THE

BOOK OF THE FARM

DIVISION II.

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

VIRGIL.

THE

BOOK OF THE FARM

DETAILING THE LABOURS OF THE

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

BY

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FOURTH EDITION

REVISED, AND IN GREAT PART REWRITTEN, BY

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OF THE 'FARMING WORLD';

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

IN SIX DIVISIONS

DIVISION II.

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Published by Wm Blackwood & Sons, Edinburgh & London.

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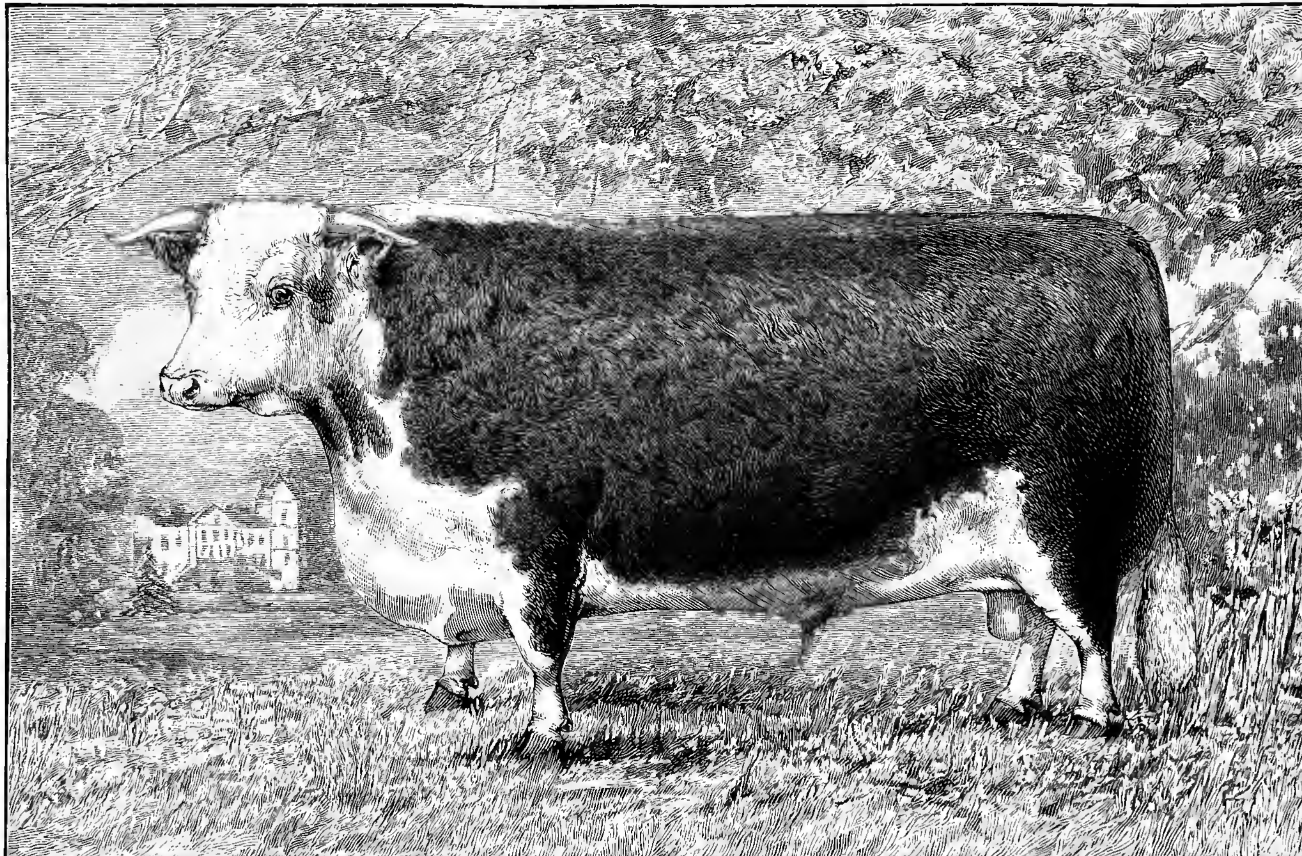
(1850)

Published by Wm Blackwood & Sons, Edinburgh & London



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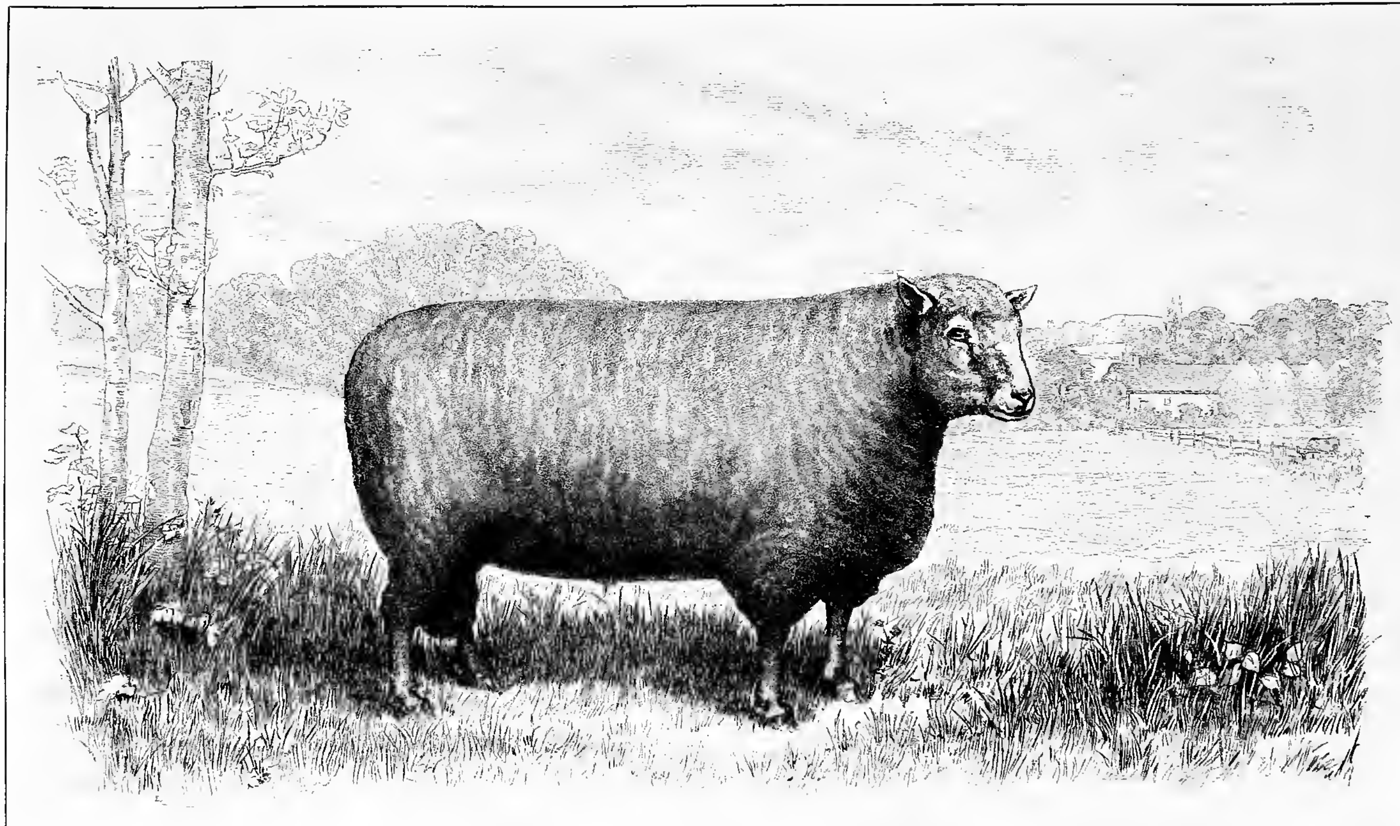

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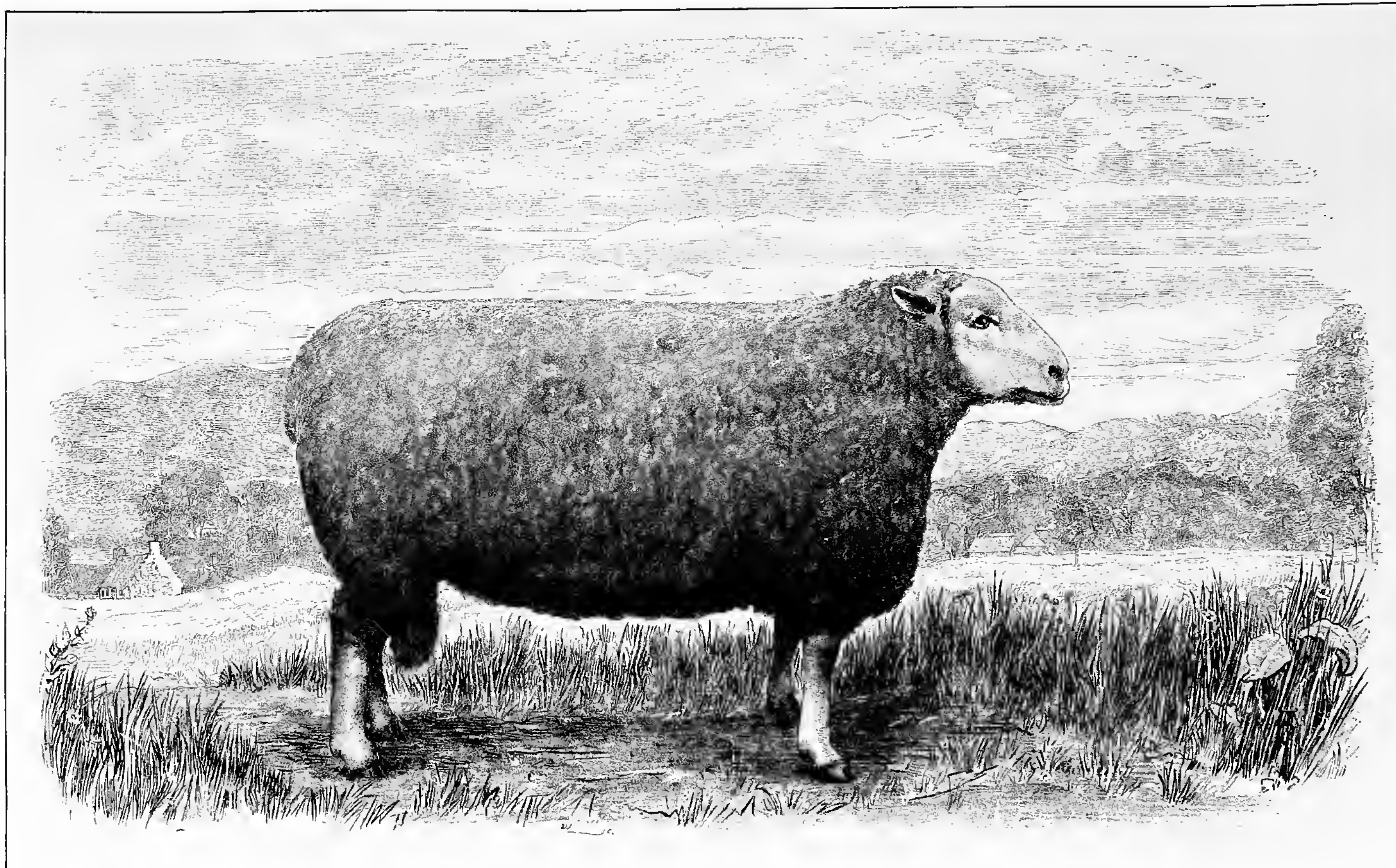

LINCOLN RAM.

THE PROPERTY OF HENRY SMITH, ESQ., THE GROVE, CROPWELL BUTLER, NOTTINGHAM.

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

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:—

[1] *Cattle and Cattle-Breeders*, p. 13.

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.

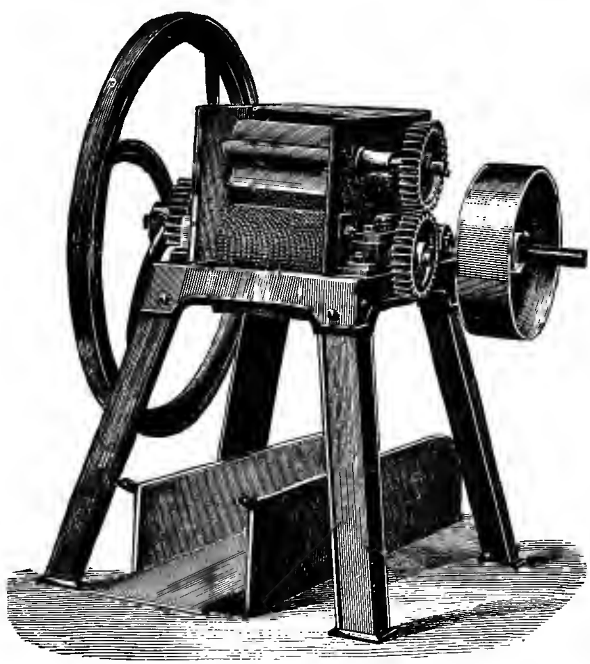

Fig. 118.—*Furze masticator.*

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 (digestible and indigestible together)
" (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 (sugar, mucilage and woody fibre together)
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]—

	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		

[1] *Jour. Royal Agric. Soc. Eng.*, xxiii. 137.

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. Albuminoids.	Digestible. Carbohydrates.	Digestible. Fat.	Nutritive Ratio.
	lb.	lb.	lb.	lb.	lb.	
Oxen, growing—						
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 (carbohydrates and fat)		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.	Carbohydrates.	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.	Carbohydrates.	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.	Carbohydrates.	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.

		Digestible.		
	Dry Matter.	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.				
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.				
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.				
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.				
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.				
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 overfeeding, 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.

	Dry Matter.	Digestible. 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.	Carbohydrates.	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—

	Dry Organic Matter.	Digestible. 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, 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.

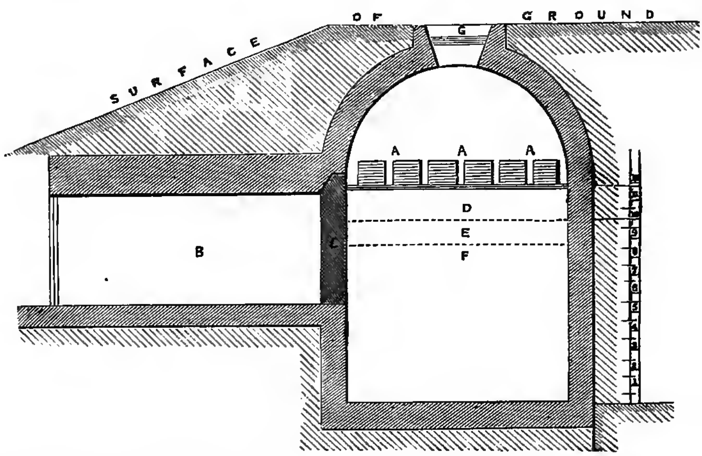

Fig. 119.—*Section of Lord Egerton's silo, showing its condition at the end of the third day's work.*

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.

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

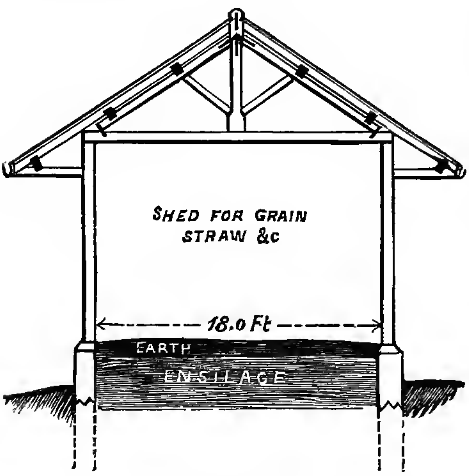

Fig. 120.—*Transverse section of M. de Chezelles's "Grange Silo."*[1]

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.

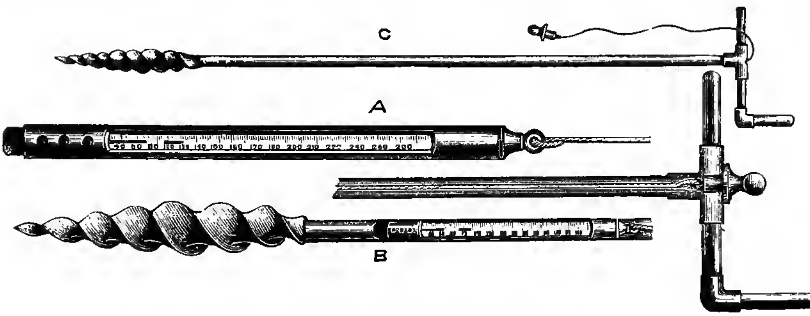

Fig. 121.—*Self-registering thermometer.*

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 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-

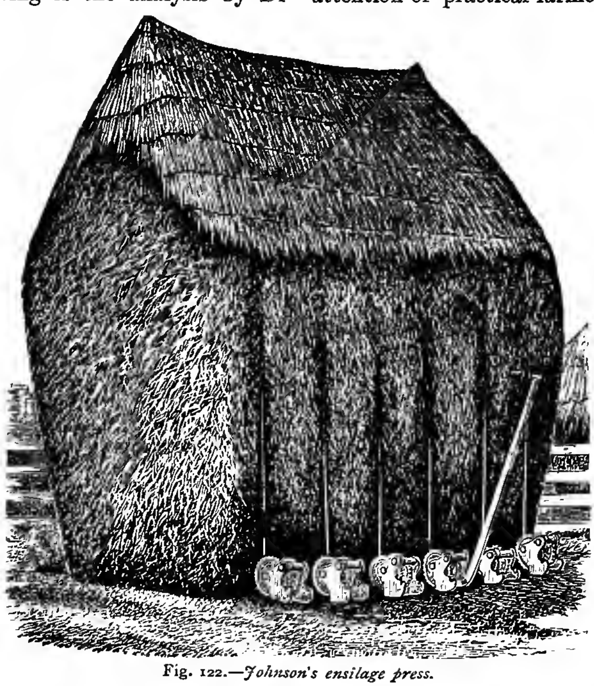

Fig. 122.—*Johnson's ensilage press.*

[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.

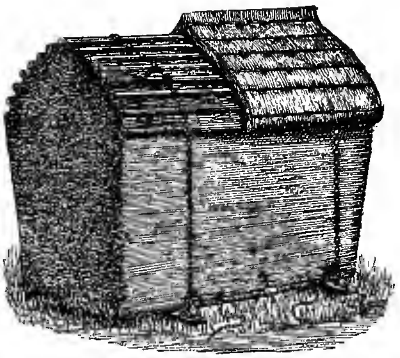

Fig. 123.—*Reynolds's ensilage press.*

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.,

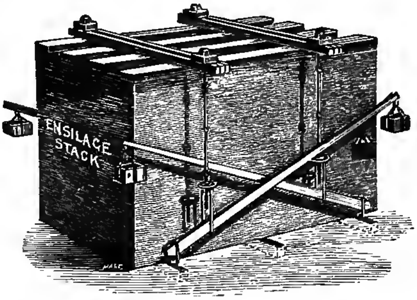

Fig. 124.—*Blunt's ensilage press.*

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.

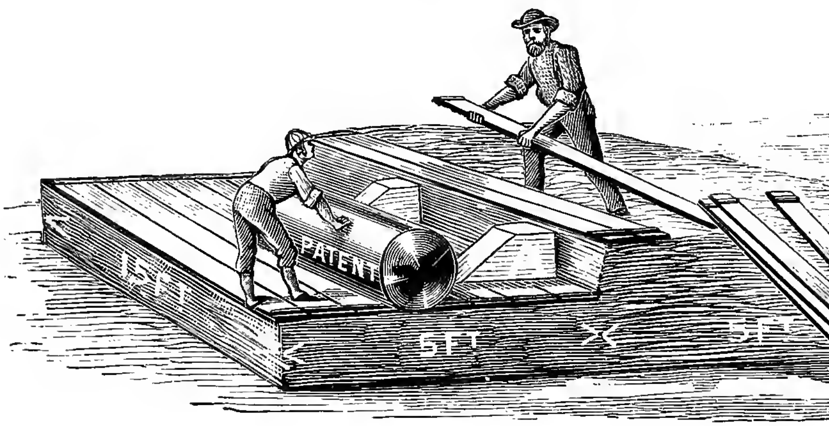

Fig. 125.—*Pearson's ensilage roller system.*

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.

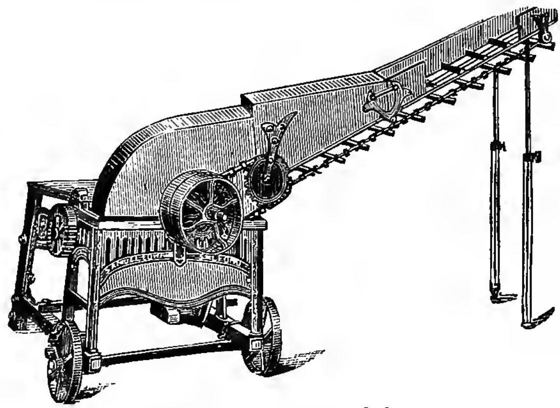

Fig. 126.—*Ensilage cutter and elevator.*

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.

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

[1] *Jour. Royal Agric. Soc. Eng.*, xxiii., sec. ser., 133.

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. cwt.	qr.	lb.	Daily gain per head. lb.
Two bullocks—				
Oat silage . .	2	3	11	2
Roots and straw-chaff	1	3	25	1⅓

Daily gain in favour of oat silage, ⅔ 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					12 2 3 8 . . .	2 19 6

Estimated cost of growing 1 acre clover, and making it into silage (3 years lay):—	
Sowing	£0 2 0
Seed	1 5 0
Carting manure 2 years . .	1 0 0
For 3 years	£2 7 0

£0 15 8	for 1 year.
1 0 0	two cuttings, carting and stacking.
0 4 0	weighting the ensilage stack.
£1 19 8	for 1 acre=£2, 19s. 6d. for 1½ acre.

LINSEED-CAKE.

Months.	lb. per day.	days.		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 cwt. 1 qr. 15 lb. 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.

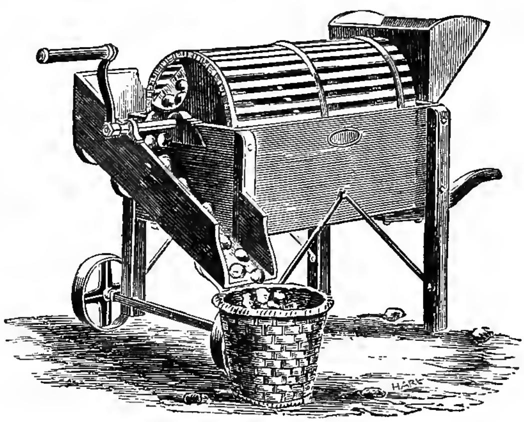

Fig. 127.—*Root-washer.*

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 excellent 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.

Fig. 128.—*Combined pulper, slicer, and finger-piece cutter.*

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

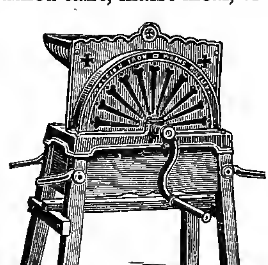

Fig. 129.—*Root-pulper.*

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.

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 mod-

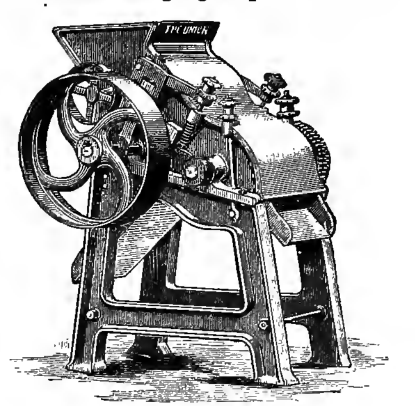

Fig. 130.—*The "Union" bruising and grinding mill.*

ern 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.

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

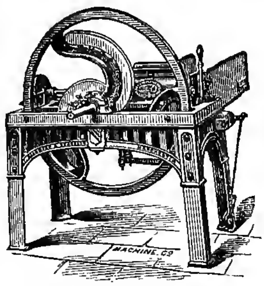

Fig. 131.—*Chaff-cutter.*

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.

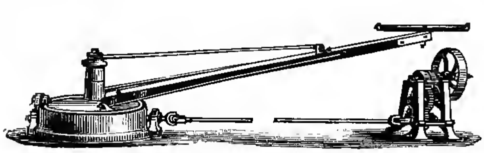

Fig. 132.—*Horse-gear.*

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

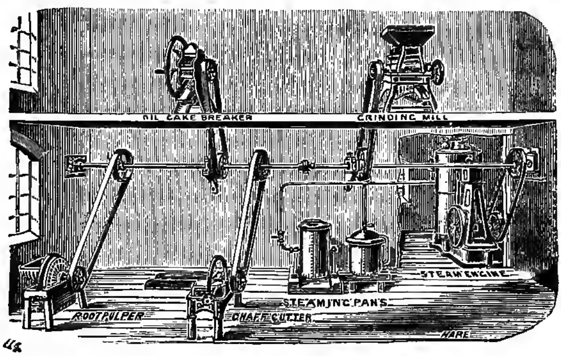

Fig. 133.—*Steam food-preparing machinery.*

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

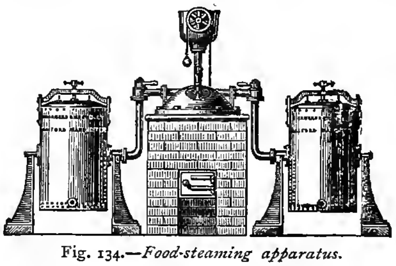

Fig. 134.—*Food-steaming apparatus.*

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

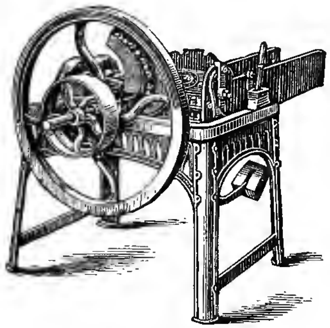

Fig. 135.—*Chaff-cutter.*

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

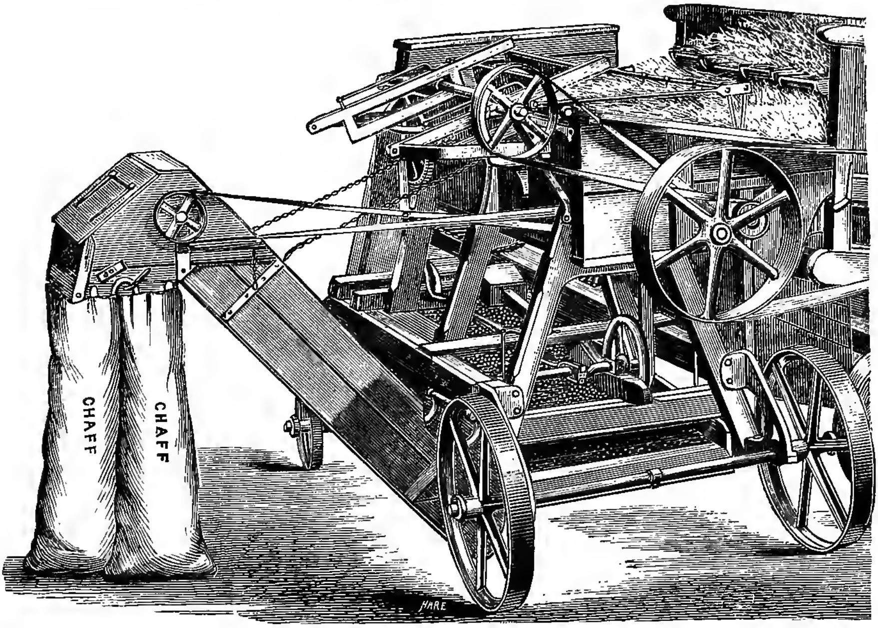

Fig. 136.—*Self-feeding chaff-cutter.*

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

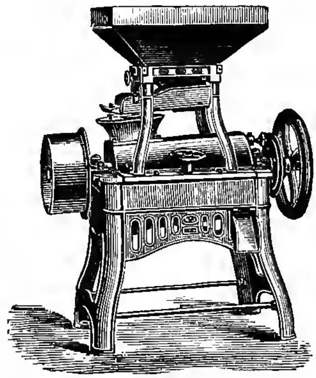

Fig. 137.—*Corn-grinding mill.*

& 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 service-

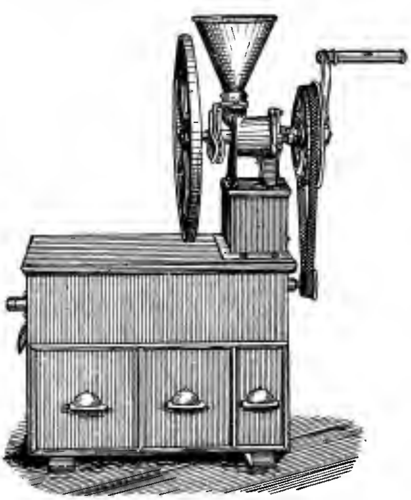

Fig. 138.—*Hand flour or grist mill.*

able 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.

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.	...	...		7 0 0	2 12 3	4 7 9
½ cwt. roots . . .	20	...	...	3 10 at 15s. per ton.	...	[1]31½	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 7/8 of the total weight.
" " Mangels " 1/8 " "
" " White Turnips " 1/12 " "
" " Hay " 6/7 " "

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:—

[1] *Jour. Brit. Dairy Farm. Ass.*, vol. ii., No. 2, 101.

	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

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. Palm-nut 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.

	£	s.	d.	£	s.	d.
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	Value of residue . .	4¼d.			
					s. d.	Taking nitrogen at .	5d. per lb.			
Cost of ration per week . .					6 8¾	Phosphoric acid at	3d. "			
Value of residue per week .					2 5¾	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 painstaking 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 au 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:—

	£	s.	d.	£	s.	d.
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:—

	£	s.	d.	£	s.	d.
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

[1] "Early Maturity of Stock." By H. Evershed.

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 oilcake, 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, 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 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 re-remarked 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 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.

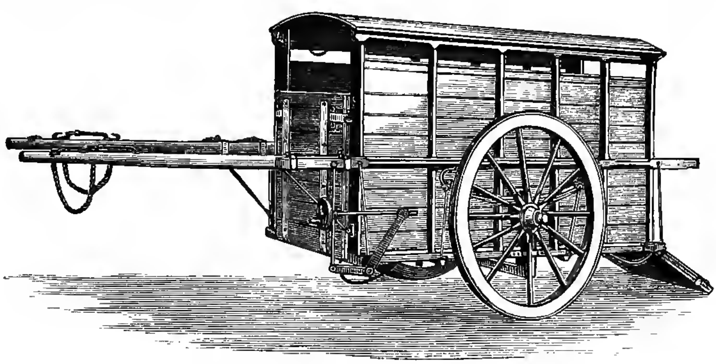

Fig. 139.—*Cattle-cart.*

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.

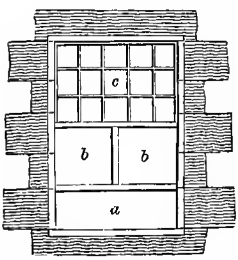

Fig. 140.—*Stable window.*

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 hórses 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 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 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.

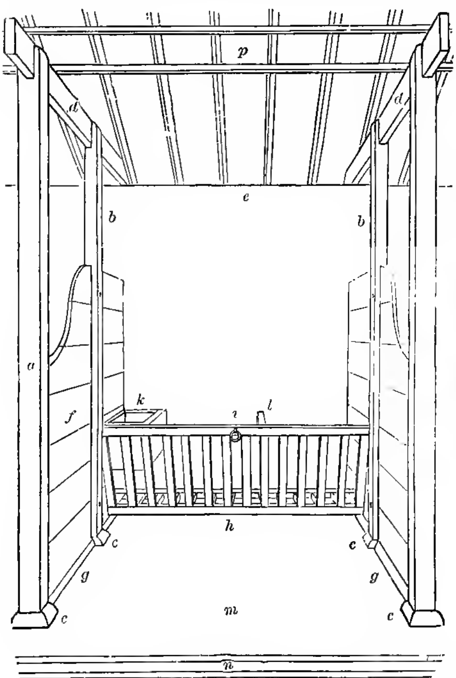

Fig. 141.—*Stall for a work-horse stable.*

- *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.

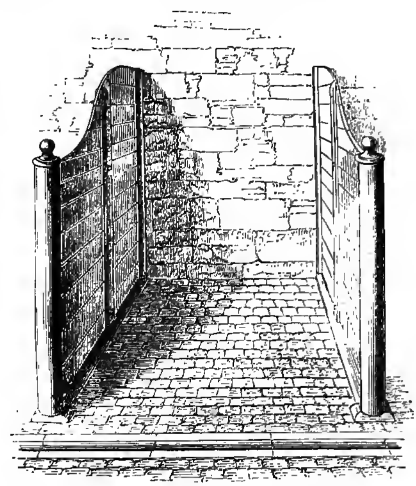

Fig. 142.—*Stall with cast-iron hind-posts.*

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 $\frac{1}{4}$ 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 191$\frac{1}{4}$ 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 956$\frac{1}{4}$ 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

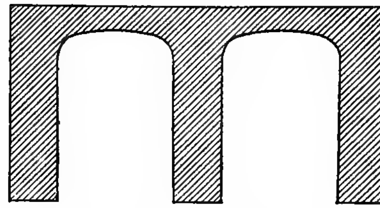

Fig. 143.—*Support for manger.*

the level of the floor of the stall, and should be supported on arches thus (fig. 143).

Fig. 144 represents a section of a

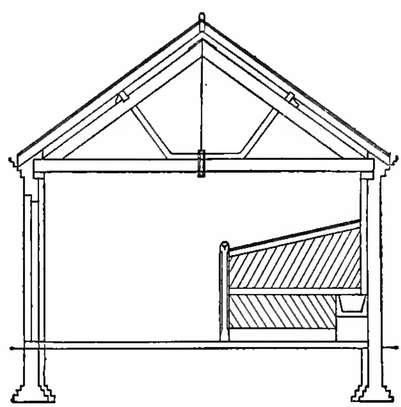

Fig. 144.—*Position of improved manger.*

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,

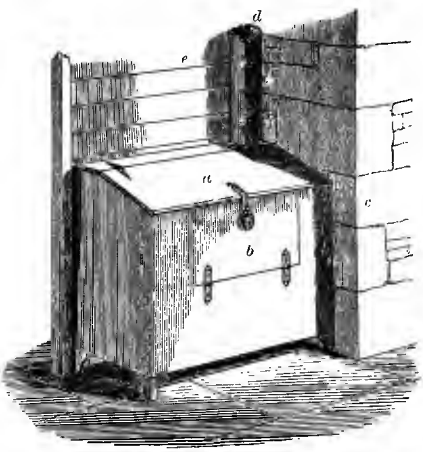

Fig. 145.—*Corn-chest for work-horses.*

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.

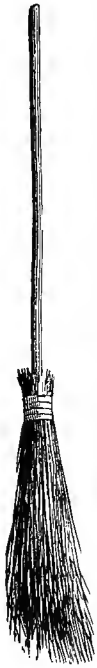

Fig. 146.—*Birch broom for stables.*

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

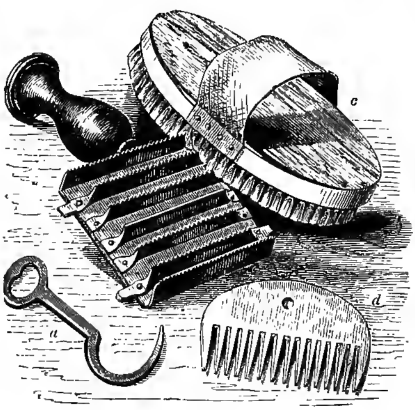

Fig. 147.—*Curry-comb, brush, foot-picker, and mane-comb.*

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

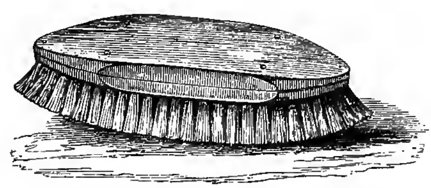

Fig. 148.—*Water-brush.*

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.

[1] *Live Stock of the Farm*, 317.

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 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,

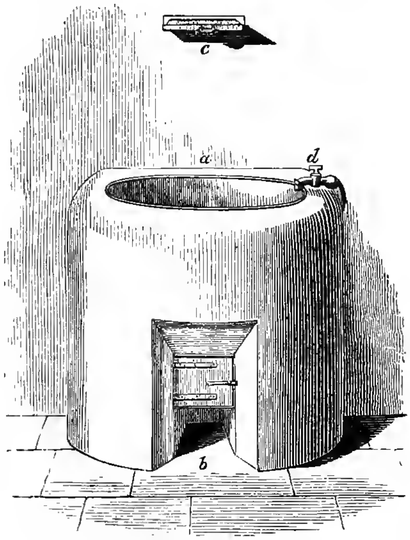

Fig. 151.—*Boiler and furnace.*

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.

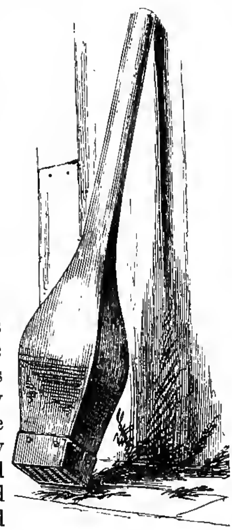
Fig. 152.—*Hand whin-bruiser.*

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, suffcent 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.

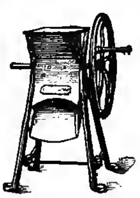
Fig. 153.—*Peat-breaker.*

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;

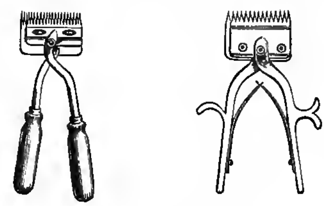

Fig. 154.—*Horse-clippers.*

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 buttermilk 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-

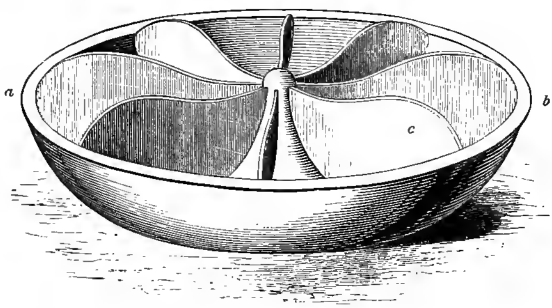

Fig. 155.—*Ring pigs' trough, to stand in a court*

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.

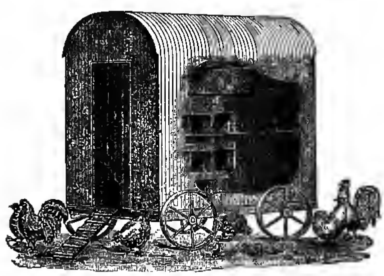

Fig. 156.—*Poultry-house on wheels.*

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.

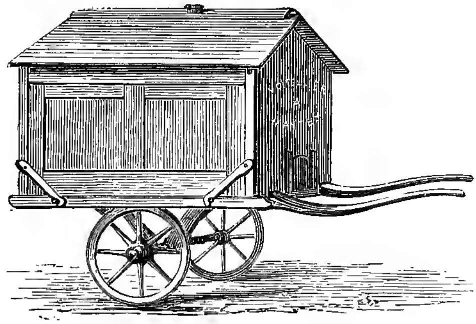

Fig. 157.—*Portable (French) poultry-house*

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.

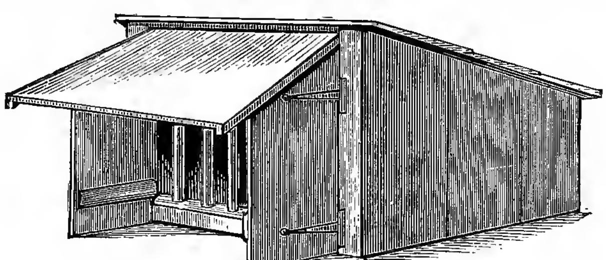

Fig. 158.—*Shelter-coop.*

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-

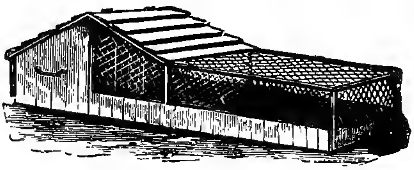

Fig. 159.—*Coop and run.*

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,

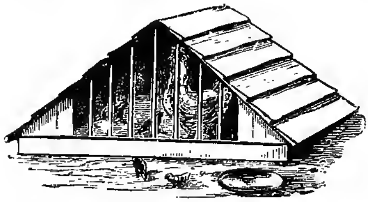

Fig. 160.—*Old-fashioned triangular coop.*

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,

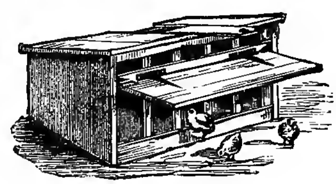

Fig. 161.—*Shelter-coop.*

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.

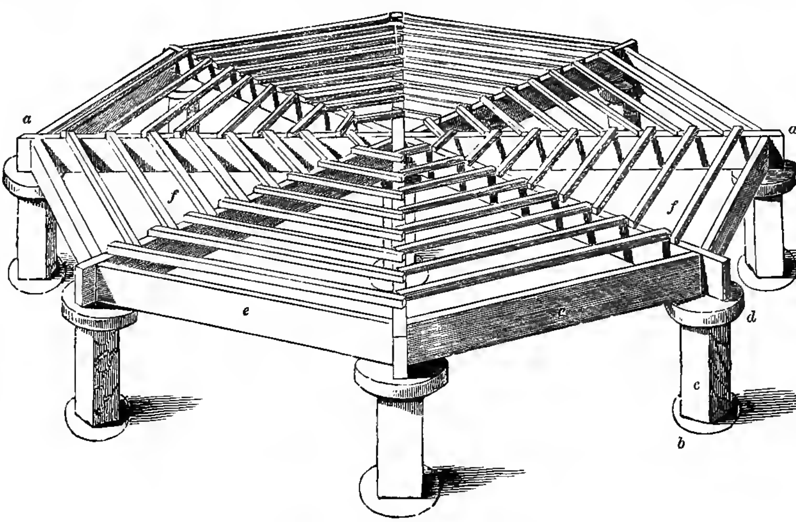

Fig. 162.—*Wooden rick-stand.*

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.

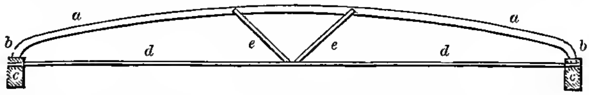

Fig. 163.—*Truss for a galvanised corrugated iron roof.*

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

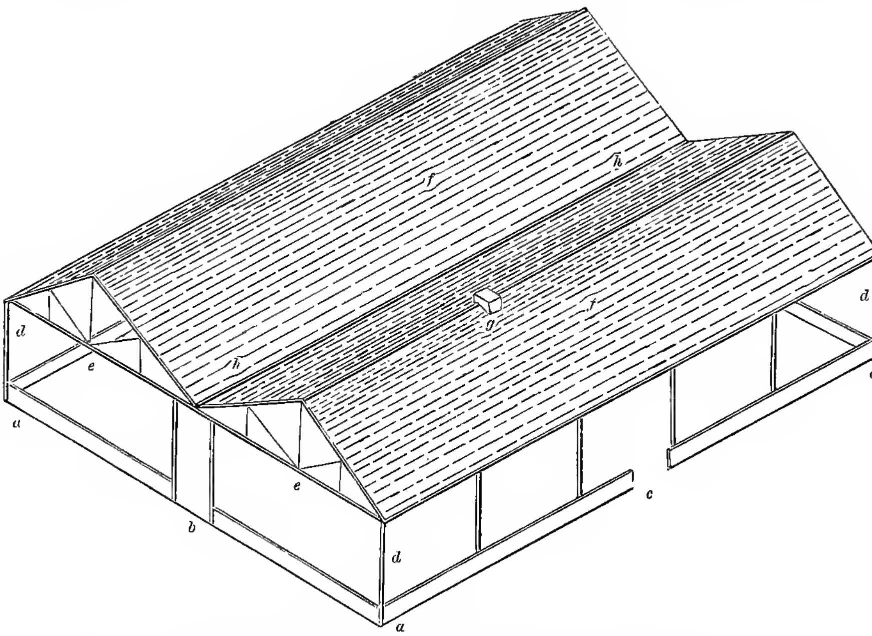

Fig. 164.—*Isometrical perspective of an iron-roof covered stackyard.*

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

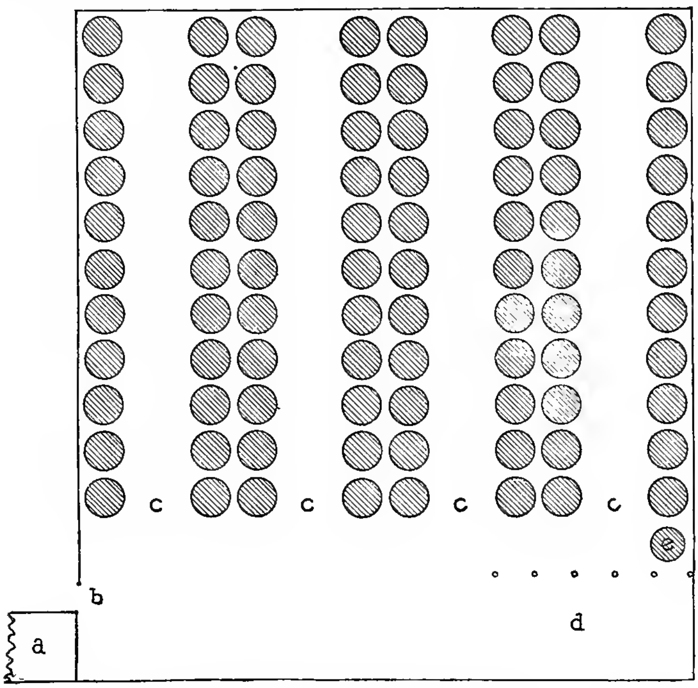

Fig. 165.—*Ground-plan of a stackyard.*

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,

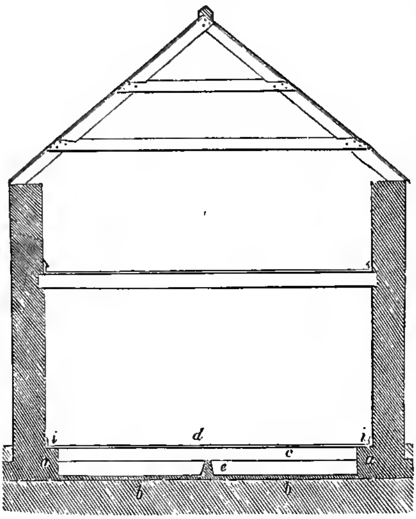

Fig. 166.—*Section of the corn-barn floor.*

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,

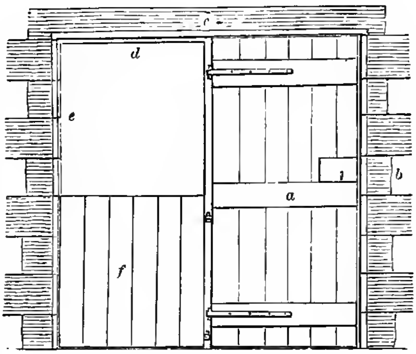

Fig. 167.—*Corn-barn door.*

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

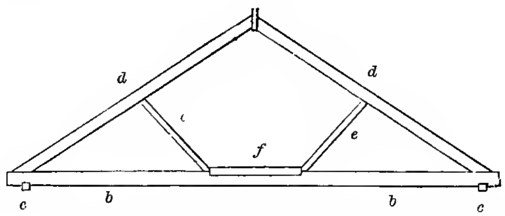

Fig. 168.—*Wooden king-post truss-roof.*

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.

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.

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

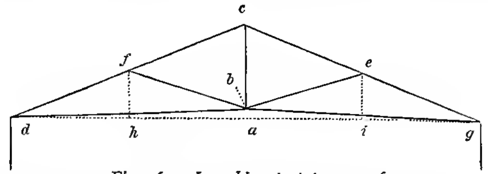

Fig. 169.—*Iron king-post truss-roof.*

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.

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.

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

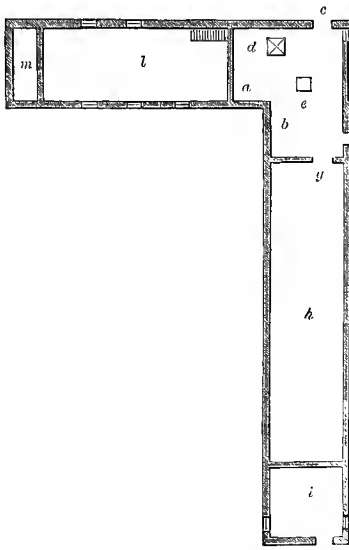

Fig. 170.—*Upper barn and granaries.*

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.

by modern threshing-machines no other plan would, as a rule, be practicable.

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.

Precautions against Vermin.—Rats

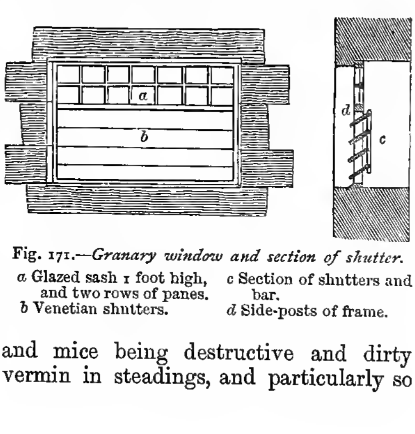

Fig. 171.—*Granary window and section of shutter.*

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.

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

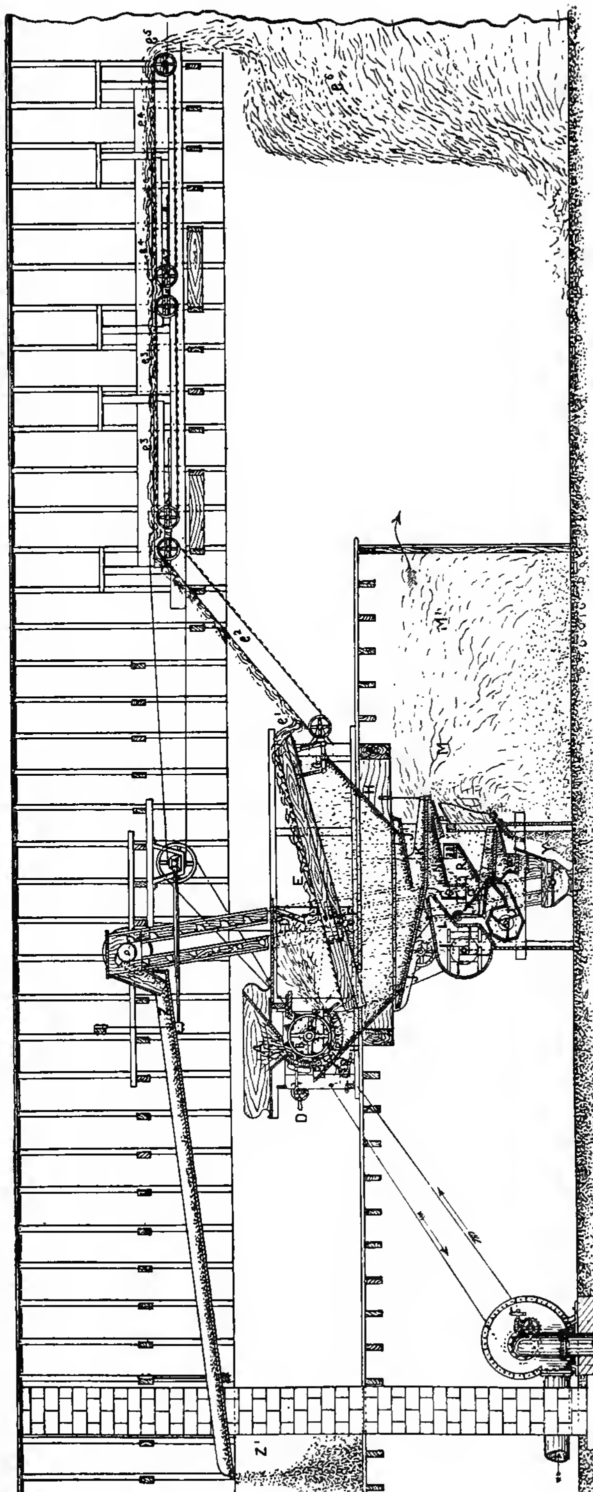

Fig. 172.—Modern Scotch threshing and dressing machine.

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-

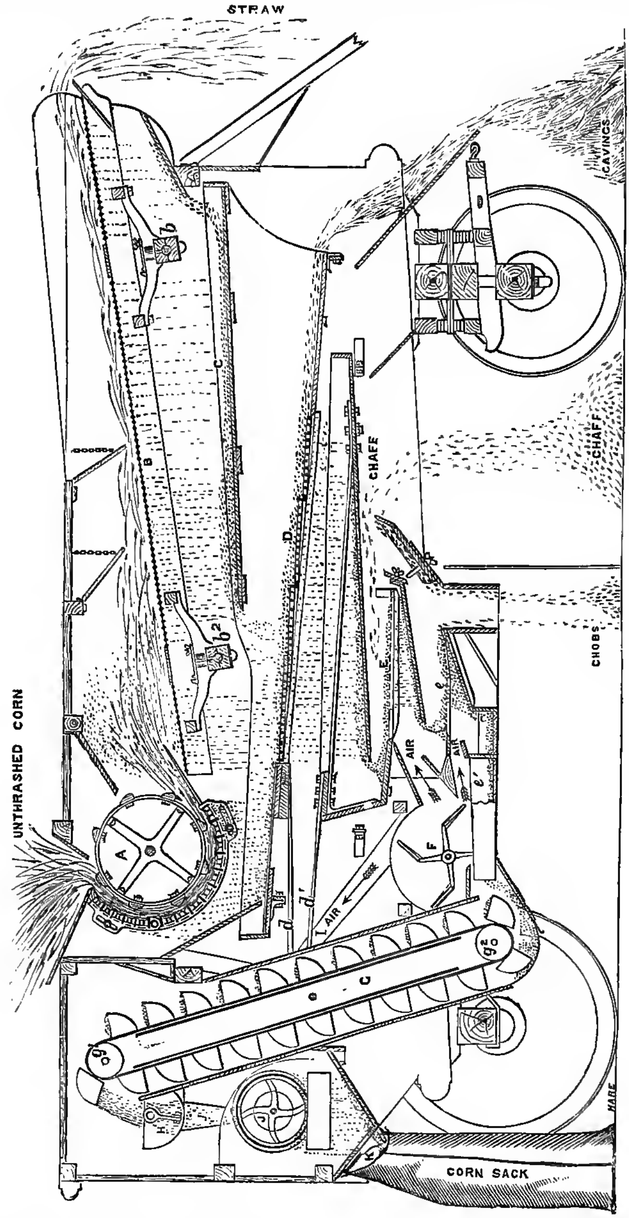

Fig. 173.—Section of portable threshing-machine.

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.

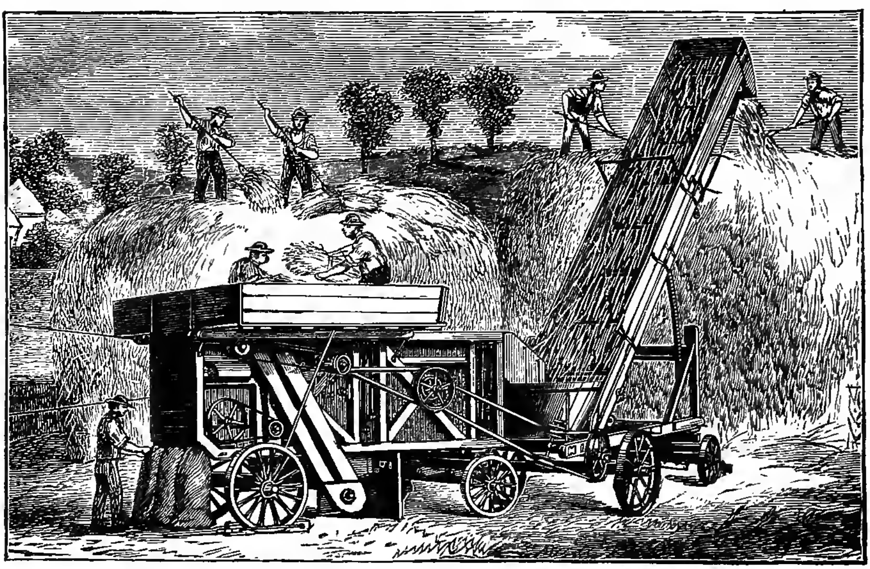

Fig. 174.—*Portable threshing-machine, showing straw-elevator.*

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,

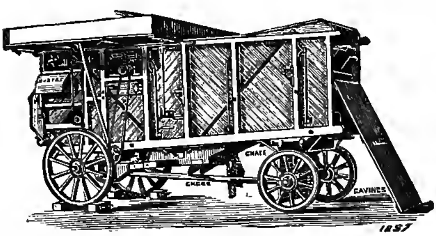

Fig. 175.—*Ransome's threshing-machine.*

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.

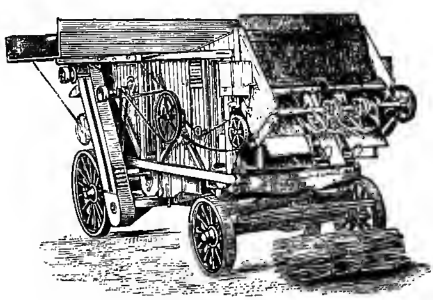

Fig. 176.—*Straw-trusser attached to threshing-machine.*

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.

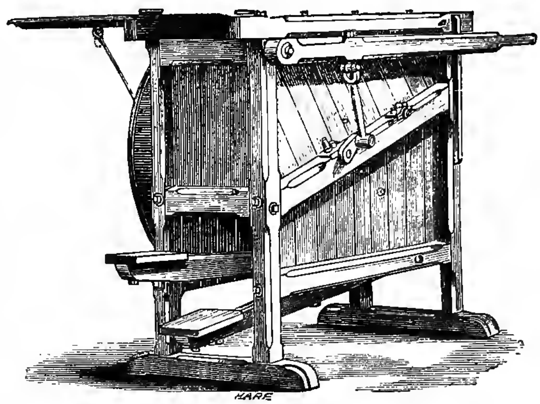

Fig. 177.—*Small threshing-machine.*

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 weight of water per cubic foot .	62.5	)176000(234	cubic feet, the quantity of water required per minute to produce 4 horses' power.
Multiplied by the height of the fall	12	1500	
	750.0	2600	
		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

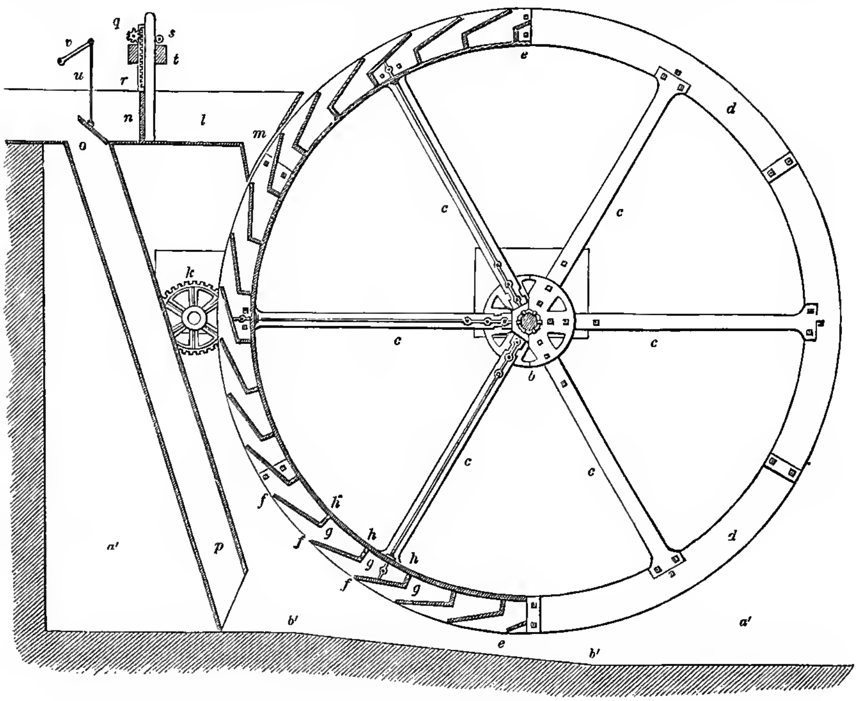

Fig. 178.—*Section and elevation of a bucket water-wheel.*

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.

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.

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

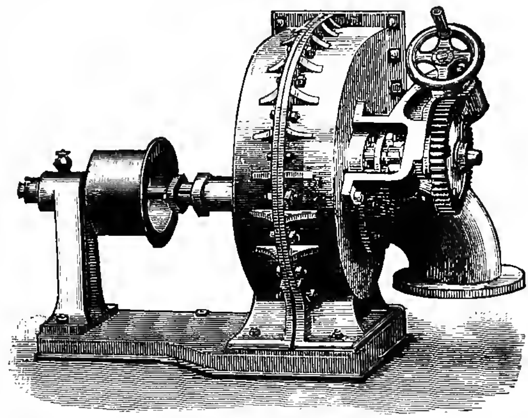

Fig. 179.—*Morton's turbine.*

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

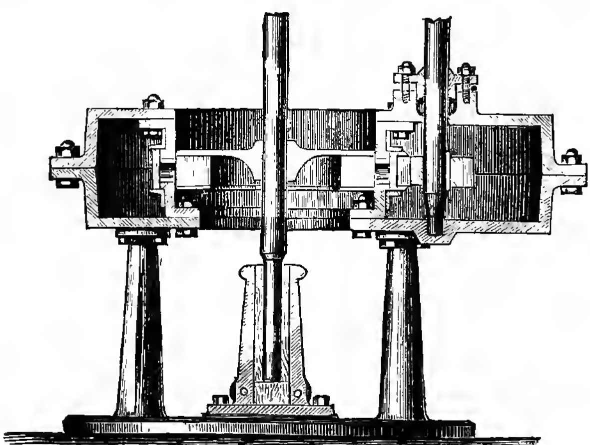

Fig. 180.—*Vertical section of horizontal turbine.*

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.

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

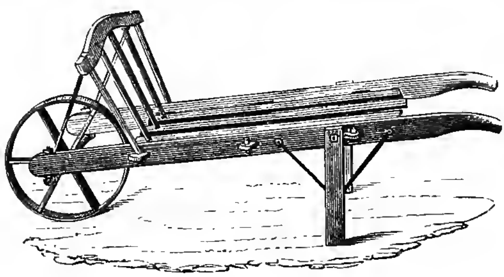

Fig. 181.—*Corn-barrow.*

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.

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-

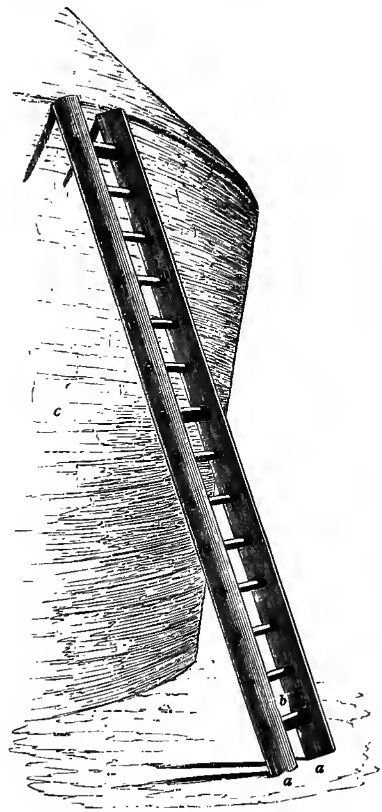

Fig. 182.—*Ladder*, 15 *feet long*.
a a Spars of ladder. *c* Stack.
b Steps of ladder.

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

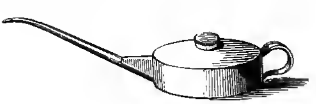

Fig. 183.—*Oil-can.*

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 mow after another, in parallel order, until the stack is threshed or the barn filled.

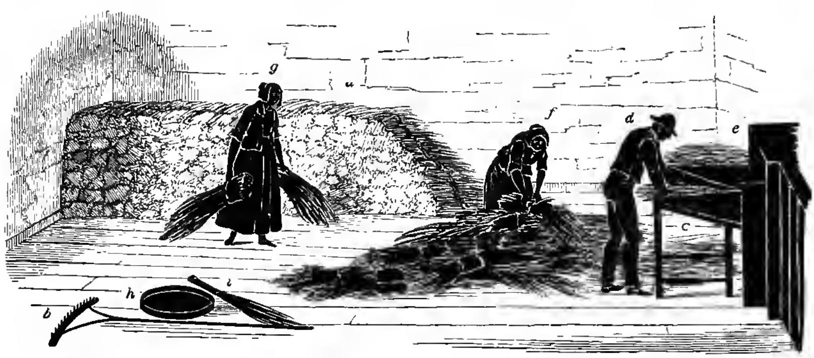

Fig. 184.—*Feeding in sheaves into the threshing-machine of the olden type.*

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.

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 "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.

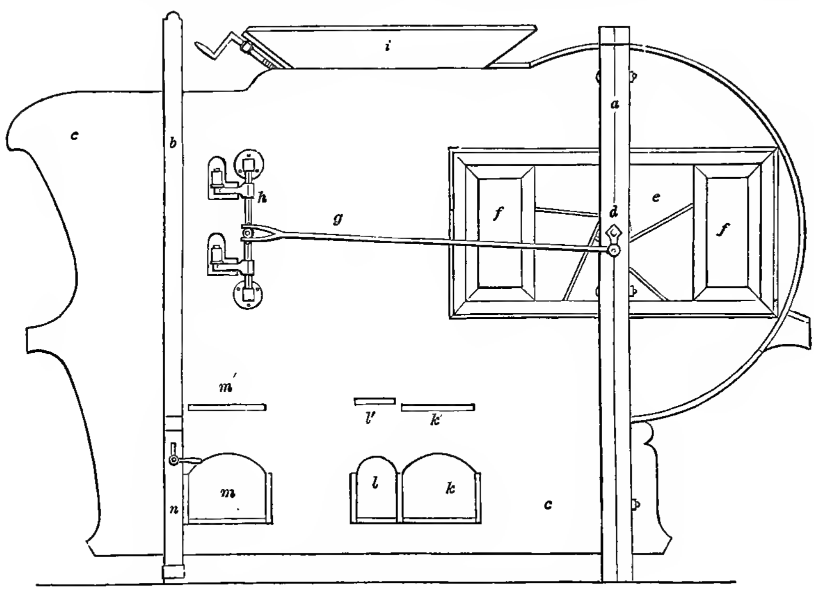

Fig. 185.—*Elevation of the dressing-fanner.*

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.

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

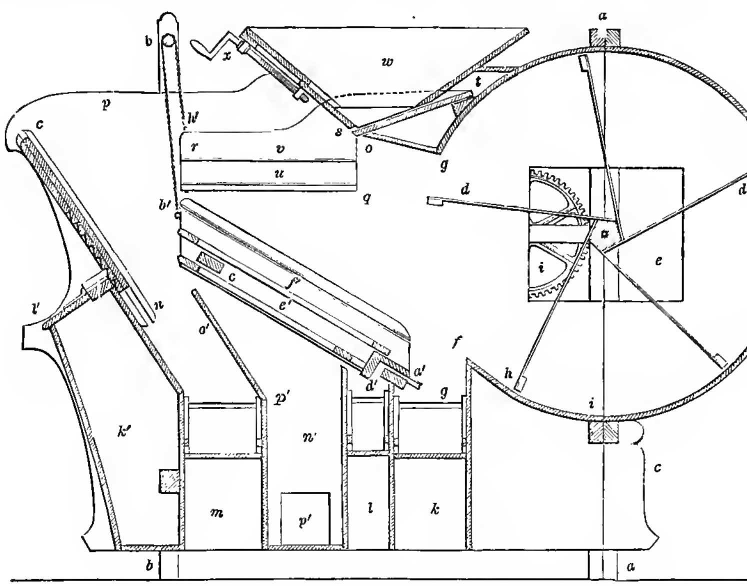

Fig. 186.—*Longitudinal section of the dressing-fanner, with riddles and sieves.*

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-

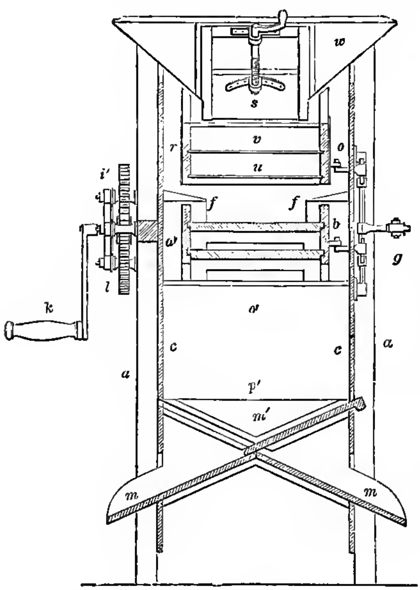

Fig. 187.—*Transverse section of the dressing-fanner.*

a a The frames.	*u v* Riddles.
c c Side-boardings.	*w* Hopper.
m m Light spouts.	*s* Sluice.
m' Sliders to change direction of discharge.	*g* End of connecting-rod.
o' p' Sloping division.	*b o* Attachments of riddle-frames with bell-crank.
a' b Sieve-frames with sieves.	*i'* Toothed wheel.
f f Flaunch-boards.	*k* Winch-handle.
r o Riddle-frames.	*l* Framework.

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

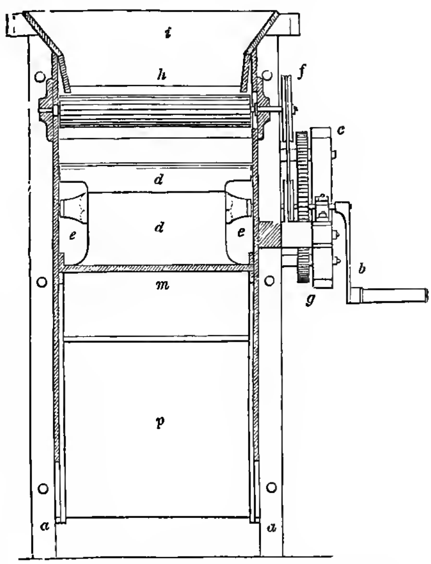

Fig. 188.—*Transverse section of the finishing-fanner or duster.*

a a Frames.	*i* Hopper.
b Winch-handle.	*m* The sole.
c Wheel-framing.	*p* Division under the sole.
g Wheel.	*d d* Arms of fans.
f Pulley of feeding-roller.	*e e* Axle of fans.
h Feeding-roller.	

are intercepted, and fall through it, while the best corn passes on, and is delivered at the end spout.

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

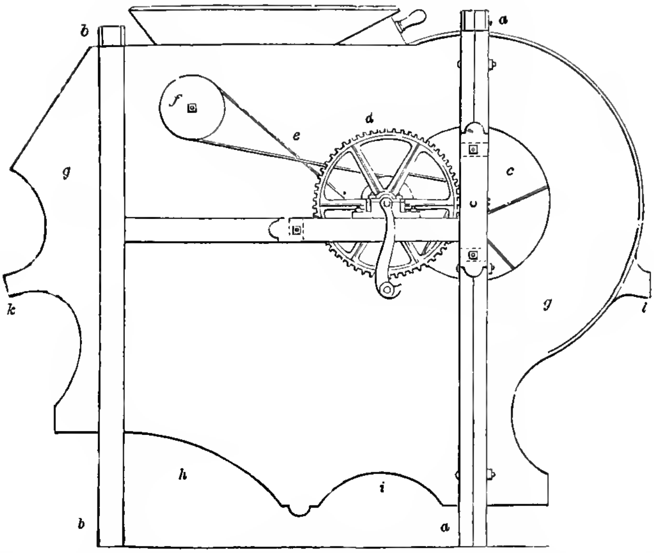

Fig. 189.—*Elevation of the finishing-fanner or duster.*

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.

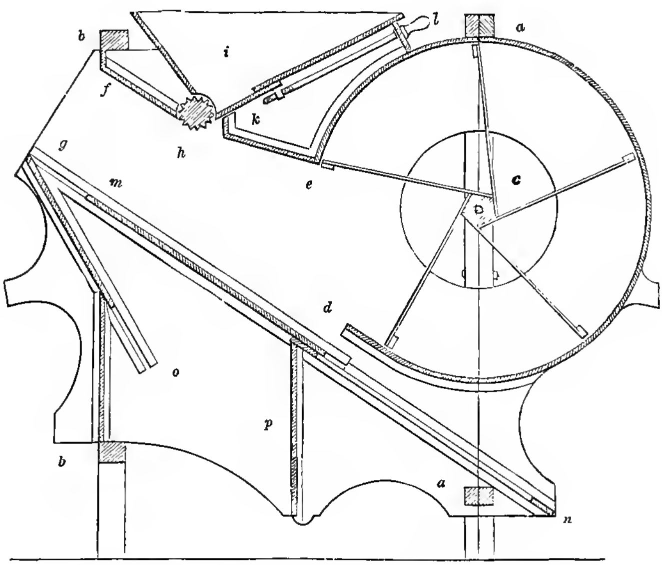

Fig. 190.—*Longitudinal section of the finishing-fanner or duster.*

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, suffi-

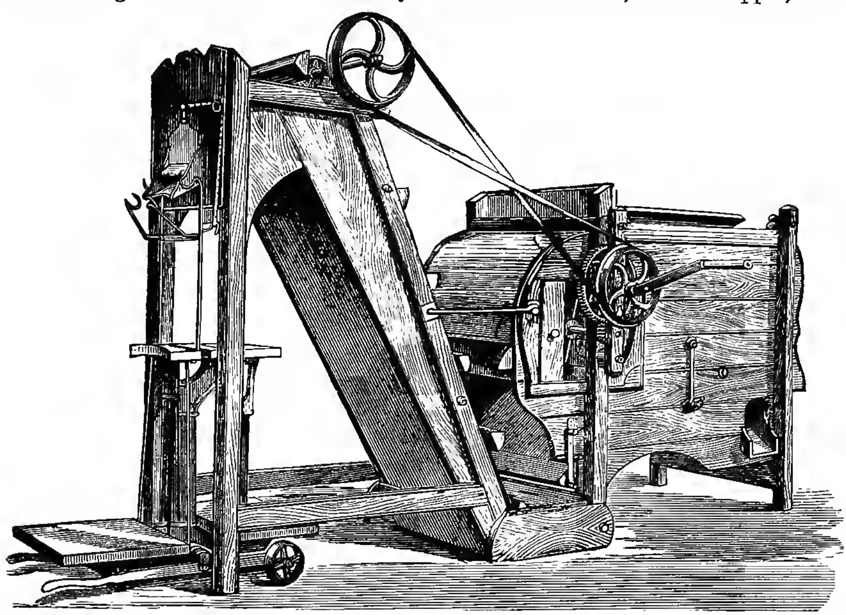

Fig. 191.—*Combined winnower and bagging-machine.*

ciently 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.

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

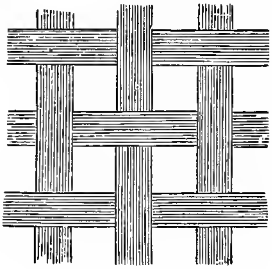

Fig. 192.—*Old wooden wheat-riddle.*

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

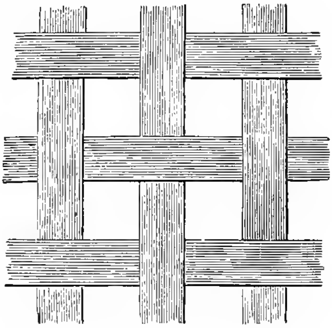

Fig. 193.—*Old wooden barley-riddle.*

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.

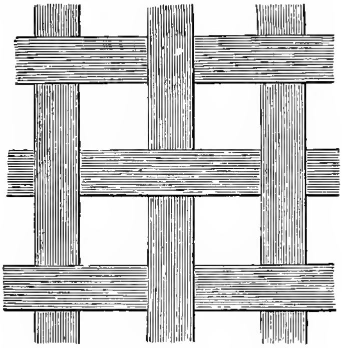

Fig. 194.—*Old wooden oat-riddle.*

Riddles.—Although they are now little used, it may be interesting to pre-

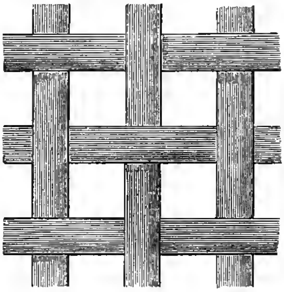

Fig. 195.—*Old wooden bean-riddle.*

serve here some of the illustrations of the barn implements in use in former

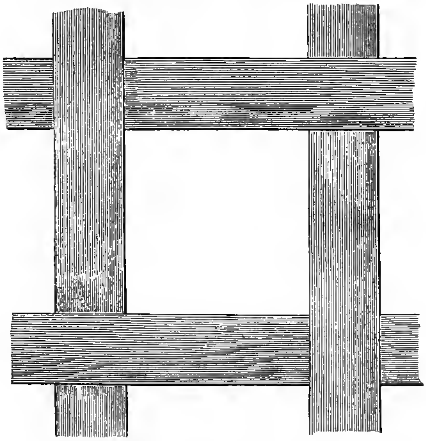

Fig. 196.—*Old wooden riddle for the roughs of wheat and corn*

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

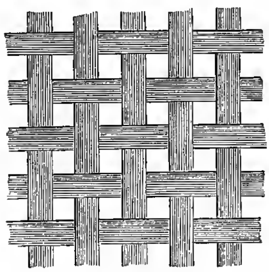

Fig. 197.—*Wooden sieve.*

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.

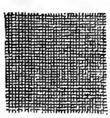

Fig. 198.—*Iron-wire sieve.*

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.

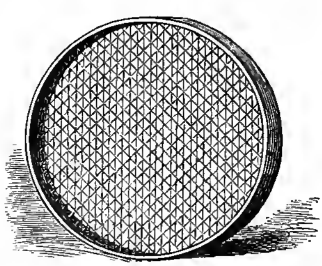

Fig. 199.—*Triangular-meshed iron-wire sieve.*

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.

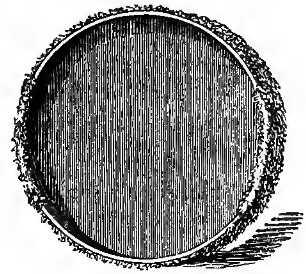

Fig. 200.—*Wecht of skin.*

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-

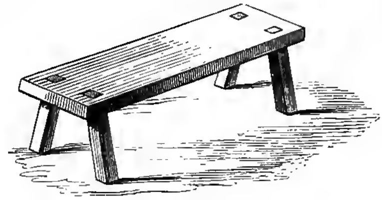

Fig. 202.—*Barn-stool.*

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.

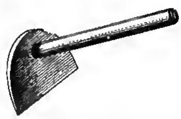

Fig. 203.—*Barn wooden hoe.*

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.

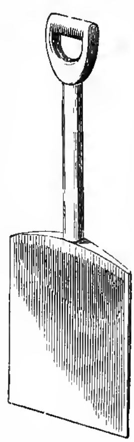

Fig. 204.—*Wooden corn-scoop.*

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

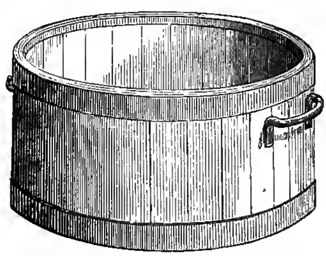

Fig. 206.—*Imperial bushel of a convenient form.*

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

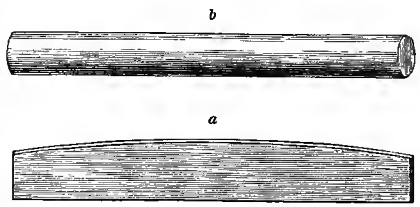

Fig. 207.—*Corn-strikes.*
a Flat corn-strike. *b* Cylindrical corn-strike.

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

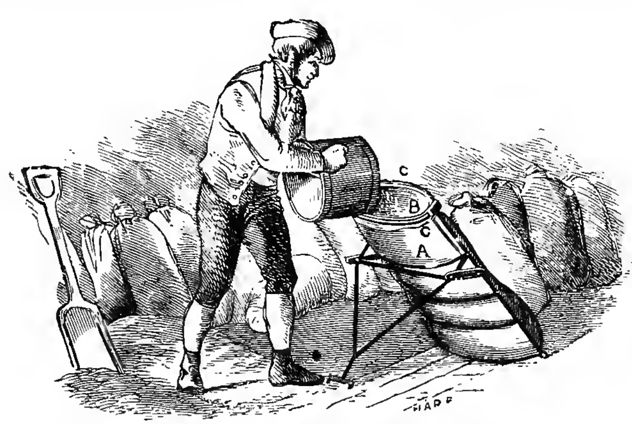

Fig. 209.—*Bagging grain with sack-holder.*

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.

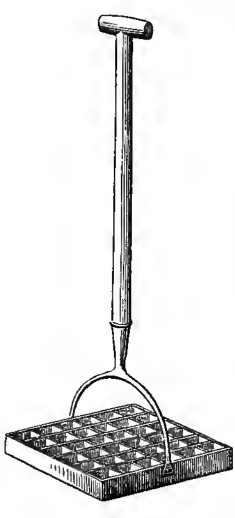

Fig. 210.—*Simple hand-hummeller.*

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.

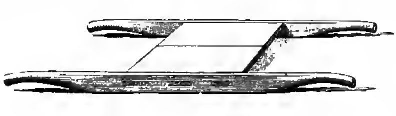

Fig. 212.—*Sack-lifter.*

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

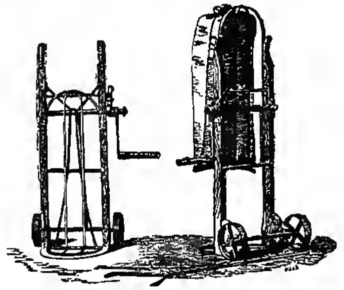

Fig. 213.—*Combined sack-barrow and lifter.*

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.

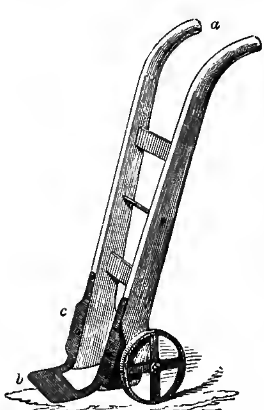

Fig. 214.—*Sack-barrow.*
a Handle. *b* Shelf. *c* Shields over wheels.

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 perpendicu-

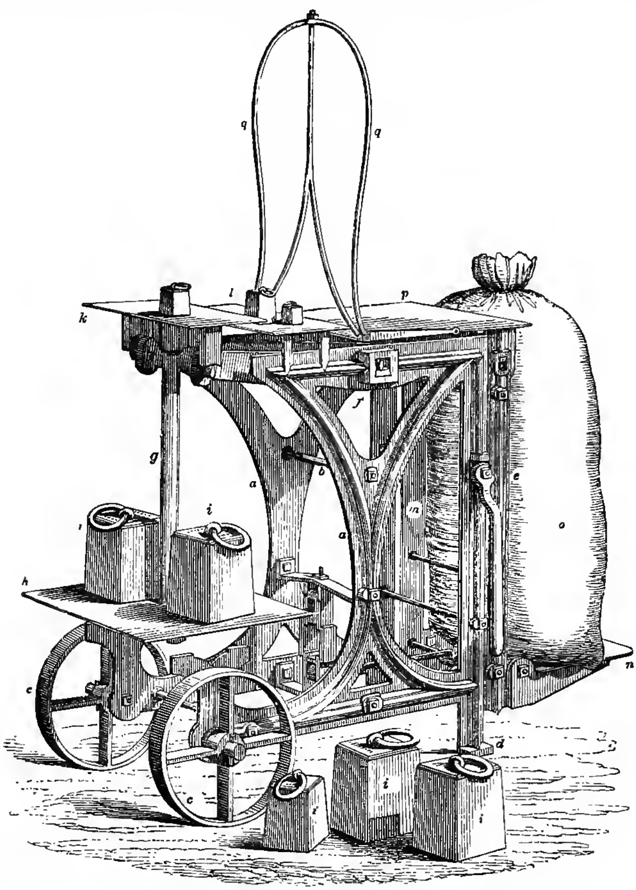

Fig. 215 —*Balance weighing-machine.*

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.

lar. The frame may be painted or left plain.

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

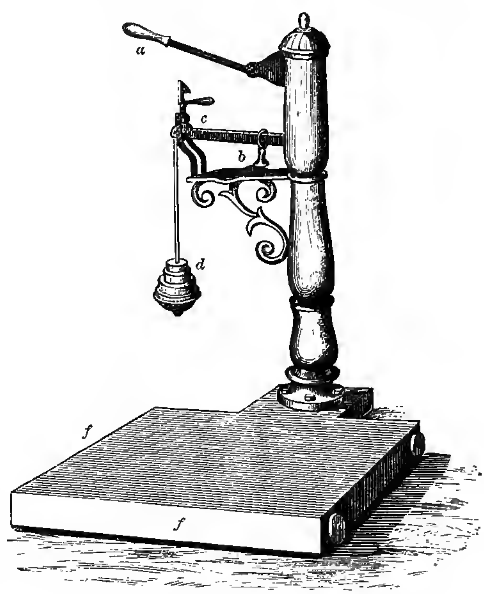

Fig. 216.—*Portable weighing-machine.*

a Lever. *d* Weight-plate. *ff* Platform.
c Balance. *b* Sliding-weight. *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 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,

Fig. 217.—*Classification of wheat by the ear.*

[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:—

		Mean temperature, Fahr.		
	Lat.	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. 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. 221.

4-rowed bere or bigg. *6-rowed barley.* *2-rowed barley.*

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.

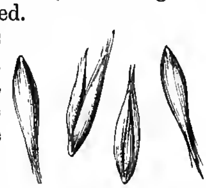

Fig. 225.—*White Siberian early oat.*

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.—*Spike of Tartarian oat.*

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.

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.—*Partridge field-pea.*

Fig 231 is the partridge field-pea of the natural size.

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 "fire-fang" 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.

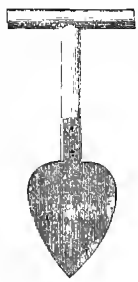

Fig. 232.—*Dung-spade.*

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-

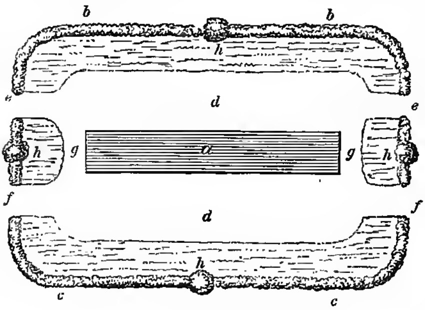

Fig. 233.—*Dung-pit for four fields.*

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 rain-water 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.		Dry dung.	
	Cow.	Horse.	Cow.	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	8.8
" magnesia	..	..		
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

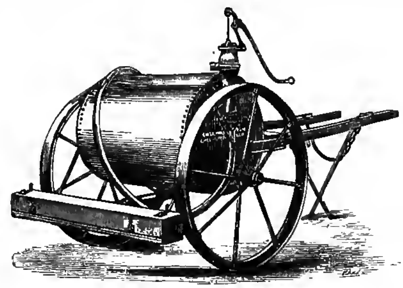

Fig. 234.—*Liquid-manure cart.*

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-

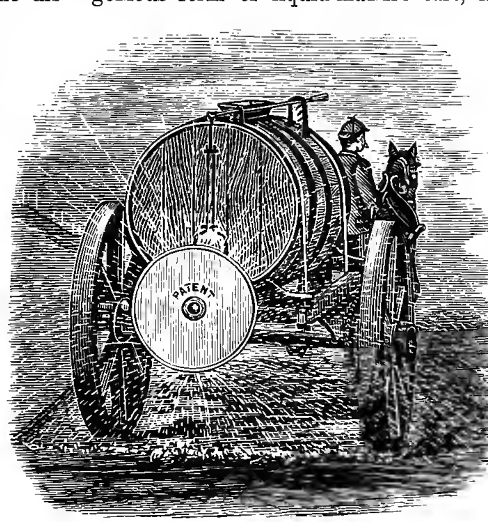

Fig. 235.—*New liquid-manure cart.*

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

Fig. 236.—*Scoop for filling a water-barrel.*

inches in diameter, the helve passing through its sides in an oblique direction, and a little above its centre of gravity.

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

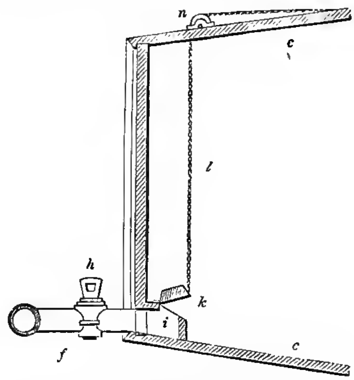

Fig. 237.—*Apparatus for discharging liquid manure.*

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

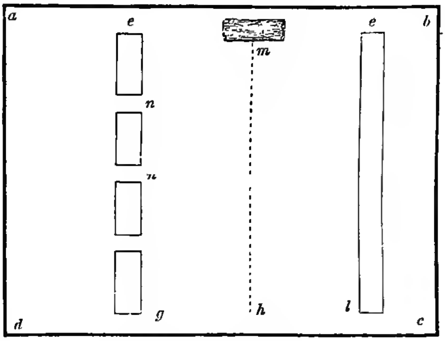

Fig. 238.—*Claying of soil.*

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.

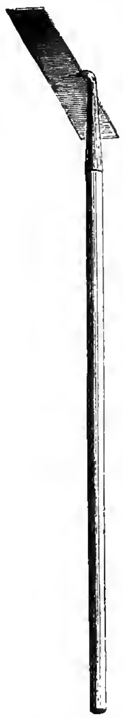

Fig. 239.—*Mud-hoe, harle, or claut.*

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.