the loose straws and liquid mud on all the roads around the steading to the lowest side of the roads, and out of the way of carts and people passing along; while the rest should take graips and shovels, and form the raked matter into heaps, to be led away, when it will bear lifting, to the compost-heap.

The general subject of forming composts will be referred to in other parts of the work.

Collecting Sea-weed.—The supplies of sea-weed are usually most abundant in winter. Farmers who have access to the sea-coast should therefore lose no opportunity of laying in a store of this useful fertilising material. The value of sea-weed as manure will be explained in the chapter dealing with Manures.

[1] *Prin. of Agric. Prac.*, p. 113.

END OF THE FIRST VOLUME.