A TECHNICAL TREATISE

ON

SOAP AND CANDLES;

WITH A GLANCE AT

THE INDUSTRY OF FATS AND OILS.

BY

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PREFACE.

AT this advanced age it is quite unnecessary to speak of the importance of the arts of manufacturing soap and candles, as they have become necessary to all civilized nations, and it has been well said that we may judge of the degree of civilization of a people by knowing the amount of soap they consume; and the chemists who by their research discovered the methods of making artificial soda, and the true constituents of the fats and oils and their utilization may be considered among the greatest benefactors of their race, giving to the world cheap cleanliness, as well as cheap light.

To remove these arts from the darkness of empirical rules to the light of modern science is one of the principal desires in the construction of this work, for the author has had an experience of nearly forty years in these and kindred arts, in pharmacy, chemistry, soaps, perfumery, etc., and he well knows how little science has been consulted in making these useful articles, and how much guesswork with the usual uncertain results, depending upon the experience which the operator may have had, and the more or less secret his processes. These experiences and processes may have served a useful purpose when the arts were confined to making domestic soaps and tallow candles, but they cannot avail at the present time, when they have become a thoroughly scientific manufacture.

To render this work as complete as possible, and bring all the processes and formulas up to the present time, the author has given much time and care to its compilation; aided by his long experience, and having access to all that has been discovered and written in France, Germany, England, and this country, he issues it with confidence that it will be found a useful guide, and by its simplicity and correctness well adapted for the use of the soap and candle manufacturer of the present age.

Americans, true to their renown, have made the greatest advance in the mechanical part of these arts by their numerous improved machines and apparatus for the saving of labor and improvement in the products, and the author has illustrated some of the most recent, most admirable, and most durable. From such causes they are making rapid strides towards the highest excellence, aided by these improvements, so that our products will compete favorably with any now made, although we must still yield to France the palm for superiority in toilet soaps.

In the department of candles there may be considered quite a revival in the manufacture at this time, particularly for the better class of goods, and he has therefore given it careful consideration. The use of gas in the large cities and petroleum everywhere, the latter particularly affording a good and cheap light for the million, has caused this manufacture to suffer neglect for some years; yet gas has its disadvantages and petroleum its dangers, so that candles are becoming much more used at feasts and festivals and in the homes of the wealthy, aiding much in the decorations of modern homes by their attractive designs and giving a softer and more pleasant light.

Knowing the importance of the arts of which he treats, the author has sought to make his book as complete as possible, and he believes he has left out nothing that would be useful or important. How well he has performed his task experience in its use must show.

In conclusion the author takes pleasure in acknowledging his obligations to the writings on the same subject of Professors Morfit and Dussauce, both published by the publishers of the present work, and of those of Messrs. Lichtenberg, Steinheil, and Malepeyre, and very many others of later dates, indeed too many to enumerate in this place.

PHILADELPHIA, MARCH 4, 1881.

NOTE.—Owing to the difference that obtains in the several countries as to the weights and measures and thermometer scales, the author has rendered all the French or decimal weights into that most used in this country —the avoirdupois; when fluids are called for, into that of the apothecary, and when the centigrade scale of the thermometer is given, which is generally the case in most scientific books, into that of Fahrenheit, thus simplifying the subject to the reader.

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A TECHNICAL TREATISE

ON

SOAP AND CANDLES,

WITH A GLANCE AT THE

INDUSTRY OF FATS AND OILS.

SECTION I.

INTRODUCTION.

THE term soap is now applied to all those compounds of oils or greases or sebacic acids with the salifiable bases or alkalies, which by their detergent properties aid in the removal of dirt or grease in washing, scouring, and scrubbing. The term detergent means the power of rendering soluble in water the adhering grease or dirt on the skin or clothes ; for which purpose soap is now universally applied by all nations. Indeed we can almost form a true estimate of the degree of civilization to which a country has attained, by knowing the amount of soap used by its inhabitants.

It is perhaps unnecessary here to mention the great importance and usefulness of the art of manufacturing soap, as an article so universally used has attracted the attention of chemists from the most remote period ; yet, although soap has been made and used for so long a time, it is only in modern times that its manufacture has reached a scientific character, for it is less than sixty years since Chevreul first advanced the proper theory of saponification, and made known the elements of the fats and oils and their chemical reactions with the bases or alkalies.

To the magnitude of its agriculture, manufactures, and commerce we turn to discover the wealth of a nation, and in applying the light of science to all of the most important manufactures, and thereby improving the quality and cheapening the cost, we increase the demand, give importance and character to an art, enlarge and extend the product, and bring wealth to a country and its people.

While as Americans we are proud to know that we excel in the many new machines and apparatus intended to facilitate the manufacture of soaps, and are constantly improving the quality of our products, yet we still procure from Europe many of their superior productions; but as we realize that there is still something to learn, and we seek to excel, we are quite likely ere long to equal any soaps made in any country.

The arts of manufacturing soaps and candles rest upon exact principles and fixed rules, and are true chemical industries. So it is important that the manufacturer should endeavor by steady experiment and practice to learn these arts scientifically, that he may fully understand their true foundations.

Being chemical arts, it has been necessary to use many scientific terms, but the author has sought to give the simplest explanations while yet retaining accuracy, that the worker, who may be without experience, may fully understand the meaning of all he reads, and it is his object here to make all processes as simple as possible, compatible with their accuracy and importance.

In conclusion, he desires to give a word of advice founded on experience, to all who wish to enter into the important manufacture of soaps, as well as to those already in it; to seek the most approved means of making good honest soaps, soaps that will bear all tests, and bring him reputation, respectability, and fortune, for though by sophistication and adulteration a larger quantity may be marketed by the attraction of low prices, yet quality is the only true test, and superiority should be the aim, as it is the only road to respectability in the trade.

SECTION II.

HISTORY OF THE SOAP AND ALKALI TRADES.

If we could go back sufficiently far in the history of nations, we should find that commerce meant the barter of the commonest natural products. Just as people progressed in civilization so did their wants increase, and to meet their requirements it became necessary to apply to natural products much study, to shape them to suit the desired uses. So we see the beginning of manufactures which now represent the most important factor in the commerce of nations. While in early times everything was accomplished through agriculture and the increase of the earth, it is still the most important, but guided by the intervention of science.

In considering the history of manufactures, we will see that they have been chiefly developed through chemical research, and few, if any, have been more interesting or important to the progress of a country than the branches known as the soap and alkali manufactures and trade. So we must consider chemistry as a science built on a framework which has been raised by the labors of such men as Berzelius, Lavoisier, Scheele, Gay-Lussac, Leleivre, and others, and see the application of derived knowledge to the arts and manufactures, and appreciate the natural consequences of cheap soap and cheap oils, "cheap cleanliness and cheap light."

While we find that soap has been used for some centuries and by many nations, it is not so well established that the ancients were acquainted with it, as it is known that they used ashes and alkaline earths; which, though they had a detersive power, yet as found in nature were very corrosive and destructive to fibrous material and to the human skin. These natural substances are still used in some countries as substitutes for soap.

It is difficult correctly to ascertain at what time or by what nation soap was first made and used. It is claimed by some that the Greeks first invented it, yet it is first distinctly spoken of as an invention of the Gauls, whence the Germans obtained the art and were distinguished for their superior goods, which was at least a century before Italy established its manufacture in the eighth century, and in the beginning of the tenth century it was introduced into France, where large factories were established in Marseilles by a colony of Phoceans, decendants of the Greeks. Marseilles was particularly adapted to this industry, as all the needed materials were there abundant. Olive oil was common, and the neighboring sea-coast provided the vegetable sodas, and the seaport on the Mediterranean had a large commerce with all Europe and the Levant. So France became the great market for this useful product, and was celebrated for the superior quality of its soaps, and very deservedly, as the processes then in use have been faithfully adhered to, and all these combinations are to this day wisely continued with the addition of improved applications natural to the advance in everything else. These manufacturers have with prudence added to their materials only such as have proved after careful experiment to be of decided advantage.

In the war with Spain in the beginning of this century the sources of much of their material both alkali and oil were cut off, very much to their disadvantage, and the government with great wisdom offered a large reward for the discovery of the means of substitution. This was accomplished by Leblanc who discovered a process for making caustic soda from culinary salt; a discovery that has been of great importance, and may be said to have revolutionized the soap and alkali trades; for artificial soda as it is called is now universally used. So with their olive oil which became scarce and dear, for it was also largely supplied by Spain; the manufacturers were compelled to try other oils, and poppy oil, hempseed oil, sesame oil, and groundnut oil, were used in combination. The latter oil especially proved a success, in fact an improvement to the soap. So at the present time no Marseilles (Castile) soap is made with olive oil alone, as the addition of any of these oils in certain proportions has been proven beneficial; preventing the soap from acquiring too solid a consistency when dry, which that made from olive oil alone was sure to have, except when made with lye from barilla, which contains a large percentage of potash, and the hygroscopic character of this alkali had a like effect in keeping the soap plastic and more soluble.

In turning from France to England we see that but little progress was made in this art; soap was indeed made, but only in the crudest form and generally in the household or for fulling. The first mention of its manufacture was in 1524, in London; in 1641 a factory for its production is described in some records in the British Museum. The trade was retarded, like many others, by the special privileges granted to a subject by the sovereign, and again by the heavy excise duties. These obstructions prevented progress so that but little improvement can be found from the time of Queen Anne till the present century, when in 1804 Muspratt made artificial soda by Leblanc's process, which immensely cheapened and increased the manufacture of the article. Yet to the date of the first International Exhibition of 1851, England had made so little progress that she was surprised that the manufacturers of other countries carried off nearly all the prizes given for that branch. This surprise caused an agitation for the repeal of the excise, which was finally accomplished in 1853. The result of this repeal was so beneficial that we find in 1870 the amount manufactured had increased fully fifty per cent.

Yet England has not kept pace with some other countries in the progress of the art, though some important discoveries in cheapening the cost of soap have there been made, particularly the addition of rosin, palm oil, and silicate of soda. The former article may be considered an ameliorater, making it more soluble; the latter while cheapening does not materially injure its quality, the silicate of soda, having an alkaline reaction and a detersive quality, being less objectionable than the many articles now in use as sophistications of soap, some of which are pernicious and should be abandoned.

In 1870 England manufactured about 250,000,000 pounds of hard and soft soap, but since then we cannot trace any material increase, for countries that then were principally dependent for soaps on England now make most of their own. But of alkali England has steadily increased its supply until it now in quantity excels all other nations.

The Germans, who in early times made the best soap and exported it to other countries, have made but moderate progress in modern times. At the present day, however, the practice of the art being open to all the people, who have established many small factories and applied to the trade its true chemical character, they are producing superior goods, though this superiority is not sufficiently maintained to claim particular notice in comparison with the products of other countries. The soft soap of Germany is still much used for household purposes as well as for manufacturing, and it has acquired a reputation for excelling in quality that of other countries. Why, we cannot say, for there have been neither many improvements nor much science given to its manufacture.

Of the manufacture of alkali in Germany there had been but a limited improvement for many years, until it was found that England was extending her alkali trade to an enormous extent, when the Germans saw the necessity of improving their goods and economizing their processes, which latter had heretofore been conducted in a very wasteful manner. This compelled them to establish large works and to employ experts at liberal wages. The result has been not only a better product, but a large increase in the quantity manufactured and in a single decade.

For a period of time past recollection Germany had made both soft and hard soaps with potash lyes, the latter by using salt in turning the soft soap into hard, the culinary salt or chloride of soda producing a decomposition by parting with its chlorine, forming chloride of potash, which was precipitated in the spent lye along with the glycerine, leaving a sebacic acid soda soap. This process is still in vogue in countries where wood is burnt as fuel, and potash and wood ashes are abundant; notably Russia and the newly settled portions of the United States. Germany now employs the artificial soda in almost all its soaps, and is making much of its alkali from cryolite for the use of the glass manufacturers as well as the soap boilers.

In our own country there has been a steady progress in the improvements constantly making in this useful and important art, until now we are producing goods which for quality compare favorably with any made elsewhere; moreover we have invented much new and improved machinery and apparatus that greatly facilitate the processes, saving labor and time and improving the quality. Thus the United States is at this time but little behind any other country, either in the amount made or in the quality of the article; while in the economy and facility of their manufacture this industry is in advance of that of nearly all other countries, and is steadily progressing, so that it cannot be long before we shall equal in quality and excel in quantity, for already we are making soap in larger quantities than Great Britain, and are but little behind France. We are also making so much of our own alkali that we shall soon be independent of other countries. We have hitherto been supplied from England, which is still largely in advance in the production of soda and its adjuncts, having in operation over fifty large alkali works and making goods valued at $20,000,000 per annum. At the present time the United States has several of these works and many more are projected.

When Chevreul described the exact constituents of the fatty bodies, and made known the processes for their separation, a great impetus was given to both the arts of soap and candle manufacture. The stearine or solid part was made into candles while the olein or liquid part was converted into soap, the glycerine which had previously been thrown away was extracted from the sublye and utilized and has since become of great importance in many arts.

The importation of palm and cocoa-nut oils added an important variety to the list of soaps, particularly of toilet-soaps, the former being a useful and pleasant material, improving all soaps into which it enters, which cannot, however, be said of cocoa-nut oil, as it retains a rancid odor which it seems impossible to remove, and which is to most people objectionable, so that it should be used with caution. On the other hand, it has many good qualities, making soap handsome in appearance and in use giving a copious lather. It has also properties peculiar to itself; thus it saponifies only in strong lyes, and will dissolve in salt water and is often called marine soap. It will also retain a large percentage of water without impairing its solidity or appearance. These properties it in some degree imparts to other soaps to which it may be added, and it has been the means of much sophistication and adulteration, which has given to purchasers an idea of inferior quality, yet to some it is a favorite because of the richness of its lather.

In giving statistics of soaps, we can only give approximate figures, as we find nothing later than 1870 and 1876. Great Britain has over 350 soap manufactories making over 250 million pounds of soap per annum, of which 50 million were exported. France has fewer factories but makes quite as much, including toilet-soaps, while the value is much greater. Of Germany, we have only Berlin, which makes about 30 million pounds per annum. The United States in 1870 made nearly 200 million pounds, while at this date the increase, judging from our own researches, must be fully thirty per cent., as that has been nearly the amount of increase of export. We ship much to South America and elsewhere.

Thus in reviewing the history of the soap and alkali trades we see that neither has attracted much attention till modern times, for even looking back so short a period as fifty years we find that they received but little notice, except in France, where at that time in Marseilles alone there were made about 120 million pounds per annum. About this period Paris founded soap establishments similar to those in Southern

France, and made goods that rivalled those of the older manufacturers, besides numerous and superior toilet-soaps as well as family and industrial soaps. The former were better than the world had ever known; and this superiority has been maintained against all competition.

So we reach our own times and find large soap, candle, and alkali works in nearly all countries, whose products are consumed in vast quantities, and are a staple of commerce of the first importance, requiring large capital, employing many hands, and giving wealth to the nations. Although many of these productions are still of inferior quality, the arts are of the most progressive character, and there is a steady improvement accompanied by a constant effort towards superiority—healthy elements which ere long must lead almost to perfection.

We must now leave this fascinating subject with a notice of some natural products that are used as substitutes for soap, though they have not yet been found of importance enough to supplant it in utility—such as the berries of the soap-tree (*Sapindus saponaria*) of South America and the West Indies; aquilla bark (*Quillaza saponaria*) used for washing silk and woollens; the juice of the soapwort (*Saponaria officinalis*) or "bouncing-bet," all of which form a lather with water. In California the *Phalangium pomaridianum* is used as a substitute for soap and has its odor; there are also many natural earths and clays that have an alkaline reaction and can be used as substitutes for soaps, though with caution as they usually contain other chemicals which might prove injurious to the skin or clothes. Many of these natural products have been utilized in pharmacy and the arts.

SECTION III.

MATERIALS USED IN THE MANUFACTURE OF SOAPS.

ALKALIES.

Besides the two indispensable ingredients that constitute the materials of which all soap is made, viz., alkali and fats or oils, there are several others scarcely less important in the art, as lime, salt, water, etc., all of which will be properly described.

The two important alkalies potash and soda, which are the oxides of the metallic bases potassium and sodium, in the new chemical nomenclature are termed potassium hydrate and sodium hydrate, meaning the caustic alkalies in solution, and are described by the formulæ $NaHO$ caustic soda, KHO caustic potash. From these oxides the bases can be formed, which have for the chemist many peculiar and interesting properties, but for the soap maker are of but little interest, having no practical use in his art. But as regards the oxides or what we call potash and soda, he cannot be too intimately acquainted with all their properties, in fact an accurate knowledge of them is necessary to facilitate his manufactures, for by this means he can intelligently account for all success as well as all mistakes that may occur in his processes.

While each of the alkalies mentioned will form soaps, the soaps so formed will have different characters, though each may have equal detergent power in dissolving grease and dirt, yet they have different uses in the arts and for domestic purposes, and are quite different in their physical properties, the soaps from potash being soft, those from soda hard. This property is often utilized to modify the quality of soaps, to make one harder or the other softer.

The other ingredients of soap, namely the fatty acids, have many and distinct properties, the study of which is scarcely less important than that of the bases or alkalies, for as a fatty or sebacic acid may be more or less solid, so will it impart this property to the soaps into which it enters; thus stearine or the hard principle of fats will form a much more solid soap than oleine or the liquid part. This rule may have some exceptions under certain conditions.

In the working of these fatty acids, or their behavior when combined with the alkaline bases, they may each have some peculiarity either in saponification or in the resulting soap, so we see the importance of a close study of the characteristics of each. For those in common use we can take for our guide the experience of others, but there are constantly arising new oils, greases, waxes, etc , with whose properties we must experiment to discover their peculiarities and their usefulness in forming soaps.

We shall describe in the proper places the secondary substances indispensable in this manufacture, giving their properties and mode of use, but it will be unnecessary to detail all their chemical properties, as such descriptions would take unnecessary space, so we will confine ourselves to the properties they possess when applied to the arts of making soap and candles.

Yet if the soap maker has the inclination and the time to study all the chemical properties of materials he may use, in fact to study chemistry generally, it would be of great advantage and add much interest to his work and no doubt result in a great improvement to his wares.

With these few preliminary remarks we will proceed to the description of all known ingredients and materials in use for making soap.

POTASH. *Potasse*, Fr. *Kali*, Ger.

Potash was at first called fixed vegetable alkali, because it is generally obtained from the ashes of many plants. It is known in the market by different names, derived from the vegetables which furnish it, or from the countries it comes from. However, vegetables are not the only source from which potash is extracted. A great part of the minerals which compose the crystalline rocks contain it in variable quantities, in combination with different acids, principally silicic acid. Pure potash is not met with in nature.

However, the principal source of potash is the combustion of vegetables. The presence of potash in vegetables was an enigma for a long time, for vegetables, properly so called, do not create potash; but they have the valuable faculty of borrowing from the soil and manures the soluble salts they contain, among which are potash and soda, combined with various acids, and especially organic acids. During the combustion the organic acids are decomposed, and the carbonic acid resulting from this decomposition combines with potash and soda to form subcarbonates of these bases.

Of late years potash has been procured in great abundance from the salt-rocks in Stassfurt, in Prussia, and Kalucz, in Hungary, principally from carnalite, a chloride of potassium and magnesium. The magnesia is precipitated from the solution with hydrochloric acid, leaving the potassium salt; the chloride of potash is then submitted to the process described for the production of caustic soda from chloride of soda (Leblanc's process), and caustic potash is thus produced in quantities that have almost superseded, on the continent, all potashes from other sources.

Independently of the carbonates of potash and soda, the ashes of vegetables contain also several other salts, particularly the chlorides of potassium and sodium, sulphates of potash and soda, carbonates and phosphates of lime and magnesia, silicate of alumina, and a certain quantity of organic matters not decomposed, which color the saline residuum obtained by the lixiviation of the ashes. By calcining this residuum to redness in a reverberatory furnace, white potash is obtained.

We must here make an important observation. Vegetables which grow on the sea-shore, or in the neighborhood of salt mines, give by their incineration very small quantities of potash; they principally contain soda. Those, on the contrary, which grow inland and in soils free from chloride of sodium, yield, by their combustion, ashes which contain principally carbonate of potash, mixed with very small proportions of soda. These vegetables are the only ones employed in the preparation of the carbonate of potash.

Independently of the culture, it is easily demonstrated that the quantity of ashes furnished by different vegetables is not identical. It varies considerably according to the different species, the influence of climate, and particularly the nature of the soil in which they have grown. Experience also proves that the young parts of the plants, in which circulates a rich and abundant sap, are those which contain the greater percentage of salts of potash. It is thus that the leaves of a tree yield more potash than the branches, and these more than the body of the tree.

D'Arcet, who has experimented much on the manufacture of alkalies, has published an interesting paper on the extraction of potash from the ashes of the horsechestnut. He ascertained that one hundred parts of dried chestnuts yielded nearly half their weight of ashes at 65 alkalimetric degrees.

The following table gives the quantity of potash contained in certain vegetables:—

Comparative Table of the Quantities of Ashes and Potash contained in different Vegetables.

Names of the vegetables.	Quantity of ashes.	Quantity of alkali.	Chemist who made the analysis.
100 parts of—			
Willow . . .	2.80000	0.28400	Kirwan.
Elm	2.36727	0.39000	"
Oak	1.35185	0.15343	Pertuis.
Poplar . . .	1.23476	0.07481	"
Yoke-elm . . .	1.12830	0.12540	"
Beech	0.58432	0.14572	"
Pitch-pine tree . .	0.31740	0.73180	de Fontenelle.
Vine	3.37900	0.55000	Kirwan.
Stalks of corn . .	8.86000	1.75000	"
Wormwood . .	9.74400	7.30000	"
Fumitory . . .	21.90000	7.90000	"
Fumitory . . .	22.10000	8.01500	de Fontenelle.
Vines of hops . .	10.00000	3.01500	Thillaye.
Vines of Windsor beans	10.00000	4.12900	"
Common nettle . .	10.67186	2.50330	Pertuis.
Common thistle . .	4.04265	0.53734	"
Ferns	5.00781	0.62590	"
Reed	3.85395	0.72234	"
Reed	3.33593	0.50811	"
Turnsole . . .	20.70000	4.00000	"
Genista . . .	3.00500	1.30870	de Fontenelle.
Heath	2.91090	0.84000	"
Stalks of corn . .	9.35100	2.00400	"
Erigeron Canadense .	10.80000	2.65200	Bouillon Lagrange.
Horsechestnut tree bark	18.46000	4.84000	de Fontenelle.
Centaury . . .	8.44000	2.00800	Kirwan.
Burdock leaves . .	4.84000	0.98400	de Fontenelle.
Camomile . . .	5.63900	1.80000	"
Orange leaves . .	14.24000	2.40400	"

The above numbers give an approximative idea of the quantities of ashes left by the different species of vegetables, but these numbers are not absolute. The different parts of the same plants do not yield the same quantity of ashes, as is shown by the following table:—

	Oak.	Beech.	Yoke-elm.	Pine.
Bark	6.00	6.62	13.4	...
Leaves	5.50	...	...	2.60
Trunk	3.30	0.61	0.6	1.19

Ashes, whatever is the part of the vegetable which has furnished them, present a complex composition, variable with each species, and even with every individual. The compounds they contain are, some soluble, some insoluble. The first, among which is the carbonate of potash, are the only ones employed in industry, after separating them, by washing, from the insoluble compounds. The relative proportions of the soluble and insoluble salts present great differences, as is shown in the following table, in which Berthier has given the quantities per cent. of soluble and insoluble matters.

Substances employed to produce ashes.	Soluble parts for 100 of ashes.	Insoluble parts for 100 of ashes.
White Beech	19.22	80.78
Red Beech	16.30	83.70
Oak	12.00	88.00
Lime tree	10.80	89.20
Birch tree	16.00	84.00
Alder tree	18.80	81.20
Fir tree	25.70	74.30
Pine	13.60	86.40
Mulberry	25.00	75.00
Walnut tree	15.40	84.60
Elderberry	31.50	68.50
Straw	10.10	89.90
Stalks of Potatoes	4.20	95.80
Fern	29.00	71.00

Among the insoluble compounds, the carbonate of lime predominates: after being well washed and dried, the insoluble residuum does not contain less than 75 to 90 per cent. of its weight of carbonate of lime; the phosphates of lime and magnesia, silica, etc., are the compounds which generally accompany it. Their proportion varies between the limits of from 25 to 10 per cent.

Essentially formed of carbonate of potash, a small quantity of sulphate of potash and chloride of potassium, and of a trace of silicate of potash, the soluble compounds which alone have to fix our attention present, in the relative proportions of these different salts, variations which are interesting to notice. The following table enables us to establish the composition of the mixture of soluble salts extracted from the ashes of some vegetables.

	Birch.	Yoke-elm.	Elm.	Oak.	Mulberry.	Fir tree.
Carbonic acid . .	0.170	0.247	0.224	0.240	0.230	0.123
Sulphuric " . .	0.023	0.073	0.073	0.081	0.083	0.069
Chlorine. . . .	0.002	0.047	0.052	0.001	0.040	...
Silica	0.010	0.010	0.010	0.002	....	0.020
Potash	0.795	0.507	0.641	0.676	0.520	0.506
Soda		0.121			0.115	0 282
	1.000	1.005	1.000	1.000	0.988	1.000

Such are the principal variations in their composition that the different vegetable species present. However, whatever is their composition, the extraction of the potash is effected in the same manner. The ashes remaining after the combustion are carefully lixiviated, and furnish liquors which, evaporated to dryness, yield a colored residuum called *salin.* This, by a simple purification by fire, is transformed into commercial carbonate of potash.

EXTRACTION OF POTASH.

The industrial fabrication of potash from ashes is carried on only in countries where wood is abundant. Thus the largest quantity of that employed in the arts, comes from Russia or from this country. As we have before said, vegetables when fully developed contain a smaller proportion of salts of potash than when their vegetation is less advanced. Starting from this principle, confirmed by experience, branches, small trees, and herbaceous plants must be preferred, as being richer in salts of potash. If the operation is conducted with the latter vegetables, they are to be cut carefully, and spread on a dry and smooth place, where they are left until completely dried; after their desiccation, they are collected and put into heaps, near by the place where they are to be burned. In damp countries they are dried under large sheds. When trees are burned for the purpose of extracting potash, they are divided into large pieces and dried in the open air.

The processes of combustion are not the same in every country. Formerly, and even yet in some localities, the combustion was effected on the ground. For this purpose an open place is selected, and several heaps of plants are formed, and are set on fire; as fast as the combustion takes place, new plants are added. When they are all burned, let the ashes cool, then spread them under sheds where they are exposed to the air for a few days, so that all the potash they contain may be transformed into the carbonate by absorbing carbonic acid from the air. The ashes are then lixiviated with water, in wooden or in cast-iron vats. The liquors are afterwards evaporated to dryness in cast-iron kettles. The crude potash, resulting from this evaporation, is bleached and granulated in a reverberating furnace.

Combustion of the Plants in Furnaces.—The combustion in furnaces, now in use in several manufactories, gives a larger quantity of ashes, the incineration of which is more complete than when the combustion takes place in the open air.

By this process, the combustion of the plants is conducted in furnaces made of refractory bricks; they are provided, at their lower part, with a cast-iron grate, under which is a large ash-pan, also made of bricks, the object of which is to receive the ashes from the incineration of the plants. To render the combustion more uniform and complete, pipes disposed around the base of the furnace, bring cold air under the grate. To preserve the inside of the furnace from the destructive action of the fire, the bricks are covered with a coating of clay about one-third of an inch thick, which, before beginning the operation, is allowed to dry for several days.

All the preliminaries being arranged, throw on the grate a few armfuls of dry plants, and set them on fire; when the combustion is well established, feed the fire with new loads of materials, which are proportioned to the intensity of the combustion, which ought to be neither too slow nor too rapid. In the latter case, a too rapid combustion will occasion a certain loss of alkali, which volatilizes; in the first case, the operation if too much prolonged, becomes difficult, and gives imperfect results, because there is always a certain quantity of organic matter which is not burned; but by practice, the operation may be regulated at will by means of the pipes which bring cold air under the grate. When the combustion is too rapid, slacken it by closing the pipes; when too slow, allow the cold air to come under the grate.

The operation is well established only after a few hours. To obtain a complete incineration, stir the fuel from time to time with a long iron rod, so as to permit the fire to act equally on the entire mass. When the vegetables are too damp, they sometimes form agglomerations of ashes on the grate, which render the combustion slower; to destroy these agglomerations and give a new start to the combustion, pass an iron hook between the bars of the grate.

During all the time of the operation, the ashes which are produced fall in the form of powder into the ash-pan placed under the grate, from which, when they have filled the pan about three-fourths full, they are taken with a shovel and carried into a building, where they are spread on the ground in beds three or four inches thick. From time to time the surface is stirred, so as to assist the transformation of the potash into carbonate. It is to facilitate this reaction, that ashes recently calcined are exposed to the air for a few days before being lixiviated.

Leaching or Washing of the Ashes.—This operation has for its object the extraction of the carbonate of potash, existing in the ashes. To proceed, use wooden or sheet-iron vats, of a capacity of 200 to 250 gallons—generally 8 or 10 are disposed one over the other; they receive the name of barrel; the number of barrels varies according to the importance of the fabrication. Each vat is provided with a double bottom covered with a strainer which acts as a filter. By this means clear and limpid lyes are obtained. These vats have, at the bottom, a cock to draw off the lye.

The vats being thus disposed, charge them to four fifths of their capacity with ashes, and pour on them a quantity of water sufficient to cover them entirely. After standing from fifteen to eighteen hours, open the cocks, and collect the lye in a special receiver. By using this lye instead of water for the treatment of new ashes, we obtain after twelve or fifteen hours of reaction, a new lye marking from 10° to 12° Baumé, which can be brought up to 15° or 18° by successive passages through new ashes; but this method, which is long and costly, is not much employed, the manufacturer generally preferring to have liquors at 10° or 12°.

Continue the lixiviation of the ashes by successive washings with pure water. It is ascertained that the material is completely exhausted when the liquid has lost all alkaline taste, but there is a more exact process, which is to collect some of the liquid and try it with the areometer. The instrument will descend to 0° if the ashes are completely exhausted. The lye thus obtained, besides the foreign salts, contains the carbonate of potash in solution; it is generally colored brown, due to a small quantity of organic matter, which has escaped the combustion.

The liquors marking from 10° to 12° are evaporated in a series of cast-iron kettles heated by the same hearth. The evaporated water is replaced by the addition of fresh liquors. When the lyes have acquired a syrupy consistency, they are evaporated to dryness in a thick cast-iron kettle. The operation is finished when the substance becomes dry and friable.

The crude potash thus obtained is strongly colored brown. To bleach it, it is placed in a reverberatory furnace, heated to whiteness. Towards the end of the operation, the temperature is raised enough to redden the salt, expel the water, and destroy the organic matter which colors it. It is, however, very essential, that the temperature should not be too high, for then the potash would experience a kind of vitrification which would render it heavy and difficult to dissolve in water. When the potash has become white, that is the moment to take it from the furnace. Potash well prepared is light, porous, and strongly alkaline. Exposed to the air, it attracts moisture and becomes deliquescent. The loss experienced by the crude potash, when calcined, is about fifteen per cent.

Red American Potash.—Potash deprived of carbonic acid by lime has received the name of caustic potash. All commercial potashes may be transformed into caustic potash by the following process:—

In a large iron kettle, heat 250 gallons of water, which raise quickly to the boiling point; add, in successive doses, 400 pounds of carbonate of potash, and stir the mixture to facilitate the solution. When the salt is entirely melted, pour into the kettle, in portions, 200 pounds of quicklime, previously mixed with double its weight of water, and boil the mixture for two or three hours. The lime combines with the carbonic acid which is united to the potash, and forms an insoluble carbonate of lime, while the caustic potash remains in solution in the liquor. After a settling of 18 or 20 hours, decant the clear liquor carefully, without disturbing the lime which is at the bottom of the kettle, and this liquor is rapidly evaporated to dryness in cast-iron kettles. The crude potash obtained is heated to redness in a thick cast-iron kettle, so as to melt it. To give this substance the red color, characteristic of the caustic American potash, add to the melted mass one per cent. of protoxide of copper, the oxidation of which is determined by small proportions of saltpetre. When the shade is obtained, run the melted mass into small cast-iron kettles, in which it becomes very hard by cooling.

This is the usual process of manufacturing caustic potash; but in this country it is conducted more economically. The ashes are directly treated by lime, and the mixture is lixiviated by water. Lyes in a caustic state are obtained, and are concentrated to dryness, and the mass is melted as we have seen.

American potash is very caustic, and quickly attracts the moisture of the air. It is much used in the industries, principally in the fabrication of soft soap.

In Paris is manufactured a fictitious article, which must not be confounded with the American potash. The latter has really potash for a base, while the first is a mixture of caustic soda, salt, and sulphate of potash. The materials are melted together, and are colored red with oxide of copper.

Fictitious potash is distinguished by a very strong saline taste, which American potash does not possess.

Ashes made from Tartar.—These ashes are prepared only in countries where wine is made, and can be produced advantageously in California, Ohio, New Jersey, and other States where the culture of the vine is advanced.

This alkali, the purest found in commerce, is obtained by the calcination of the dregs of wine. To produce the combustion of these dregs, it is essential to have them perfectly dry. To obtain them in this state, they are introduced into cotton bags, then submitted to a graduated but energetic pressure, so as to extract the wine they contain. This wine is generally very acid, and is used to make vinegar. After the pressure, break the cakes into pieces, and expose them for some time to the air to dry; then burn them in large furnaces having a circular form. Like all vegetable salts with potash for a base, the lees of wine give carbonate of potash by calcination. This salt results from the decomposition of the tartrate of potash contained in the dregs.

When carefully manufactured, the ashes of dregs give one of the best commercial potashes. In this state they contain only a very small proportion of chloride of potassium and sulphate of potash. This alkali is generally in a porous and light mass, having a greenish color with blue veins. This color is due to the oxides of iron and manganese. Pure ashes dissolve almost entirely in water, and leave only a residuum of 7 to 8 per cent. of insoluble matters. 200 pounds of good dregs, perfectly dry, produce from 10 to 12 pounds of ashes, the titer of which varies between 25 and 33 alkalimetric degrees. When the dregs contain much tartrate of potash, they give, by their combustion, an alkali of a much higher titer. The white potash is obtained by treating the ashes by water, which dissolves the soluble salts, and amongst them the carbonate of potash. The lye is evaporated to dryness, and the mass is bleached in a reverberatory furnace. By this refining, ashes give about half of their weight of white potash. But it is generally in the form of ashes that this alkali is found in commerce.

Potash made from Beet-root Molasses.—Chemical analysis has long since demonstrated that the salts of potash exist in a large proportion in beet-root molasses. This fact has found a useful application in industry. It is to M. Dubrunfault that is due the discovery of the processes for extracting potash from the saline residues left after the distillation of the molasses, which is extensively used in the production of alcohol. It is from the saline residues that potash is obtained. Potash, being undecomposable in the conditions in which the operation takes place, is found, after the decomposition of the sugar by fermentation and the extraction of the alcohol by distillation, in the liquid residuum. It is extracted from this residuum by evaporating the water, and by the incineration of the concentrated residuum. The product of the incineration constitutes a light, porous, and friable mass. It is crude potash; its titer is from 40 to 50 alkalimetric degrees. The white potash is obtained by lixiviating the crude potash in sheet-iron filters having a cylindrical form. The exhaustion takes place with warm or cold water; the use of warm water is more advantageous, but it dissolves some of the sulphuret. Cold water gives a purer product, but the operation takes longer, and the residuum is not so well exhausted of its alkali.

The lyes marking from 25° to 30° Baumé are evaporated in cast-iron kettles until they mark from 45° to 46°. They are poured while boiling into sheet-iron vats; and after eight or ten days, a very abundant crystallization of different salts is obtained. Among the crystals we meet chloride of potassium, and the larger part of the carbonate of soda, which was dissolved in the lyes.

The mother liquors are very rich in carbonate of potash. To extract this salt, they are concentrated in cast-iron kettles with flat bottoms, until they are reduced to a syrupy consistency. By continuing the operation, the mass swells considerably, and becomes dry and friable. The drying is accelerated by stirring with an iron stirrer. Thus obtained, the potash is not pure, but is mixed with extractive matters, which color it; it contains besides from twelve to eighteen per cent. of water. To bring it to a commercial state, it is calcined in a reverberatory furnace. This last operation destroys the coloring matter and drives off the excess of water with which it was combined.

Potash thus prepared is very white; it is one of the best and richest found in commerce; it is advantageously employed in the fabrication of soft soaps, and according to several manufacturers, it is preferable to any other, because it gives more consistency to the soap. This effect is probably due to the presence of a certain quantity of soda.

Composition of Commercial Potashes.—Carbonate of potash is the base of the commercial potashes, but besides this salt, they contain several others, and principally more or less considerable proportions of sulphate of potash and chloride of potassium. The presence of these salts is demonstrated by dissolving half an ounce of potash in 3½ ounces of distilled water; the solution is saturated by acetic or pure nitric acid. After the saturation, filter and divide the filtrate in two portions, which are separately submitted to the following reagents:—

1. If, into one part of the liquor, chloride of barium is poured, an abundant white precepitate, insoluble in nitric acid, is formed. This precipitate is sulphate of baryta, which indicates that the carbonate of potash contains a sulphate.

2. If, into the other part of the liquor, we pour a solution of nitrate of silver, a white precipitate, insoluble in nitric acid, soluble in ammonia, is formed. This precipitate is chloride of silver, and indicates that the potash contains a chloride.

The same methods may be employed to detect sulphates and chlorides in crude sodas.

The most esteemed potashes are those of America, Russia, Tuscany, Dantzick, and particularly that made in France from beet molasses.

The following table gives the composition of the principal commercial potashes. The free potash and soda are represented by their equivalent in pure carbonate.

	Potash of Tuscany.	Potash of Russia.	Potash of America (red).	Potash of America (pearl ash)	Potash of the Vosges.	Potash of molasses.
Potassium sulphate .	13.47	14.11	15.32	14.38	38.84	1.197
Potassium chloride .	0.95	2.09	8.15	3.64	9.16	4.160
Potassium carbonate.	74.10	69.61	68.04	71.38	38.63	76.440
Sodium carbonate. .	3.00	3.09	5.85	2.31	4.17	16.330
Hygrometric water .	7.28	8.82	....	4.56	5.34	0.624
Insoluble substances and loss . . .	1.20	2.28	2.64	3.73	3.86	1.249
	100.00	100.00	100.00	100.00	100.00	100.000
Alkalimetric degrees	56.0	53.1	55.0	54.4	31.6	69.3

We see, by the above table, that independently of the sulphates and chlorides, all potashes contain soda in variable proportions; the American potash is that which contains the least, and that of molasses contains the most. The insoluble residuum is partly composed of carbonates and phosphates of lime and magnesia, silicate of alumina, and the oxides of manganese and iron. The first of these oxides colors them blue, the second communicates to them a red shade.

Purification of Potash.—It is easy to separate from potash the greater part of the sulphate it contains. It is sufficient to dissolve it in the least possible quantity of water. The sulphate, much less soluble than the carbonate, remains undissolved; it is stirred several times with water, which dissolves the alkali. This solution is used to dissolve a new quantity of potash. The sulphate washed and dried is sold for about half the price of the potash itself, and as that sulphate has no useful effect when mixed with potash, it is better to extract it and sell it separately.

The chloride of potassium, very slightly soluble in a liquid saturated with carbonate of potash, is partly separated by the same process.

The solutions obtained at 45°, by this process, are evaporated in kettles of gradually decreasing depth.

It is into the deepest kettle, directly heated, that the liquid is introduced: as fast as the evaporation reduces the volume, fill the kettle with the solution, and the other kettles with the solutions already concentrated in each preceding kettle. In this way, as fast as the solution concentrates and retains the water with more tenacity, it is placed in a flatter vessel, in which the stirring is more easily effected, and the column of liquid being of less height above the bottom, the saline incrustations, which would be an obstacle to the passage of heat, do not form so easily. The desiccation is achieved in the latter kettle, which is flatter.

The carbonate of potash, economically purified by this process, is used in the arts requiring a purer product than commercial potash. Wherever wood-ashes can be bought at reasonable prices for the manufacture of soft soaps, a large saving is attained and they deserve far more consideration than has hitherto been given them. Under favorable conditions the lye produced from wood-ashes will cost but one-half, often but one-third of the price of that made of potash. The reason for this is partly found in this, that by the home manufacture of potash in the form of lye, both the cost of boiling and calcination as well as the expense of transportation will be saved. The supply from this source is constantly diminishing, and recently commerce has been supplied from new sources. The rock-salt mines and the beet-sugar factories have become the most reliable. Their potashes are richer in alkali and freer from impurities, and are from this fact more desirable, requiring much less labor in the preparation of the lyes.

For the proper tests for potash the reader must turn to *Alkalimetry.*

SODA. *Soude*, Fr. *Natron*, Ger.

Soda, the base of all hard soaps, exists in nature in the waters of various lakes and springs in many parts of the world, and the ashes of marine plants, which were formerly the source of all commercial soda. But since the discovery and manufacture of artificial soda from culinary salt, that is in general use for making soaps, and being furnished comparatively pure, and in a caustic and concentrated form, there is a saving of much labor and cost for plant outlay. The caustic sodas of commerce are generally sufficiently pure for all ordinary soaps of commerce, though for superior toilet soaps the lye should be perfectly pure. The soap maker will find it necessary to make his own lye, and that from the crystallized carbonate of soda made caustic with the hydrate of lime is the most reliable.

Chemically pure soda is composed of sodium and oxygen, but is never found in this state in nature; it is always in combination either with chlorine, with which it forms chloride of sodium (common salt), or with acids, principally carbonic acid. With this latter it forms the carbonate of soda. This salt is met with abundantly in several countries of the world, and particularly in the East, where it has been known for a long time by the name of *natron*.

Natural sodas are the carbonates of soda, obtained by the incineration of several species of plants growing on the seashore. These plants furnish very variable proportions of carbonate of soda mixed with different salts. Those which give the most are: the *Salsola soda*, and the *Salicornia Europæa*.

During their vegetation, the plants draw from the soil the salt it contains, and assimilate the soda, which they transform, at least partially, into organic salts, principally in acetates and oxalates, decomposable by heat. Gay-Lussac ascertained by analysis, that the salsola soda contained a considerable proportion of oxalate of soda. When these plants are burned, the organic acids are destroyed, and the carbonic acid resulting from the combustion combines with the soda to form a carbonate. Sodas take their names from the countries which produce them.

Soda of Narbonne.—This soda, more generally known by the name of *salicor*, is the best manufactured in France. It is the richest in pure or carbonated soda, which is the only useful alkali for the preparation of solid soaps. The plant which produces it is designated by the name of *salicorna annua*. The plant is cultivated in several parts of the south of France. The plant is cut before its complete maturity;

is spread in the sun to dry, and then incinerated. Good salicors give from 20 to 25 per cent. of carbonate of soda.

Soda of Aigues-Mortes.—This soda is prepared in the neighborhood of Aigues-Mortes. It is obtained by the incineration of very different plants growing naturally and without cultivation, on the shores of the Mediterranean. These plants are collected, dried, and burned on the ground, or in proper furnaces. This soda is found as a black and compact half-melted mass. It contains a large proportion of common salt. Its richness in carbonate of soda is about 8 to 10 per cent.

Soda from Sea-weeds.—This soda, prepared for a very long time on the coasts of Normandy and Brittany, varies greatly in its composition. It is furnished either by sea-weeds, or by plants designated by botanists under the names of *fucus maritimus*, *vesiculos habens*, and commonly called goemon. These plants are collected at low tide, dried in the sun, and calcined. The residuum is a black mass, often porous, and is called kelp-soda. This soda is not very rich in carbonate, for its proportion is never above 5 per cent.; it generally contains only from 2 to 3. It is most valuable on account of the bromine and iodine it contains.

Spanish Sodas.—Prior to the present century, Spain furnished, under the names of sodas of *Alicante*, *Malaga*, and *Carthagena*, the greater part of the carbonate of soda used in Europe. Among the numerous varieties of Spanish sodas, three kinds are principally distinguished in the market; they are known by the names of barilla, mixed, and salted barilla.

The first, which is the richest in pure alkali, and consequently the most valuable, is furnished by the plant known by the name of *salsola soda*. When the plant has attained its full growth, it is cut and dried in the sun, and incinerated in cylindrical pits dug in the ground, about five feet deep. To begin the operation, a few armfuls of dry material are thrown into the pit, and ignited. The combustion is kept up by adding little by little new dry plants and is accelerated by stirring the mass from time to time with an iron rod. This operation lasts about four days, and is finished when the pit is filled to two-thirds or three-fourths of its depth with the products of the combustion. A few days after, the residuum is taken out, then broken into large pieces and put into barrels.

The soda thus obtained is called soft barilla; it is a hard and compact mass, of a gray-ash color. Recently prepared, its fracture is smooth.

Mixed Barilla.—Mixed barilla is obtained in the same manner as the above, by the combustion of certain marine plants growing on the shores of the Mediterranean. The only difference between these two kinds is that the first is manufactured only from choice plants, carefully cultivated and free from weeds; on the contrary, the mixed barilla is prepared with plants not so well cultivated, which grow in grounds nearer the sea—it is used to manufacture solid soaps.

Salted Barilla.—This kind differs from the two above named by the strong proportion of neutral salts it contains, and by being less alkaline. The plants which produce it grow without cultivation on the sea-shore in soils strongly impregnated with salt. During their growth, these plants absorb a large quantity of salt, which is found in the ashes after the incineration. Although less pure, less alkaline, and less esteemed than the two last described, the salted barilla is still of great use in the manufacture of Marseilles soap. Its blackish color, and its being more highly sulphuretted than the others, together with the large proportion of salt it contains, cause it to play, in the fabrication of marbled soap, the same part as salted soda. The blue of the marbling is brighter and more intense, it progressively contracts the molecules of the soap, and during the operation keeps it constantly separated from the lyes. But since the discovery of artificial soda its use is limited.

Natron.—Is a natural sesqui-carbonate of soda, abundantly found in several parts of the world, and particularly in Egypt.

Egyptian natron is now extracted from two lakes, one near Cairo, and the other a short distance from Alexandria. During winter these lakes are filled with a water of a violet-red color, which passes by infiltration through the soil of the surrounding hills. During its course it runs through a soil in which salt and carbonate of lime are abundant. By the contact of the water, a spontaneous reaction takes place between these two salts, which are reciprocally decomposed. Deliquescent chloride of calcium is formed, which infiltrates into the lower part of the soil, and the sesqui-carbonate of soda effloresces at the surface. This double decomposition is considerably favored by the dampness of the soil and the heat of the climate. Rain water or waters which exude from the soil dissolve the efflorescence of carbonate of soda, and flow into the lakes in which they reach a height of about six feet. These lakes are from thirteen and a half to fifteen miles in length, and about three-quarters of a mile in width. The bottom is stony and solid. During the great heat of the summer, these waters concentrate and evaporate, and the natron deposits on the soil, from which it is extracted in gray crystalline plates, which are purified and bleached by successive solutions and crystallizations.

Commercial natron is in mass or in plates, with a grayish-white color. Its fracture is granular or crystalline, and it contains from 20 to 30 per cent. of pure soda. In very dry years these lakes furnish about 450,000 lbs. of natron.

In Hungary, and certain parts of South America, there are similar lakes furnishing, during the summer, an abundant efflorescence of sesqui-carbonate of soda. Natron is also collected in some of the lakes around Tripoli, but it is not so abundant as in the lakes of Egypt, although the product is purer.

History of the Fabrication of Artificial Soda.—The discovery of the process for the manufacture of soda from chloride of sodium has exercised on the progress of modern industry so powerful an influence, that it is necessary here to dwell upon the circumstances under which it was produced. The priority of this discovery has never been successfully contested, and the name of Leblanc, to whom it is due, is now known all over the world; however, on many points of detail, some doubts existed, which have only recently been explained. In 1856, M. Dumas presented to the *Académie des Sciences*, a paper which definitely established the true history of this important question.

Long since, the old Academy of Sciences had offered a prize of 2400 francs ($480) for the conversion of chloride of sodium into carbonate of soda. Father Malherbe, in 1777, was the first who thought that he had attained the industrial solution of the problem; he proposed to convert first the salt into sulphate of soda, and then to heat this salt with charcoal and iron. Macquer and Montigny, in 1778, made a favorable report on this work. Guyton de Morveau, associated with Carny, had, a few years before, erected an establishment at Croisie, in which the salt, being mixed with lime, was afterwards allowed to rest in contact with the air. Very soon the carbonate of soda effloresced on the surface of the mixture, but the results were not economical.

In 1789, De La Metherie proposed to calcine sulphate of soda with charcoal; he thought that he should thus obtain sulphurous acid and carbonate of soda, while in reality he obtained only sulphuret of sodium. This incorrect hypothesis, as we shall see, became the basis of the discovery of Leblanc. As early as 1787, he had begun the study of this interesting question; when he knew of the experiments recommended by De La Metherie, he tried them, and ascertaining their worthlessness, attempted to modify them. He then conceived the idea of associating the carbonate of lime with the sulphate of soda and charcoal, when its success was certain and the magnificent discovery of the fabrication of soda was accomplished. Ten months after the publication of De La Metherie, the problem was solved by Leblanc. It was then that, associated with the Duke of Orleans, Dizé and Shee, he thought of rendering his discovery an industrial one. In the act of association, and in a sealed package opened in 1855, he described the process as he then understood it. It consisted in heating in closed crucibles 100 parts of sulphate of soda, 50 of chalk, and 25 of charcoal. It was not yet the industrial process as we know it at the present day. However, the trials in the laboratory were continued; a manufactory was established at St. Denis, and soon (September 23, 1791), on the report of D'Arcet, Desmarets, and de Servières, Leblanc obtained a patent for fifteen years. In his description, the crucibles had disappeared; they were superseded by a reverberatory furnace; the proportion of sulphate of soda was diminished one-half; in a word, the real industrial process was exposed with such precision that since that time very few changes have been made.

Unhappily, fortune was not to reward Leblanc. The manufactory of St. Denis was just beginning to work when the revolution put an end to all business; the property of the Duke of Orleans was seized, and, the manufactory being included, the fabrication was stopped. Soon, the Continental war preventing the importation of Spanish sodas, the French industry felt the loss of this important element so essential to its work. Then, on the proposition of Carny, the committee of public safety obliged the inventors of the process to manufacture soda from chloride of sodium, and to sacrifice to the country the fruit of their discoveries. Leblanc first offered his processes to the committee; soon a report from Lelievre, Pelletier, D'Arcet, and Giroux, rendered them public, but it was not Leblanc who put them into practice. The property of the Duke of Orleans was sold, and the manufactory with them. However, that same manufactory was given back to Leblanc as an indemnity for the publication of his process; but he could not find the capital necessary for conducting it, and, notwithstanding all his exertions, he utterly failed to accomplish anything, and was at the time of his death, in 1806, in a state of abject poverty.

However, if the author of this discovery was dead, it was not so with the discovery itself; notwithstanding the difficulty of obtaining saltpetre to manufacture sulphuric acid, and then the sulphate of soda, the process of Leblanc was soon put in practice by several manufacturers. It was first Payen, then Carny, who applied it: the first near Paris, the second at Dieuze. The fabrication of soda was rapidly growing, and in 1806 glasses were seen at the exposition of industry, sent by the manufactory of Saint-Gobain, prepared with artificial soda. However, the new product had one defect which often caused it to be rejected by the trade; this defect consisted in its sulphuretted nature. D'Arcet found the cause of that imperfection. Leblanc's furnace was rectangular, and the flame was not active enough in the angles, and there resulted a partial transformation of the sulphate of soda into sulphuret of sodium. D'Arcet rounded off the angles, and transformed the rectangular furnace into an elliptic one. With this improvement, the fabrication of artificial soda rapidly increased, and in 1812, notwithstanding the absolute prohibition of foreign sodas, the price of that substance had diminished fully two-thirds.

Fabrication of Crude Soda.—This fabrication comprises three distinct operations, which are: 1. The transformation of the chloride of sodium (common salt) into sulphate of soda, by sulphuric acid; 2. The mixture of the sulphate of soda with the chalk and charcoal; 3. The calcination of the soda, or the conversion of the sulphate of soda into carbonate, in a reverberatory furnace.

Sulphate of Soda.—The sulphate of soda manufactured in France and England is destined for the preparation of crude soda. The processes followed in its manufacture vary according to the localities. When hydrochloric acid has to be collected, common salt is decomposed by sulphuric acid in cast-iron cylinders, heated in various ways.

But at Marseilles, where the fabrication of artificial soda constitutes one of the most important trades, the greater part of the hydrochloric acid produced during the operation is lost. The sulphate of soda is directly prepared in reverberatory furnaces by decomposing salt by sulphuric acid. These furnaces are generally divided into two compartments. The part placed near the hearth is destined for the fabrication of the crude soda (carbonate of soda); the second part is separated from the first by a low brick wall; the side of this part is formed of hard stone, in which a cavity is cut; it is in this cavity that the sulphate of soda is prepared, by the reaction of sulphuric acid on salt. The proportions of acid and salt generally used are:—

Salt	2000 lbs.
Sulphuric acid at 50°	3200 "

The salt is first introduced into the cavity, then the sulphuric acid at 50° is poured upon it. Under the influence of heat the decomposition takes place; the hydrochloric acid resulting from the reaction is disengaged, and the sulphuric acid combines with the soda to form sulphate of soda.

The operation lasts from three to four hours. It is ascertained that it is finished, when the mixture has acquired a pasty consistency, and when no more hydrochloric acid is disengaged. To bleach the sulphate and disengage the last portions of hydrochloric acid it contains, the temperature of the furnace is raised. When the salt is sufficiently dried, it is taken out.

If the operation has been well conducted, a nearly white sulphate is obtained. Thus prepared, the salt constitutes an acid sulphate. It is specially employed to prepare soft, or purely alkaline soda.

The above quantities give from 2200 to 2260 lbs. of sulphate of soda well prepared, or from 110 to 113 lbs. of sulphate for 100 of salt. By a later process the hydrochloric gas forming hydrochrotic acid is saved, thus preventing the escape of the gas which contaminates the air of the neighborhood.

Mixture.—This operation consists in mixing the sulphate of soda, previously calcined, with the proper proportions of carbonate of lime and charcoal. To obtain an alkali of a high degree, it is essential that the quantities should be in such proportions, that the sulphate of soda will be entirely transformed into carbonate. Theory indicates the respective proportions of the substances to be employed; but in practice, the doses of carbonate of lime and charcoal have to be increased. Not only is a more complete decomposition of the sulphate of soda attained, but the insolubility of the sulphuret of calcium is also determined by the formation of an oxy-sulphuret of that base, nearly insoluble in cold water; then by lixiviating the crude soda with cold water, the solution contains only the alkali nearly free from sulphuret.

The best proportions to use are:—

Calcined sulphate of soda	2000 lbs.
Dry carbonate of lime	2100 "
Charcoal	1100 "

To render the reaction more easy, the substances are previously ground in vertical mills, then passed through a metallic sieve. The carbonate of lime must be perfectly dry; generally it is desiccated by exposing it for a few days on top of the arch of the furnace. The mixture of the substances being intimately effected, the calcination is proceeded with.

Calcination.—As we have already said, the furnaces are generally made in two compartments. The first, where the temperature is the highest, is used to calcine the soda; in the second, the waste heat is utilized to prepare the sulphate of soda.

When an operation is begun, the furnace must be brought up to a strong red heat before introducing the mixture. That condition being complied with, introduce the mixture into the furnace, and after spreading it as evenly as possible, leave it exposed for some time to the action of the heat. In order to have an equal and regular heat, the fire requires great attention, especially at the beginning of the operation.

When the reaction begins, the mixture softens and agglutinates, and the parts exposed to the highest temperature begin to melt. At that moment, stir the mixture with an iron rod so as to hasten the decomposition of the sulphate.

From this time, feed the furnace with fresh fuel so as to obtain a bright and continued fire. Continue to stir the mixture from time to time. It is ascertained that the operation is almost finished when the fusion is nearly complete, and when the incandescent substance throws out luminous jets, which burn with a white or bluish flame. These jets, are due to the combustion of the oxide of carbon; when they become more rare and less intense, it is a characteristic sign of the conversion of the sulphate of soda into carbonate.

Then slacken the action of the fire, for a higher elevation of temperature would cause the volatilization of an appreciable quantity of soda.

Thus, when the luminous jets have diminished in intensity, draw off from the furnace the melted mass, which is received in square sheet-iron boxes five or six inches deep and three feet in diameter. These boxes are placed on rails and then put under sheds. After the soda is solidified and cooled, it is broken into large pieces and put into barrels.

This soda is generally in a melted and compact mass, particularly if the calcination has been pushed too far; but when the operation has been well conducted, its texture is not so compact, and sometimes is porous. It is preferred in this state, because by lixiviation it is more easy to deprive it of its soluble salts. When well prepared it resembles good Spanish soda; it has a gray-ash color, and is without smell. Its richness in pure alkali is generally constant, and depends essentially on the purity of the sulphate. If the sulphate contains only a few hundreths of undecomposed salt, and is completely converted into carbonate by proper proportions of chalk and charcoal, a soda is obtained which generally contains thirty-six per cent. of alkali. This soda, designated by the name of soft soda, or alkaline soda, is specially used for the saponification of oils in the fabrication of marbled and white soaps.

As soon as the furnace is empty, load it again as at first with a mixture of sulphate of soda, chalk, and charcoal, and operate as we have indicated.

The complicated reactions are thus explained: Under the influence of the charcoal, the sulphate of soda is transformed into sulphuret, and at the same time, oxide of carbon is disengaged. Afterwards, the sulphuret of sodium and the carbonate of lime are mutually decomposed, and from that decomposition result sulphuret of calcium and carbonate of soda; but as this reaction takes place at a temperature at which the carbonate of lime is decomposed, a part of the soda is obtained in a caustic state. The proportion of caustic soda contained in the carbonate of soda, is as much more considerable as the dose of charcoal has been increased, and that the mixture has been carried to a higher temperature. In a subsequent chapter we shall give the process for analyzing caustic alkalies.

We think it will interest the reader to know the real cost of the substances used and produced, and we give below a detailed table of the expense of manufacturing 20,000 lbs. of artificial soda in France. These numbers are very exact, and deserve full confidence.

Raw Materials.

Sulphate of soda, 14,000 lbs. at $1.60 the 100 lbs.	$224 00
Carbonate of lime in powder, 14,700 lbs. at 6 cents the 100 lbs.	8 82
Powdered coal to transform the sulphate into carbonate, 7000 lbs. at 22 cents the 100 lbs.	15 40
Coal used as a combustible about 3 tons	16 00

Other Expenses.

Labor about 6 days	5 00
General expenses	6 00
Total	$275 22

Production.—20,000 lbs. of crude soda marking 36 alkalimetric degrees.

We see by the above table that the expense of manufacturing 20,000 lbs. of crude soda is $275.22, which puts the price of 100 lbs. at $1.38.

Artificial Salted Soda.—Artificial salted soda is a mixture of soft soda and common salt. The proportion of salt varies from 25 to 40 per cent. of the weight of the soda.

The use of this soda is necessary for the coction of marbled soaps. On account of the large proportion of salt it contains, it has the property of contracting the paste of the soap, and preventing its dissolution in the lye. Like soft artificial soda, it is prepared by the decomposition of the sulphate of soda by chalk and charcoal, only in the preparation of the sulphate, the quantity of sulphuric acid necessary to decompose the salt is diminished, so that the sulphate obtained contains from 30 to 40 per cent. of undecomposed salt. The proportions generally employed are:—

Salt	2000 lbs.
Sulphuric acid 50°, from . . .	1200 to 1400 lbs.

The decomposition is conducted in the same manner as for the soft soda. The sulphate obtained is calcined and mixed with the carbonate of lime and coal in the following proportions:—

Sulphate of soda	2000 lbs.
Carbonate of lime	1300 "
Coal in powder	9000 "

The substances are reduced to powder, and intimately mixed together. The decomposition takes place in the same manner as for the soft soda.

Salted artificial soda has a less constant composition than soft soda. Independently of the strong proportion of salt it contains, it is also more sulphuretted than the latter. This inconvenience is due to a more or less considerable portion of sulphuret of sodium, which has not been decomposed during the reaction, and is left mixed with the soda. This inconvenience may easily be remedied by completely transforming all the sulphuret into carbonate, by introducing an excess of chalk into the mixture. Thus, an oxi-sulphuret of calcium, very slightly soluble in cold water, is obtained, and by lixiviating the soda with cold water, a solution is obtained, which only contains traces of the sulphuret.

It is evident, that under many circumstances the sulphuret might be troublesome, and such would be the case, if this soda were used in the fabrication and purification of fine soaps. But we must remark, that artificial salted soda is particularly employed in the fabrication of marbled soaps, and besides its advantage of contracting the paste of the soap, the sulphuret it contains contributes to develop the beauty and intensity of the marbling.

Chemical analysis demonstrates that 100 parts of crude artificial soda contain on an average:—

Pure soda	20 to 25
Salt	30 to 35
Undecomposed sulphate of soda	2 to 5
Foreign salts	1 to 2

The insoluble residuum is composed of oxysulphuret of lime, and coal.

Refined Carbonate of Soda.—Purified carbonate of soda is designated in the trade by the name of soda ash. This salt is very important on account of its numerous applications in industry. It is specially used in the preparation of toilet soaps. For their fabrication the richest in alkali is preferred, and principally the one which is entirely free from sulphuret.

For a long time this salt was obtained by the lixiviation of the ashes of sea-weeds, but now it is extracted from artificial crude soda.

To prepare this salt, select the soda which is richest in alkali, and containing the least sulphuret. The lixiviation may be effected by various processes. In the manufacture of crude soda, where sal soda is also prepared, the process is rational, simple, and economical. Baskets made of metallic cloth are filled with coarsely powdered soda, and then successively passed through solutions of soda growing weaker and weaker. The last passage is through pure water. By this operation a solution at 25° or 28° B. is obtained. To have it perfectly limpid, it is left to settle for several days, and is then concentrated.

This operation is generally conducted in four cast-iron kettles arranged in steps, and heated by the same hearth. The first receives the heat directly all over its surface; the flame afterwards heats the others, and then is lost in the chimney. The top kettle is employed to boil the solutions, the middle ones to evaporate them, and the lower one to concentrate them to dryness. During the operation, add new solutions to take the place of the evaporated water, in such a manner that the level of the liquors is always the same. To prevent the salt from attaching itself to the bottom and the sides of the first kettle, take it out with a skimmer as fast as it deposits, and let it drain on an inclined plane, or on shelves lined with lead. Continue this until all the solutions are evaporated to dryness.

To obtain a very pure and very rich carbonate of soda, some manufacturers evaporate the solution until a pellicle is formed on the surface, and in this state pour it into sheet-iron vats, where it crystallizes. A few days after, the mother-liquor is decanted, and the salt is left to drain. The crystals contain only a few hundreths of foreign salts; the mother-liquor contains uncrystallizable caustic soda, sulphate of soda, and chloride of sodium. Whatever be the method of operating, the salt of soda obtained always contains a large amount of water, interposed between its crystals. Besides, it is colored by organic substances, which give it a brownish shade.

To obtain this salt very dry and very white, calcine it in a reverberatory furnace, strongly heated. Furnaces in which the calcination takes place have their beds entirely covered with a thick and half-melted coat of salt itself; the bricks or stones being rapidly destroyed under the influence of a high temperature. The carbonate of soda thus obtained is very white, and is much richer in pure soda when the crude soda, from which it is exhausted, is itself pure.

The sal soda is obtained nearly chemically pure, as we have said, by concentrating the solutions of crude soda and causing them to crystallize. The crystals being drained and calcined in a reverberatory furnace, yield a carbonate of soda of 90 or 92 alkalimetric degrees.

The amount of refined soda ash from crude soda, varies according to the quality of the soda used. Generally, 1000 pounds of good crude soda, at 36°, yield from 380 to 400 pounds of a very white refined soda ash, and marking from 80 to 85 alkalimetric degrees.

Crystallized Carbonate of Soda or Crystals of Soda.—Crystals of soda constitute the pure subcarbonate of soda. Although less used than the dry carbonate of soda, this salt finds numerous applications in the arts. In soap factories it is used to prepare the pure lye of soda.

Nearly all the crystallized sal soda found in commerce is obtained by the lixiviation of artificial soda. To prepare it use the purest and richest soda. The crude soda is lixiviated in the same manner as we have indicated above. All the solutions which mark from 20° to 25° B., are mixed in large sheet-iron vats and allowed to rest; a few days after, when all the liquors are clear, they are decanted and submitted to a gentle ebullition in a cast-iron kettle.

When the boiling solutions mark from 28° to 30°, they are poured back into the vats, which are surrounded with coarse cloths, so as to retard the cooling. By resting, a sediment is deposited at the bottom of the kettles, and the liquor becomes perfectly limpid. When the temperature is at 70° to 75° C. (158° to 167° F.), the liquors are decanted and then set to crystallize, either in earthen jars, or in small sheet-iron vats of a capacity of 6 or 8 gallons.

In winter, the crystallization takes place in the space of a few days. When the concentration of the lyes has been carried to 34° or 35° B., the crystallization is so complete that very little mother-liquor is left. The concentrated lyes at 28° to 30°, give less crystals, but the product is richer. The caustic soda and the foreign salts remain in solution in the mother-liquor, while in the first case, they crystallize with the carbonate of soda.

Another process is also used to prepare the crystals of soda. It consists in dissolving refined soda ash, of a high degree, in boiling water. The operation is effected in a cast-iron kettle. When the liquor marks 30° B., $\frac{1}{1000}$ of quicklime, diluted with water, is added to it. After an ebullition of a few minutes the fire is removed, and the liquor is allowed to rest, so as to become limpid. This result being obtained, the clear liquid is drawn off and left to crystallize. The crystallization takes place in a few days; the salt is then separated from the mother-liquor and allowed to drain. This process yields whiter, finer, and purer crystals than those obtained by the direct treatment of the crude soda.

The first process, however, is generally used because the crystallized carbonate of soda can be extracted from the crude lyes, while, by the second, it is necessary to employ the refined salt of soda.

The mother-liquor from the first crystallization yields after a strong concentration at 34° B. a new quantity of crystals of soda, which can be purified by dissolving it in half its weight of boiling water. The uncrystallizable mother-liquor is used to prepare a caustic salt of soda of a weak degree. This salt contains only from 40 to 50 per cent. of pure soda.

Crystallized carbonate of soda contains 62.80 per cent. of water, so that 100 pounds represent only 37.20 of dry carbonate. This salt is very soluble in water. Boiling water dissolves almost its own weight, and cold water almost half. In the arts, the great solubility of this salt is utilized to purify it; for this purpose it is dissolved in the least possible quantity of boiling water. The liquor is left to crystallize, and it deposits, by cooling, fine crystals of pure carbonate of soda.

This salt is thus formed:—

Carbonic acid	15.42
Soda	21.78
Water	62.80
	100.00

Caustic Salts of Soda.—The caustic salts of soda represent for the same weight, a larger quantity of pure soda than the same salts when carbonated. Starting from this principle, there is an advantage in using salts of soda, the carbonic acid of which has been partly or totally eliminated, for the ponderal quantity of the missing acid is substituted by an equivalent weight of pure soda. It is thus that in their different applications of industry, caustic alkalies produce, at equal weights, more considerable results than when in the state of carbonates.

The fabrication of the caustic salts of soda is very simple. For this purpose it is sufficient to mix the crude soda with 30 per cent. of powdered lime (hydrated lime), and proceed with the lixiviation in the same manner as in the preparation of the salt of soda.

The result of the washing gives lyes marking about 25° B. These lyes, being clarified by settling, are rapidly evaporated to dryness in cast-iron kettles. The salt is drained and carried into a reverberatory furnace, where it is spread in a layer from three to four inches thick.

The furnace is at first heated moderately to dry the salt slowly without melting it, then the temperature is raised until it becomes red. This is an essential condition to expel the water, and destroy the organic matters, which color it. During the operation the mass is stirred, so as to multiply the points of contact of the substance with the caloric. The product thus obtained is white, and excessively caustic. Exposed to the air it absorbs carbonic acid, and passes to the state of carbonate.

Salts of soda, more or less caustic, are also found in the trade. They are prepared with the mother-liquors from the fabrication of the crystals of soda. These liquors contain in solution, large proportions of caustic soda mixed with different salts principally with sulphates and chlorides. By concentrating them to dryness, and incinerating the residuum, a kind of caustic salt of soda is obtained.

From these remarks it may be seen that owing to the facility of obtaining the artificial caustic soda which is now made ready for use and in a very nearly pure state, and that almost all manufacturers of soap are at present using it in their works, most of the caustic soda of commerce will bear analysis for its percentage of sodium hydrate. We give the analysis of an English caustic soda, branded 70°, which we have tested.

Sodium hydrate	83.840
" chlorate	4.686
" chloride	6.522
" sulphite	4.503
" sulphate	0.039
" silicate	0.470
Aluminum	trace

This shows at a glance that the caustic soda made for the manufacture of soap is reasonably pure—this sample showing no trace of carbonate of soda, the other salts not being in sufficient quantity to impair the soap, which if boiled would almost entirely precipitate with the waste lye. The healthy rivalry of the manufacturers of soda is such that an impure article could scarcely find a market. These sodas possess many advantages to the soap-maker in these days over those formerly in use, and a saving of much time and labor that had to be spent in making caustic the sodas of commerce, which were of such varying qualities and strengths, and filled with so many foreign salts, that it required an expert chemist to analyze them. At present, when we know the relative purity or strength of a certain make of soda, and by test ascertain the amount of caustic soda it contains, the hydrometer of Baumé will give us the specific gravity, and we can easily judge of the quantity necessary to use.

The following table may prove useful in this connection.

Specific gravity.	Per cent.	Specific gravity.	Per cent.
2.00	77.8	1.40	29.0
1.85	63.6	1.36	26.0
1.72	53.8	1.32	23.0
1.63	46.6	1.29	19.0
1.56	41.2	1.23	16.0
1.50	36.8	1.18	13.0
1.47	34.0	1.12	9.0
1.44	31.0	1.06	4.7

It is almost needless to explain that the specific gravity of the solution increases with the amount of caustic soda dissolved in it. In another section we will give the necessary working tables for manipulation.

On the score of economy in the cost of soap-maker's lye, there might be conditions where the barilla, kemp, and other soda ashes could be economically used, but they can hardly apply to this country, unless it be in the far West, where many natural sources of soda are found, and where there are several soda works already established, and whose products rival the English.

CAUSTIC SODA FROM CRYOLITE.

From cryolite, a mineral found in Greenland, a caustic soda is now made in this country, Germany, and Denmark, which is nearly free from impurities. Cryolite is the fluoride of aluminum and soda, and in preparing the soda, the sodium aluminate is dissolved out with water, and decomposed with carbonic acid, the hydrate of alumina being separated, and formed into an alum useful in the arts. The remaining carbonate of soda is dissolved and condensed to form crystallized carbonate of soda, or it is decomposed with lime to form caustic soda, in the manner already described. The sodas from this source are so nearly pure that they claim a preference in the manufacture of most soaps, particularly those made by the cold or extempore process when all the impurities the alkalies may contain remain in the soap. Cryolite is also the most convenient source of aluminum, a valuable silver-like metal.

AMMONIA. *Ammoniaque*, Fr. *Ammoniak*, Ger. *Volatile alkali.*

This important alkali deserves mention here, but has few properties applicable to our art, unless in an analytical test in some experiments, when it can be recommended as a normal alkali free from impurities. For soap it has no practical use, though we find several patents have been given for its addition to other soap where it is claimed to improve its detersive action. It has many uses in pharmacy and the arts, but they are foreign to the subject of our work.

RUBINIUM AND CAESIUM

are alkalies recently discovered which are analogous to potash in their character, but have no application in the art of making soap, as they are scarce and expensive.

LIME. *Chaux*, Fr. *Kalk*, Ger.

Lime, called quicklime and caustic lime, is, chemically, calcium oxide, and does not occur naturally, but always with an acid oxide, as carbonate, sulphate, silicate, etc. The use of lime to the soap-maker is important, for by its power of extracting the carbonic acid from alkalies, they are thereby made caustic and suitable for combining with the fatty acids and forming soap, though it does not form a component part of it. A soap can be made of lime and a sebasic acid, but it is insoluble.

Lime used for technical purposes is prepared by calcining natural carbonate of lime in kilns. During the burning the carbonic acid is disengaged, and quicklime is the product of the calcination.

The qualities of lime essentially depend on the purity of the carbonate used to prepare it. When the calcareous stone (carbonate of lime) is mixed with large proportions of quartz, magnesia, or alumina, a lime of an inferior quality is obtained, which slacks with difficulty, and forms, with water, a paste without homogeneity. It is then called *poor*, and is rarely used in soap-making. Lime prepared with a carbonate sensibly pure, that is, which contains only traces of foreign matters, is of a superior quality, and is called *fat*. It rapidly combines with water, and grows very warm. If very little water is added, it slacks and forms a white and light powder, with a burning and caustic taste, and turning the blue vegetable colors green. Lime thus prepared is known by two different names. For the chemist it is *hydrated lime*, for the manufacturer it is *slacked lime*.

If a sufficient quantity of water is poured on slacked lime, it combines with that liquid. The elevation of temperature, which takes place during the combination, often reaches 350° C. (662° F.). If the quantity of water is large enough, a more or less thin paste is obtained, which is called *milk of lime*. It is always in this form that lime is used to prepare caustic lyes of potash or soda.

Lime recently burned is white, or slightly colored, if the limestone used to prepare it contains oxide of iron. To ascertain if it is completely caustic, treat a few drachms by nitric acid. If the lime is entirely caustic, it ought to dissolve in the acid without disengaging carbonic acid. If there is any effervescence during the solution, it is a proof that it still contains carbonate of lime, which has not been transformed into caustic lime. Entirely caustic lime is more desirable, as it decomposes the carbonates of potash and soda better.

Its density is not constant, it varies according to the nature and purity of the carbonates which have produced it. Its mean specific gravity is 2.4.

Quicklime exposed for some time in the air, attracts its water and carbonic acid: it is transformed into carbonate of lime. In this state it has lost all its causticity, and does not possess the property of depriving the carbonates of potash and soda of their carbonic acid.

Water will dissolve a certain proportion of lime. Very exact and recent experiments have shown that one thousand parts of water dissolve one of quicklime. That small quantity is, however, sufficient to communicate to water a strong alkaline reaction, and restore the blue of litmus paper, reddened by an acid.

Lime-water is a valuable reagent for ascertaining the causticity of lyes of potash and soda. Pour a small quantity of the lye to be tested into a glass, and add to it perfectly limpid lime-water; if the lye is completely caustic, the two liquors remain limpid; if, on the contrary, there is in the lye a portion of undecomposed alkaline carbonate, a white precipitate of carbonate of lime is produced.

Lime plays an important part in the preparation of lyes. It is the essential and indispensable agent of their causticity. When we examine the preparation of lyes, we shall indicate the special conditions of this operation, one of the most important in its manufacture. We may here state that lime is not an integral part of soap—its action being chemical. It combines with the carbonic acid of the alkaline carbonate with which it is in contact, and forms an insoluble carbonate of lime. The pure alkali, or hydrated alkali, remains in solution in the water, and constitutes the caustic lye used in the fabrication of soaps.

We may add, that lime used to prepare lyes must always be of good quality, and, if possible, recently burned. It ought to mix easily with water, and should not effervesce with acids. In places where it is difficult to obtain it readily, it ought to be kept in barrels perfectly closed, and in a dry place, because by being exposed to the air it attracts moisture and carbonic acid. But when lime-kilns are near a manufactory of soap, it is better to use lime recently burned.

When the lime is supposed to contain impurities it would be advisable to submit it to the alkalimetric test, for this purpose. Besides titered nitric acid a solution of sal-ammonia is needed, which in one hundred parts, contains about twenty-five parts of sal-ammonia. For this test weigh off exactly 2.8 grammes (43.20 grains) of burned lime, place it in the 100 cubic centimetre (3.38 flu. ozs.) trial glass, add at first some water, so that the lime be slacked and reduced to powder; then again 40 cubic centimetres of water (1.35 flu. ozs.), 25 cubic centimetres (0.845 flu. oz.) of the sal-ammonia solution, and finally fill up to the mark with water, until in all 100 cubic centimetres (3.38 flu. ozs) are obtained. Now place a tightly fitting cork in it, shake repeatedly, and allow the whole to clear off, by settling. Then take 10 cubic centimetres (0.338 flu. oz.) of the liquid into a beaker, which contains already 10 or 20 cubic centimetres (0.338 or 0.676 flu. oz.) distilled water, color with tincture of litmus blue, and admit by means of a graduated pipette the normal nitric acid, until the blue color changes into that of a red onion. The cubic centimetres of nitric acid used, multiplied by ten, give the percentage of caustic lime which the tested lime contains.

A very good mode for keeping lime for use is to slack it into a stiff paste and put it into water-tight vats or barrels where it will keep a long time, while only the upper surface having absorbed carbonic acid can be removed before using for causticizing the lye.

WATER. *Eau*, Fr. *Wasser*, Ger.

Water in the manufacture of soap performs a prominent and indispensable part, and may well be called a raw material. It is particularly important to have it pure, both for the soap and as an ingredient for the lye. There are often dissolved in the water of wells and springs various earthy salts, lime, dolomite, etc. These salts often decompose a portion of the soap, and when used in making or melting they also cause a loss in the causticity of the lye, which in a large factory results in a great pecuniary loss.

Thus it is exceedingly important to see that the water used is entirely pure, and if that is not possible, to ascertain the extent and kind of impurities, and to find a suitable remedy to make the water fit for use. To give exact instructions for the analysis of all waters would require much space which is not possible here. Yet, as it is important we will give the test recommended by Fleck, which not only offers the most reliable but furnishes the most ample and accurate results for the technic, and besides all this, is very feasible. It rests upon the decomposition of the earthy salts which are present in the water, by means of a soap solution of a certain degree. To ascertain the final reaction of the water to be tested, it is only necessary to color the same with an always equal amount of reddish litmus tincture until it becomes light red. As soon as all the earthy salts are decomposed by the soap, the liquid takes with a new addition of soap solution, a drop at a time, its former bluish color. The soap solution is so normal, that 20 cubic centimetres (0.676 flu. oz.) of it in 100 cubic centimetres (3.38 flu. ozs.) of a saturated solution of gypsum, become decomposed. By this the degree of hardness of a water is determined; as also in the case of a water, of which 100 cubic centimetres (3.38 flu. ozs.) require 20 cubic centimetres (0.676 flu. oz.) soap-solution, and is noted as 20; in other words, the cubic centimetre of soap solution used, expresses the immediate degree of hardness of the water tested.

The main requisite for these tests is an entirely neutral soap; which must contain neither free nor carbonated alkali. The common soaps being for this purpose seldom applicable, Marseilles soap, therefore, as a rule, is used for this purpose. In the absence of this soap, a neutral soap can easily be made, by dissolving a common oil or tallow-soap in distilled water, and settling it with warm culinary salt, and by washing out the grainy soap with a gradually diluted culinary salt solution upon a filter, till the liquid indicates but a weak alkaline reaction. Finally, the yet moist soap is pressed in linen, in order to remove the still adhering parts of the solution of culinary salt. After drying it somewhat in the air, it is dissolved by warming with about ten times its volume of 70° or 80° alcohol, allowing it to cool off, settle, and then filter. Stronger alcohol must not be used, because the solution would congeal. To cause this soap solution to decompose 20 cubic centimetres (0.676 flu. oz.), put 100 cubic centimetres (3.38 flu. ozs.) of a saturated solution of gypsum into a beaker, color the liquid with some reddened litmus tincture, and add from a 0.10 cubic centimetre (0.027 flu. dr.) graduated pipette or burette, so much of the soap solution as will cause the red color again to become blue. To reach this point with more accuracy, there is next to the first beaker a second beaker, also filled with gypsum water, which by means of litmus tincture has been colored blue. If on the appearance of the desired blue shade of color, 20 cubic centimetres (0.676 flu. oz.) have been used of the soap solution, it will have the correct titer; but if less have been used, it must in the same proportion be diluted with so much weak alcohol, that 20 cubic centimetres (0.676 flu. oz.) are reached. Supposing 12.5 cubic centimetres (0.422 flu. oz.) had been required, then to every 12.5 cubic centimetres of soap solution 7.5 cubic centimetres (0.248 flu. oz.) alcohol would be needed; if of the first 11 (0.371 flu. oz.) was had, so would need

$$12.5 : 1000 = 7.5 : \times = 600 \text{ cubic centimetres (20.28 flu. ozs.) alcohol}$$

to be added, so that 1600 cubic centimetres (1.689 quarts) soap solution are formed, which accordingly is ready for use.

Since the waters which are to be tested as to their degrees of hardness, almost without exception, contain larger or smaller quantities of bicarbonate of lime, which reddens the tincture of litmus, only by boiling can the carbonic acid as an insoluble carbonate of lime separate. The waters must be boiled about five minutes before commencing to add the soap solution, and then be mixed with so much nitric acid that the liquid obtains a light red color. If a nitric acid of a certain strength is applied—for instance of one-tenth equivalent to the liter (1.05 quart) (54 : 10,000)—then the quantity of the nitric acid used will also prove the hardness of the water, since 1 cubic centimetre (0.27 flu. dr.) of such an acid corresponds to about 2 cubic centimetres (0.54 flu. dr.) of the normal soap solution. If, therefore, in the testing of a well-water 8 cubic centimetres (0.270 flu. oz.) of the latter acid have been used, while, on the other hand, for the solution of the carbonate of lime 4 cubic centimetres (0.135 flu. oz.) of the $\frac{1}{10}$ standard nitric acid had been applied, it follows, therefore, that 2 cubic centimetres (0.54 flu. dr.) of the soap solution have to be brought into account for the carbonate and nitrate of lime, and 6 cubic centimetres (0.203 flu. oz.), hence 6° for the permanent degree of hardness.

Every degree of hardness corresponds to 100 cubic centimetres (3.38 flu. ozs.) 12 milligrammes (0.18 grains) gypsum, or 5 milligrammes (0.077 grain) of pure lime, so that for the single degrees of hardness the following values are proved, which permit an approximate conclusion as to the soap which is decomposed by the water.

Degree of hardness.	In 1000 kg. water.		1000 kg. of water decompose soap with 28 p.c. water.	Degree of hardness.	In 1000 kg. water.		1000 kg. of water decompose soap with 28 p.c. water.
	Lime.	Gypsum.			Lime.	Gypsum.	
20	1.01 kg.	2.45 kg.	14.75 kg.	10	0.50 kg.	1.23 kg.	7.31 kg.
19	0.96 "	2.33 "	14.02 "	9	0.45 "	1.10 "	6.58 "
18	0.91 "	2.21 "	13.30 "	8	0.40 "	0.98 "	5.85 "
17	0.86 "	2.08 "	12.57 "	7	0 35 "	0.86 "	5.12 "
16	0.81 "	1.96 "	11.85 "	6	0.30 "	0.74 "	4.39 "
15	0.76 "	1.84 "	11.12 "	5	0.25 "	0.61 "	3.66 "
14	0 71 "	1.72 "	10.39 "	4	0.20 "	0.49 "	2.93 "
13	0.66 "	1.59 "	9.67 "	3	0.15 "	0.37 "	2.19 "
12	0.61 "	1.47 "	8.94 "	2	0.10 "	0.25 "	1.46 "
11	0.56 "	1.35 "	8.21 "	1	0.05 "	0.12 "	0.73 "

But there are some waters the hardness of which exceeds 20°, *i. e.*, such, as besides a large amount of gypsum contain also chloride of calcium and dolomite salts, which decompose a larger amount of soap. The purest waters are rain and snow waters. River water is generally sufficiently pure for making soap and lye. A simple remedy for waters containing lime, is a solution of silicate of soda of 20° B., 5 per cent. of which added to the water will cause the lime to precipitate and leave the clear water sufficiently pure for use.

SALT.

Culinary salt or sodium chloride playing an important part in the manipulation of soap it is necessary to give some of its characteristics and the impurities that impair its usefulness and cause a loss of soap.

Most of the salt of commerce contains foreign salts such as chloride of magnesium, sulphate of soda, gypsum, etc. These impurities decompose a large proportion of soap, forming metallic and insoluble soaps that are either precipitated or if held in the soap impair its detersive qualities and injure its appearance. The salt furnished by the evaporation of sea water is so very impure that it should be entirely avoided. That from mineral springs is very much better though often contaminated with organic matter, while that made from the salt mines or rock salt has, as a rule, the fewest impurities, although it is never entirely pure.

In boiling soap, salt is so important a material for refining that the soap-maker should pay proper attention to procuring it reasonably pure, otherwise he may fail in obtaining a good color, or he may lose by the decomposed soap and alkali carried off with the waste lye. Should he suspect that his salt has many impurities he can refine it in the manner indicated for hard water, viz., with silicate of soda. This process is quite simple, it being only necessary to dissolve the salt in a suitable quantity of warm water and to add the solution of silicate of soda in the proportion of say 5 per cent., when after stirring for a time and being left to rest, it will carry down with the precipitate almost all of the lime and other salts, and the soap-maker may use the upper clear portion with confidence. By means of the crystal carbonate of soda a solution of culinary salt can also be somewhat purified, as the contaminating salts are thereby changed into insoluble carbonates which precipitate and can easily be separated.

FATS AND OILS.

Both fats and oils occur as the constituents of animals as well as plants; in animals these substances are deposited in particular tissues in larger quantities, and are found in all parts of plants, principally in the seeds and fruit; and are characterized by their physical and chemical properties. Such as are liquid at ordinary temperatures are termed fat oils, those that have a soft consistency are called lard or butter, while those that have a higher melting point and are solid at the normal temperature, are classified with tallow and suet. In a pure state they are generally colorless and but of faint odor and are of an average specific gravity of 0.9. They are insoluble in water and but slightly soluble in alcohol, but freely in ether and carbon bisulphide and in volatile oils. Some fat oils absorb oxygen and dry up and are called drying oils, others only assume a rancid state when exposed to the air.

When heated to 250° or 300° C. (482° or 572° F.) they are decomposed, forming volatile acids of a disagreeable and irritating odor. At a still greater heat they form a combustible gas which has three times the illuminating power of coal gas and is very much purer.

The fatty bodies are of very great importance in numerous industries, in domestic economy and for lubricating machinery, but perhaps their greatest and most important use is in the fabrication of soap and candles, so indispensable in all civilized countries.

We have already mentioned that the true properties and constituents of oils and fats were unknown until Chevreul, Scheele, and others published the results of their researches, their nature and elementary composition, and gave a scientific character to all manufactures into which they entered and particularly to the making of soap and candles. These researches have been fully confirmed by all later experiments, and possess so much interest and importance that we shall endeavor to give this branch of the subject thorough and complete treatment.

The fats and oils finding application in the manufacture of soap are either of vegetable or animal origin, and either liquid, as linseed oil, hemp oil, olive oil, poppy oil, fish oil, etc., or they are more or less solid, as tallow, lard, palm oil, cocoa-nut oil, etc. Under the influence of alkalies, and the bases of metallic oxides generally, they are all decomposed into various sebacic acids and glycerine.

Liquid fats, *i. e.* oils, assume at a low temperature a firm consistency (linseed oil only at 27° below 0 C., 16.6° F.), while the solid fats, *i. e.*, tallow, etc., at an increased temperature become oily (some even below 100° C., 212° F.).

All fats and fatty oils are according to their chemical composition called glycerides, *i. e.*, glycerine combinations in which are comprised according to the theoretical view, of 3 atoms of water or 3 atoms of hydrogen of the glycerine, which is according to the general chemical formula $C_6H_8O_6$, and 3 atoms or equivalents of sebacic acids.

According to the first or older view glycerine is considered $= C_6H_5O_3 + 3HO$, and contains, according to this view, a substance, the so-called glyceryl-oxide or lipyloxide, $= C_5H_5O_3$, which occurs in glycerine with 3 equivalents of water, but appears in the fats combined with 3 equivalents of sebacic acids. In the fats we find especially palmitic acid of glyceryl-oxide or so-called palmitin $= C_6H_5O_3 + 3(C_{32}H_{31}O_3)$, furthermore stearic acid glyceryl-oxide, so-called stearine $= C_6H_5O_3 + 3(C_{36}H_{35}O_3)$, and finally oleic aid of glyceryl-oxide or so-called oleine $= C_6H_5O_3 + 3(C_{36}H_{33}O_3)$.

According to a more modern view, glycerine is considered as a so-called triple acid alcohol $= C_6\left.\begin{matrix}H_5\\H_3\end{matrix}\right\}O_6$, in which the three separately written hydrogen equivalents (H_3) are represented in the fats by 3 equivalents of the above-mentioned sebacic acids. The palmitin of the fats is according to this tripalmitin $= C_6\left.\begin{matrix}H_5\\(C_{32}H_{31}O_2)_3\end{matrix}\right\}O_6$; the stearine is tristearine $= C_6\left.\begin{matrix}H_5\\(C_{36}H_{35}O_2)_3\end{matrix}\right\}O_6$; the oleine is trioleine $= C_6\left.\begin{matrix}H_5\\(C_{36}H_{33}O_2)_3\end{matrix}\right\}O_6$.

The pure fats of the vegetable as well as of the animal kingdom, the tallows no less than the lards and oils, are not combinations of merely one sebacic acid with the above mentioned glyceryl-oxide, but contain altogether at least one liquid fat, *i. e.*, the combination of one solid and one liquid acid, with glycol-oxide. These combinations have a consistency similar to the sebacic acids contained in them, but are somewhat more fusible. Many fats of the most varied origin differ in the pure state only by the relative quantities of the same solid and liquid combinations, which they obtain one from the other; for instance, olive oil and human fat; others, however, contain the same solid fat as these, but as to their combinations and their properties are an essentially different liquid acid in combination with the glyceryl-oxide. In others again, for instance palm oil and cocoa-nut oil, the solid acid certainly, and perhaps also the liquid acid, is a peculiar acid. In general, we have at the ordinary temperature the firm combinations called *stearines*, and the liquid combinations called *oleines*. However, we mean by stearine, stearic glyceryl-oxide, the combination of a specific accurately known solid acid, which is contained in many animal fats, especially in that of oxen, sheep, etc. By the term oleine or elaine, oleic or elaic acid glyceryl-oxide, we mean the liquid combination which occurs in a great many animal fats, as well as in many vegetable fats, and in both the same chemical combination exists. A number of vegetable oils, however, contain another oleic acid, which is sometimes called oleine acid. It possesses the property of drying to a tough solid body when exposed to the air, while common oleic acid only thickens to a smeary fatty substance. For this reason the oils which contain the former are called drying oils, and the others fat oils.

The second combination of a solid sebacic acid with glyceryl-oxide, which is sometimes mixed with stearine and again with oleine, is called palmitin (margarine), and the acid palmitic acid (margaric acid) is next to the oleic acid the most extensively distributed sebasic acid. It is found as a solid ingredient along with stearic acid in ox-tallow, and in fat as well as drying oils, and palm oil. The pure combinations of the above-mentioned substances are odorless; but the most of the raw fats, those of the vegetable kingdom as well as of the animal kingdom, possess a specific odor, by which they may be distinguished from one another. In some, it orignates from an admixture of volatile oils, for instance, in the oil of mace; in others from glyceryl-oxide combinations with volatile acids, for instance, lactic acid, valerianic acid, capronic and hircinic acids, as in mutton tallow; in others, as in linseed oil, the odor depends upon unknown admixtures.

To the touch the fats are known by their specific lubricity, in water they are all insoluble, most of them also in alcohol, excepting castor oil. Heated alcohol takes up a goodly amount of the fats, which after cooling off again almost entirely separate, but they are freely soluble in ether, volatile oils, sulphuret of carbon, chloroform, acetone, and pyroligneous acid (wood spirit). They are rich in hydrogen and oxygen, of the latter they contain 70 to 80 per cent. but nitrogen (azote) is not contained therein. Their specific gravity is always less than that of water, and changes according to the kind of fat between 0.910, and 0.930 at 15° C. (59° F.).

The fats in fluid condition expand at every increase of temperature over 1° C. (33.8° F.) by $\frac{1}{1200}$ to $\frac{1}{1000}$ of their volume, so that at 120° C. (248° F.) they have $\frac{1}{10}$ more volume than at 0° C. (32° F.). In the dark they become phosphorescent, by a slight increase of temperature; the real fat oils and fats boil only at 170 to 250° C. (338 to 482° F.), the drying oils, however, beween 100 and 115° C. (212 and 239° F.).

No fat can be distilled without decomposition; while it boils at the high temperature of 300° C. (572° F.), the escaping vapors are not those of the undecomposed oils, but those of the formed products of decomposition, which, according to the applied temperature, as well as to the amount or kind of the divers sebacic acids contained therein, vary very much. The glyceryl-oxide is first decomposed, a very volatile body is formed, which is violently irritating to the eyes, at the ordinary temperature is liquid, soluble in water, and is called *acrolein*. By this property, it is easily ascertained whether a fat-like substance is really fat, a combination of glyceryl-oxide, or not; for the least amount of glyceryl-oxide makes itself noticeable by the intensely sharp smell of acrolein. The oleic acid, too, will be in a great measure decomposed, and but little distils over unchanged. From it is formed the so-called sebacic acid, with a series of substances such as carburetted hydrogen gas, the so-called oil-forming gas (chiefly illuminating gas) and like carburetted substances. If stearic acid be present, it separates in palmitic acid and also in several carburetted substances, and even the palmitic acid does not distil entirely over unmixed, although a large part thereof is found among the products of the distillation.

If the pressed or rendered fats are exposed to the air, they absorb oxygen, at first slowly but afterwards more rapidly. During the process the so-called drying oils cover themselves with a skin, and thereby withstand the influence of the air much longer. The other oils or fats become somewhat tough and thick, and gain a disagreeable odor, show an acid reaction, and taste sharp and are gritty. This is especially the case when the oils have absorbed much albumen and similar matter from the organs of plants or animals from which they have been obtained. By the shaking up of such oils in hot water and a small quantity of hydrate of dolomite, this condition, which is called *rancid*, may be changed.

Many acids absorb the glyceryl-oxide entirely or partly from the sebacic acids. If a little hydrate of sulphuric acid for instance is carefully mixed with olive oil, so that no heating ensues, glycerine will be separated, which with the sulphuric acid combines and forms a compound of glycerine and sulphuric acid, while the sebacic acid is free. But if the oil is carefully mixed with half its volume of hydrate of sulphuric acid, then the sebacic acids combine also with the sulphuric acid and form bodies which by the addition of water are decomposed, transferring all the sulphuric acid thereto, in cold air gradually, by boiling at once, into several other acids, among which, however, neither palmitic nor oleic acid is found.

Upon the influence of sulphuric acid on fats, rests in part its application in purifying the same. The oils obtained from seeds by pressure are never free from albumen and other impurities; a moderate addition of sulphuric acid causes these substances to coagulate and produce in water soluble glycerine sulphuric acid. If, on the other hand, too much sulphuric acid is used, there will be formed monomargaric, hydromargaritic, hydromargaric, monoleic, and hydroleic acids, which are very limpid and contain less carbonic acid than oleic and margaric acid.

In the melting of tallows and animal membranes, we must be careful in the application of sulphuric acid. A large quantity of this acid makes the melting easier, but we obtain, as experience teaches, tallow which is very fusible, which for the manufacture of candles is not desirable, and obviously originates from the formation of hydromargaric acid, etc.

In order to obtain the hardest possible tallow for chandlers, such as even in warm weather may be moulded and may be easily taken from the moulds, the melted tallow should be permitted to cool off very slowly. Stearine and palmitin will then separate in noticeable crystals, and in a temperature of 20° to 25° C. (68° to 77° F.), a large part of the olein can be removed by pressing. Thus a tallow is obtained which at all seasons of the year may be manufactured into candles. These are harder, less fusible, and whiter, since the olein is generally of a yellowish hue. Such candles are in the market under the name of stearine candles, which must not be confounded with stearic acid candles, which are sometimes also called stearine candles. This will be more fully explained in the section on candles.

Diluted nitric acid at first acts on the oils similarly to sulphuric acid. It sets one part of the glycerine free. Concentrated acid, however, reacts very strongly with it; they froth violently, and at times even ignition ensues. A great number of products of oxidation are thus formed—volatile and less volatile acids.

Nitric acid causes a very singular change in the olein, the sebacic acid, and the fats. The olein of the drying oils does not undergo this change. Without withdrawing from the olein its glyceryl oxide, the nitric acid will change it at the ordinary temperature into a white body, called elaidin, and the acid produced therefrom, the elaiodic acid, is not liquid like the oleic acid, but solid. Both these acids have the same chemical composition.

The salifiable bases decompose, as has already been observed, the combination of the sebacic acid with the glyceryl oxide, and unite with the stearic, palmitic, and oleic acids, and all other sebacic acids, into salts, which are called soaps when the base is an alkali, and plasters when the base is protoxide of lead (litharge). The glyceryl oxide separates, by the combining of 1 eq. of the same with 3 eq. of water, into glycerine. Caustic ammonia produces the same decomposition, but only after a very long time; or it unites with the oils into a thick and milky fluid, which is known under the name of volatile liniment. Carbonated fixed alkalies form also creamy liquids, from which, however, diluted acids separate the fat unchanged. Culinary salt and sulphate of copper are dissolved by the fats without changing them.

The number of the various fats found in the animal and vegetable kingdoms is infinitely large; almost every kind possesses a fat or oil which, either on account of its smell, color, etc., differs from the other. In a great part these differences exist only in the various quantitative mixtures of the liquid and solid parts, and are caused by small, unessential admixtures, a small amount of volatile substances which are to be considered as unessential to the fat. There have been very many different kinds of solid and liquid fats found which have not yet been thoroughly examined.

FATS OF ANIMAL ORIGIN.

Tallows are those fats or greases obtained from the ox, the sheep, the goat, and the deer, and are the hardest, having the highest melting point. The first two named find the most prominent application in the manufacture of soaps, and are mixtures of oleine, margarine, and stearine, in varying proportions, according to the age, the season, and the nature of the food. Animals fed upon dry food furnish the most solid tallow, that of those that are pastured is less so, while those fed upon swill furnish a very soft grade. It is also noticed that fat produced in summer is softer than winter fat. The fat occurs enveloped in very thin cellular tissues which are moist in fresh tallow and are easily decomposed and soon undergo a change in the air. It is necessary therefore, especially in summer, to keep it in a cool place or at once to separate it from the membranes by rendering. Besides the three constituents above mentioned, tallow contains the glycerides of some volatile sebacic acids, as lactic, capric, capronic, and valerianic acids, besides some peculiar matters not yet fully tested and explained.

To obtain the tallow from the membranes which surround it, the fatty tissues are cut into small cubes, placed in a suitable vessel and exposed to a heat which exceeds that of boiling water. In the heat the membranes are destroyed, the melted tallow runs out and can be separated from the membrane by straining. This process has been in practice a long time and is so still. Sometimes a still higher temperature is applied in order to cause the residium to undergo a roasting, thereby trying to obtain a greater yield of pure tallow. In general though, this method remains imperfect and a larger or smaller loss of tallow is sustained, much remaining in the tissues, which are but imperfectly opened by this operation and become so hard that they yield the tallow under the press with difficulty. Furthermore it is an impossibility to obtain an even temperature with which to operate through the entire melting process. On the bottom it becomes too high, to the detriment of the color and quality of the tallow. Finally during the melting process are developed from the animal substances gaseous and other vapors of a disgusting odor.

The application of steam in lieu of a free fire is but a slight improvement, because the temperature remains too low and besides by the immediate contact of steam with the fat, the substance of the membrane is changed into glue, which can be separated from the tallow only with great difficulty. In hermetically sealed vessels by an increased pressure and a direct stream of steam the raw tallow may be melted, the fat finally separating from the glue solution which settles on the bottom.

That in the process of mere melting the membrane yields the fat with so much difficulty, is demonstrated especially in the fact that the tissues are not completely destroyed and opened. To manipulate to a more complete opening, various means have been proposed and applied, which answer the purpose equally well so that one or the other is brought into use. Most convenient is the method of allowing the lumps of fat, instead of cutting them into small pieces, to pass through narrow rollers whereby all tissues are opened, and after this the tallow may be rendered in the heat. Another process (by Evrard) consists in the mixing and warming of 300 parts of cut tallow with caustic natron lye (made of 1 part calcined soda dissolved in 200 parts water). The odorous substances, partly volatile acids, combine with the natron and remain in the lye dissolved, while the pure fat is separated. By this mode Faiszt obtained from 100 parts of raw, 88 parts of pure tallow, and from the lye by the addition of acid 8 parts more, hence together 96 parts. In this manner all the fat may be obtained, and yet no special advantage is found in this process, especially if we consider the labor, and also the circumstance that in this case no greaves or cracklings are yielded which find a good and profitable use in feeding swine and dogs.

In the same manner D'Arcet, according to his acknowledged excellent method, brings diluted sulphuric acid to operate on the raw tallow whereby the important advantage is had, that, by the chemical destruction and opening of the tissues, the development of the fetid vapors is lessened and they become more bearable. According to D'Arcet the raw tallow is melted with half its volume of water, to which has previously been added 3.3 per cent. of sulphuric acid, keeping the entire mass boiling until the separation of fat and tissues is finished. Although this operation was originally calculated for an open fire, it may nevertheless be performed over steam, since by the acid the separation of fat is furthered in a high degree. In the apparatus of Taulet the heating of steam is performed from the outside, in that of Chamby by a direct introduction of steam, whereby the greaves or cracklings are so loosened that they are pressed out with ease, or by mere reboiling render the tallow completely. Experiments with the first apparatus yielded 2 to 4 per cent. more than the operation over an open fire. With regard to the direct introduction of steam, experience has taught to apply less water by an increase of acid, *i. e.*, to apply about one-fifth water with 6 per cent. acid, since by means of the condensed water the proper proportion is established.

On the same principle as that of D'Arcet, the method of Lefevere is founded. He prescribes the maceration of the cut-up tallow for three or four days in the diluted acid, and then the remelting of it in fresh water. As long as fresh tallow, or at least some which is not too old, is worked, the methods before mentioned are ample, even the simple rendering, especially if the raw tallow has been pressed through rollers. It matters not whether by the one or the other method a few per cent. of fat more or less are gained, if the remaining greaves can be used for feeding cattle and swine. Experiments of comparison whether the yield by the one or the other method of melting tallow is more profitable are still wanting. The statement that so much pure tallow was obtained from 50 kilogrammes means nothing, since the raw tallow is unequal in fat, and yields at one time more, at others less, so that a superabundance of membranes is on hand. The real drawback that presents itself in the rendering out by melting is the unbearable smell, which becomes, not only for the immediate neighborhood but for a wide circle, a source of the greatest nuisance, so that especially in larger cities frequent complaints are entered against this evil. Many propositions have therefore been made, to have the rendering of tallow performed in such a manner that the bad smell may not appear. The most thorough investigations have been made by Stein, and later by Grodhaus and Fink, in Darmstadt. It is known that the smell of the bad tallow is caused by the decaying of the membranous parts, which thereby taint the fat which in a pure state is less changeable. The chemical change must have great similarity with that which ensues in the formation of cheese, wherein fat and azotic substances by mutual contact succumb to corruption. In this case at least so much is known—that the smell emanates chiefly from acids which develop their smell not only while free but even while latent in bases. Resting on this, Stein deemed it possible to remove the fetid smell of the tallows melting by a double principle, by either suppressing the corruption or by making their bad smelling product odorless. The experiments which Stein made in the first direction were whereby he applied either antiseptics, as for instance sulphuric acid or tannin, or such substances as destroy putrids, as neutral chromate of potassa, hypermanganesic acid with sulphuric acid and also nitric acid; all these however have not had a satisfactory result, and the required operations were moreover too complicated.

Stein therefore searched for the other principle by disinfecting the odorous products and thus removing the trouble caused in rendering tallow. He then started with the belief that they are predominant volatile oils, so that it was necessary to change them into salts, which on their part would be without smell or of a lesser odor. In this case too the purpose could obviously be reached in a dual manner. The salts mentioned could be formed in the liquid itself, or, since the odoriferous acids must needs be volatile, could be formed outside. For the first case lime-water was tried, which manifestly must needs work similarly to Evrard's method (lye of soda), but in preference to this possessed the undeniable advantage of an always even and very great degree of dilution, so that the free acids in all probability became neutralized, but no fat was saponified, and possibly the lime combinations of the acid were of a less fetid smell than the natron combinations. In fact the smell decreased in a noticeable manner when it was placed in lime-water; but when it was melted therewith, the smell increased, so that the application of lime-water must be avoided. In a very ingenious manner Stein now tried the conversion of the bad smelling acids into ethyl-oxide salts, which have even an agreeable smell. Although a very successful result was hereby reached because the smell vanished and did not reappear even in the process of melting, however another circumstance happened which retarded the process. The sulphuric acid which separates from the sulphuric ether acid (necessary in the forming of the ethyl-oxide) furthers the solution of the glue producing formation, in consequence whereof the formation of an emulsion ensues from which the fat can be separated only with difficulty. Hence this process of melting had also to be abandoned.

It now only remained to cause the escaping odors, after coming forth, to be made harmless. This process too is based on the idea that these substances are acids, which might be bound by an acidifiable base, and for such Stein applied hydrate of lime in combination with coarse-grained charcoal—the lime to retain the bad smelling acids, the coal the other bad smelling combinations. For this purpose a 5 to 7½ centimetre (1.96 to 2.94 inch) wide sieve-crown, which could be placed steam-tight upon the steamboiler, which in place of the sieve bottom was covered with canvas, filled with slackened lime and fresh-burned charcoal of hazelnut size, and thus placed upon the melting vessel. All vapors which escaped from the latter had to pass through the lime-coal mixture, and proved on their exit perfectly odorless.

Although the melting of tallow under application of the described apparatus, which Stein calls the "charcoal cover," is sufficient for the strictest requirements in regard to the objectionable smell, this process will not meet with general use, since it requires a steam-tight sealing of the charcoal cover upon the melting vessel, which in operations in larger quantities is only fulfilled with difficulty. To this must be added, that for every renewed melting a new filling of the cover with lime and charcoal will be necessary. This process can only be called practical if applied in the melting by steam; but if—as is still the practice in most soap-boiling establishments—the melting is performed over an open fire, where in the cover a paddle has to be applied, in order to stir the tallow, then the products escape through the opening for the paddle and enter the work-room. To avoid this, the cover and paddle ought to be connected air-tight by means of an India-rubber hose.

There is therefore no doubt, after the above stated experiments of Stein, that the smell, which is caused by the melting of old tallow, may be removed by chemicals, in one way or another; the carrying out on a larger scale, however, is obstructed by so many difficulties, that it appears quite justifiable to reach the purpose by a more simple and secure remedy. In fact Grodhaus and Fink, of Darmstadt, have abstained from applying any chemical preparation, and endeavored to remove the evil in a philosophical way. Their experiments, which have resulted satisfactorily, are in their totality so instructive, that we deem it entirely justifiable to report them here in full.

The melting of the tallow is performed either in the boiler over an open fire, or by meams of steam melting in large reservoirs made of sandstone or in wooden vats. It has already been mentioned, that the rendering over an open fire gives particular cause for developing the bad smell, because, near the end of the melting process, the fleshy and sinewy parts in the fat, the greaves, are constantly burnt, which must be avoided by constant stirring. By this stirring which cannot be dispensed with, the tallow upon the higher sides of the boiler decomposes, and the products which originate thereby are volatilized.

For these reasons Grodhaus and Fink believed that their experiments should be extended as well to the dry melting of tallow as to the wet process. The wet method of melting over an open fire could be employed, since by it the same process for diverting the smell may be followed as by the method of dry melting. Since the endeavors of Professor Stein to avoid the formation of odors had from the beginning no favorable result, and the method proposed by him to disinfect the odoriferous gases by means of the "coal cover" requires much attention and expenditure of time, and for technical as well as economical reasons will hardly ever find application, Grodhaus and Fink, therefore, limited their experiments to the search for easier means of destroying the developing fetid vapors. For these experiments two melting vats were placed in juxtaposition, and in them the raw tallow was melted with diluted sulphuric acid and by means of steam; furthermore, two boilers were placed contiguous to each other over an open fire with their joints—a so-called Russian chimney, which reached about 90 centimetres (35 inches) above the roof of the one-story melting house. In the following experiments, which were made for the purpose of carrying the vapors through the chimney, through one of the already mentioned boiler-fires, a warmed chimney was used, because, if the experiments with such a low chimney would furnish favorable results, a higher chimney would undoubtedly, wherever it existed, promise still greater success.

The first experiment was to decide whether the developed vapors by a steam melting process could be burned by means of a common boiler fire. Hence one of the above-mentioned melting coops was provided with a well fitting cover. In this cover was a hole 7½ centimetres (2.92 inches) wide, over which a tin pipe was fixed and carried under the grate of one of the boilers over an open fire. The contents of one of the melting coops consisted of raw tallow, of first and second qualities, mixed with the required amount of diluted sulphuric acid. The fire under the boiler close by burnt briskly when the steam was admitted into the melting vat. As the vapors developed therein, it was found that they were drawn off completely through the tin pipe which had been placed upon the cover, and streamed towards the fire; they passed freely through the grate, the fireplace, and the chimney. But it very soon became manifest that they extinguished the fire, which before the commencement of the steam development burned very brightly. The admission of steam into the melting vat was now interrupted, the fire was again started afresh and the steam readmitted, and the same observation made for a second and a third time, viz., that the fire was extinguished. The experiment of drawing the vapors under the grate of a fireplace, and there to burn them, gave according to this trial no favorable result.

A second experiment was made in this manner: the tin pipe which was intended to carry the vapors from the melting vat was made to discharge itself into the fireplace. The vapors were easily drawn from the melting vat into the flames, did not extinguish the fire, and did not have the least smell at the opening of the chimney, and thus the fetid smelling products had been destroyed. This mode of wet melting, where the melting vessel can be supplied with a well fitting cover and the stirring of the contents does not become necessary, can be highly recommended. For a permanent apparatus of this kind a cast-iron inlet pipe would answer the purpose best, and should be immured in the side wall of the fireplace about 6 centimetres (2.36 inches) above the grate, right into the flame where this iron pipe might be placed, while outside the wall a tin pipe might serve.

By a third experiment the tin pipe for carrying off the vapors was brought into immediate connection with the chimney of the boiler fire. Here too the success was complete; the vapors passed off entirely, and no particular smell could be noticed from the chimney opening. That this manner of carrying off the vapors operates in a high chimney better than in a low chimney is self-evident. Even if it should happen that in foul weather the smoke of the chimney with the impregnated vapors should be pressed down into the streets, the spreading of a bad smell would not be so great as if the vapors were dispersed from the melting-room.

A further experiment was made by which tallow was melted over an open fire, and where otherwise the well fitting wooden cover of the melting kettle was supplied with an opening for the stirring paddle; in order immediately to draw the vapors off and admit them into the fireplace and there to burn them up, but this operation led to no practical result. The vapors drew off but slowly into the fire, and escaped when the opening for stirring was not closed, or rather through it and the cracks between the rim of the cover and the kettle, instead of making their escape through the pipe. This arrangement would only be applicable when the cover closes perfectly and an opening for the paddle either could be entirely dispensed with, or a steam-tight paddle could be used. This experiment, changed in such a manner that the vapors which develop during the melting over an open fire were carried off by means of a pipe through the chimney, furnished a satisfactory result. The vapors vanished so readily that the opening for the paddle might be left open during the entire period of melting without the least escape of vapors or fetid gases.

According to the above-described experiments we would recommend, as the most suitable and convenient of all the means thus far known, the carrying off of the vapors and odoriferous matters which form and develop in the operation of either wet or dry melting, by steam or over an open fire, by the application of a pipe to the chimney of a fire after it is started. Where the dry melting is preferred, the cover must be made of strong plate-iron and be provided with a slit for the paddle. For the purpose of scooping out the melted tallow, the cover must furthermore consist of two parts which are joined by hinges. Only in rare cases, by reason of inclement weather, may it happen that the vapors which thus stream through the chimney opening descend into the street and become noticeable.

The facts reported by Grodhaus and Fink we can confirm by our own experience; we will not fail, however, to draw attention to the fact, that the chimney used for the carrying off of vapors must be built of well burned bricks, otherwise in its higher parts where a condensation of water takes place it will gradually become soft and be destroyed.

According to the same method and based on the same principle the melting of tallow is performed in England, with this exception, that the vapors are not, as in the process of Grodhaus and Fink, carried immediately into the chimney, but are admitted into a wide pipe which is carried into the fire. The absorption here is so strong that not only all vapors out of the melting kettle, but also a certain quantity of air is drawn in with it, and the admission of the vapors will be noticed at the opening of every developing pipe. The combustion occurs in the mouth of the pipe, and the gases reach the chimney almost entirely disinfected. In other establishments at Manchester, the vapors are led through a coke oven. In the large soap manufactories of Cowan & Son, twenty square kettles for the preparation of the fat are placed along the wall; every kettle has two openings, of which one opens outside and admits air, while the other is in connection with the ash-pit in which the draught may be regulated according to desire. All kettles communicate with a horizontal pipe which carries the vapors under a particular fireplace.

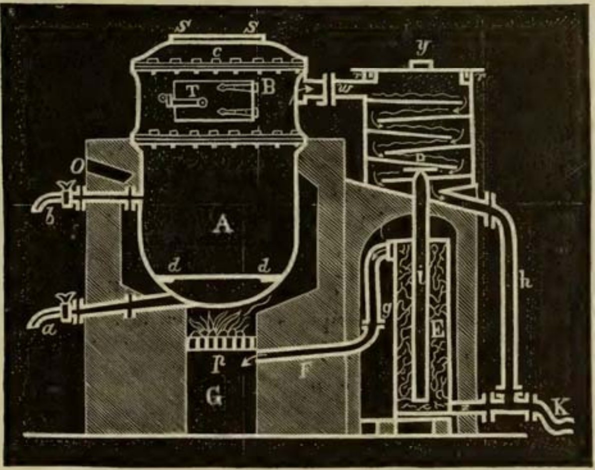
Among the many new inventions for rendering tallow, etc., in a manner to avoid the offensive odors arising from the operation, that invented by Vohl is perhaps the most successful. The kettles are provided with covers through which the gases are conducted and consumed.

Figure 1 represents this apparatus.

A is the cast-iron cauldron, lined with sheet lead, and has a riddled bottom *d d; a* is a tap to draw off the waste water; *b* is the tap through which the fat is drawn; *p* is the fire-grate; B is the door for filling; *c* the cover, with a mica plate S S; in the door is also a mica plate T for viewing the interior.

D is the vessel into which the gases pass by the tube *w*; *y* is a cover with sand joints *r r*; powdered lime is placed in D on oblique shutes to absorb the offensive gases. Any liquids condensed flow off through the pipe *h*, and the gases and steam pass into the condenser E, which contains coke moistened with sulphuric acid. The liquids pass through the pipe K, while the gases pass through the tube F into the ash-pit G under the furnace. G has a door through which a powerful draft can be sent, carrying all the gases into the fire to be there consumed.

Fig. 1.



In the rooms in which the raw materials are stored, there generally prevails such an unbearable smell, which the decomposing and putrefying substances diffuse, that it has been suggested to preserve the raw material in closed spaces, these to be connected by means of a pipe with a fireplace or with a high chimney into which all exhalations and the air that enters from the outside through the door cracks may be carried. But this evil might be met in a more efficacious way; for instance, by working up the hides and bones, and treating them with phenyl acid, which is furnished to the industries by Dr. Calvert. These hides come from South

America and Australia. Before they are shipped they are placed in water which contains 2 to 3 per cent. of phenyl (carbolic) acid. Hides treated in this manner showed not a trace of bad smell.

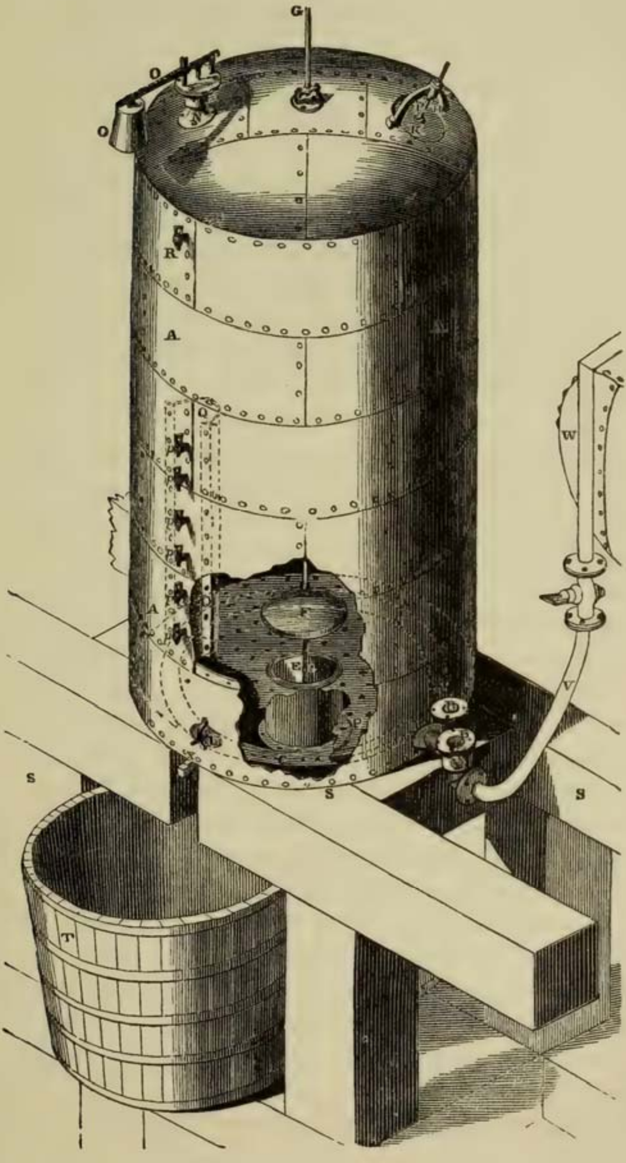
A similar contrivance, especially for the melting of tallow for candles and soap manufactories, is used in the establishment of Price of Battersea, England. The raw fats are melted in large vessels which are covered with flat hermetically fitting covers of lead and riveted to the wall. In the centre of the cover is a square opening of 80 centimetres' (31 inches) width, which is supplied with a water trap, and makes the attention to the vessel convenient. Upon the cover is placed the short end of an inverted ∩ forming pipe of 15 centimetres' (5.89 inches) diameter, the other end of which being 4½ metres (14.76 feet) long runs under the flooring of the work-room and opens into a canal. In the lower part of the pipe enters another pipe which is in connection with a force-pump which squirts water through a *rose* from above. The vapors in the vessel condense as soon as they come in contact with that stream of water, and the descending liquid matter impregnated with all the miasms flows into the Thames.

There are yet a number of other ways for rendering tallow, which, however, are mostly but modifications of the one or the other of the above-stated methods. Thus, the tallow in many establishments is rendered over an open fire or by steam, pressing the greaves and treating them again separately with diluted sulphuric acid and heat. By this means the cellular tissues are destroyed, the tallow flows out completely, and is washed out at first with a sub-lye and lastly with water. In more modern times in many of the larger soap manufactories, rendering modes have been introduced which are described in our article on lard.

LARD.

In the United States hog's lard has numerous applications in the arts, and occupies an important place in commerce on account of the large quantities produced and the many useful purposes for which it is used. Not the least important are

Fig. 2.



those of soap and candles. Lard consists of about 63 parts of oleine with 37 parts of stearine, the oleine or oil having many uses while the stearine is used in the fabrication of soap and candles. In making candles it is treated chemically, producing stearic acid and glycerine, being rich in this latter useful article; while the oleine or red oil is made into soap. This process will be detailed in our section on candles.

Lard is much used in cooking and is generally pure, yet it is sometimes sophisticated with the stearine from cotton-seed oil. It is rendered or melted in several ways, chiefly by the open fire, for it is made in nearly every farm-house. In cities and in large operations steam is found to present the most economical mode. Many inventions are in use for rendering lard, and among them few are more appropriate than the one here illustrated for rendering tallow and lard by steam and pressure, Fig. 2.

Rendering by Steam. Wilson's Process. The apparatus consists of a series of steam-tight digesters, each of 1200 to 1500 gallons capacity. These digesters are composed of boiler-iron plates tightly riveted together in the form of an inclosed cylinder, in length about two and one-half times greater than the diameter, and are furnished with diaphragms or false bottoms. The drawing, Fig. 2, is very explicit, and the mode of working these machines, and the use and application of their various appointments will be mentioned in reciting the process as practically carried through in the laboratory of the inventor. It is as follows: The false bottom being arranged in its place, and the discharging hole closed up, the steam-tight iron tank or cylinder is filled through the man-hole with the rough lard material, to within about two and a half feet of the top. This done, the man-plate K is securely fitted into the man-hole H, and steam let on from an ordinary steam boiler, through the foot valve, into the perforated pipe C within the tank. Set the weight on the valve at the requisite pressure, and during the steaming, frequently and carefully assay as to the state of the contents of the tank by opening the try-cock R. If the quantity of condensed steam in the tank is too great, it will be indicated by the ejection of the fatty contents in a spurt. In such a case it is then requisite immediately to open the regulating cock X and draw off the condensed steam, through it, into the receiving tub T, until the fatty matter ceases to run from the try-cock aforesaid. After ten or fifteen hours' continued ebullition, the steam is stopped off, and that excess already in and uncondensed, allowed to escape through the try-cock and safety-valve. After sufficient repose, the fatty matter separates entirely from water and foreign admixture, and forms the upper stratum. It is drawn off through the cocks *p p* in the side of the tank, into coolers of ordinary construction. The tank being emptied of its lard contents, the cover F is raised by means of the rod G, from the discharging hole E, and the residual matters at the bottom let out into the tub T. If, on inspection, the contents of this tub have retained any fat, it must be again returned to the tanks, when they are being filled for a fresh operation. Experience has determined that, to produce the best result, the steam pressure should be not less than fifty pounds to the square inch, though that often used is seventy-five pounds, and may be augmented to one hundred pounds when it is desired to expedite the operation. We should, however, advise against so high a pressure in the preparation of tallow; it may do well enough for lard; but if these closed tanks are made to operate as digesters, the effect produced by the decomposition of bones and other matters, which, in the wholesale way of preparing fats at the West, are generally thrown in indiscriminately with the rough suet, would be to deteriorate its quality. The better way is to take a little more time, and thus insure a better result. The process is sufficiently economical as it is, for, whilst by a pressure of between fifty and seventy pounds, the bones, etc., are made to yield all their oleaginous or fatty matter, there is no action occasioned which will convert them into an offensive constituent. In making lard from the whole carcass of the hog, excepting the hams and shoulders, a yield is always obtained, by the use of this apparatus, full twelve per cent.

greater than by any other methods; whilst in rendering tallow, the gain exceeds the product furnished by the ordinary plans at least six per cent. To say nothing of the economy both of time and labor (fifty per cent. of each), the material obtained is so much superior, that it always commands, if not the preference, at least a slight advance of price, in the market. The marc or residuum, thrown out into the tub T, being rich in nitrogenous and phosphated matter, when dried and mixed with bog or street earth, and gypsum, makes manure equalling the best guano.

Proper management of the apparatus will generally prevent any escape of the offensive vapors incident to the operation; but occasionally leaks will occur at the valve. The condensed steam carries down all the impurities of the fat, and leaves it clean and white. Moreover, it is firm if rapidly cooled in vessels of *small* capacity, for the temperatures of *large* volumes fall so slowly, that partial granulation ensues and softens its consistency.

With all these advantages, however, this process is not wholly faultless; for the difficulty of separating all the water slightly endangers the purity of the fat, as the former introduces, in solution, a portion of animal matter, which, in time, becomes putrescent, and imparts an offensive smell to the latter. Repeated washing of the fat with fresh water, and careful remelting and settling, would remedy this defect in a great measure.

Butter

finds but little application in the manufacture of soap, on account of its cost, though if it were less costly it would prove a very advantageous material particularly for toilet soaps, as soap made with it is of beautiful consistency and appearance, and it is subject to less loss in saponification than most other fatty bodies.

Butter is the fatty substance with which the globules of milk are formed. These globules do not freely float in this liquid; they are surrounded by a very thin membrane, which prevents them from joining together. When, by any process, they can be united, butter is formed. A butter well prepared must be of a fine yellow color, of a middling consistency, with a peculiar and slightly aromatic odor, and an agreeable taste. It must be easy to cut into slices.

The composition of butter seems to be very complex. M. Chevreul has demonstrated that this body contains five neutral substances, which are, *olein*, *margarin*, *butyrin*, *caprin*, and *caproin*. These fatty bodies, treated by alkalies, are saponified and transformed into oleic, margaric, butyric, capric, and caproic acids; the last three are volatile, and can be separated from the two others by distillation.

According to Heintz, butter contains ordinarily olein, much palmitin, a little stearin, and small quantities of neutral bodies giving by saponification myristic and butyric acids.

Butter dissolves in 28 parts of boiling alcohol at 35° C. (95° F.); it melts at 36° C. (96.8° F.). It becomes rancid very easily; this alteration can be prevented by salting or melting it.

Butter washed with warm water, cooled and pressed yields, by successive crystallizations in a mixture of alcohol and ether, a substance melting at 48° C. (118.4° F.), which presents the characteristics of margarin. The liquid fatty body extracted from butter by pressure is almost entirely formed of a substance different from olein, and is transformed by saponification into glyceryl oxide and a new acid, *oleo-butyric* acid.

The relative proportions of the immediate principles of butter vary under different circumstances; however, the following composition has been assigned to it:—

Margarin	68
Butyrolein	30
Butyrin Caprin Caproin	2

Bone Fat

The grease contained in the bones of the sheep and the ox is a very useful material for soap, saponifying in the same manner as tallow, though making a softer soap, its melting point being much lower. It usually contains many impurities; that extracted from fresh bones finds application as a very fine lubricator for machinery.

To produce this fat, the bones are broken, as much as possible in a lengthwise direction. Where large quantities are worked up—as in bone-kilns—they are crushed by passing them through iron rollers. The crushed bones are then put into a kettle, partly filled with water, and heated to the boiling point, which causes the fat to float on the surface, where it is skimmed off with a flat iron-spoon and passed through a sieve, which retains the solid particles. When it is noticed that no more fat separates, the bones are taken out, by means of a large perforated shovel, and replaced by fresh ones, so that the water may be used several times.

The fat thus obtained is generally of a brownish color and of an unpleasant odor, and when cooled off, congeals to a grainy, smeary consistency, and retains some water, which may be separated by remelting and settling.

The soda soap made with bone fat is not very solid, but with a suitable quantity of linseed or hempseed oil and potash lye a soft soap is made, which after some little time shows a very fine so-called natural grain derived from the crystallized stearic and palmitic acid potash soap.

In several places still another kind of bone fat is yielded, in the process of making glue. This fat is at the ordinary temperature liquid like oil, and has a dark brown color, which, however, does not pass over into the soaps boiled therein, but by salting passes down into the sub-lyes, so that a nearly white soap is yielded, which is not very hard. Hence it is customary to mix it with other fats, palm oil, tallow, etc. This fat often contains from two to three per cent. of lime, most likely lactic acid lime, which is soluble in fat oils.

This lime causes the fats boiled in the soda lyes to become spongy, and can only be separated by adding culinary salt, and then with difficulty. To avoid these troubles, the lime should be separated, which can very easily be done if the fat is worked with a sufficient quantity of water containing sulphuric or muriatic acid. Whether or not such a fat contains lime, can be ascertained, if a sample thereof is mixed with a solution of oxalic acid and well stirred. If lime be present there appears after a little while a liquid, which becomes muddy by the formation of oxalate of lime; in the other case the water which is under the oil appears, after separating from the oil, entirely clear.

HORSE FAT.

This fatty body, though repulsive on account of the careless manner in which it is prepared from the carcass, is yet, when extracted from the recently slaughtered animal, a very suitable and good material for the manufacture of common soap, the product with soda lye being white and of good consistency.

The appearance of this fat varies according to the organs from which it is taken, and the care given to its production. It is either solid, forming a real tallow, or it is more or less of the consistency of lard, and is generally of a dirty-white color.

The horse fat which appears in commerce, and which comes from slaughtered horses, and appears to be produced with more care, of course deserves in many respects the preference. It is almost odorless, of a yellowish tinge, of the consistency of butter, and yields just as white and solid soap as pure tallow or bleached palm oil, and does not impart to the clothes washed therewith that disagreeable smell which they acquire from the common horse fat soap.

GLUE FAT.

In making glue from hides, tendons, etc., much fat is collected which if well prepared can be usefully employed in making soap. As found in commerce glue fat contains a large amount of lime and other impurities, which can, however, be extracted with dilute sulphuric acid. When the fat is boiled in a five per cent. solution of sulphuric acid for about an hour, the lime and other impurities are carried down with the water, the clear grease floating on the surface whence it can be ladled off. This sebacic acid will then make with soda lye with or without rosin a good and firm soap, useful for all domestic purposes. It should be boiled, for in the Swiss or cold soaps it would not answer so well.

NEAT'S FOOT OIL.

If this product were abundant it could be usefully applied in making soaps of good quality, but it is generally used for dressing leather, for which it is admirably adapted. It is prepared by boiling in water the feet of cattle deprived of flesh and sinews, and removing the grease which floats upon the surface. It is of a greenish-yellow color, and if fresh has no odor, is limpid at ordinary temperatures, becoming solid in the cold. It forms with soda lye a very fine white soap partaking of the nature of the fat, being somewhat soft, olein being the largest constituent of the oil.

KITCHEN FAT.

The refuse fat of families, hotels, restaurants, etc., finds a very useful purpose in soap manufacture, and when it is systematically collected and properly purified becomes of much value. It is, however, often of inferior quality, being soft, green, and limpid, and in this state is termed weak stock. In this condition it may be much improved by boiling with salt and alum, but a much better mode would be the purification with dilute sulphuric acid, a process often mentioned in this treatise.

We deem the utilization of this and other refuse greases and fats of so much importance that we shall give a special section more fully explaining it.

Fish Oils.

In this category are classed the oils from a very numerous variety of animals many of which are not, strictly speaking, fishes. The oils of commerce are extracted from whales, seals, porpoises, and many kinds of fishes, and are almost always designated by the name of the source, as whale, seal, cod-liver oil, etc. Many called train oils are extracted from the seal, herring, etc.

Train oil has a specific gravity of 0.925 to 0.930, and is principally composed of common olein with palmitin. Its peculiar smell originates from valerianic acid, glyceryl oxide, and a substance which is considered to be a combination of a special acid, viz., dolphic or phocenic acid, with glyceryl oxide.

Various means are applied in purifying the bad smelling and dark colored train oils. Shaking with milk of lime, with diluted potash or soda lye, culinary salt, and copperas is common, as well as filtering with wood ashes. According to Davidson, train oil should be shaken with a decoction made of oak bark, then have mixed with it 4 parts of chloride of lime (bleaching powder) stirred into 12 parts of water, permitting it to clear off, when a thick whitish mass will be separated, and add diluted sulphuric acid to settle the lime which becomes free. We are convinced, by experiments which we have made on a large scale, that this means is by far the best of all those used for disinfecting, since train oil loses by this treatment the greater part of its disgusting smell, so that such train oil unsaponified appears almost odorless. But nevertheless the smell reappears when the train oil is changed into soap. Hence train oil can only be used in manufacturing very common soaps, or by mixing small quantities of it with other fats.

Cod-liver Oil

is obtained from three species of fish, viz., from the torsk (*Gadus callarias*), the say (*Gadus carbonarius*), and the shark

(*Gadus pollachius*); in France, according to Gobeley, from the livers of *Raja batis* and *Raja cavata*. It has been proposed to term the first sorts Morrhua oil, and the latter Raja oil. The shark livers furnish the oil but slowly; they must therefore be cut up into pieces and boiled down. The say livers, as well as the torsk livers, when thrown into water have a great portion of their oil to flow out spontaneously; that of the latter is a thinner liquid but somewhat darker, while that of the former is lighter but of a thicker consistency. All livers are finally boiled down, and furnish ordinarily the common cod-liver oil, which, however, never possesses the disagreeable smell of common train oil.

The main bulk of cod-liver oil is likewise composed of palmitic acid (11 to 16 per cent.), oleic acid (70 to 74 per cent.), and glycerine (9 per cent.); furthermore of a peculiar substance, called *gaduin*, a body of the nature of a weak acid, small portions of lactic acetic acid, valerianic acid, gall substances, iodine, phosphorus, sulphur, traces of bromine and inorganic salts. By shaking up with water the dark cod-liver oil becomes somewhat lighter, since a part of the pigment substances are dissolved. Diluted sulphuric acid causes the separation of brownish flakes; concentrated sulphuric acid causes the train oil to become of a brown color.

Train oil has the property of dissolving large quantities of colophony, without thereby changing its consistency, *i. e.*, not becoming a thicker liquid. Rosin being usually much cheaper than train oil, this peculiarity has been utilized for the purpose of adulterating it. Such an adulteration is, however, easily detected by placing the suspected train oil in a flask with an equal volume of alcohol, and shaking it, when the rosin will be completely dissolved. When left to settle, both liquids separate into two layers, of which the lower is the train oil. By keeping a record of its original volume we may conclude how large a quantity of rosin had been added, making an allowance for a small portion which had been dissolved in the alcohol.

Sometimes the fat of *salmo-phymallus*, known under the name of *ash-fat*, is brought into commerce in place of train oil. It is a mild yellow oil, which has a weak fishy smell, and is for making soap no less applicable than train oil.

OILS AND FATS OF VEGETABLE ORIGIN.

The vegetable oils applied to the manufacture of soaps are very numerous and valuable, and are found in the fruits, seeds, etc., of plants. They are usually termed fixed oils, and are generally limpid at ordinary temperatures; some, however, have more or less consistency, containing palmitin, stearin, etc., combined with the olein. All have a specific gravity less than water, or about 0.920.

We append tables of the usual vegetable fatty bodies employed in making soap, with their sources of production and their yield from the seeds, etc.:—

Fixed oils.	Vegetables which produce them.
Olive oil	Olea Europæa.
Groundnut oil	Arachis hypogæa.
Hempseed oil	Cannabis sativa.
Almond oil	Amygdalus communis.
Coleseed oil	Brassica oleracea.
Rapeseed oil	Brassica napus.
Cocoanut oil	Cocos nucifera.
Cotton-seed oil	Gossypium herbaceum.
Beechnut oil	Fagus sylvatica.
Cocoa butter	Theobroma cacao.
Hazel-nut oil	Corylus avellana.
Poppy oil	Papaver somniferum.
Ben oil	Guilandina moringa.
Laurel oil	Laurus nobilis.
Linseed oil	Linum usitatissimum.
Castor oil	Ricinus communis.
Camelina oil	Myagrum sativum.
Nut oil	Juglans regia.
Sunflower-seed oil	Helianthus annuus.
Sesamum oil	Sesamum orientale.
Pitch-tree oil	Pinus abies.
Pine oil	Pinus sylvestris.

Etc. etc.

The following table gives the quantities of oils which may be extracted from the vegetables:—

100 parts in weight.	Oil extracted.	100 parts in weight.	Oil extracted.
Nut	40 to 70	Euphorbium	30
Castor	62	Wild mustard	30
Hazel-nut	60	Camelina	28
Cress	56 to 58	Woad	29 to 36
Sweet almonds	40 to 54	Gourd	25
Bitter "	28 to 46	Lemon-tree	25
Black garden poppy	56 to 63	Onoporde acanthe	25
Radishes	50	Epicea seeds	24
Sesamum	50	Hempseed	14 to 25
Linden	48	Linseed	20 to 30
Earth-nut	43	Black mustard	15
Cabbage	30 to 39	Beech	15 to 20
White mustard	36 to 38	Sunflower seed	25
Turnip	33.5	Apples	15
Plum	33.5	Grapestone	14 to 22
Coleseed	36 to 40	Horsechestnut	8
Rapeseed	35 to 40	Olive	12 to 20
Cotton-seed	20		

Physical Properties of Oils.—Fixed oils, at the ordinary temperature, are nearly always liquid; some however, such as palm oil, cocoanut oil, etc., are more or less consistent. They are also more or less mucilaginous, with a feeble taste, sometimes disagreeable. Some are colorless, but generally they have a sight yellow tint; some are of a greenish-yellow color, and this color is due to a peculiar principle they hold in solution. Their specific gravity is less than that of water, all floating on this liquid, but it varies.

OLIVE OIL

is perhaps the oldest known and used for the purpose of making fine soaps, and possesses all the best characteristics for the purpose, making a firm white soap having an agreeable odor. At ordinary temperatures it is fluid, but at a low degree of heat it congeals, the stearin crystallizing. It consists of about seventy-five per cent. of olein with twenty-five per cent. of stearin.

Olive oil being consumed as food in large quantities, there is much care taken to produce a fine quality for this purpose, and the best of the first and second pressing is usually reserved for table use. It is obtained from the ripe olives by submitting the crushed fruit to a pressure either between warmed iron plates, or heating the mass slightly, before putting it into the bags. The first oil is called virgin oil. The marc, being again steamed or heated, is submitted to the press a second time; this product is still a very good oil. At the third pressing the marc is often mixed with hot water, and when it is pressed the oil runs out combined with the water and some albumen and floats upon the surface, whence it is skimmed off. For an inferior oil the marc is thrown into vats and allowed to ferment; the remaining oil being liberated floats on the surface. This last oil is usually much colored and of unpleasant odor, but it is the oil usually applied in making soap. The resulting soap does not retain either color or odor, but is white and sweet.

The oil of manufacture, or *huile d'infer*, as the common oil is termed, is consumed in large quantities at Marseilles and elsewhere, to the amount of nearly four million gallons per annum, principally in manufacturing the Marseilles or castile soap, and, owing to its great value, it is the subject of much adulteration with other bland or sweet oils, principly nut oil, sesame oil, poppy oil, and cotton-seed oil. The detection of these sophistications is quite a difficult matter, although we give elsewhere some directions for that purpose.

Olive oil, though making some of the best soaps known to commerce, is now seldom used alone, the soap becoming when dry too hard for general purposes. It is now customary to add to it a certain quantity of hemp-seed, rape-seed, poppy-seed, or ground-nut oil, these oils being slightly drying oils and producing a softer soap, qualify the olive-oil soap in its consistency.

PALM OIL

may be considered next in importance to olive oil in the fabrication of soap, for which purpose it is consumed in vast quantities, in England especially, where it was first used. It enters into nearly all their best rosin soaps, and this admixture has given both character and popularity to English yellow soaps. It is also used advantageously in many soaps for toilet purposes.

It is obtained from the fruit of a species of palm, the *Avoira Elais* or *Elais guianensis;* according to others, however, from *Cocus butyracea*, as well as from an areca species. It is, however, not improbable, that all these plants produce similar vegetable oils. Palm oil is a product of the soil of tropical Africa and South America (Guiana); the Canary Islands, and also of some other regions. Owing to its general application in manufacturing soap it has become a very important article of commerce, a place to which it was assigned by dint of a remarkable connection of circumstances, and by the endeavors of the English government in the suppression of the slave trade. Since this traffic, by the measures taken against it by England—if not yet entirely suppressed—is much limited, the natives of those coast districts are compelled, in lieu of as heretofore trading in human beings, to pay for their necessary commodities, at this day, with some of the useful products of the African soil, including palm oil. The largest consumption of palm oil is in England, which country, in 1879, imported 147,993,216 lbs., but the consumption of it is also very great in Germany, France, and the United States. The different kinds in the market have various names; the *prima lagos* and *secunda lagos* being the most excellent; the former can be more easily bleached than the latter.

The fruits of these palms are of the size and dimension of a pigeon's egg, and contain a solid kernel under a fleshy cover. The palm oil is extracted from this latter, not from the kernel. For this purpose the pared flesh is boiled out in water, when the oil collects on the surface in a fluid state, and can easily be skimmed off. After cooling off it forms a reddish-yellowy fat of the consistency of butter, which melts at 29° C. (84.2° F.). Since the word oil is applied to designate the liquid fats, the name of palm *oil* is an improper one; palm butter would be more correct. Its smell is strong, but agreeably aromatic, and reminds one of orris root. As it appears in commerce, the palm oil is always more or less rancid, *e. i.*, it contains free sebacic acids, instead of being in the fresh state neutral with glyceryl oxide. The quantity of these free acids increases with age, and at the same time the melting-point rises: the dark orange-red color changing into lemon-yellow. Pelouze and Bendot found in fresh palm oil one-third, in that which melted at 31° C. (87.8° F.) one-half, in another sample, which melted at 36° C. (96.8° F.), four-fifths of its weight in free acid. In very old palm oil, Stenhouse found the melting-point 37° C. (98.6° F.).

From the tests made by Fremy and the above-mentioned chemists it was gleaned that this vegetable fat contains free oleic acid, a specific sebacic acid, palmitic acid, and some palmitin, *e.i.*, palmitic acid oxide of glyceryl. The latter can be obtained by pressing the palm oil at 10° to 12° C. (50° to 53.6° F.), and a second time at about 20° C. (68° F.) in large quantities, as a wax-like white mass, of which a sort of stearin candles can be made, while the yellow oil that flows off may be made into soap.

Since the reddish-yellow color of the palm oil is not destroyed during saponification, but remains in the soap, the oil must, if white soaps are to be manufactured, first be bleached. This is done, either by means of oxides, as muriatic acid, nitric acid, sulphuric acid, etc., alone or with permanganate or chromate of potassa, or by heating the palm oil to a certain degree. In all these cases the color will be more or less completely destroyed, without reappearing in the soap. It must, however, be observed, that the bleaching by means of oxidation generally, especially with sulphuric acid and chromate of potash, furnishes a better and a whiter oil, and is more easily accomplished, although more expensive, than the bleaching by heat. The latter requires, moreover, more attention in the managing of the process, and a greater loss (from three to four and a half per cent.) is entailed, than by the first method.

For the bleaching of palm oil by means of bichromate of potassa, a quantity of palm oil is melted at 60° C. (140° F.), and left standing over-night, so that all impurities may settle upon the bottom. On the day following, the clear oil is placed in a clean barrel and allowed to cool off to 40° to 38° C. (104° to 100.4° F.). At the same time a portion of water is heated to the boiling-point, and in this is dissolved a suitable quantity of bichromate of potassa. If for instance 1000 kilogrammes (2200 lbs.) of palm oil are to be worked, 45 kilogrammes (99 lbs.) of water are taken, and 15 kilogrammes (33 lbs.) of the bichromate of potassa are dissolved therein. After the solution has cooled off somewhat, pour in 60 kilogrammes (132 lbs.) commercial muriatic acid. This mixture of chromic acid salt solution and muriatic acid is now poured into the palm oil, which during this process is being well stirred. After a period of five minutes, the oil becomes dark-green, by separation of chromate or by formation of chrom-chloride, which by a continuation of the stirring entirely separates, or is retained by the water in solution. Should the oil not yet be sufficiently bleached, the operation should be repeated by using ¼ kilogramme (8.8 ozs.) bichromate of potassa and 1 kilogramme (2.2 lbs) muriatic acid, as before.

The bleaching of palm oil by the application of heat is more simple, but does not readily furnish such a clear oil as is required for some soaps. Here two things have to be observed: first, that the heat is not too much increased, because the oil might assume a disagreeable brownish color, which appears in the soap; secondly, that the oil is previously melted upon water, or at least melted at a moderate heat, and left to rest for a short time, and poured off as clear of all sediment as possible. If the latter, consisting especially of small pieces of fruit and of small imperfect fruits, is heated with the oils which are to be bleached, a good oil is never obtained. The temperature which is applied in this case varies, and some operators go as high as 160° C. (320° F.); but it is found that palm oil can be bleached thoroughly at 120° C. (248° F.), or as much as is possible by the process of heating. The contact of the air accelerates the process of bleaching; and palm oil is bleached the fastest and best in a kettle which is covered with a well-fitting lid, in which an iron pipe of 7½ to 10 centimetres (2.9 to 3.93 inches) thickness is inserted, which opens in the chimney of the fire space, of the kettle similar to the apparatus used by Grodhaus and Fink or Vohl, elsewhere illustrated, for the removal of the fetid vapors in the process of rendering old tallow. This has at the same time the advantage, that the sharp poignant smelling vapors are removed without any danger whatever, since it is performed at the lowest possible temperature without the oil becoming in the least brown, and the process is finished in from three to ten hours, according to the quantity. It is generally preferable not to bleach too large quantities at once, indeed there is rarely a saving of time; since a portion of 400 kilogrammes (880 lbs.) bleaches in four separate portions, *i. e.*, each time 100 kilogrammes (220 lbs.) easier and better than when all is taken at once.

The finishing of the bleaching process is best ascertained by placing from time to time a few drops of the oil upon a porcelain plate, and thus comparing their color. As soon as it is observed that the succeeding drops are no longer of a different shade of color than those preceding, the operation is considered finished.

In cooling off the bleached oil, great care must be taken in adding water to it, for if it is not performed with the greatest care, an explosion may ensue. It is more judicious to add a portion of formerly bleached cold oil, until the temperature has sunk below 100° C. (212° F.), when, without the least danger, water may be added to hasten the cooling off, so that the oil may be drawn off into wooden vessels.

If carefully conducted the palm oil thus bleached possesses either a light yellowish color, or it is of a greenish hue probably emanating from a small quantity of copper from the kettle. The soap boiled from it is not entirely white when fresh, but assumes whiteness after being a short time exposed to the light.

By the bleaching of palm oil, not only the color of the oil and the glyceryl oxide are decomposed, but the palmitin also while losing 1 equivalent of carbon and 1 equivalent of hydrogen is changed into palmitic acid which causes a loss of about 2.75 per cent. in oil, which by the bleaching with chromate of potassa and muriatic acid is avoided.

Palm oil is sometimes confounded with galam butter, shea butter, or bambuk butter, which has much similarity with it, possesses a dirty-white or reddish color, and melts at 30° C. (86° F.), readily becoming rancid, and in this acting similar to palm oil. The galam butter is the product of *bassia parkii*, a tree belonging to the saponaes species, growing in the interior of Africa. The others are, we believe, derived from the same source.

Palm Kernel Oil

has recently made its appearance in the market, and it is but a short time since it found application in the manufacture of soap. It is obtained by crushing and pressing the stony kernels which are contained in the fruit of the *avoira elais*. In the raw state it has an almost coffee-brown color and a peculiar cocoa-like fragrance. Before its application to the making of soap it must be bleached. To do this, the following recipe will answer: 50 kilogrammes (110 lbs.) of fat are well stirred with a rake in a sub-lye or in a solution of culinary salt of 26° B., at a temperature of 100° C. (212° F.). After this it is left to settle awhile, during which time the fat which has already lost considerable of its color, rises to the surface. It is then scooped off, warmed to 35° C. (95° F.) mixed with 1 kilogramme (2.2 lbs.) of crude muriatic acid and a solution of ¼ kilogramme (8.8 ozs.) chromate of potash in water, and well stirred. On the following day the oil is reheated to 35° C. (95° F.), and again ¼ kilogramme bichromate of potassa and 1 kilogramme muriatic acid are added. The oil thus bleached, called in commerce palmitin oil, has a faint reddish tint and an agreeable smell similar to that of a mixture of palm oil and cocoa-nut oil, and in consequence thereof it may be used with good results for making the so-called Swiss soaps, also for colored toilet soap, which in this case is not subject to that disagreeable odor which cocoa-nut oil soda soap possesses.

Cocoa-Nut Oil.

Of this valuable oil three kinds are at present known in commerce, Ceylon, Sidney, and Cochin China oils, the latter being considered much the best—whether from a different species of palm or the care in its preparation is not known. These oils are obtained by boiling the ground or crushed kernels of the nuts of the *cocos nucifera*, the *cocos butyracea* and perhaps other species. Cocoa-nut oil is a white usually rancid fat of the consistency of lard with an unpleasant taste and smell; it melts at 20 to 22° C. (68 to 71.6° F.) and congeals at 18° C. (64.40° F.).

Tyndall made some experiments, and obtained by the operation, from 210 kilogrammes (462 lbs.), dividing the cocoa-nut kernels into portions of 3⅓ kilogrammes (7.33 lbs.) in pressing bags made of bast mats, various sorts of oil of steadily increasing melting points, after having five times increased the temperature of the masses which were prepared for pressing, viz.,

1	portion of	42⅞	kilogrammes	pressed at	14–15° C. (57.2–59° F.)
2	"	6⅝	"	"	18–19° C. (64.4-66.2° F.)
3	"	10⅝	"	"	24°C. (75.2° F.)
4	"	13⅜	"	"	29–30° C. (84.2–86° F.)
5	"	45⅝	"	"	40–41° C. (104–105.8° F.)

Together 119⅛ kilogrammes (262 lbs.)

The remaining cakes which were pressed out weighed 77½ kilogrammes (170.5 lbs.), the rest of 13⅜ kilogrammes (29.4 lbs.) was mostly oil which runs down from the press into a separate vessel. From this it is manifest that the kernels contain 60 per cent. or somewhat more, and probably two different fats, one fluid and one solid, which in the seed are separately present, but during the process of pressing become mixed with each other the higher the temperature becomes. So that, according as may be desired, the oil may be pressed out at first fluid, then firm or even of a medium consistency. In fact, by the above stated experiment the first and second portions were entirely liquid and translucent, the third half liquid and milky, the fourth firm and of a dirty-white color, the fifth pure white and very solid.

The solid fat which has received the name *kocin* was formerly deemed to be the combination of a specific acid, viz., kocin, cocoa-nut tallow, or cocoa-nut stearic acid, with oxide of glyceryl. Heintz, moreover, has shown that the latent acid which is contained in kocin combined with oxide of glyceryl is a mixture of two different acids, lauric and myristic, which is in the proportion of 14 parts of lauric with 3 parts of myristic acid, with 6 to 6½ parts of palmitic acid, and it has the same melting point as the hitherto presumed acid of kocin = 35° C. (95° F.). Myristic acid melts at 34° C. (93.2° F.), lauric acid at 44° C. (111.2° F.). The mixture has therefore a lower melting point than the average of the two acids. A similar action Heintz proved to exist in the case of palmitic and stearic acids. In cocoa stearine we hence have lauric and myristic acids of oxide of glyceryl.

The action of cocoa-nut oil in the process of saponification is peculiar, and quite different from that of tallow and other fats. The cocoa-nut oil soap can only be separated by concentrated solutions of culinary salt, and then becomes so extraordinarily hard that it cannot be cut. For this reason a clear boiling to the solid would in case of the cocoa-nut oil soap be entirely contrary to the end in view, and very difficult. While furthermore, tallow for instance treated with very strong lye floats above and then can hardly or not at all be saponified; in the case of cocoa-nut oil just the contrary happens. It does not form that milk-like mixture with weak lyes by which the process of saponification is usually preceded, but floats as a clear fat above, only when by a continued boiling and evaporation the lye has reached a certain strength, the saponification suddenly ensues. For saponifying cocoa-nut oil, lyes of such strength are used that the soap with the lye receives the intended contents of water, and a separation thereof becomes unnecessary. Of course the amount of the alkali must be so accurately calculated that the soap receives no excess of alkali, or at least but very little.

The highly disagreeable odor which is natural to cocoanut oil is retained by the soaps made from it, and thus far no remedy has been made known that is capable of removing it. Since the odorous matter is volatile, it seems feasible to remove it by heating. By an experiment made for this purpose this was accomplished only to a certain degree, but it is not impossible that by a still further continued and also increased heating, this purpose may yet be accomplished. The gradual addition of a little water to the heated oil seems also to operate efficaciously in the removal of the smell.

If cocoa-nut oil is slowly heated until it reaches 165° C. (329° F.) it develops a poignant rancid smell not unlike that of lacteal acid; the oil remains thereby colorless and obtains a high degree of limpidity. By continued heating to 240° C. (464° F.) and if this temperature is kept constant for a while, the fat loses the capability of immediately congealing after it cools off. Only after 24 hours a part of such oil becomes firm, which can be easily pressed out from the liquid mass, and it is very solid and entirely colorless. Perhaps this solid matter might in many cases be used to advantage in the manufacture of candles. After remaining for 40 hours exposed to the cold, the other part of the oil also congeals.

The properties of this article, as given above, are possessed in common by the Cochin China, Ceylon, and Sidney cocoanut oils; only the latter are, as a rule, of a somewhat softer consistency, and also less white in color, than that from Cochin China; nor does the saponification occur with each oil in the same manner, which probably is caused by the fact that by the pressing of the kernels the liquid and the solid fats are not always kept mixed in the same proportions.

GALLIPOLI OIL,

also called Illipe oil, or Bassia oil, is obtained from the seeds of *Bassia latifolia* and *Bassia longifolia*. It melts at 26° to 28° C. (78.8° to 82.4° F.); is, in its solid state, greenish-white, when melted yellow, and has a weak, not disagreeable smell.

Of late it has been much used in England and France for the purposes of soap manufacture.

ALMOND OIL.

This well-known oil, though making a very superior soap of a beautiful wax-like appearance, is too costly for any except the finest toilet soaps, and then it is generally mixed with equal parts of refined hog's lard. It is found in commerce of a clear yellowish-white color, and, if fresh, has no odor, and is of a pleasant, sweet, nutty taste. It is made by expressing the almond kernels, which are ground and steamed and placed under heavy pressure. The oil obtained is submitted to the action of steam-heat, the impurities subsiding with the condensed water; the marc is dried and powdered to make a useful toilet powder. Both the sweet and the bitter almonds are used for making the oil, the former containing nearly fifty per cent. of oil, while the latter have less than thirty per cent.

SESAME OIL.

This valuable oil, from the seeds of the *Sesamum orientale*, has many good properties for forming a superior soap especially adapted for the toilet, but generally in combination with other oils or fats.

The plant, originally indigenous to India, however generally thrives in warm climates, and is frequently cultivated as an oil plant. In India three varieties are said to be known, viz., with white seed, with partly colored, and with brownish-black seed grains; the latter furnishing the oil of commerce, and containing 40 to 50 per cent. The sesame seed comes in great quantities from India and Africa to Europe, to France, Germany, and England, where by pressing the oil is obtained. It is yellowish, in a pure state odorless and tasteless. When first pressed it tastes somewhat sharp, but this taste is soon entirely lost. If exposed to the air for some time it attains a hemp-like smell. The oil has a specific gravity of 0.923 at 15° C. (59° F.); at 8.° C. (46.4° F.) it congeals and assumes a consistency like palm oil; heated to 150° to 200° C. (302° to 392° F.) it becomes somewhat lighter in color.

Sesame oil finds a very extensive application as table oil, illuminating oil, and especially for soap-making. It is used in a similar manner to olive oil, and serves frequently for adulterating it. According to Pohl sesame oil, mixed with sulphuric acid, turns quickly to a brownish-red color, while olive oil attains a green-yellow or brownish-yellow hue; according to others the presence of sesame oil in another oil is perceivable by a stronger foaming, which becomes visible when the oil is left to descend in a thin stream from a height of 1.2 to 1.5 metres (47 to 59 inches). What influence the state of the seed, the age of the seed, and the manner of pressing have on the properties of the oil, has not yet been ascertained. Soda soap made from sesame oil always remains somewhat soft, and hence it is best applied for making soft soap, or added to fats making a hard soap.

Rapeseed Oil and Coleseed Oil.

This last named oil is acquired from *Brassica campestris.* The seeds give 40 per cent of their weight of a light, thinnish, limpid oil, whose specific gravity is 0.913. *Brassica napus* furnishes the so-called rapeseed oil, which has a peculiar smell. In all other respects these oils show congruous action, and are adapted for making soft soap. The soda soaps remain always somewhat soft.

Groundnut Oil.

This oil is obtained from the fruit of the *Arachis hypogæa*, a legumine plant. This small, creeping plant is indigenous to South America and the coasts of southern Africa and Asia. Since the later part of the last century it has been cultivated in our Southern States, and in Italy, Spain, and the southern parts of France.

The plant is small and has, like many plants of the same species, an inclination to twine around other objects. As soon as the fruit commences to form, the blossom-bearing stem has a particular inclination to creep into the soil. Blossoms which do not reach under the soil, remain either not bearing or the fruit does not ripen. In the cultivation of the plant, the main thing consists in taking care that all stems which have finished blossoming are covered with earth. In the wild state, the plant produces five or six pods or shells; but their number increases greatly in the cultivated state. The pods are 2½ to 3½ centimetres (0.97 to 1.36 inches) long, have one to three seeds in each, and have dirty-yellowish, leathery, rugged, lengthwise-raised shells. The fruit itself is longitudinally round, outside covered by a very thin, curly, brown skin; it is white similar to white beans, which it in taste also resembles, if the oily taste be not considered. When roasted it does not taste unlike the roasted almond, for which it is often a substitute. In Spain, its flour is mixed with the roasted fruit of cocoa, or it is used as a substitute for the latter. Its oil has a light green color, and does not seem to become easily rancid. It furnishes an excellent soap, which is firm, white, and odorless. Within the last few years, it has for this purpose been applied in Germany, France, and elsewhere with profit.

BEN OIL

is obtained from the seeds of the *Galandira moringa* and is very applicable in perfumery, it having the property of resisting rancidity better than almost all known oils. For this reason it is used in oiling clocks. The more solid parts are extracted by congealing the oil and the limpid oil used for this purpose. For soaps this oil has no advantages over sesame and some other oils, while it is usually much higher in price.

AVOCADO OIL

is an oil obtained from the oleaginous fruit of the avocada pear tree (*Laurus persia*), a native of Trinidad. It is very similar to palm oil in its action with the alkaline bases, but has less coloring matter, and forms a good soap without being bleached, but can be easily bleached to make a white soap.

SUNFLOWER OIL.

The oil from the seeds of the *Helianthus annuus* is a remarkably fine oil for the fabrication of soaps. It is a light-colored, sweet-tasted oil, and we think deserves especial attention, for if it were cultivated it might form a profitable material for many other purposes besides soaps. The soaps made from it with soda lye have a fine appearance, remaining plastic, and have the quality of retaining much water.

COTTON-SEED OIL,

now much used in soaps and to adulterate more costly oils, has many properties that recommend it to the soap-maker, besides its usual low price, and we give it a somewhat extended notice. It is extracted from the seed of the cotton plants, *Gossipium herbaceum*, *G. arboreum*, and other varieties. When deprived of their fibres the seeds are bruised, and heated up to from 75° to 88° C. (167° to 190.4° F.), and by pressure eighteen to twenty per cent. of oil is obtained, which has a dark-brown color. This oil has in its crude state at 12.2° C. (54° F.) a specific gravity of 0.931, after being washed in a jet of steam of 100° C. (212° F.), 0.934 at 10° C. (50° F.). The raw cotton-seed oil smells and tastes, and is otherwise, except in color, similar to linseed oil, and it can be substituted for it for many purposes. The raw oil congeals at —2° to —3° C. (28.4° to 26.6° F.), and is most excellently suited for furnishing hard and soft soaps. The so-called refined cotton-seed oil, the best quality of which is fully equal to the lower qualities of olive oil as to smell and taste, congeals between 2° and 0° C. (35.6° and 32° F.), and its specific gravity at 16° C. (60.8° F.) is 0.926 to 0.927.

In large quantities the oil appears reddish, while in smaller quantities it is more or less of a dark dirty-yellow. If a few drops of cotton-seed oil are placed in a test glass and mixed with a solution of chloride of zinc, it will become dark brown, while rapeseed oil becomes golden yellow, and olive oil green; pure sulphuric acid turns it instantly dark red-brown. Rapeseed oil treated in the same manner becomes green, and olive oil assume a light orange-yellow. Perchloride of tin turns cotton-seed oil into a thick translucent mass of orange-red color, while rapeseed oil thus treated will become green, and olive oil greenish-blue, but neither of these two will thicken. Phosphoric acid colors cotton-seed oil under ebullition to a golden yellow; rapeseed oil treated in the same way turns whitish-blue, olive oil bluish-green. By means of these reactions, it is easy to ascertain whether cotton-seed oil has been used in adulterating rape-seed oil or olive oil.

The better grades of cotton-seed oil are frequently mixed with expensive oils, and there are many firms in England and the United States who refine cotton-seed oil, of which enormous quantities are sent to Italy, to serve in the adulteration of olive oil. The loss caused by the process of refining is between twelve and fifteen per cent.

The *modus operandi* of this refining is at present not generally known. Although Pohl had the following process for refining patented, yet it seems to us, that it cannot be rational. According to this process the seeds are crushed between iron rollers, and pressed in iron presses, whereby a dark crude oil and an excellent oil cake are obtained, which latter is very useful for feeding cattle. 100 parts of the crude oil are mixed with 12 parts of a mixture which consists of a solution of potash of 42° B., a solution of tartaric salts of 42° B., and milk of lime of 10° B. This solution is to be mixed with the heated, almost boiling oil, the entire mass stirred for a period of two hours, and then allowed to rest for twenty-four hours, when the oil will have lost its dark color and may be filtered. After filtration, and after the oil has been nearly drawn off, there still remains a residue with some oil, which is boiled for two hours with ten per cent. of strong salt water. The oil rises to the surface, and can, when the residue has become firm, after a little while be poured out, and then applied in the usual way to make a good soap. (See formulas for these soaps.)

Castor Oil.

This oil is extracted from the seed of the shrub *Ricinus communis*, either by pressing in the cold way, or, as is frequently done in this country, by a slight roasting and crushing of the seeds and boiling in water, whereby the oil gathers on the surface, when it is skimmed off, and by heating is freed from water and afterwards filtered. If the seeds are at first pressed while cold, and afterwards moistened with alcohol, and pressed out a second time, about 30 per cent. more oil is obtained. This is a pale yellow, nearly odorless, and a very thick liquid; its specific gravity is 0.954. In the cold it congeals slowly. While fresh it is odorless and of mild taste; exposed to the air it soon becomes rancid; by shaking it with water and calcined magnesia this rancidity can be removed. In small portions it slowly dries when left exposed to the air. In the saponification ricinus oil furnishes three acids: 1st, the stearic ricinic acid, which melts at 74° C. (165.2° F.); 2d, ricinic acid, at 22° C. (71.6° F.); and 3d, the acid of oil of ricinus, which melts somewhat below 0° C. (32° F.). Ricinus oil has the property, when saponified with soda, of furnishing transparent soaps; but for this purpose the lye has to be entirely free from other salts or carbonic acid. It is particularly suitable for toilet soaps.

Poppy-seed Oil.

Extracted by expression from the seeds of the *Papaver somniferum*. When pure it resembles olive oil in its appearance and taste. It is nearly colorless, or of a yellow color. Its specific gravity is 0.9249 at 15° C. (59° F.). It solidifies at —17.7° C. (0° F.). The concrete oil sometimes retains this state at —2.2° C. (28° F.). It becomes rancid with difficulty. It is soluble in 25 parts of cold, and 6 of boiling alcohol; it mixes in all proportions with ether. It is very siccative. It has nothing of the narcotic properties of the poppy.

To effect its extraction, break the capsules as soon as they have experienced a certain degree of desiccation. Separate the seeds, and sift them so as to get rid of the dirt; reduce them to a kind of flour, which is put into coarse cloth bags, and submitted to the action of the press. The oil is collected in earthen jars and allowed to rest; then decanted and put into barrels.

Before the introduction of sesame and earthnut oils into the fabrication of Marseilles soap, this oil was used in a certain proportion for the fabrication of marbled soap. The reason for such an addition was that olive oil alone gave too hard a soap; an addition of from 10 to 20 per cent. of black poppy oil attenuated the strong consistency of the soap and rendered it more unctuous and soft, and it retained its water much longer.

HEMPSEED OIL.

Extracted from the seeds of the cultivated hemp, *Cannabis sativa.* The composition of hempseed varies a little according to the specimen, as may be seen by the following analyses:—

Oil	33.6	35.65
Organic matter	23.6	51.31
Nitrogenized matter	16.3	
Lignin	12.1	
Mineral substances	2.2	7.39
Water	12.2	5.65
	100.0	100.00

When fresh, hempseed oil is of a greenish-yellow color; it becomes yellow with time; its odor is disagreeable, and its taste sickly; its density equals 0.9252 at 15.5° C. (60° F.). It thickens at —15° C. (5° F.) and concretes at —27.5° C. (17.5° below 0° F.). It is soluble in all proportions in boiling alcohol, but requires 30 per cent. of cold alcohol to dissolve it.

The process for obtaining it consists, the same as with all the other oils, in reducing the seeds to flour, submitting the latter to the action of the press, and purifying the oil obtained with sulphuric acid, or with caustic alkali. It is used in the fabrication of soft soaps, of green soaps, especially when this fabrication is carried on in winter, because it can be submitted to a very intense cold without solidifying. It is also added to castile soaps to keep them softer.

NUT OIL.

Extracted from the walnut, fruit of the royal nut tree *Juglans regia.* The oil recently extracted is fluid, nearly colorless, with a faint odor, and a taste which is not disagreeable. The oil of the second pressure is greenish, caustic, and siccative. The oil extracted from the unpeeled kernel has generally a greenish-yellow color.

Its specific gravity at . . 12° C. (53.6° F.) = 0.9283
" " . . 25° C. (77° F.) = 0.9194
" " . . 94° C. (201.2° F.) = 0.8710

At —15° C. (5° F.) it thickens, and at —26.1° C. (15° below 0° F.) it takes the consistency of a white mass.

The extraction of the oil must be made only two or three months after the fruit has been gathered. After separating the kernels and peeling them, they are crushed, so as to form a paste, which is put into bags and submitted to the action of the press. The oil which runs first is called virgin oil, and is used as an aliment; the residium is moistened with boiling water, and is pressed anew; this second oil is reserved for manufacturing purposes. Nuts give about 50 to 60 per cent. of oil. This oil enters into the composition of green soaps; it is employed also for lighting.

BEECH-NUT OIL.

Extracted from the fruit of the beech (*Fagus sylvatica*). This oil is of a light-yellow color, with a peculiar odor, a sickly taste, thick and muddy when first extracted; it is limpid, although a little viscous, after a sufficient rest. Its specific gravity is 0.9225 at 15.5° C. (60° F.); at —17° C. (1.4° F.) it congeals into a yellowish-white mass. It may be kept a long time without alteration, and, unlike other oils, it improves by age. It forms with soda a soap firm enough, but which remains plastic.

The kernels are reduced to a pulp, which is put into coarse cotton bags, and submitted to the action of the press; the resulting oil is stored in large jars, to allow it to deposit the mucous parts, and the oil thus refined is ready for the market. This process generally gives from 15 to 20 per cent. of oil.

CAMELINE OIL.

A drying oil of a light-yellow color extracted from the seeds of the *Myagrum sativum.* It has a peculiar taste and odor, and is much employed on the continent of Europe in combinations for fabricating soft soaps, for which it is well adapted, as it tends to make them clearer. Its specific gravity is 0.926; it congeals at 0° C. (32° F.).

MUSTARD-SEED OIL.

This oil, abundantly produced in making table mustard, is extracted from the seeds of the *Sinapis nigra* and *Sinapis alba*, is a valuable oil for many purposes besides soaps. The white mustard yields about 36 per cent. of oil, the black about half that quantity. The soap from this oil is of a superior quality.

COLZA OIL,

obtained from the seed of the *Brussica campestris* to the amount of nearly 40 per cent. of its weight, is a very fine oil much used on the continent of Europe as a lamp oil. It makes an excellent soap with soda lye.

HAZEL-NUT OIL,

made from the nuts of the *corylus avellana*, which are very rich in oil, yielding nearly 60 per cent., is a very fine oil of a pale-yellow color, analogous to almond oil, for which it is often substituted in perfumery and pharmacy. It also makes a beautiful soap, though too costly for general use.

LINSEED OIL

is obtained, as is well known, from the seeds of the flax plant, *Linum usitatissimum*, by pressure and the aid of heat. These seeds furnish in their dry state from 25 to 30 per cent. of oil, which possesses a beautiful yellow color and a peculiar smell. It is rather limpid, and even at a very low temperature does not congeal. Beside the liquid glyceryl-oxide combination, it contains a small portion of palmitin. Exposed to the air, the oil dries to a tough mass, which when entirely dry is insoluble in ether or alcohol. The olein of linseed oil is the combination of oxide of glyceryl with a peculiar acid, which in many of its properties varies from the oleic acid of other fat substances. This oil when exposed to the air very easily changes, and absorbs oxygen rapidly. Oxidized oleic acid, if treated with alkalies, furnishes dark colored soap. Fresh linseed oil saponified with soda makes a soft soap of a light-yellow color, of which, by adding culinary salt, solid soda soap may be obtained. If this is exposed in thin layers to the open air, it will become dry and yellow. After a few weeks it may be dissolved in water mixed with soda and salt. If this process be repeated, the liquid receives an almost black hue, a yellow soap will be the result, which in a great measure contains only palmitic acid, while the oleic acid has been destroyed; by decomposing with muriatic acid, a brown substance separates.

OLEIC ACID, OLEIN, COMMERCIAL RED OIL.

The oleic acid which is found in commerce is obtained as an auxiliary product in the fabrication of stearic and palmitic acids for making stearin acid candles. As by this process the solid acids are never completely separated from the oleic acid, it contains more or less stearic acid or palmitic acid.

Pure oleic acid is a liquid as clear as water, scentless, and tasteless, of an oily consistency, and does not redden litmus paper, either by itself or in alcoholic solution. It is not soluble in water, but with alcohol and ether is easily mixed. At 4° C. (39.2° F.) it congeals into a white crystalline mass. By dry distillation it passes over but little altered into the receiver, and it may be distilled by the steam bath without any decomposition. By mixing with hydrate of potassa, oleic acid is divided into palmitic and acetic acids; at the common temperature it absorbs a large amount of oxygen, but a much more rapid absorption takes place at 100° C. (212° F.), when the oleic acid assumes a yellow or brownish color, becomes rancid with acid reaction, and loses the power to congeal at a lower temperature. Nitric acid changes the oleic acid in a short time into elaidic acid.

The common oleic acid of commerce, which has suffered more or less from the changes caused by the influence of the air, is brownish-yellow or brown, rancid with acid reaction. It makes a difference, whether the oleic acid was obtained by saponification of the fat with lime and separation with sulphuric acid, or by the process of the so-called acīdy saponification and distillation. The latter is generally rejected by soap manufacturers for the production of soda soaps, and is, therefore, much cheaper than that obtained by the process of saponification with lime in the fabrication of stearic acid. According to Stas, the natron soap, produced from distilled oleic acid, does not retain as much water as soap made with the oleic acid made by the saponification of lime. According to Buff, the former possesses a sharp disagreeable smell, and its potash soap has not the property of becoming soluble in potash lye. This is the case, only when oleic acid has been distilled at too high a temperature. It is to be questioned, whether a stream of steam and a temperature of 250° C. (482° F.) are sufficient to volatilize the sebacic acids, which have already been separated by sulphuric acid, viz.: whether stearic and palmitic acids do not require a higher degree of temperature, for their separation from the oleic acid and their volatilization, and furthermore, whether the oleic acid, separated by sulphuric acid from glycerine, has not been already so changed that it will act differently from that which has been obtained by the saponification of lime.

The soap manufacturer has, therefore, always cause to observe the difference in the two kinds of oleic acid, which are in commerce, and to direct his attention to a possible adulteration of the oleic acid with the cheaper kind. The small quantities of sulphate, which will be formed, cannot be injurious to the soap, since the applied alkalies, as potash or soda, already contain large quantities of sulphate.

In the fabrication of soap oleic acid serves principally in producing soft or potash soaps, especially the so-called *elain soaps*, for which equal equivalents of potash and soda with the necessary amount of oleic acid are boiled. But there is also a solid olein soap made, as will be described hereafter. Accurately speaking, caustic alkalies would not be required in order to change oleic acid into soap, since it combines easily with the carbonated alkalies. But in fact there would be very little gained by it, for by the mixing of oleic acid with the solutions of carbonic acid alkalies there ensues such a strong ebullition of the mass, owing to the escape of the carbonic acid, that the lye can only be added in small portions. This is troublesome, and takes much more time than if the alkalies are applied in the caustic state. Besides this, soaps which are made with carbonate of soda always retain a spongy quality, which is not desirable to consumers.

We have seen above, that oleic acid, when melted with hydrate of potash and moreover with an overplus of it, will be dissolved into palmitic and acetic acids. According to theory there are thereby originated, from 100 parts of oleic acid, about 90 or 91 parts palmitic acid. Since the latter has almost the threefold value of oleic acid, while this by its change into palmitic acid loses only 10 per cent. of its weight, it would be of great advantage, if it could be changed in a cheap and easy manner into palmitic acid. Such an operation is proposed by Juenneman, who describes it in the following way: In the cover of a modern vat, several vessels of stone are so applied, that not only the cover upon the vat, but also the vessels of stoneware fit tightly; on the bottom a serpentine pipe is fixed which conveys the steam. The oleic acid is now poured into the stoneware vessels and 10 per cent. of common nitric acid is added, then steam is admitted through the pipe into the vat (it is best to apply surcharged steam) and the mixture is thereby heated to 100° C. (212° F.), then one per cent. finely powdered starch flour is gradually added; an operation by which in the first place the formation of palmitic acid is intended, which, às we have already stated above, changes the oleic acid into the solid elaidic acid, being isomeric to it. A strong ebullition insues, the mass being stirred for about one hour, is kept at an equal temperature, then ladled over into another vat, and with sufficient water by means of steam, boiled out. Thus the oleic acid has become a light yellow mass, which melts at 45° C. (113° F.), *i. e.*, elaidic acid. It is then placed in a copper kettle, with an equal weight of hydrate of lime added thereto. This kettle of copper is inserted in an iron kettle, from the sides of which it must have a space of 5 centimetres (1.95 inches), the space between is to be filled with melted paraffine; into one of the kettles a thermometer is inserted, which for the security of its scale, is surrounded by a pipe made of copper. The hydrate of lime is made by sprinkling caustic lime with boiling lye of potash, whereby the lime is reduced to a fine powder, which must be used at once. Now, the outer kettle is to be heated, until the elaidic acid contained in the inner kettle has reached a temperature of 220° to 230° C. (428° to 446° F.), which heat is to be retained, while constantly stirring with an iron ladle, for seven or eight hours. Then a sample is taken out, in order to ascertain, by analysis with diluted sulphuric acid, whether all the fat has been changed into palmitic acid. As soon as this is the case, the fat is transferred into a suitable apparatus for distilling, and distilled after adding the requisite quantity of sulphuric acid and a stream of surcharged steam.

That which passes over is pure palmitic acid, a firm, white mass, which melts at 62° C. (143.6° F.), and can be applied to manufacture the so-called stearic acid candles of prime quality. This product, however, has not yet found practical application.

Although soap manufacturers do not require the pure palmitic acid, they can make use of it, to mix it with a suitable proportion of oleic acid (3 parts oleic acid, 2 parts of palmitic acid), thus reëstablishing the original proportion of the liquid to the solid acid, and for obtaining a mixture of sebacic acids, from which fine and solid soaps may be produced.

VEGETABLE TALLOW.

By this name a fat, which is pressed out of the seeds of *Brindonia indica*, is known. The seeds give 75 per cent. of their weight in fat of a grayish-white color, and of the consistency of common tallow, with which it has much similarity. This product can be purified and bleached by treating it with about one-half per cent. of concentrated sulphuric acid, previously diluted with water. After sufficient influence of the acid is had, it is removed by washing it out. With soda vegetable tallow makes a hard, white, and odorless soap. It is thought that this article might be profitably used for manufacturing soap.

SHEA BUTTER OR GALAM BUTTER.

A vegetable fat which has only recently been introduced into commerce. It is of the consistency of butter, and of a gray or greenish-white color, and is obtained from the dried and bruised seeds of *Bassia parkii*, by boiling them in water, and by skimming off the rising fat. Its melting point varies from 23°, 24°, 29° to 35° C. (73.4°, 75.2°, 84.2° to 95° F.). Shea-butter furnishes a very hard and white soap, which lathers but little, but for its first mentioned peculiarity might be used with good results, to make solid soaps from weaker sorts of fat.

BUTTER OF NUTMEG OR OIL OF MACE.

Extracted from the kernel of the nutmeg, fruit of the nutmeg tree, *Myristica aromatica*, *M. officinalis*, *M. moschata*.

Pure butter of nutmegs has a pale yellow color; its odor and taste are strong and sweet; it is composed of—

Concrete oil, similar to tallow	43.07
Yellow butyrous oil	58.08
Volatile oil	4.85
	106.00

By pressure, in filtering paper, and by repeated solutions, and crystallizations in ether, a solid matter is extracted from the butter of nutmeg, called *myristin*. Submitted to distillation it yields about one-eighth of its weight of volatile oil.

The nutmeg contains two oils, one volatile, and the other fixed and concrete; the first is a whitish-yellow, lighter than water, with an acrid and pungent taste, and an odor of nutmegs; the second is white without taste and odor. It gives by analysis:—

White insoluble substance (stearin)	24.00
Butyrous insoluble colored substance	7.60
Volatile oil	6.00
Acid (by approximation)	0.80
Fecula	2.40
Gum	1.20
Ligneous residuum	54.00
Loss	4.00
	100.00

The mace or outside envelop of the nutmeg contains also two different oils, one fixed and the other volatile. This butter is principally prepared in Holland in the following manner: Fresh nutmegs are crushed in a mortar and are slightly heated until reduced to a paste; they are then introduced into cotton bags, and pressed between metallic plates previously heated.

Tallow of Virola.

Extracted from the fruit of the *Myristica sebifera.*

This kind of vegetable tallow is found in commerce in the form of square masses, similar to cakes of soap, but not so long nor so thick. They are often covered with a kind of efflorescence of a nacreous appearance, which exudes in the same manner as benzoic acid. This tallow melts at 43° C. (109.4° F.), and is soluble in alcohol and ether. The mode of extraction consists in crushing the kernels and boiling the paste in water; the fatty substance separates and collects on the surface, where it solidifies on cooling.

Oil of Laurel.

Extracted by expression from the berries of the laurel of Apollo, *Laurus nobilis.*

The oil of laurel found in commerce is green, with a butyrous consistency, and slightly granular, similar in appearance to half-solidified olive oil. It contains a volatile oil which gives it a disagreeable odor. It melts by the heat of the hand at about 40° C (104° F.). Alcohol extracts from it the green coloring substance and the volatile oils; it leaves a colorless, concrete oil, similar to tallow. This solid part has received the name of *Laurine.* The fruit of the laurel contains two kinds of oils—one volatile, which resides in the pericarp; the other fixed, which is furnished by the kernel. The first is obtained by distillation, and the other by decoction. To obtain the concrete oil, the fruit is crushed and reduced to a paste which is boiled with water; the mixture is strained and pressed; the grease formed of a fixed and a volatile oil solidifies on the surface, and is removed and melted anew over a water bath to expel the water. It is kept in closed vessels.

Cocoa Butter.

Extracted from the *Cacao Theobroma* in the form of a whitish semi-solid grease. The beans yield nearly forty per cent. of oil, finding application in pharmacy as a vehicle for applying many drugs, and in perfumery for cosmetics. For soap it has not been largely used, though it would make a superior soap for toilet purposes.

CARAPA OIL,

or vateria tallow, is the product of the kernel of a species of personia, a palm-tree, met with in Bengal and Coromandel. It is of a bright yellow color, and known as pine tallow.

MALABAR TALLOW,

obtained from the fruit of the *Vateria indica*, is a white, wax-like tallow, melting at 35° C. (95° F.); it is natural to Mozambique, and but little known in Europe or the United States.

GOA BUTTER,

a fat from the seed of *Brindonica Indica*, is used by the natives as butter. It is white, of pleasant taste, and melts at 40° C. (104° F.); it is also used in medicine.

GRAPE-SEED OIL.

The seeds from wine lees yield about 10 or 12 per cent. of a pale-yellow oil that might be utilized for soap. It is now used in the countries of production as a table oil.

OIL OF TOBACCO SEEDS

has been used for various purposes. It is perfectly bland, and resembles poppy-seed oil.

OIL OF BELLADONNA SEEDS

is similar to that from the tobacco seeds, and is used in some parts of Germany as a lamp oil.

WAXES.

Beeswax.—Wax is the substance secreted by the bee, an insect belonging to the family of the *Mellifica*, order of the *Hymenoptera*. As it exists in the combs and after purification, wax is a solid fatty body, compact, of a yellow color, more or less dark, insoluble in water, soluble in fixed oils, in 20 per cent. of boiling alcohol and ether, and in spirit of turpentine; it has no taste; its odor is aromatic and similar to that of honey. Wax is dry, not greasy, to the touch, tenacious, yet brittle. Yellow wax melts at 62° C. (143.6° F.) to 63° C. (145.4° F.). Its sp. gr. is 0.9750. It burns without leaving any residuum.

There are two kinds of wax, the *yellow wax*, the properties of which we have just described, and the *white wax*, which is the bleached yellow wax. The white wax is obtained by melting the yellow wax and reducing it to thin plates, like ribbons, and exposing them to the sun and air for several days, until perfectly white. It is white, slightly diaphanous when thin, without taste, nearly without odor, hard and brittle at 0° C. (32° F.), and very malleable at 30° C. (86° F.); it becomes softer when heated; at 65° C. (149° F.) it is completely liquid, but it cannot be boiled without decomposition.

Like yellow wax, it is insoluble in water, partly soluble in alcohol, but dissolves very well in ether and in fixed and essential oils. Its sp. gr. is from 0.960 to 0.966. Its fracture is slightly granular; it sticks to the fingers when kneaded; it is inflammable, and burns with a white flame without leaving a residuum. Beeswax has but little application for soaps, though it is customary to add a little to the finest soap to improve its appearance and consistency.

Palm-tree Wax.—Produced by the *Ceroxylon audicola*, which is very abundant in New Granada. It is obtained by scraping the epidermis of the tree. The scrapings are then boiled in water, and the wax floats on the surface without melting. In a crude state it has the form of a gray-white powder. Purified by treatment with boiling water and alcohol, it is yellowish-white, but slightly soluble in boiling alcohol, and precipitates by cooling. It melts at 72° C. (161.6° F.).

Carnauba Wax is produced by a palm tree which grows abundantly in the provinces of the north of Brazil. To obtain it, the leaves are cut and dried in the shade, and soon the wax is separated in the form of thin scales which are melted. This wax is soluble in boiling alcohol and in ether; by cooling it crystallizes; it melts at 88.5° C. (191.3° F.); it is very brittle, and is easily reduced to powder.

Myrtle Wax is obtained by boiling in water the berries of several species of *Myrica*, especially the *Myrica cerifera*, a tree very common in the Southern States. These berries give 25 per cent. of their weight of wax. The crude wax is green and may be saponified. Purified by treatment with boiling water and cold alcohol, this wax is greenish-yellow, and melts at 47.5° C. (117.5° F.).

Ocuba Wax is obtained from a *Myristica* in the province of Para, and in French Guiana. This tree produces a fruit with a stone covered with a thick crimson pellicle, which colors water red. To extract the wax, the stones are crushed, reduced to a pulp, and boiled for some time with water; the wax floats on the surface. This wax is yellowish-white, soluble in boiling alcohol, and fusible at 36.4° C. (97.7° F.).

The wax of bicuyda, obtained from the *Myristica bicuyda*, is yellowish-white, soluble in boiling alcohol, and melts at 35° C. (95° F.). It is but little known to commerce.

ROSIN OR COLOPHONY.

With the name "rosin" we designate a group of bodies which appear in nature solid, brittle, and again in semi-solid substances; they are not soluble in water, but soluble in ether, alcohol, and sulphuret of carbon, they are rich in carbon, poor in oxygen, and free from nitrogen, and burn with a fuliginous flame. None of the rosins are a chemical elementary body, but, like all immediate matters furnished by the plant, a complicated mixture of substances. The integral components of rosin are the resinous acids, carbonate containing substances, which eject from carbonate of alkalies the carbon, and combine with the alkalies. Besides the abietic acids there are in the natural rosins volatile oils, gums, often cinnamonic acid and benzoic acid.

They are divided into three principal groups: 1st, common rosins; 2d, balsams; and 3d, gum resins. The latter are distinguished from the common rosins by their contents of gum. The balsams are generally solutions of rosins in volatile oils, or mixtures of volatile oils and rosin.

That the resins belong to the most extensive vegetable substances, is well known, and has been proved by numerous chemical experiments and investigations. These substances have been found in all classes of the vegetable kingdom, yea, even in the tissues of the fungi; also in all organs of plants, and in all known vegetable tissues their presence has been proved. All resinous matters are products of a so-called regressive metamorphosis of matter.

Notwithstanding the extraordinary distribution of the resins in the vegetable kingdom, the number of the plants which furnish applicable resins is proportionately small, and the number of the families to which these plants belong is also relatively limited. For soap manufacturers only that rosin has interest which is furnished by most of the *Pinus* species, and is presented in commerce under the name of common rosin or colophony.

The balsams of the *abies*, hence of the pines, firs, etc., are called turpentines. They originate partly in the bark, partly in the young wood of the trees. In the bark it seems to be prevalent in the pith, *i. e.*, the starch grains which are inclosed in the pith of the resinous fibres; while in the wood substance it appears to be the parenchyma which furnishes the material for the formation of rosin. The rosin, or balsam, ducts of the *abies*, wherein the turpentine often gathers in masses, and is conducted outside or to the wood substance, is found in all the trees of this family. They appear least in the bark, frequently though also in the wood substance, and originate either by transformation of entire tissue-cords or by separation of the respiration tissues.

Turpentine is the origin of the productions known as oil of turpentine, pine-tree rosin, black pitch, and colophony, and is especially produced in North America and Europe. The resin is either accidentally exuded, or the yield of rosin is the object of a planned operation of the rosin scraper or pitch maker, whereby the rosin is caused to flow from the trees by intentional incisions in the same.

The turpentine, which flows spontaneously from the trees and is dried by the atmosphere, contains but little oil; while the fresh exuded oil, on the other hand, contains almost all of its oil. If the turpentine is distilled with water, the oil passes over, and a rosin mass remains as a residue, the "boiled turpentine." If rosin is melted without water, until it becomes clear, then the colophony or rosin remains. All rosins destitute of oil, originating from turpentine, either by spontaneous exudation, or by distillation of the volatile oils, are as common rosins, despite their difference of origin, brought into one category, namely, the pine-tree rosin.

Up to the most recent period, it has been endeavored to prove the existence of several different abietic acids in rosin, *i. e.*, an amorphous combination, pinic acid ($C_{40}H_{60}O_4$), and another crystallizing in rhombic prisms, the sylvinic acid ($C_{40}H_{60}O_4$). According to Streaker the first is only the amorphous modification of the latter. According to the investigations of Laurent, French turpentine is said to contain a combination of great affinity with sylvinic acid, which he called pimar acid; and, according to Unverdorben, there is in colophony a specific abietic acid, which originates from the sylvinic acid by heating, viz., colopholic acid. But in opposition to this are the investigations of Maly, who in turpentine, in fir-tree rosin, and in colophony proves but one acid, to wit, the abietic acid ($C_{44}H_{64}O_5$), which in the substances named appears either as such, or is substituted by its anhydrite. The resinous trees form the anhydride. If this is exposed to the air, it is transformed by absorption of water into abietic acid. By melting the always crystallizing acid changes into its amorphous anhydrid. Fir-tree rosin contains, therefore, according to Maly, abietic acid; colophony, on the other hand, its anhydrid. The amorphous substance of the fir rosin is soluble in 72 per cent. of alcohol. It is an indifferent substance. It was formerly termed the *gamma* rosin or turpentine, in contradistinction to the two acidy combinations of the pine-tree rosin, which were formerly called alpha and beta rosins.

Besides its application in the fabrication of soap, common rosin finds varied uses. The most important of these employments are the manufacture of varnishes, lacquer, cements, brewers' and bottlers' pitch, and for lubricating wagons and machinery.

For the purposes of soap-making it is sometimes desirable to have a very light rosin. This may be attained by artificial bleaching. The rosin is melted in a kettle and allowed to settle until all dross has gathered on the bottom, which is performed in about half an hour. The clear rosin is scooped over into another kettle, and to each 100 pounds of it 20 pounds of salt solution of 9° B. are added. This entire mass is left boiling for one hour, when the fire is diminished. As soon as the boiling ceases, the rosin settles upon the bottom, and the salt lye separates as a brownish fluid on the surface. This salt lye is ladled out, the salt water renewed, and again boiled. If the rosin is not yet sufficiently discolored, the operation is repeated for the third time.

Rosin is employed as well in the fabrication of hard as of soft soaps; but never worked up alone, always in conjunction with some fats. Soap of pure rosin never becomes solid, but even for a soft soap it cannot be applied alone, inasmuch as it never attains the peculiar consistency which is expected of a good soft soap.

SECTION IV.

THE RECOVERY OF OFFAL AND OTHER REFUSE FATS AND GREASES.

It is a peculiarity of modern times, that science and industry are constantly endeavoring to utilize otherwise useless and rejected offal and refuse matters for various objects. This is a gain which should be all the more prominent, since it advances the national welfare, and also aids in the removal of such matters which, having become putrefied, infect the air with poisons which are often the cause of disease and epidemics. In the vicinity of large cities, establishments which attend in a rational manner to working up and utilizing the offal of organic nature, are a great blessing. Thus Paris has in its environs such manufactories on a grand scale. The largest and most important of them is the one of Souffrice & Co., at St. Denis. It would be very interesting to state here what a variety of things are manufactured in that establishment. In the year 1862 they began to utilize the remnants and the offal from the slaughter-houses, from which they drew a yearly yield of 120,000 francs ($24,000). The year following they gave their attention to the scum, dross, and dregs of the river Seine. In consideration of the vast advantages which this undertaking would have on the state of the public health, the Prefect of the Seine granted to this firm, for a nominal revenue, the sole yield accruing from the work of clearing the river of cadaverous and floating fats, as well as other stuffs injurious to health. In December, 1864, Souffrice & Co. undertook the removal of the putrid waters, the sweepings and the vegetable remnants from twenty-five public institutions of Paris. The vegetable refuse was purified by steam, and used for feeding hogs. In this way the firm mentioned was enabled to fatten 3000 hogs per annum. In December, 1867, they constructed two distilling apparatuses for the manipulation of the black residues of the refined rape-seed oil, and obtained thereby an annual production of 500,000 pounds of pure sebacic acids, which are a suitable ingredient for the manufacture of soaps. They furthermore purchased from the railway companies the old wheel grease, to obtain the fat contained therein, and paid for it annually 100,000 francs ($20,000). Besides the fats and sebacic acids, the chief product of the establishment is an azotic fertilizer. Of this, thousands of tons are annually manufactured.

THE YIELD OF OFFAL FATS BY MEANS OF SULPHURET OF CARBON.

For the recovery of fat from refuse matter the introduction of sulphuret of carbon has wrought a great service, since by its aid it has become possible to extract fat from such substances as contain but small portions of it, and which by further pressing will no longer yield it. Some time ago Deiss had his aim directed to it, and applied the sulphuret of carbon in the manner indicated. Thus he extracted fat from the black tar-like residues, which are yielded by the distillation of fats in the stearine manufactories, from the sawdust which had served for the filtering of oil, from the dirty remnants, which were formed by refining the oils with sulphuric acid, from wagon grease, and from oily polishing rags.

The residuum of the distillation of fat which, by a faulty saponification, often contains upwards of twenty per cent. of fat, must, before the treatment with sulphuret of carbon, be mixed with sawdust in order to enhance the filtration of the dissolved fat.

The sediment from the treatment of oils with sulphuric acid often contains fifty per cent. of sebacic acid. In order to gain this the residuum is treated by washing out the sulphuric acid with hot water, then dried, mixed with sawdust and extracted. The sawdust, which is used for filtering oil, still yields with sulphuret of carbon, even after being pressed as much as possible, a further 15 to 18 per cent. of oil.

The old wagon grease is first treated with sulphuric acid, then washed and dried and finally extracted. Fatty rags are, without any further manipulation, at once treated in sulphuret of carbon. This treatment has a threefold advantage: the gaining of the fat, cleansing of the rags, so that they may again be used, and averting great danger of fire, which originates frequently from spontaneous combustion in heaping up these oily rags in the work-rooms.

For all the above mentioned purposes benzine might also be used in lieu of sulphuret of carbon, but the latter has the advantage of possessing a greater power to dissolve fats. Besides this, it should be noticed that offals, which have been lying in dampness, and contain glutinous fat, cannot be worked up with benzine, while worked with sulphuret of carbon they furnish good results.

WOOL-FAT AND FULLER'S-FAT.

Already in the second decade of this century, Kurrer, von Westrumb, and others, had drawn attention to the fact that immense quantities of fat were lost from the washing vats of the cloth manufactories, spinning establishments, dyeing factories, etc., and they recommended that these losses be redeemed. In the washing of the wool must also be estimated the sebacic acid, which the not unimportant quantity of soap furnishes, and is requisite for the process of scouring, as well as the comparatively high amount of the wool yolk or suint. The oldest method for the utilization of the fatty substances of the soap waters, consisted in leading the water running from the washing-tubs into especial cisterns, mixing it there with milk of lime, then letting it settle until it had cleared off. After removing the liquid above, the slimy sediment was taken out, strained through coarse canvas for removing the sand, hair, etc., and well dried. The slime having assumed a doughy consistency, it was straightened out into pieces of the size of half a brick, and dried in the air. The dry pieces, called "suinter," from the French word "suint" (wool-sweat) were then dried in retorts, for the fabrication of illuminating gas. This manufacture of *suinter*, as simple as may appear its manipulations, requires great space and appointments. The drying of the limy fat masses, which can only be accomplished in thin layers, proceeds in damp weather but slowly, and is during the winter season only manageable in artificially warmed and ventilated localities. To this must yet be added, the slow settling of the fatty masses, but loosely combined with lime, and the difficulty, on account of the ever varying amount of fat of the soap-water, to guess the right proportion of the precipitation. Either too much or too little lime may be applied, and hence suffer in the first case disadvantage for the fabrication of illuminating gas, in the latter case great loss of the sebacic acid. For this reason this method of fabrication has been abolished, and the fat is at present gained from the rinsing waters by decomposing the same with sulphuric acid. A compact, creamy mass is separated, which is mainly composed of sebacic acids, and, according to its respective origin, is either called wool-fat or fuller's-fat. By the first appellation is designated the fat obtained from the offal liquids of the wool-washing establishments, while the soap-waters of the cloth manufactories, dyers' establishments, etc., furnish the fuller's-fat. From the suint, potash is now obtained in France in paying quantities.

For recovering these offal fats, the following process is pursued: The soap-water is put into reservoirs of pine wood. Such a reservoir, which is 2.70 metres (8.85 feet) long, 1.73 metres (5.57 feet) wide, and 1.57 metres (5.15 feet) deep, holds up to the filling level 7000 litres (1849 gallons). Sulphuric acid is added, and, in order to hasten the separation, steam is admitted for a period of from one to two hours. The use of sulphuric acid depends, as is self-evident, on the amount of alkali contained in the soap-water; but a little surplus is always allowed, since by it a quicker and more complete separation, and in consequence thereof a more solid refined mass is obtained. On an average 50 pounds of sulphuric acid of 66° B. are sufficient for a complete separation of 7000 litres of soap-water, and furnish 390 to 410 pounds, on an average; hence 400 pounds of fat substance, according as this is allowed time to drop off into the filtering basins. The filtering vessels consist of baskets, which are filled with coarse hemp cloth. When now the caseous doughy mass is amply drained of water, by filtration, and has reached the requisite plastic consistency necessary for forming it into pressed cakes, it is wrapped up in hemp cloths, and in the usual way laid between plates in a hydraulic press, and, at first cold, somewhat later with admission of steam, pressed until the complete exhaustion of the liquid contents is reached. In the press cloths remains thereby a solid residuum about one-half of the mass which had been taken, while an equal mass of watery fat runs into the reservoir. The latter quantity reduces itself likewise by the various operations of the refining process to one-half of its weight, whereby a yield of 25 per cent. of salable wool-fat from the pressed mass, *i. e.*, 7.1 grammes (0.25 oz.) per litre (2.1 pints) soap-water may be accepted as the mean value of fabrication.

The crude aqueous fat contained in the press reservoirs yet needs the purifying and draining of water. For the purpose of purifying, the fat is placed in iron tanks of 3½ feet diameter and 5 feet in height, which are inserted into iron housings. According to the greater or lesser purity of the fat the fifth or fourth part of its volume of water and from 2 to 3 per cent. of its weight of sulphuric acid of 66° B. are added, and heated by a direct introduction of steam to a moderate boiling, and kept up for one hour. Thereupon the steam is cut off, the mass allowed to settle for a few hours, and then the lower dull and slimy stratum is drawn off. The liquid drawn off is replaced by a like quantity of pure water, and with it boiled up moderately in order to remove the sulphuric acid traces. Now the whole is allowed to deposit, and, after removing the watery stratum, the clear mass of fat is then drawn off. The fat thus gained is still very aqueous. For removing the water the fat is put into kettles in which pipes, either of iron or copper, and of a spiral shape, are placed, and through these serpentine pipes the steam vapors circulate and evaporate the water.

Frequently the wool-fat is bleached before draining, because it receives a better appearance, and thereby a correspondingly increased commercial value, and is, moreover, freed from its disagreeable smell. The bleaching is performed in wooden vats, which are lined inside with lead, and provided with a stirring apparatus as well as with a heating serpentine. The bleaching liquid is composed of a solution made acid by sulphuric acid and chromate of potash—3 parts of sulphuric acid of 66° B. to one part of chromate of potash—of which, in most cases, a small quantity produces the desired result. In the first place the deoxidized fat is placed in the vat while it is yet warm, and heated while the diluted acid is added under constant stirring (in small portions) on account of the ensuing ebullitions of the chromate of potash, which is to be diluted in threefold its weight of water. The temperature must during the entire operation—which lasts one hour and a half—not exceed 56° C. (132.8° F.). After standing several hours the bleached fat mass settles on the surface. Thereupon the watery salt containing liquid is removed, washing the fat afterwards with pure water, and after the removal of the wash-water the stratum of fat is taken off, which, by heating with indirect steam, is then freed from water.

If fuller's-fat is heated and permitted slowly to cool off in vessels, a separation of a solid and liquid mass takes place. In order to attain this the fat is heated to 75° C. (167° F.), placed in large vats of 2½ to 3 feet diameter, and 6 to 10 feet high, and its temperature slowly decreased to 9 to 12° C. (48.2 to 53.5° F.). To attain the most perfect separation possible, the cooling off must be effected very gradually, otherwise the solid sebacic acids are only kept suspended in the liquid mass as a curd, which is difficult to separate from the liquid mass. By a careful operation the sebacic acids separate on the sides and bottom of the vat in crystals. The liquid part may be drawn off by means of a spigot in the bottom of the vat. The solid masses are then pressed out in order completely to remove the oily part. Such a process of separation requires in the summer season—in case a cool cellar is not at disposal—from three to four weeks; during intense winter coldness it may become necessary to surround the vessels for crystallization with non-conductors of heat, thus to delay the cooling off. The liquid fat which is drawn off is called *wool-fat train.*

The value of the pressed residuum, as noted above is equal to 50 per cent. of the weight of the mass, and it may be stated that carefully mixed samples of different pressings in the manufacturing business result in the following composition:

Water	10.66
Fatty substances	34.74
Other organic matters	22.37
Fine sand	30.32
Soluble silicate	0.08
Sulphuric acid	0.28
Phosphoric acid	0.09
Oxide of iron and clay	0.99
Lime	0.25
Magnesia	0.10
Alkalies	0.12
	100.00

According to this, this material is very well suited for manufacturing illuminating gas on account of its great value in fat and other organic matter, of which the former furnishes per pound 9, the latter 7, cubic feet of illuminating gas. Since 100 pounds of gas-coal give on an average 500 cubic feet of illuminating gas, and 8 cubic feet of wool-fat gas have a lighting capacity of at least 10 cubic feet of coal gas, there will be no error in considering the press cakes as of equal value with good gas coal, especially if all other accessory circumstances are taken into consideration.

Inasmuch as in the pressed residuum, which represents 50 per cent of the mass, 34.74 per cent. fat substances are contained, therefore 17.37 per cent. of the total fat value of the manufacturing material have only a secondary value; hence the method just described is yet a very faulty one and capable of improvement. Vohl has therefore proposed to mix the soap-water with chloride of calcium, and to decompose the lime-soap thus produced by muriatic acid. He operates as follows:—

The soap-water is mixed with an aqueous solution of chloride of calcium as long as a caseous precipitate ensues. The lime-soap thus formed is separated by straining by means of large baskets, which are lined with hemp cloth (not too coarse), and then freed by letting drop off and pressing out the greater part of the water contained therein. The mass drained of its water is then placed in well-covered vats of 12 feet high and 4½ feet wide, and decomposed therein with a corresponding quantity of muriatic acid, which is as free as possible from sulphuric acid. By a direct introduction of steam the decomposition is accelerated, and the separated sebacic acid kept liquid. The gases which during the decomposition of the infused steam vapors are developed, pass through a cooling worm of cast iron, which empties into a tightly closed iron box. The latter contains slaked lime, and is, by means of a pipe conduit, connected with the heating apparatus of the steam-boiler. By this apparatus all noxious gases and vapors are completely destroyed. After the decomposition of the lime-soap has been completely effected, the mixture is left for six hours to rest, and then, by means of a spigot in the bottom of the vat, the solution of chloride of calcium is drawn off, which in turn is again applied for a new precipitation. The fat mass is now again mixed with one-half of the quantity of diluted muriatic acid of the proportion used for decomposition, and for one-half to three-quarters of an hour steam is again passed through. Thereupon the steam is cut off and the entire mass is left at rest. Three strata have now formed, one lower aqueous sour liquid, one upper clear stratum of fat, and one middle emulsion-like stratum, consisting of fat and diluted acid. The clear diluted acid is now drawn off, without, however, allowing the emulsive stratum to pass off with it. The emulsion causes great difficulty in the separation of the sebacic acids from the watery liquid.

The sebacic acids are then either freed from water, and at once brought into the trade, or they are previously bleached. For draining off the water the emulsified oil stratum is either heated by the addition of culinary salt over an open fire (in case of a common kind of fat), or (for better sorts of fat) with indirect steam. This latter mode of heating is applied especially when the soap-waters originate from the scouring or boiling of silk, or from Turkey-red (Adrianople red) dyeing establishments; hence in greater part being the result of olive-oil soap.

For bleaching purposes a solution of sulphuric acid mixed with chromate of potash is used. When separated and washed, the yet warm sebacic acids of the lime soap are placed in the vats (with the emulsion stratum), and while being diligently stirred the bleaching liquid is added, and the mixing kept up for half an hour longer. After resting six hours the bleached sebacic acids are, in a great measure, separated; the green aqueous liquids being drawn off they are washed once or twice with warm water. After the wash water has been removed the oil emulsion is drawn off. The clear fat mass is then at once drained of water. The emulsive stratum is mixed with 10 to 15 per cent. of *canadol* (a kind of benzole), whereby an immediate separation ensues, and the canadol is again separated by distillation. This treatment of the emulsified stratum with canadol takes place only after five or six bleaching operations, that is when sufficient material has accumulated to fill a distilling apparatus. The canadol regained can always be used again for renewed operations. In this manner the sebacic acids recovered from the silk-scouring and Turkey-red dyeing establishments are of a light yellowish color, and possess but a faint odor.

Vohl has not, we are sorry to state, communicated the results of his experiments, so that a comparison between his and the usual method of operation is impossible. It is known, however, that chloride of alkalies cannot be completely removed from sebacic acids by washing with water. From this fact reason is found for objections to Vohl's method. Vohl attempts to remedy this difficulty by the partial application of canadol.

The wool-fat, as usually brought into the market, is a solid, tough, dirty, yellow-brownish mass, which is difficult to remove with the spade from the casks in which it is packed for transportation. It finds application in the manufacture of soaps, and in the fabrication of lubricators. For soap-making it serves principally in the preparation of rosin soap; but soap-boilers do not much like to work it on account of its inferior yield, which is explained by its chemical composition. Fuller's-fat forms a thick oily mass, and is a much more valuable fat, as its price indicates, which is quoted at about double that of wool-fat. It likewise finds application chiefly in the fabrication of oils for lubricating and in the manufacturing of rosin soaps. These offal fats are never by themselves used for soaps; but always in combination with other fats, particularly palm oil or tallow, and especially with rosin, saponified. By using these refuse fats for lubricating materials, it is considered that they are not neutral, but contain free sebacic acids. It is therefore almost always more desirable to use them for soap.

Vohl in 1867 attempted to calculate the amount of soap used in the city of Cologne, and the loss of fat caused thereby, and reached the result, that that city, which at that time contained 120,000 inhabitants, lost annually by the soap used 1,200,000 pounds of fat. This calculation extends only to the soap consumed for private purposes. Establishments of industry, hospitals, and other public establishments are not considered in his calculation, so that the total loss in fat is really still higher. In consideration of the large amounts which this loss represents, and considering that the products of decomposition of the soap-water, which finds its way into gutters, culverts, etc., develop unwholesome miasma, Vohl proposed to collect the soap-waters even in private residences, and to deliver the same to the respective manufactories for working them up. This proposition, however, will for a long time to come remain naught else but a well-meant desire, and we must regard it already as a great progress, when those who possess a great quantity of refuse and offals containing an amount of useful materials, begin gradually to utilize them.

SECTION V.

THE ADULTERATION OF THE FATTY BODIES.

Fats and oils are subject to adulteration and falsification, particularly those of great commercial value, and generally with fats and oils of lower prices.

By exposure to the air they absorb oxygen and become rancid; some oils dry into a kind of varnish, and are called drying oils; the fats are adulterated with foreign substances to increase their weight.

We cannot here go into a general analysis of all these important materials, but will examine such as are in common use and most liable to sophistication.

Olive Oil.

Olive oil for the manufacture of soaps is ordinarily adulterated with cole-seed oil, cotton-seed oil, and poppy oil. These mixtures are sometimes disguised by coloring them green with indigo, so as to create the impression that green olive oil is present. The adulteration with black poppy oil is the most frequent, not only on account of the cheapness of this oil, but also on account of its sweet taste, and its odor being but little pronounced. We shall see hereafter the process for detecting these falsifications.

Oil of Sweet Almonds.

The oil of sweet almonds is principally falsified with poppy oil and with sesame oil. Several processes have been proposed for detecting this falsification.

Oil of sweet almonds becomes cloudy at —20° C. (4° below

0° F.), and solidifies at —25° C. (13° below 0° F.), while poppy oil begins to solidify between 3.9° C. (39° F.) and 6° C. (42.8° F.).

One part of aqua ammonia mixed with 9 parts of oil of sweet almonds forms a white soft soap, very smooth and homogeneous, if the oil be pure; on the contrary, it is clotted if it contains more than one-fifth of poppy oil.

RAPESEED OIL.

This oil is falsified with linseed, mustard, and whale oils, oleic acid, etc. Ammonia with pure oil gives a milk-white soap; and a yellowish-white soap, when the mustard and whale oils are present. Gaseous chlorine colors rapeseed oil brown, when it contains whale oil; if pure, it remains colorless.

SESAME OIL.

This oil is ordinarily mixed with earth-nut oil.

LINSEED OIL.

This oil is falsified with hempseed oil, and especially with fish oil. Pure linseed oil treated by hyponitric acid becomes pale pink; by ammonia, dark yellow, and gives a thick and homogeneous soap.

BLACK POPPY OIL.

This oil is often mixed with sesame and beech-nut oils. The pure oil is colored a light yellow with hyponitric acid, while beech oil acquires a pink color. Ammonia colors it a light yellow; the consistency is slightly thick, and the soap is a little granular.

HEMPSEED OIL.

The adulteration of this oil is always done with linseed oil. The pure oil treated by ammonia becomes yellow, thick, and granular.

Castor Oil

is generally mixed with black poppy oil. The adulteration is easy to detect with alcohol at 95° B.; a certain quantity of oil agitated with this liquid is dissolved and leaves the foreign oil as a residuum.

Neat's Foot Oil.

This oil is without doubt the most adulterated oil found in commerce; it is mixed with whale, black poppy oil, and olein.

Oleic Acid.

This acid is often mixed with rosin oil. The pure acid, treated with an acid solution of nitrate of mercury, yields a pale straw-colored foam; the rosin oil yields a very dark orange foam.

Palm Oil.

This oil has been mixed with or manufactured entirely of yellow wax, lard, mutton suet, colored with turmeric, and aromatized with powdered orris root, without any genuine palm oil. By treating the suspected oil with ether, all the fatty bodies are dissolved; the turmeric and orris root remain insoluble. By saponification the mixed or artificial oil takes a reddish shade due to the action of the alkali on turmeric. Sometimes powdered rosin has been mixed with it; this falsification is easily detected by treating the oil with alcohol: the rosin is dissolved while the oil remains insoluble

Cocoa-nut Oil.

The commercial oil is often adulterated with mutton suet, beef marrow, or other animal greases, sometimes also with the oil of sweet almonds and wax. The oil falsified by these substances does not completely dissolve in cold ether. The ethereal solution is muddy like that given by pure butter.

The oil thus falsified has a taste and an odor less agreeable, a color rather grayish than yellowish, and has less consistency. The melting point is the best method of ascertaining the purity.

Adulterated with greases or tallows the oil melts at 26° to 28° C. (78.8° to 82.4° F.); with oil of sweet almonds it melts at 23° C. (73.4° F.).

ASSAYS OF OILS.

Fatty oils are characterized by certain special properties, by which it is easy to determine their purity, or to know in what proportions they are mixed.

All retain in solution substances, which become colored under the influence of certain chemical agents. These substances may acquire a special coloration only by operating at a known temperature. The discoloration is about the same if we operate on oils of the same kind, obtained at the ordinary temperature, or at a higher temperature than that of the atmosphere.

By old oils, we understand those which, though prepared for some time, have been placed in good conditions of conservation. Olive oil, for example, placed for one or two years in a warm place, kept in a vessel half full, and exposed to the contact of the air, if tested in a certain manner, is colored like the oil of sesame. This discoloration indicates a decided alteration of the substance it holds in solution. This characteristic may be met with in the oil used in manufactures, never in that employed for food. The latter is generally colorless, or very little colored. By some other modes of testing, this oil behaves like one which has been well preserved, or has been recently obtained.

Several authors have spoken of coloration, but their processes to produce these colorations are difficult; besides, the colorations obtained are not characteristic enough to enable us to determine the purity of a commercial oil. We must understand by this name, the oil as it is usually prepared in the arts. The following processes are easy of employment:

With the oil tried, a coloration ought to be produced similar to that assumed by the same kind of oil placed in similar conditions. If there is a mixture, the coloration obtained will be proportional to the volume of each oil in the mixture.

We know that fatty oils are formed of fatty acids, and glycerin; that these combinations are more or less stable according to the conditions of conservation of the oils; lastly, that by the nitrogenous substances they contain, substances which play the part of a ferment, the glyceric combinations are decomposed into glycerine and fatty acids.

If an aqueous solution of potash is made to act at the ordinary temperature on a *rancid* non-siccative oil, the fatty acids set free unite first with the potash; then the alkali has its action on the undecomposed compounds.

If the same oil, but *not rancid*, is treated in the same manner with potash, the alkali reacts at first on the combinations which in rancid oil are decomposed by the ferment.

If we treat a commercial oil at the ordinary temperature for thirty seconds, by a solution of potash, and afterwards if this mixture is acted upon by an alcoholic solution of bromine, this substance is absorbed by the fatty substance much quicker than if it had not been saponified. This absorption is assisted by a more complete saponification, and it takes place with a production of heat which varies for every kind of oil.

We shall now enter into some details in regard to the processes of assaying oils.

QUALITATIVE ASSAYS.

First Process.—It consists in allowing a mixture of warm aqueous sulphuric acid and concentrated nitric acid to react on oils for 30 seconds. The quantity of acid to be used varies according to the temperature at which the operation is conducted.

At 7° C. (44.6° F.), 8° C. (46.4° F.), 9° C. (48.2° F.), the quantities to be taken are—

1st. Sulphuric acid sp. gr. 1.80 to 1.84 (65° to 66° B.)	7	cub. cent.	(1.89 flu. dr.)
2d. Water	3	"	(0.81 flu. dr)
3d. Oil	4	"	(1.08 flu. dr.)
4th. Nitric acid sp. gr. 1.35 to 140 (35° to 40° B.)	3	"	

At 10° C. (50° F.), 11° C. (51.8° F.), 12° C. (53.6° F.), 13° C. (55.4° F.), 14° C. (57.2° F.), take

1st. Sulphuric acid	6	cub. cent.	(1.62 flu. dr.)
2d. Water	3	"	
3d. Oil	4	"	
4th. Nitric acid	3	"	

At 15° C. (59° F.), 16° C. (60.8° F.), 17° C. (62.6° F.), 18° C. (64.4° F.), 19° C. (66.2° F.), take

1st. Sulphuric acid	5	cub. cent.	(1.35 flu. dr.)
2d. Water	3	"	
3d. Oil	4	"	
4th. Nitric acid	3	"	

At 20° C. (68° F.), 21° C. (69.8° F.), 22° C. (71.6° F.), 23° C. (73.4° F.), 24° C. (75.2°), take

1st. Sulphuric acid	4	cub. cent.	
2d. Water	3	"	
3d. Oil	4	"	
4th. Nitric acid	3	"	(0.81 flu. dr.)

Measure in a graduated tube the sulphuric acid, which is introduced into a test-tube closed at one end, 20 centimetres (7.9 inches) in height, and 18 millimetres (0.70 inch) in diameter. Let the acid drain well, then, in the same tube, measure the water which is poured upon the acid, and mix quickly by shaking the tube. The produced heat ought to range from 44° C. (111.2° F.) to 48° C. (118.4° F.). Into this warm mixture pour the oil which has been measured in another graduated tube. Lastly, add the nitric acid carefully measured. Apply a sheet of India rubber to the opening of the tube and shake it strongly for 30 seconds, then dip it immediately into cold water, where it is left for five minutes. The oil collects at the surface of the liquid and begins to be colored. After five minutes, remove the tube and keep it in a vertical position where it is left to rest. Fifteen minutes after observe the coloration.

When the acid mixture is not warm enough, the earth-nut oil blackens very little or not at all; if the tube is not dipped into cold water, the brown coloration easily disappears and becomes dark-red. The reaction of the warm acid mixture on the coloring matter ought to be suspended by an immersion of five minutes in cold water.*

The following Table A gives the colorations taken by different oils.

Note.—It is important that the sulphuric acid should always be very concentrated (sp. gr. 1.80° to 1.84°).

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* The temperature which succeeds the best is from 16° C. (60.8° F.) to 17° C. (62.6° F.), in using 5 cub. cent. of sulphuric acid.

TABLE A.

OILS USED.	Temperature. 44.6°; 46.4°; 48.2° F.		Temperature. 50°; 51.8°; 53.6°; 55.4°; 57.2° F.		Temperature. 59°; 60.8°; 62.6°; 63.8°; 65.6° F.		Temperature. 67.4°; 69.2°; 71°; 72.8°; 74.6° F.	
	Oil.	Acid.	Oil.	Acid.	Oil.	Acid.	Oil.	Acid.
Virgin olive oil,	Dark nankin	Colorless	Pale nankin	....	Pale straw	....	Straw	....
Ordinary " "	Dirty-yellow	Greenish	Dark nankin	Colorless, or slightly greenish	Dark straw	Colorless, or slightly greenish	Straw	Colorless, or slightly greenish
Rancid " "	Dirty-yellow	....	Nankin, a little yellowish	....	Straw, yellowish shade the most often; dark straw	....	....	....
Sesame oil,	Red-brown	Strongly colored orange	Red-brown	Orange-red	Dark orange	Yellow, infusion of saffron	Orange	Yellow, infusion of saffron
Earth-nut oil,	Soot, or infusion of coffee	Very little coloration	Soot, or infusion of coffee	Very little coloration	Soot, or infusion of coffee	Slightly orange color, which disappears	Soot, or infusion of coffee	Slightly orange color, which disappears
Colewort oil, not refined,	Brown. In one quarter of an hour becomes red-orange.	Very little coloration	Red-orange, or red-currant	Colorless	Red-orange, or red currant	Colorless	Red-orange, or red-currant	Colorless
Colewort oil, refined,	Red-currant	Colorless	Red-currant	Colorless	Red-currant	Colorless	Red-currant	Colorless
Neat's foot oil,	Dark brown	Very little coloration	Dark brown	Very little coloration	Dark brown	Very little coloration	Dark brown	Very little coloration

FALSIFICATIONS OF LARD.

Alterations.—Lard exposed to the air in jars not well closed becomes rancid and turns yellow. If kept in copper vessels, or in earthen jars glazed with sulphide of lead, it may, by contact with the air, attack the copper or the glazing, and then contain stearate and oleate of copper or lead. The copper is detected by pouring on the grease a few drops of ammonia, which immediately becomes blue. A red coloration is given by a solution of yellow prussiate of potash.

Lead is detected by burning the lard, and carefully examining the residuum to see if there are any metallic globules. The residuum is then treated by nitric acid which dissolves the metal. Filter, and to the filtrate add sulphuric acid, which gives a white precipitate.

Lard may also contain an excess of water, which is ascertained by pressing and softening it with a wooden spatula; the water oozes from it in the form of drops. By melting it at a low temperature, the water separates from the grease.

Falsifications.—The principal adulterations of lard are the addition of common salt, the admixture of a grease of inferior quality, or that of a kind of grease obtained by the cooking of pork meat. Plaster of Paris is sometimes added.

The addition of salt is easily detected by digesting the lard with hot distilled water. The salt in the water is abundantly precipitated with nitrate of silver. The precipitate is white, soluble in ammonia, and insoluble in nitric acid; it becomes black when exposed to the light.

Plaster of Paris is detected by melting in warm water the suspected lard. If it contains plaster, this falls to the bottom in the form of a white powder. The inferior greases are often very difficult of detection; they are ascertained by the less white color of the lard and by a taste entirely different. The greases from the cooking of pork meat give to the lard a grayish color, a soft consistency, a salted and disagreeable taste.

FALSIFICATIONS OF TALLOWS.

Tallows are generally adulterated with greases of inferior quality. Water is also incorporated in them by a long beating. Cooked and mashed potatoes have been also introduced into them. Fecula, kaolin, white marble, sulphate of baryta, are also added to tallows. The principal adulteration is the addition of bone tallow; properly speaking, it is not a falsification, it is only a change in the quality of the product.

The mineral matters, the fecula, the cooked potatoes, are easily ascertained by dissolving the tallow in ether or sulphide of carbon. All the foreign substances remain insoluble, and their nature is then easily determined.

Iodine water, or the alcoholic tincture of iodine, will color blue the insoluble residuum, if it contains fecula. This fecula can be determined in the tallow by triturating the grease with iodine water and adding a few drops of sulphuric acid. The blue color will appear immediately if there be fecula.

For the mineral substances there is a process as simple as the above to ascertain their presence in tallow; it is to melt the tallow with twice its weight of water. The foreign substances are precipitated and the grease floats on the surface.

Instead of using ordinary water, the tallow may also be boiled for a few minutes with 2 parts of acidulated water for one part of tallow. The whole is allowed to rest in a test glass, or in a funnel placed over a water-bath, kept at a temperature of about 40° C. (104° F.), so as to prevent the too rapid cooling of the tallow, and to give time to the impurities to separate and deposit. Iodine added in this last treatment will disclose the presence of fecula or starch.

To ascertain the presence of water, knead dried powdered sulphate of copper with the tallow (half its volume of the powder). If there be much water, the mixture will take a blue color, if the tallow is white; and greenish, if the grease is yellowish. As for the quantity of water added, the only way to ascertain it is by drying a sample in an oven.

FALSIFICATIONS OF WAXES.

The yellow and white beeswax are adulterated, 1st. With *earthy substances, flour of sulphur, yellow ochre, calcined bones;* 2d. With *resins, pitch;* 3d. With *amylaceous substances, flour, starch, etc., sawdust;* 4th. With *fatty substances, tallow, stearin, paraffine, stearic acid;* 5th. With *water.* Let us examine in turn these different adulterations.

Yellow Wax and Sulphur.—Projected on a red-hot piece of iron, such a wax disengages an odor of sulphurous acid.

Yellow Wax and Yellow Ochre.—This falsification is ascertained by melting the suspected wax in warm water. There forms at the bottom of the vessel a yellow precipitate, which, dissolved in hydrochloric acid, gives a liquor in which a few drops of yellow prussiate of potash will produce a precipitate of Prussian blue. Instead of melting the wax in water, it may be dissolved in spirits of turpentine, ether, or benzine; the wax alone will be dissolved.

Yellow and White Wax and Calcined Bones.—This fraud is also ascertained by the fusion of the wax in warm water, or its solution in spirits of turpentine, ether, etc. The substance which falls to the bottom of the vessel in the first case, or the insoluble part in the second, is treated by warm hydrochloric acid. The acid liquor gives, by the addition of ammonia, a white precipitate of phosphate of lime, which, after a complete washing, becomes yellow by the addition of a drop of nitrate of silver.

Wax and Resins, Pitch, etc.—The presence of these substances in wax is ascertained by the following characteristics:—

1. The wax sticks to the teeth when chewed; pure wax does not stick. The taste betrays the foreign substance; the wax is viscous, and its color and odor are different.

2. Treated by cold alcohol, this reagent dissolves the resin, the wax being but slightly soluble or nearly insoluble. The alcoholic liquor being evaporated gives resin for a residuum.

3. Treated by 3 or 4 drops of sulphuric acid, it gives, by operating on the liquefied wax, a red coloration; the wax in

solidifying takes a violet shade. This reaction is very precise, and enables us to detect 1 per cent. of resin; however, in this last case, the resin has a greenish shade.

Wax and Starch or other Amylaceous Substances.—The presence of starch is ascertained by Delpech's process, by dissolving the wax in spirits of turpentine, which does not dissolve the starch or other amylaceous substances. To detect starch, boil the wax with water, and test, by an alcoholic tincture of iodine, the cold and clear liquor. A blue color indicates the presence of starch. The wax may also be treated by warm water acidulated with 2 per cent. of sulphuric acid. The starch is transformed into dextrine and remains in solution, leaving the wax to cool and solidify. By weighing the latter, the difference in weight gives the proportion of starch.

Wax adulterated by fecula is less unctuous and less tenacious than pure wax; by striking it, it divides into small fragments; its color is a tarnished yellow. It does not entirely dissolve in spirits of turpentine, and leaves a white deposit easily detected by the tincture of iodine.

The introduction of flour into wax is also practised, some samples containing as much as 68 per cent. A wax containing 10 per cent. of flour takes a bluish shade by standing in iodine water. A wax adulterated by 23 per cent. of flour falls to the bottom of the water; pure wax floats on the surface of this liquid.

Wax and Tallow.—Wax adulterated by tallow is ascertained, first by the taste and disagreeable odor; it is less brittle, and more unctuous to the touch.

Thrown on red-hot coals, this wax disengages a disagreeable odor, and gives a thicker smoke than pure wax.

The variations in the melting point enable us to ascertain the adulteration. This process is precise enough, since it enables us to detect one-eighth of tallow in the wax.

SECTION VI.

THE CHEMICAL EQUIVALENTS APPLICABLE TO SOAP.

By equivalents the chemist understands—to maintain the simplest example—the certain equal values of the different acids, which are requisite to produce with a certain amount of weight of a base a solid chemical combination; just in the same manner as if we chose a certain acid for a departure. In the first case, we would, for instance, require for 47.11 parts in weight of potash, 40 parts weight of sulphuric acid, 54 parts weight of nitric acid, 36.4 parts weight of muriatic acid, 75.0 parts weight of tartaric acid, 51 parts weight of acetic acid, etc., all these acids supposed to be free from water, in order to produce the corresponding neutral salts of these acids with potash. The acids are therefore according to the stated parts weight *equivalent.* To neutralize 40 parts in weight of sulphuric acid 47.11 parts weight of potash, 31.0 parts weight of soda, 17 parts weight of ammonia, 28 parts weight of lime, 76.5 parts weight of barytes, etc., would be requisite. Here the bases are according to the stated weight amounts equivalent. In what manner these calculations have been ascertained does not pertain to this treatise.

Entirely in the same manner correspond the various sebacic acids, which are applied in the making of soap, respecting their combinations with the oxide of glyceryl, that is, the fats themselves; and it would according to our conviction be a very great progress in the production of soap, if here too, as is done in the making of salts from one acid and one base, for the fixed amount of sebacic acid, the fixed amount of alkali would be applied. Many will probably shrug their shoulders in a contemptuous manner, when reading this proposition, and state, that the correct proportions could be easier gained by experiment. But the author has been witness to the fact as to what this experimenting means. If for instance a want of alkali is ascertained, we add at random —since every support for a correct determination is wanting —a portion of lye. By the next test we find that the soap has too much "bite," *i. e.*, an overplus of alkali, which is likewise to be abated at random, by adding more fat. Thus it changes alternately to and fro, till at last the true proportion is deemed to have been found. Thus comes the trouble that we finally do not know what yield of soap may be calculated upon, for as a rule the fat which is added for correction is never weighed into the kettle, and thus all control of the work ceases. By using the equivalents all uncertainty vanishes at once, and the corresponding necessary amounts of fat and alkali can be ascertained with the same security in advance, as if the point in question had been to neutralize a certain quantity of alkali by sulphuric or nitric acid. The other is even easier, since a little overplus of alkali in the case of soap does not matter, and by natron soap is removed by the cutting of the pan with salt, but in case of soft soaps it becomes very necessary. The advice which we here desire to impart to soap manufacturers is not merely founded upon tests made on a small scale, but upon experience gained by experiments in the working up of fats into soaps on an extended scale. It is the result of an experience which is frequently made in every-day life, that even errors are upheld with the greatest stubbornness by those who cannot be compelled to learn anything new. In our case it is for most of those concerned the difficulty of determining the strength of the lyes. And yet nothing is easier than this operation; but even if it were more difficult and required more time, these would hardly enter into consideration in comparison with the loss of time and other disturbances which are connected with the correction of erroneous proportions between fat and alkali.

The equivalents of fats which are used in making soap are among themselves not so different that in practice much consideration need be shown regarding this, although it may be somewhat different with the soaps which are manufactured from the same. The differences are in fact so insignificant, that, besides a small loss in alkali, it would not cause the least disadvantage, if for that fat, which for its saponification requires the least amount, just as much alkali were taken, as if we had to do with a fat, which for its saponification required the greatest amount of alkali. What alone is to be the matter of consideration in this case is, from the outstart, the requisite quantity of alkali, but on no account a surplus, or, in other words, it is to be ascertained in advance, how much fat of a given weight, to the lyes on hand, has to be taken to obtain the most possible neutral soap, so that every correction, be it of fat or be it of alkali, becomes superfluous.

The neutral soaps contain for 1 equivalent of sebacic acid 1 equivalent of caustic potash, and according to this proportion the quantity of alkali must likewise be measured when, in place of sebacic acid, the neutral fats are to be saponified.

Inasmuch as we now know the composition of the neutral fats—they are almost without exception combinations of 3 equivalents sebacic acid with 1 equivalent of glycerine, the former composed one-half of oleic acid—so their equivalents too may be easily calculated, and we find thus the threefold equivalent

For Tallow: Tristearin . . $C_{114}H_{110}O_{12}$
Trioleïn . . . $C_{114}H_{104}O_{12}$

$$\frac{C_{928}H_{214}O_{24}}{2} = C_{114}H_{107}O_{12} = 887$$

For Palm Oil: Tripalmitin $C_{102}H_{98}O_{12}$
Trioleïn . . $C_{114}H_{104}O_{12}$

$$\frac{C_{216}H_{202}O_{24}}{2} = C_{108}H_{101}O_{12} = 845$$

For Cocoa-nut oil: Trilaurin $C_{78}H_{74}O_{12}$
Trimyristin $C_{90}H_{86}O_{12}$
Trioleïn . . $C_{114}H_{104}O_{12}$

$$\frac{C_{282}H_{264}O_{36}}{3} = C_{94}H_{88}O_{12} = 748$$

For Oleic Acid . . . . $C_{114}H_{104}O_{12}=$ 884

Since these figures represent the threefold equivalents of the respective oils, we hence need for their saponification 3 equivalents of alkali; of natron 93 parts in weight, and of potash 104.76. For the equivalent weights, for instance 100 kilogrammes (220 lbs.), of those fats and of oleic acid, we would therefore require—

For Tallow:	10.50 kg.	(23.1 lbs.)	soda or	15.87 kg.	(34.91 lbs.)	potash
" Palm Oil:	11.00 "	(24.2 ")	"	16.66 "	(36.65 ")	"
" Cocoa Oil:	12.44 "	(27.37 ")	"	18.82 "	(41.40 ")	"
" Oleic Acid:	10.52 "	(23.14 ")	"	15.92 "	(35.02 ")	"

Whereas a small overplus of alkali is not only not harmful, but really enhances the saponification of the fats, we may without any hesitation to 100 parts of neutral fat take 12.0 or 12.5 parts soda, and for soft soaps 16 or 17 parts of potash, of which it is always demanded that they "bite" strongly. An addition is allowed of 2 or 3 of fluid as an overplus; if the soap contain cocoa-nut oil, proportionately more.

From the above it evidently follows that a fat furnishes the more soap, without regard to the changing contents of water, the more alkali the respective sebacic acids demand for their saturation or saponification. The most productive according to this is cocoa-nut oil; the least soap furnished is by tallow.

SECTION VII.

SAPONIFICATION—THEORETICAL, CHEMICAL, AND PRACTICAL.

SOAP, in common parlance, means that in common use for various purposes, and is a chemical compound resulting from certain constituents derived from fats, oils, and greases of various kinds, both animal and vegetable, with certain salifiable bases, which, in the kind of which we write and called detersive soaps, are potash and soda.

Chemists apply the name of soap to any compound of the fatty acids with a base: thus we have lead soap, used in pharmacy, and called diachylon plaster. Zinc soap is also used in medicine and in painting. Lime, magnesia, tin, copper, mercury, silver, and gold are made into soaps that find various uses in the arts. Of all these we have but little to write except of lime soap, which has great importance in the fabrication of stearic acid for candles. These processes will, however, be treated of in our section on candles.

Caesium and rubidium (oxides of) may also be used in forming soaps having the properties of a potash soap; but, as these two alkalies have thus far been found in nature in but limited quantities, they cannot have any application to our art.

Before Chevreul made known his researches, it was supposed that fats and oils formed a combination with alkalies. He, however, explained that fats, when saponified and again separated, had properties quite different from those existing before saponification, and showed that fats and oils are compounds of peculiar acids, stearic, palmitic, oleic, etc., non-volatile substances, while fats which have a peculiar odor have in addition to these acids volatile fatty acids, as butyric, valerianic, etc., and they were all combined with a sweet principle known as glycerine.

Berthelot held and proved that all the fats and oils used in the fabrication of soap are ethers of glycerine $C_3H_8O_3$, that substance being viewed as a trivalent alcohol $\left.\begin{matrix}C_3H_5\\H_3\end{matrix}\right\}O_3$. Palmitin, for instance, the principal constituent of palm oil, is glyceryl tripalmitate, that is, glycerine in which three atoms of hydrogen are replaced by the radical of palmitic acid $\left.\begin{matrix}C_3H_5\\3C_{16}H_{31}O\end{matrix}\right\}O_3$. Stearine (tristearine) and oleine (trioleine) have an analogous constitution. When the fats, palm oil for instance, are saponified with caustic alkalies, say caustic soda, the fat, that is the ether, is decomposed into alcohol, *i. e.* glycerine, and the palmitate of sodium, *i. e.* the soap, is formed, according to the following equation:—

Tripalmitin $\left\{\begin{matrix}C_3H_5\\3C_{16}H_{31}O\end{matrix}\right\}O_3$ and caustic soda $3NaOH =$ glycerine $\left.\begin{matrix}C_3H\\H_3\end{matrix}\right\}O_3$ and sodium palmitate $3\left\{\begin{matrix}C_{16}H_{31}O\\Na\end{matrix}\right\}O$.

The glycerine formed in the process of saponification remains after the separation of the soap dissolved in the mother liquor, and can be separated and utilized.

Besides the mode of saponification of fats and oils by means of the metallic bases, *i. e.* alkalies, there are several other modes, as by acids, by heat, by steam, and by fermentation, which will be explained in their appropriate place.

Thus, though we find that the fats and oils consist of so many different and distinct substances, they are chiefly distinguished by consistency at ordinary temperatures, the liquid part being called olein and the solid stearine, and their consistency depending upon the preponderance of one or the other of these constituents. Correctly speaking, stearine the solid part may not be all stearine, but may contain margarin, palmitin, etc., while the oleine may contain margarin, cocin, etc. Yet when any of the fatty acids are separated their action with the alkalies is the same, and they can be united in the same manner to form soaps, but the soaps formed will owe their greater or less solidity to the amount of the solid or liquid constituents of the fatty body or sebacic acid. In the saponification of the fats with hydrate of lime for the purpose of forming stearic acid for candles and separating the oleic acid and liberating the glycerine, either of the acids is the more readily saponifiable, and for the oleic acid the lye need not be entirely caustic, as it can be saponified with carbonated lyes.

In this process glycerine, which we have explained is a kind of alcohol, takes up the elements of water with which it had previously been formed with the fatty acids. Glycerine forms about 8 to 10 per cent. of the neutral fats, lard being usually richer in this valuable article.

It must not be supposed that in the production of soap the materials combine as readily or as rapidly or with the same exactness as ordinary salts form to make a union or a decomposition, for it is not a momentary process. On the contrary, it occupies a considerable length of time, and the formation of the soap is not complete until in the boiling process the fat is first made into a milky emulsion with the weaker lye, and, by the further addition of alkali, it becomes saturated, and finally finished and separated from the mother-lye, and is ready for use. Or, again, when the soap is made by the extempore or cold process, it is at first combined mechanically; it has to remain in the frames for some hours that the materials may react spontaneously upon one another, and, by increased heat of the chemical action, saponification is completed. So we find that saponification does not take place suddenly and throughout, but passes through several stages, and only gradually are the sebacic acids decomposed and formed into salts, or, in other words, soaps.

When, however, we melt tallow with as little heat as possible, say about 37.7° C. (100° F.), and add half its weight of strong alkali of 36° B. of the same temperature, and constantly stir for some time, we will find it suddenly acquire a solid consistency, with a great elevation of temperature, proving the great chemical attraction of the materials. Yet saponification is not yet complete, for it seems to have an excess of alkali, which it does not lose until some hours, when the combination is complete and the soap neutral.

Despite the fact that saponification is increased by boiling, rapid boiling is not advantageous, especially in the preliminary stages, when with the first weak lyes the emulsion is forming. A moderate heat causes a better combination, and the heat should not be much increased until toward the end, when the mass has acquired more consistency and has absorbed sufficient alkali, when it can be boiled rapidly to a finish.

When the alkali is dissolved in alcohol and mixed with the heated or melted fats or oils, the combination is very rapid, and the resulting soap contains all the glycerine which cannot be separated except by a decomposition with an acid and the addition of some water. By this effect the observant soap-maker is enabled to make some beautiful soaps of transparent appearance, which will be more fully explained in their proper place.

Although the decomposition of the sebacic acid with caustic alkalies will take place at common temperatures, yet it is but slowly; but, as in the case of almost all chemical processes, it is essentially assisted by the aid of heat. If the melted fats or oils are mixed with the lye and left to rest, the greater density of the lye will cause it to fall to the bottom, while the fat will float upon the top, so that but a limited contact will be possible with the materials. Thus, it is necessary to cause a constant motion of all the particles by stirring or by boiling, that they may be brought together and the soap in forming take up gradually the lye, which is being absorbed and is getting weaker, finally becoming clear when the decomposition is complete, forming a neutral salt, *i. e.*, soap and a glycerine oxide, *i. e.*, glycerine and water.

If it were possible at all times to keep perfectly pure materials, fats and alkalies, particularly the latter, the process of soap-making would be very much simplified, and, when combined in the proper proportions, soap would be formed and the quality would always be uniform. But, as this is impossible, the closest attention must be paid to the action of the materials in hand, in order to learn from their action what it is necessary to use and what it is proper to do to form a pure soap. We will find that nearly every fat or oil has a somewhat different action in contact with the lye, though many will impart their peculiarities to the other. Thus tallow will impart to resin its mode of saponification, without which resin, though readily saponifiable in lyes, even in carbonated lyes, will not make a detergent or solid soap. So cocoa-nut oil will not saponify in weak lyes, but does so readily in strong lyes; and, when mixed in certain proportions with other fats, it can be boiled in weak lyes, and will impart its property of saponifying in strong lyes when in other proportions it is mixed with other fats and oils. Thus we see that the making of soap, though a simple matter, yet requires a close attention to these peculiarities to acquire the requisite skill.

We thus find, in making soap by boiling the fatty bodies, that, though they may contain many impurities, and the alkalies or bases may have a larger percentage of foreign salts and other extraneous substances, yet by this mode of manipulation, of first forming an emulsion with a portion of the lye and boiling to a clear liquid, and in the second lyes using a portion of culinary salt (chloride of sodium), or what is called "cutting the pan," the soap that has formed will separate, and, with all the unsaponified fat, float on the surface, and the salt and most of the impurities will fall to the bottom with the mother-liquor or spent lye, which can be removed, and the soap, if finished, put in the frames, or, if not sufficiently purified, it can be again boiled with weaker lye and salt, again cut and separated, or it can be fitted or finished in weaker lye to give it the proper consistency, or boiled in strong lye, which also separates and can be removed, as the case may require. Culinary salt is here very useful, but it should be in rather strong solution, otherwise a portion will remain in the soap dissolved in the water. The proper concentration of the salt solution is known by the manner in which the soap appears on the stirrer, the soap separating in curds from the liquid. The liquid in the pan separates and falls to the bottom, while the soap is floating on the top, forming into slabs, and then into grains or curds, when the heat is removed, allowed to rest, that the spent lye may subside and be run off, or the soap may be ladled out into frames; and the soap is made.

Soap as here noticed is also insoluble in strong lyes, and when it has taken up all that it can, or becomes from long boiling saturated, it floats upon the surface of the lye, though it is possible to add water or weak lye and it is often filled or sophisticated in this manner.

Other salts have the property of separating soap from its lyes, as chloride of potassium, acetate of potassium, chloride of ammonium, or sal ammoniac and sulphate of soda, the latter salt, however, is sometimes added to soap made from weak stock, bone, or kitchen fat, etc., having the property of hardening it and making it more marketable, but it must be in limited quantities in strong solution and after the soap is framed, and stirred in mechanically, that it may not decompose the soap. Carbonate of soda has also this hardening property, and like the sulphate it must be added in strong solution and crutched into the finished soap.

From what we have already said, it will be gleaned by the intelligent reader that the saponification of the ordinary fatty bodies with the usual alkalies and the formation of marketable soaps is not a complicated matter but a simple process, demanding, however, much care and exactness, and resolves itself into the neutralization of the fatty acids with the caustic alkalies. Thus we will analyze a stearine soap: stearate of soda, $C_{114}H_{110}O_{12}+3(NaO.HO),=$ $3(NaO.C_{36}H_{35}O_3)$ or stearic acid soda, and $C_6H_8O_6$ or glycerine.

$$\text{890 parts stearine}\left\{\begin{array}{lll}825 & \text{parts} & \text{stearic acid}\\ 93 & \text{"} & \text{soda}\\ 65 & \text{"} & \text{glyceric acid}\\ 27 & \text{"} & \text{water}\end{array}\right.\begin{array}{l}\left.\begin{array}{l}\\ \\ \end{array}\right\}\text{give 918 parts soap}\\ \left.\begin{array}{l}\\ \\ \end{array}\right\}\text{give 92 parts glycerine}\end{array}$$

Similar equations apply to almost all other combinations of the fatty acids with the bases.

Soaps made with potash lye are always soft and retain their glycerine, and, owing to the hygroscopic character of the base, they are constantly absorbing water from the atmosphere and becoming softer, 100 parts of potash soap having been known to absorb 25 parts of water in a few weeks. These soaps are very rarely neutral but almost always contain free alkali, caustic or carbonated lye. Yet they are an important article of commerce, having various uses in the arts, and are in many countries used for domestic purposes, particularly in countries where wood is abundant and is used as fuel and wood ashes are plenty.

The making of hard soap from potash lye is done by first saponifying with wood-ash or potash lye and then cutting the soap with culinary salt, forming a double decomposition, the chlorine of the salt uniting with the potash forming chlorate of potash, the soda uniting with the fatty acid and forming a hard soap. While it is impossible to extract all the potash by this means, it is, however, no disadvantage, but tends to improve the quality by keeping the soap plastic. In this decomposition the soap also loses all its glycerine, it being carried down with the sub-lye.

The neutral fats may also be decomposed by means of super-heated steam at 260° to 330° C. (500° to 626° F.). Tilghman has invented an apparatus for this purpose, for the production of glycerine on an extensive scale. The glycerine at this temperature separates, and the sebacic acids resulting are readily saponified in carbonated alkali. This process is conducted on an improved method by Milly, with the addition of a little hydrate of lime (milk of lime) in connection with a pressure of steam at 7 to 8 atmospheres, 170° C. (338° F.). The resulting lime soap, the fatty acids, and the glycerine could be easily separated.

By using one-half of one per cent. of caustic alkali at the above-mentioned pressure and heating, the glycerine will be separated in about 10 hours and can be drawn from the bottom of the covered boiler, while the remaining sebacic acids can be formed into soap in the usual manner.

Or this process can be conducted by means of a still and worm, distilling off the sebacic acids and afterwards extracting the glycerine from the residuum. In either case the sebacic acids can be easily saponified, having a greater affinity for the alkalies when they have parted with their glycerine.

Glycerine now of great value for such varied purposes is made in one or other of the above described processes, but generally by means of super-heated steam acting upon beef or mutton tallow or hog's lard, in the process of making stearic acid for candles, to which all of these processes are applicable. This process has in view the production of those useful substances, stearic acid for candles, oleic acid for soaps, and glycerine for the arts and for pharmacy. The different changes may be explained thus:—

$$\left.\begin{matrix}C_3H_5\\3C_{18}H_{35}O\end{matrix}\right\}O_3 + 3OH_2 = 3\left\{\begin{matrix}C_{18}H_{35}O\\H\end{matrix}\right\}O + \left.\begin{matrix}C_3H_5\\H_3\end{matrix}\right\}O_3$$

Below is a more simple equation, and one that will explain quite as well the usual changes that take place when two soap materials are brought into contact to form a soap; for instance, if we take neutral stearine with hydrate of soda, the reaction may be stated thus:—

$$\overbrace{\text{stearate of oxide of glyceryl}}^{\text{Stearine.}} + \text{soda} + \text{water} =$$
$$\underbrace{\text{stearate of soda}}_{\text{Hard soap.}} + \underbrace{\text{hydrate of the oxide of glyceryl}}_{\text{Glycerine.}}$$

Of course the same simple equation can be applied to oleine, substituting it for stearine.

We have remarked that the consistency of a soap is affected by the melting-point of the fats used, and is more or less hard accordingly, and it may frequently occur that the manufacturer will have many soap greases such as bone fat, glue fat, kitchen grease, etc., and some that are recovered from offal and wool washing, etc. These greases are technically called "weak stock," and produce when used alone, and particularly with rosin, too soft a soap, that melts and wastes in the water in using. These soaps can be improved by an artificial hardening by adding 5 per cent. of crystals of sulphate of soda dissolved in the least possible amount of water, or the addition of 10 to 15 per cent. of the solution of silicate of soda at 50° B. will have a like beneficial effect. This filling is added by crutching it into the yet warm finished soap.

Gossage was about the first person to propose the use of soluble glass as a useful addition to soap, and as we have seen above with good effect, but it is sometimes used in excess to adulterate and cheapen genuine and good soaps. It has, however, a detersive power, the free alkali it contains being a solvent of grease and dirt. Silicated soaps are much in vogue, and will be fully described in their proper place, when also other fillings for soap perhaps not so suitable will be mentioned.

We have already given some of the characteristics of rosin or colophony, a substance much used in domestic soaps. It consists of the acids, pinic, sylvic, and colophonic, in different proportions, each having an equal affinity for alkalies. To some kinds of soap it gives a useful property, causing a softer consistency, to tallow soap for instance, and so may be considered in the light of an ameliorator. Though readily saponifiable, it does not alone make a useful soap, and when added to other soaps it must not be in greater proportion than fifty per cent. of the fat used, or it will affect its quality. The best results are obtained when it is saponified alone, and added to the other finished soap, while still hot, and thoroughly crutched in.

Soap is not entirely soluble in cold water. When used, the alkali is united with the grease and dirt, and the fatty acids are set free and float away, and may afterwards be recovered. In hot water soap will dissolve and form an opaque solution, but the separation occurs when it cools, the solution becoming clearer, while the fatty acids float upon the surface. These fatty acids when recovered can be purified and again used to form other soaps. Alcohol dissolves pure soap in all proportions, and on cooling forms a clear jelly. This property is utilized to make various transparent soaps.

Some writers in our art advise the forming of the neutral fats into sebacic acids, and then saponifying with carbonated alkalies, but unless the saving of the glycerine is an object there is little economy in the method, for the saponification with carbonated lyes is a tedious process, and the escaping carbonic acid causes a great deal of foam, and it takes much more time than boiling with the usual caustic lyes. Moreover, the soap so made is never as good, as it always retains a spongy condition, and dissolves too easily in water.

So it will be unnecessary to say that all these processes or methods, having in view the avoidance of caustic alkalies in manufacturing soap, have signally failed; as the making of soap is founded upon true chemical principles, and on well-established rules, so that it is hazardous for any one to deviatefrom methods founded upon such long and well tried experience.

Yet let it not be supposed that there is nothing more to learn. On the contrary, the experiments of experts are con stantly throwing new light upon the art, which with the invention of new appliances has, in a remarkable degree, improved the quality of nearly all soaps in use. But what is already known is founded upon sound principles, and it would be a loss of time and money for a novice to experiment in the direction already covered by those long accustomed to the subject, and when experience founded on science may be taken as the best guide.

Yet as we recognize that the art of the fabrication of soap is a progressive one, and new and untried materials are constantly being discovered that might find useful or economical application in it, so the enterprising manufacturer will always be on the alert, to endeavor by new means or new materials to improve his processes, or produce new goods.

SECTION VIII.

ALKALIMETRY.

The proper knowledge of the constituents of the alkalies used, with their preparation for the decomposition of the neutral fats or the sebacic acids, is beyond all doubt the most important in the art of making soap; and the difficulties attending the attainment of this knowledge are not so great but that it can be easily acquired by any one having an ordinary understanding of the principles upon which it is based, or sufficient intellect to comprehend the commonest elements of chemistry.

From carelessness or ignorance many errors are committed, and much time and labor are lost by mistakes that the correct attainment of the manner of chemical analysis or assay of the alkalies would tend to avoid. The acquirement of a thorough chemical knowledge is scarcely to be expected of men whose time has to be employed in another direction: yet it is most important that the chemical action of the materials applicable to the fabrication of soap should be well studied. To this end the author will try to give the most simple and correct methods for the testing of the alkalies.

The alkalies of commerce are never pure, but contain, besides carbonates, sulphates, sulphites, chlorates, etc., so that the object of alkalimetry is to determine the percentage of caustic or carbonated alkali a potash or soda of commerce may contain. The principles of this test are based upon the law of equivalents, which is illustrated elsewhere, and which means that a certain definite weight of a reagent is required to saturate or neutralize an equivalent of a base. So, on the variations in the quantity of pure alkali contained in the alkalies of commerce depend their value, and the amount necessary to use in solution to boil or make a soap.

To determine the quantity of real alkali the lyes may contain, it is obvious that a rapid and easy method is very desirable, and among the numerous means to this end it is the desire of the writer to give the least elaborate, and to simplify the description as much as possible.

The hydrometer of Baumé, though a valuable instrument in determining the density of a fluid, will not give an accurate test of the strength of a caustic alkali, as all the impurities dissolved with the solution tend to make it heavier. So it would show but an imperfect result, for it would not indicate the amount of alkali, but the density or specific gravity of the fluid, which might be a solution of culinary salt, or a mixture of several salts, and it is a useful instrument only when the proper preparation has been given to the lyes, and they have been brought into a state of causticity and purity necessary for the saponification of fats. Then it is exceedingly handy. To ascertain the true condition, other and more scientific tests are necessary.

Analysis by Measure, or Volumetric Analysis.

Though a simple process to the expert, it yet requires some practice and skill, for, as we have remarked, the alkalies of commerce are contaminated with so many foreign ingredients that their testing requires great exactness, and moreover, the methods of different chemists vary with each, though giving the same results. From these processes we shall try and select the simplest.

Alkalimetry was until quite recently a purely technical operation, when it assumed a scientific basis, and has developed into an almost perfect process, which simply in its entire operation consists in the neutralization of the alkaline base with an acid of a certain strength.

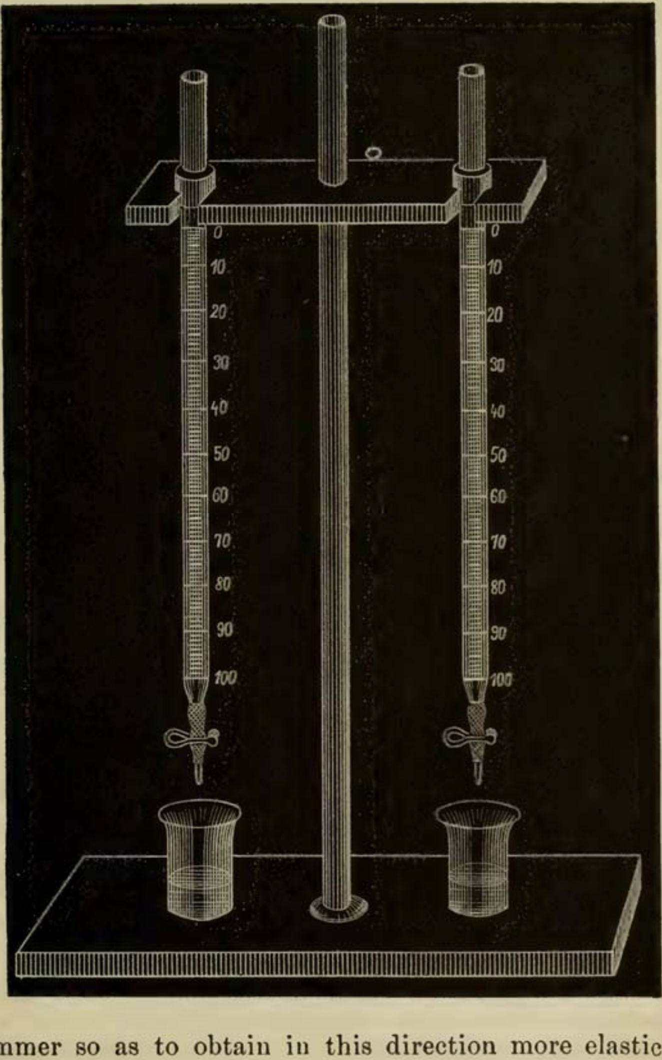
The operation itself is called titration from the acid which has a certain titre, that is, a certain weight according to the contents. A certain weight of acid corresponds to a certain weight of alkali, so that these measures may finally be reduced to weight. Mohr expresses himself as follows: "But one weighing is only performed where formerly many had been needed. The accuracy of the one normal weight is repeated in every experiment made with the liquid thus prepared. With one litre of test-acid, several hundred estimations may be made. The producing of two or more litres of test-fluid requires no more time and no more weighing than one litre. The weighing can therefore be performed whenever time and leisure admit."

Besides the acid we require certain instruments by means of which the acid is added to the solution of the body under investigation. And as here a decomposition is always carried to its limits, and not as in case of common analysis with a surplus of the precipitation, these implements must permit of a very regular flowing off by drops. They are two, the burette and the pipette.

THE BURETTE.

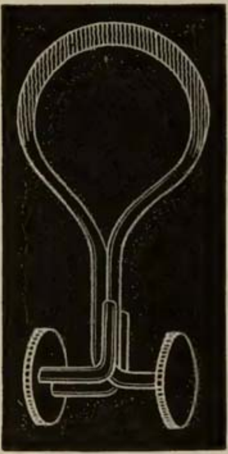
This instrument has been brought into use in various forms, but we give the preference to the clip (compression, stopcock) burette of Mohr (Fig. 3), for its simplicity and convenience of manipulation. It consists of a straight cylindrical glass tube, of not too thin sides, which is graduated into $\frac{1}{5}$ or $\frac{1}{10}$ cubic centimetres (0.054 or 0.027 fluidrachm). At its lower end it is drawn out to a somewhat distended point to allow a gum tube to be drawn over it and securely fastened. The india-rubber tube is about 40 millimetres (1.57 inches) long, and is, if necessary, tied with a strong silken thread. In the lower end a glass tube drawn out to a fine point is inserted, which as it has only to bear a certain strain of the liquid column while the compression-stopcock is opened it holds easily without any fastening. The gum tube is closed by means of a clip; this latter is made of brass wire, hard drawn, of 3 to 3½ millimetres (0.12 to 0.14 inch) thickness. To this end the wire, which is shown of its full size in Fig. 4, is bent into a 20 to 22 millimetre (0.78 to 0.86 inch) wide circle and the ends in the direction of the radius carried forth parallel. This circle is flattened upon a polished anvil with a polished

Fig. 3.



hammer so as to obtain in this direction more elasticity. On one end is soldered a right angle piece of the same kind of wire. Upon the cut off part, two smaller angles of the same wire are soldered. In a position of rest the angles are lying on each other. As soon as we press upon the handle-joints the angles open, and the gum tube relieved from pressure permits the liquid in the burette to flow out.

Fig. 4

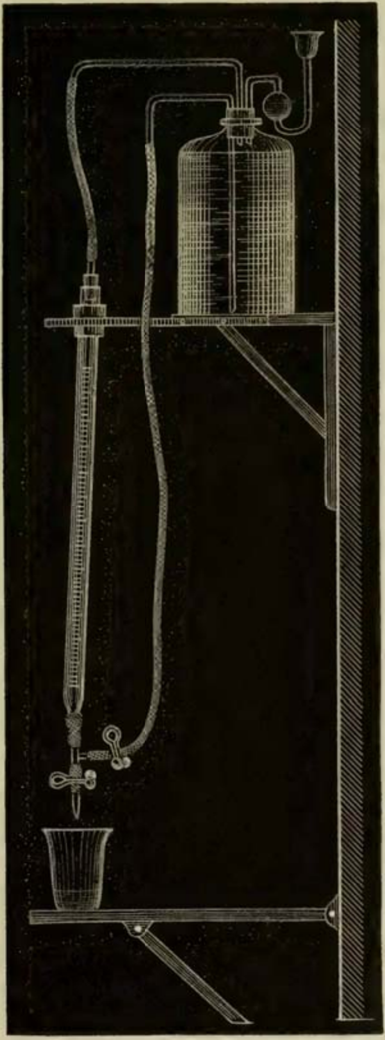


If this gum tube is sufficiently elastic, and the wire on the clip stiff enough, we need not fear that the tube when not in use will permit even one drop of liquid to flow out. Fig. 3 shows the burette provided with India-rubber tubes and clips.

When the burette is idle and filled with the liquid, as is often the case in technical operations, where experiments are so often repeated, and to be always on hand, it should then be closed above, that no evaporation may take place. Such a stopper can be easily replaced by a toy marble. That these marbles may fit more tightly, the burette has a facet-like opening, but a conical glass plug may serve this purpose better; such stoppers are tighter and are sufficient to close it.

When as in soap manufactories alkalies are mostly to be investigated, one burette is amply sufficient for the acid, but it is a great convenience to place a second burette with a normal potash solution along-side of it. Thus a hasty analysis might be easily rectified by adding alkali to the red titrated liquid until it again assumed a pure blue, and taking the used cubic centimetres of alkali from those of

Fig. 5.



the acid. The two burettes represented in Fig. 3 serve best for this purpose. But besides this it is best in case of breaking one to have several on hand, especially in places where it is impossible to obtain a new one at once.

The burette ready for immediate and continuous use is represented by Fig. 5.

The Pipette.

This very useful instrument is also a straight glass tube, which, except about 40 millimetres (1.57 inch) at its upper end and 5 millimetres (0.20 inch) at its lower end, is divided in its entire length into $\frac{1}{10}$ or $\frac{1}{5}$ cubic centimetres (0.027 or 0.054 fluidrachm). Pipettes which hold 20 cubic centimetres (5.40 fluidrachms) are chosen of a somewhat wider diameter so that they may not be too long, and then they are commonly divided into $\frac{1}{5}$ cubic centimetres (0.054 fluidrachm). In soap manufactories two pipettes are usually sufficient for all purposes, divided in $\frac{1}{10}$ or $\frac{1}{5}$ cubic centimetres (0.027 or 0.054 fluidrachm), and of 10 cubic centimetres (2.7 fluidrachms) capacity.

For use, the pipette is filled somewhat above the 0 degree, by a gentle suction, while the point is dipped into the liquid and then quickly closed with the moistened ball of the index finger of the right hand. By moving the finger slightly so much of the liquid is permitted to run out until it stands precisely at 0. In order to notice this more plainly, the pipette is held against a light surface. The lowest point of the convex segment must just touch the division line. To let the drops fall off easily and be as small as possible, the point of the pipette is covered with paraffin.

In general the work with the pipette is more convenient than with the burette. It is held perpendicularly in the right hand, taking hold of the beaker with the left hand, or, what is still better, a large porcelain cup, letting so much flow out of the pipette until the liquor appears of the desired color.

Pipettes are useful instruments to quickly measure off certain larger or smaller quantities of liquid, to which end a systematic series of all sizes should be on hand of 1, 2, 5, 10, 20, 50, and 100 cubic centimetres. The smaller, from 1 to 20 cubic centimetres, have the shape shown in Fig. 6. The body has such a diameter that the pipette may be inserted into a wide-mouthed bottle to withdraw the liquid therefrom. The larger pipettes receive either the shape as in Fig. 7, or Fig. 8; the former are less liable to break, but the latter need not be so long. The upper, thinner part, the stem, has at a cer-

Fig. 6.

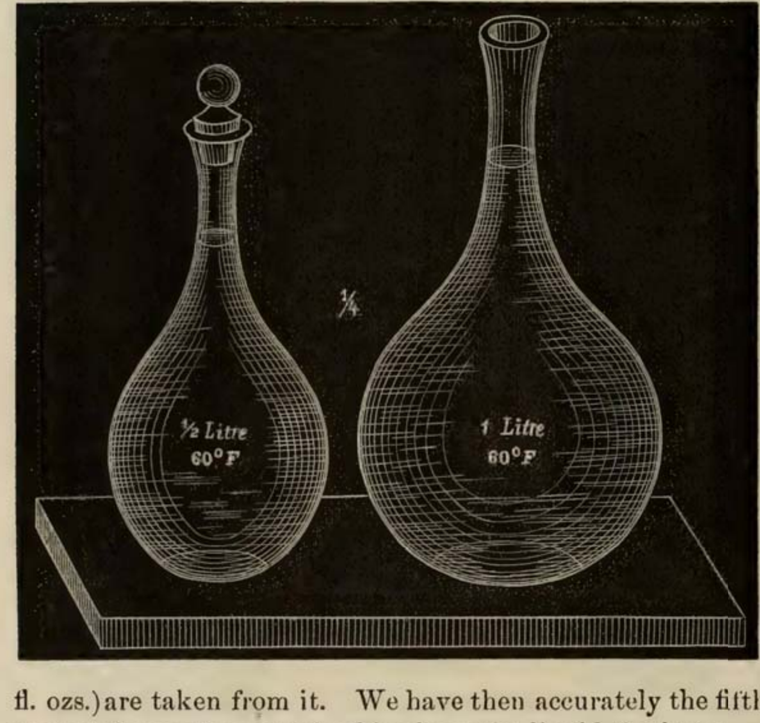
Fig. 7.

Fig. 8.

tain part the mark for the contents for which the pipette is arranged. In emptying it the pipette is permitted to run out completely, and it is well to hold its point against the moist side of the receiving vessel, from which the drop hanging on the point is removed, or we touch with the point the surface of the poured-out liquid.

The large pipettes permit in many cases a great saving of labor. Supposing we would ascertain several ingredients in one lye (alkali, chlorides, sulphates, etc.), in separate operations, then this lye is brought into a measured glass which holds about 500 cubic centimetres (16.9 fl. ozs.) up to the mark, when by means of a pipette 100 cubic centimetres (3.38 fl. ozs.) are taken from it. We have then accurately the fifth part of the matter contained in the entire liquid, for instance, the alkali, which still leaves ⅘ for testing for chlorates and sulphates, etc.

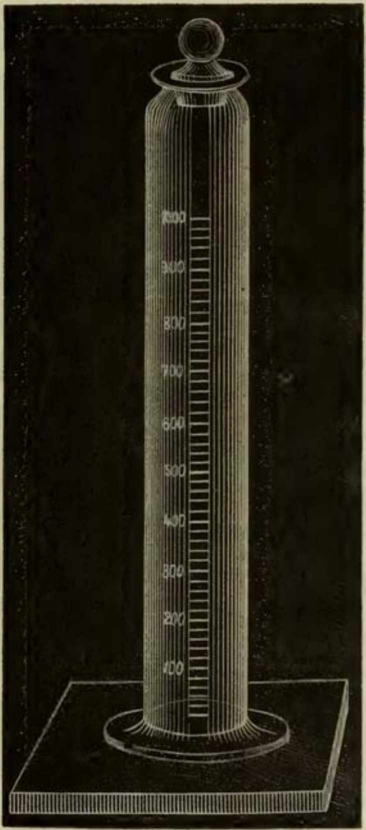
Fig. 9. Fig. 10.



FLASKS.

Measure-flasks are of very extended application; they are used of all sizes, from 100 cubic centimetres (3.38 fl. ozs.) to the litre or 1000 cubic centimetres (33.8 fl. ozs.). The latter and also the 500 cubic centimetre (16.9 fl. ozs.) flask, which is equal to ½ kilogramme (1.1 lb.), are most often used. They serve for measuring greater quantities of liquids than the full pipettes. Their usual form is shown in Figs. 9 and 10. The sizes most suitable are 1 litre, 1000 cubic centimetres

Fig. 11.

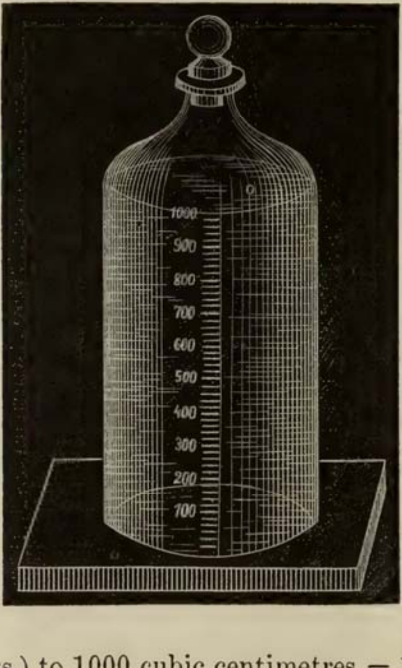


(33.8 fluidounces), 100 cubic centimetres (3.38 fluidounces). They have, on the neck, a mark, up to which they are filled with the test-liquids; upon their side they carry the figures of their capacity. Of the smaller sizes a large number are kept at disposal.

CYLINDERS FOR MIXING.

These two utensils are principally used for producing the titrimetrical liquids (acids or alkalies). The mixing cylinder has a stopper of glass, and is graduated from 10 (0.33 fl. oz.) to 1000 cubic centimetres (33.8 fl. ozs.), see Fig. 11. These cylinders are represented in Fig. 12, and also graduated from 100 (3.38 fl. ozs.) to 1000 cubic centimetres = 1 litre (33.8 fl. ozs.). Their stoppers are also made of glass. The most suitable size for mixing cylinders and mixing bottles is 1000

Fig. 12.



cubic centimetres = 1 litre (2.1 pints), but others of less capacity are also used.

SCALES AND WEIGHTS.

The most indispensable of all instruments is a good, sufficiently sensitive, balance or scale, with the accurate weights belonging thereto. For a soap manufactory such a scale is good enough which, when burdened with a weight of 4 ozs., will yet indicate with accuracy when one-half grain additional weight is placed upon it. The absolute correctness of the weights is likewise required.

TINCTURE OF LITMUS, COCHINEAL TINCTURE.

To ascertain the point where, by the addition of the titrated acid to the alkali, which is to be estimated, or from a titrated alkali to an acid, neutrality will ensue, litmus tincture is usually applied, but in some instances cochineal tincture will serve the same end. Both show by the variation of color which they undergo the small overplus of alkali or acid and the point of neutrality. The blue color of the litmus turns by dint of the overplus of acid into red, and the color of the acid reddened by the litmus changes into blue by an excess of alkali. The tincture of cochineal is originally of a chestnut-brown color, which, with alkali, becomes a splendid carmine red, and, by adding acid, receives a light brick-red color. Each of these two indicators—the term given to these tinctures—has its advantages and its faults. The tincture of litmus does not show the beginning of neutrality, since by the test with carbonated alkalies the carbonic acid becomes free and acts upon the color of the litmus, and produces a coloring which is neither red nor blue; hence the liquid has previously to be warmed in order thereby to remove the carbonic acid. But this is troublesome and confusing. This fault, however, the tincture of cochineal does not have; its color is in no wise affected by the free carbonic acid, no warming is needed, and the operation may be performed in one draught. For investigating the carbonated alkalies it is in a high degree preferable. But it is most suitable for testing caustic alkalies, especially in concentrated solution, and some experience is required to hit the proper point. Its color suffers in contact with alkalies, a chemical change takes place in consequence thereof; by the neutralization of an acid, not a brick-red color, but a carmine-red hue appears, which, by inexperienced persons, may easily be confounded with that caused by alkali. If it is intended to make use of the cochineal tincture for testing the caustic alkalies, it would be well to allow the lye to flow upon the normal acid. The tincture of cochineal, when the liquid to be tested contains even a mere trace of oxide of iron, is quite unserviceable. When, however, it is applicable, it is, without doubt, certainly much more sensitive than the tincture of litmus.

THE PREPARATION OF TINCTURE OF LITMUS.

Place 33⅓ grms. (1.175 ozs.) of good commercial litmus in a test-tube, pour about 133⅓ grms. (4.70 ozs.) of distilled water on it, place it upon a heated stove, frequently shaking it gently. After a lapse of from six to eight hours the intensely blue liquid is drained off from the residuum, to which add again 66⅔ to 83⅓ grms. (2.35 to 2.94 ozs.) of water, and let it again stand in the warmth for a short time, and decant when both extracts are mixed. The liquid contains free carbonate of alkali, which is a hindrance to its sensitiveness, and must be removed. This is done best and most completely by boiling the tincture with about 3 per cent. of the litmus used with finely powdered gypsum, and digesting it for a longer period. By this operation carbonate of lime is produced, as well as sulphate of alkali, which remains dissolved. This tincture assumes, thus prepared, after a few days, a decided lilac shade of color, but it is nevertheless as well for alkalies as for acids in the highest degree sensitive, the smallest overplus of the former making it a pure blue, the smallest overplus of acid decidedly red. At times the tincture of litmus shows the peculiarity of losing its color in a closed flask and turning brown; but it is not for this reason to be considered as spoiled. If it is brought in contact with the air it again assumes a blue color.

TINCTURE OF COCHINEAL.

According to Lucknow, who was the first to recommend this tincture as an indicator, 3 grms. (0.11 oz.) of the best cochineal are ground and transfused with a mixture of 50 cubic centimetres (1.69 fl. oz.) of alcohol and 200 cubic centimetres (6.76 fl. ozs.) of distilled water, then left to digest several hours, and finally filtered through lime-free paper. This tincture has a dark orange-red color, with a tinge of brown (dark chestnut-red). 10 cubic centimetres (0.338 fl. oz.) of water to 10 drops of the tincture produce a light orange-red fluid.

The phenomena during neutralization are, in the case of tincture of cochineal, different from those of the litmus, which, from the beginning, according to the quantity of the tincture employed, turns into purple-violet or in this shade of lighter tinge, then gradually becoming carmine-violet or cherry-red, until the close of the operation. A more or less orange shade appears, when the tincture of cochineal is used.

THE BASIS OF ALKALIMETRY.

For this various substances have been proposed. What substances are used, whether acids or alkalies, is tolerably unimportant, if they can be obtained in their purest state and be weighed off with all possible accuracy. Gay-Lussac used the anhydrous carbonate of soda as a base, and neutralized it with sulphuric acid. If the necessary care is observed, the most perfect and ample results for technical purposes are reached by using the carbonate of soda. The great tendency of fresh calcined carbonate of soda to absorb moisture caused Mohr to substitute for it crystallized oxalic acid. Although oxalic acid combines many properties which recommend it as a titrimetric substance, and is easily prepared in a pure state, and can also be weighed accurately, its application as such is nevertheless not without critical objections, since it often contains more water than corresponds with the formula $C_2O_3 + HO$, and moreover is often not free from small quantities of oxalate of potash and lime. These reasons caused Pincus to apply the pure carbonate of lime as a basis for alkalimetry, and the suitableness of this selection has been almost everywhere acknowledged.

Pure carbonate of lime is obtained best in this way: A certain quantity of nitrate of ammonia is dissolved in ten times as much water, and digested with an overplus of hydrate of lime, by frequent shaking, for several hours, then filtered, and precipitated either with carbonate of ammonia or by leading into it a stream of carbonic acid gas until all the lime combines with the carbonic acid and is precipitated. By evaporating the liquid, the nitrate of ammonia is reobtained, which, in this manner, can again be used for producing the pure carbonate of lime. The precipitate is placed upon a filter, washed with distilled water, dried, gently calcined, and preserved in a well-closed glass phial, with the inscription "Pure carbonate of lime suitable for alkalimetry."

By means of the carbonate of lime thus obtained, the normal acid is prepared. Nitric acid is to be recommended for this purpose, because it forms with most bases soluble salts. Carbonate of lime consists of:—

1 equivalent of lime = 22
1 " of carbonic acid = 28 and has the equivalent
50

Nitric acid consists of—

1 equivalent of nitrogen = 14
5 " of oxygen = 40 and hence has the equivalent
54

The normal nitric acid applied in alkalimetry must contain in the litre 54 grammes (1.9 oz.), or exactly so much anhydrous acid, that with 50 grammes (1.75 oz.) of carbonate of lime it will be neutralized. The preparing of such an acid is performed thus: Take a pure nitric acid, diluted with water, of a strength to suit, and liquid of ammonia, so fixed that equal volumes of acid and of ammonia are accurately saturated. Now weigh accurately 2 grammes of pure carbonate of lime, place the same in ½ litre flask, pour about 100 cubic centimetres (3.38 fl. ozs.) of distilled water and a sufficient quantity of tincture of litmus or tincture of cochineal on to it, and also add an accurately measured quantity of the acid corresponding with the ammonia, so that all the lime is dissolved and the liquid remains plainly of red color. The liquid is then heated to boiling, in order to entirely remove the carbonic acid. After this is done and the whole is somewhat cooled off, the surplus of the acid is removed by an equivalent of ammonia, and we thus learn, by deducting the cubic centimetre of ammonia used from the applied cubic centimetres of the acid, exactly the quantity of acid which has been neutralized by the above-mentioned carbonate of lime. Since the acid must now have such a strength that 1000 cubic centimetres (33.8 fl. ozs.) thereof are neutralized by 50 grammes (1.75 oz.) of carbonate of lime; for 2 grammes of carbonate of lime 40 cubic centimetres (1.36 fl. oz.) of acid must result. If now less acid has been used, as is always the case, the acid must be thus much diluted that 40 cubic centimetres (1.36 fl. oz.) of liquid, that is, normal nitric acid, are produced, and according to this proportion the total quantity of the equivalent of nitric acid must be diluted to correspond to the ammonia. Supposing we have 750 cubic centimetres (25.4 fl. oz.) nitric acid, its equivalent of ammonia, and of this 2 grammes (30.86 grs.) carbonate of lime, 30 cubic centimetres (1 02 fl. oz.) applied, then those 750 cubic centimetres (25.4 fl. ozs.) must be diluted to 1000 cubic centimetres (33.8 fl. ozs.), an operation which is to be performed in the mixing cylinders or in the mixing flask.

Inasmuch as 1000 cubic centimetres of this acid contain 1 equivalent of nitric acid, they also neutralize each 1 equivalent of any base, respectively alkali or the quantity of a combined acid, in which 1 equivalent of a base is contained, or they will neutralize:—

1 equivalent of potash = 47.11 grammes (1.6 ozs)
1 " of hydrate of potash = 56.11 " (1.96 ")
1 " of carbonate of potash = 69.11 " (2.4 ")
1 " of soda = 31.00 " (1.1 ")
1 " of hydrate of soda = 40.00 " (1.4 ")
1 " of carbonate of soda = 53.00 " (1.8 ")
1 " of crystallized carb. of soda = 143.00 " (5 ")
1 " of lime = 28.06 " (0.98 ")
1 " of hydrate of lime = 37.00 " (1.29 ")
1 " of carbonate of lime = 50.00 " (1.75 ")

1 cubic centimetre (0 27 fl. drm.) of the nitric acid corresponds therefore with—

0.04711 gramme (0.727 grain) of potash
0.05611 " (0.87 ") of hydrate of potash
0.06911 " (1.066 ") of carbonate of potash
0.0310 " (0.48 ") of soda
0.0400 " (0.62 ") of hydrate of soda
0.0530 " (0.82 ") of anhydrous carbonate of soda
0.1430 " (2.21 ") of crystallized carbonate of soda
0.0280 " (0.43 ") of lime
0.0370 " (0.57 ") of hydrate of lime
0.0500 " (0.77 ") of carbonate of lime.

The following table contains the quantities of bases in grammes, which are neutralized by 1 to 9 cubic centimetres (0.27 to 2.43 fl. drms.) normal nitric acid. It furnishes for incidental calculations great assistance, since by the tenfold quantities the period needs only to be removed one space from right to left, while in the case of tenth parts and hundredth parts the period should be removed one or two spaces from left to right; and the figures placed correctly under each other, and thus added:—

	1	2	3	4	5	6	7	8	9
Potash	0.04711	0 09422	0.14133	0.16844	0.23555	0.28266	0.32977	0.37688	0.42399
Hydrate of potash	0.05611	0.11222	0.16833	0.22444	0.28055	0.33666	0.39277	0.44888	0.50499
Carb. of potash	0.06911	0.13822	0.20733	0.27644	0.34555	0.41466	0.48377	0.55288	0.62199
Soda	0.0310	0.0620	0.0930	0 1240	0.1550	0.1860	0.2170	0.2480	0.2790
Hydrate of soda	0.0400	0.080	0.1200	0.1600	0.2000	0.2400	0.2800	0 3200	0.3600
Anhydrous carb. of soda	0.0530	0.1060	0.1590	0.2120	0.2650	0.3180	0.3710	0.4240	0.4750
Cryst. carb. of soda	0.1430	0.2460	0.4290	0.5720	0.7150	0.8580	0.9010	1.0440	1.1870
Lime	0.028	0.0560	0.084	0.1120	0.140	0.168	0.196	0.224	0.252
Hydrate of lime	0 037	0.0740	0.111	0.148	0.185	0.222	0.259	0.296	0.333
Carbonate of lime	0.050	0.100	0.150	0.206	0.250	0.300	0.350	0.400	0.450

If for instance by estimating a potash 8.75 cubic centimetres (2.35 fluidrachms) of normal nitric acid had been applied, it would be found by the above table:—

for 8.0 cubic centimetres 0.5528800 gr.
" 0.7 " " 0.0483770 "
" 0.05 " " 0 0034555 "

Hence together, 0.6047125 "

a calculation, which by multiplication of 0.069 × 8.75 was found only a little more intricate.

By the alkalimetric test of lye we can operate in a double manner, either by measuring the equivalent in alkali or the combination of the same, which is the point in question; weighing them off in cubic centimetres, diluting if necessary with water, adding tincture of litmus or tincture of cochineal and titrating with normal nitric acid. The cubic centimetres applied to the latter acid show immediately what per cent. contents of the alkali is contained in the lye. Or 10 cubic centimetres (2.7 fluidrachms) of the lye are placed by means of a pipette in a beaker and titrated as above described with normal nitric acid. Here, in order to find out the per cent. contents, the applied cubic centimetres of nitric acid must be multiplied by the equivalents of the alkali, or by the combination of the same. The result is in both cases the same, only that in the latter mode of proceeding a multiplication becomes still necessary. If, for example, of a caustic lye 3.1 cubic centimetres (0.8 fluidrachms) had been transferred by means of a pipette, and for its neutralization 2.635 cubic centimetres normal nitric acid had been used, then this lye contains 2.635 per cent. of caustic soda. If 10 cubic centimetres (2.7 fluidrachms) lye had been measured off, then they would have required 8.5 cubic centimetres (2.3 fluidrachms) nitric acid for their neutralization $\frac{8.5 \times 31 =}{1000}$ 0.2635; in 100 parts hence 2.635 as in the first example.

If the lye had to be investigated as to its contents of hydrate of soda, then 4.0 cubic centimetres (1.08 fluidrachm) would have had to be measured off, and the same with soda or anhydrous carbonate of soda, 5.3 cubic centimetres (1.43 fluidrachm), and in the case of crystallized carbonate of soda 14.3 cubic centimetres (3.86 fluidrachms). In that case the respective quantities of normal nitric acid used would have been 3.40 cubic centimetres (0.90 fluidrachm), 4.505 cubic centimetres (1.22 fluidrachm), and 12.155 cubic centimetres (3.28 fluidrachms), so that the same contains 3.40 per cent. hydrate of soda, 4.505 per cent. anhydrous, and 12.55 per cent. crystallized carbonate of soda.

NORMAL ALKALI.

As has already been mentioned above, it is in many cases serviceable to have on hand an alkaline liquid which is equivalent to the normal nitric acid. For such purpose a potash, a soda, or an ammonia solution may serve. The latter is preferable to either of the other two. Ammonia can be obtained in commerce in an almost pure state, under the name of water of ammonia, and can be bought in any drug store. It absorbs less carbonic acid from the air, and hence keeps unaltered for a longer period. Some little ammonia may indeed evaporate; but since we have normal nitric acid on hand, the titre may be corrected at any moment. Meanwhile there is not much fear of the evaporation of ammonia from such a diluted liquid as the normal alkali is, as it only holds 1.7 per cent. of anhydrous ammonia.

To prepare normal alkali, the commercial water of ammonia is used, which contains about 10 per cent. of ammonia; this, diluted with four times its weight of water, gives a liquid which approximates to the correct titre, 1 7 per cent., but it is somewhat stronger. To correct this, take 10 to 20 cubic centimetres (2.70 to 5.40 fluidrachms) nitric acid in a porcelain cup, color with tincture of litmus bright red, and titrate with ammonia until a pure blue color ensues. In proportion as less of the ammonia has been used than 10 or 20 cubic centimetres (2.70 to 5.40 fluidrachms) the first mixture is diluted with distilled water. For instance we had 125 grammes (4.40 ozs.) ammonia diluted with ½ kilogramme

(1.1 lb.) water, and of this liquid used for 20 cubic centimetres (5.40 fluidrachms) normal nitric acid 18 cubic centimetres (4.86 fluidrachms), then in case the first mixture contained 500 cubic centimetres (16.9 fl. ozs.) we should have to add to this 55.55 cubic centimetres (1.87 fl. oz.) distilled water in order to obtain an ammonia liquid which is equivalent to the normal nitric acid.

The testing of potash is performed in the alkalimetric way. An average sample mixed from the contents of an entire cask is weighed off, 10 grammes (0.35 oz.) are dissolved in a graduated flask of 100 cubic centimetres (3.38 fl. ozs.), and left to settle until clear, when 10 cubic centimetres (2.7 fluidrachms) are taken therefrom for titration with nitric acid, adding some litmus tincture and then warmed. Since 10 cubic centimetres of nitric acid correspond to 0.6911 gramme of pure carbonate of potash, the grammes of carbonate of potash which are contained in the 10 cubic centimetres are found by multiplication, when the used cubic centimetres of nitric acid are multiplied with the figure 0.6911 and the product is divided by 10. For example, 10 cubic centimetres solution of potash =1 gramme (15.44 grains) potash have required 8.5 cubic centimetres (2.29 fluidrachms) nitric acid 8.5 × 0.6911 = 5.8743: 10 × 0.58743 = 58.743 grammes or per cent. of pure carbonate of potash. This calculation is avoided if in lieu of 10 grammes (0.35 oz.), 6.911 grammes (106.6 grains) potash are weighed, otherwise, however, proceeding in the described manner; instead of nitric acid a solution of oxalic acid may be used, for which purpose the oxalic acid which is found in commerce is amply sufficient.

ESTIMATON OF THE AMOUNT OF SODA IN LYES OF POTASH.

For this we require, besides the normal nitric acid and the tincture of litmus, the following substances: 1. Chloride of barium; 2. Nitrate of silver; 3. Carbonated oxide of silver; 4. Solution of neutral chromate of potassa; the latter to serve as a standard. These preparations can be purchased of any druggist. From the nitrate of silver is made a solution of 17 grammes (0.59 oz) to 1 litre (1.56 quarts), which serves as normal titre.

6.90 grammes (106 grains) potash are dissolved in a little water, and the solution not being clear filtered, and the residue washed out with so much distilled water that 100 cubic centimetres (3.38 fl. ozs.) liquid are produced, the residuum is dried, calcined, and weighed. Its weight is 0.068 gramme (1.05 grain). Of the filtered substance 10 cubic centimetres (2.70 fl. drms.) were titrated with standard nitric acid, and thereby the value of alkali (soda and potash, if the first was present) and the carbonic acid ascertained. There were 8.99 cubic centimetres (2.42 fl. drms.) nitric acid, in all therefore 89.9 cubic centimeters (3 fl. ozs.) standard nitric acid used, which correspond to 1.977 carbonic acid.

Then we again take 10 cubic centimetres (2.70 fl. drms.) of the potash solution, diluting the same with 20 to 30 cubic centimetres (0.67 to 1.01 fl. oz.) water, neutralizing it with diluted chemically pure nitric acid, adding a few drops of chromate of potassa, and titrate with nitrate of silver until the first white precipitate attains a weak reddish color, which it retains. In all there are 5 cubic centimetres (1.35 fl. drm.), consequently 50 cubic centimetres (1.69 fl. oz.) solution of silver used, since 1000 cubic centimetres (1.067 qts.) thereof, with 3.5 grammes (54 grains) of chloride, correspond, there are consequently in 6.9 grammes (106 grains) potash 0.175 grammes (2.70 grains) chloride of potash.

An additional 10 cubic centimetres (2.70 fl. drms.) are to be neutralized by nitric acid, diluted in water, and mixed with chloride of barium. In lieu of the sulphates of potash or soda, then present, an equivalent quantity of chloride of potash or chloride of soda, besides a little surplus of chloride of barium, is produced hereby. The sulphate of barium is separated, completely washed out, and the liquid mixed with a sufficient quantity of nitrate of silver. Hereby all the chlorides are changed into carbonates, of which the carbonate of barium is not soluble and precipitates to the bottom, and is separated by filtration and washing out. The liquid now contains the chloride of the alkali (as originally contained in the potash) as also the carbonated alkali, formed by the chloride of potassium and chloride of sodium, calculated as carbonic acid. Only the latter comes into consideration in our analysis, and we must therefore, after having fixed by titration with standard nitric acid the total amount of it, or rather of the carbonate, now deduct that quantity which belongs to the original contents of the potash. Supposing now, through the carbonated oxide of silver, there had been found in 10 cubic centimetres (2.70 fl. drms.) of the solution of potash, 0.022 gramme (0.34 grain) in all, hence 0.22 gramme (3.30 grains) carbonate, which are equivalent to 0.355 gramme (5.48 grains) chloride. Here, from the above 0.175 gramme (2.70 grains), chloride must be deducted, and we obtain then 0.180 gramme (2.77 grains) chloride, correponding to 0.1118 gramme (1.72 grain) carbonate, as an equivalent for the sulphuric acid which had been present. But 0.22 gramme (3.40 grains) carbonate are equal to 0.40 gramme (6.17 grains) sulphuric acid, thence correspond to 0.1118 gramme (1.72 grain) carbonic acid, 0.2032 gramme (3.14 grains) sulphuric acid.

In 6.90 grammes (106 grains) of the potash are therefore found:—

Carbonic acid	. 1.977	grammes	(30.50 grains)
Chloric "	. 0.175	"	(2.70 ")
Sulphuric "	. 0.2032	"	(3.14 ")

According to the experiments of Gruneberg, sulphuric and hydrochloric acids always abound in potash. Calculating accordingly from the quantity found the chloride of potash and the sulphate of potash present, we obtain for the former—

0.3685 gramme (5.68 grs.), and for the latter:
0.3757 " (5.79 ")
0.7442 " (11.47 "), these with the undissolved residue
0.0380 " (1.04 ")
0.8122 " (12 51 ") of the applied 6.90 grammes (106

grains) potash deducted 6.0878 grammes (93.9 grains) remain for the carbonate salts. If these were pure carbonate of potash, there would be therein 1.938 grammes (29.92 grains), and, if pure carbonate of soda, 2.027 grammes (31.28 grains) carbonic acid contained therein. We have, however, above found 1.977 grammes (30.51 grains) carbonic acid, and it follows hence, that the potash contained also carbonate of soda. At the same time there are in the relations of the carbonate value to the potash and soda the conditions given, according to which the corresponding quantities of carbonate of potash and carbonate of soda may be calculated.

As, however, such calculations are not familiar to every person, the following table has been calculated. It contains in the first column from 1 to 100 per cent. progressively, the corresponding quantities of the two carbonates; in the second the standard nitric acid in cubic centimetres, which is requisite for the neutralization of 1 gramme (15.43 grains) of such a mixture. Inasmuch as our solution contains in 100 cubic centimetres (3.38 fl. ozs.) 6.0878 grammes (93.9 grains) carbonates of potassa and soda, we have, in order to possess 100 grammes (1543 grains) carbonate of a salt, to deduct from the same 16.4 cubic centimetres (0.55 fl. ozs.), and to titrate with nitric acid. In the present case 14.75 cubic centimetres (0.50 fl. oz.) of nitric acid were applied, which, according to the table, corresponds with the value of 6.25 per cent. carbonate of soda, so that in 6.0878 grammes of the carbonate of salts,

$\frac{6.254 \times 6.0878}{100} = 0.38$ gramme (5.86 grains) carbonate of soda are contained.

Mixture of carbonate of potash and carbonate of soda.						Amount of nitric acid required for one gramme of the mixed alkalies.
1.00 grm.	KO,	CO_2 +	0.00 grm.	NaO,	CO_2	14 47 ccm.
0.99 "	"	"	0.01 "	"	"	14.51 "
0.98 "	"	"	0.02 "	"	"	14.56 "
0.97 "	"	"	0.03 "	"	"	14 60 "
0.96 "	"	"	0.04 "	"	"	14.65 "
0.95 "	"	"	0.05 "	"	"	14.69 "
0 94 "	"	"	0.06 "	"	"	14.74 "
0.93 "	"	"	0.07 "	"	"	14.78 "
0.92 "	"	"	0.08 "	"	"	14.83 "
0.91 "	"	"	0.09 "	"	"	14.87 "
0.90 "	"	"	0.10 "	"	"	14.92 "
0.89 "	"	"	0.11 "	"	"	14 96 "
0.88 "	"	"	0.12 "	"	"	15.00 "
0.87 "	"	"	0.13 "	"	"	15.05 "
0.86 "	"	"	0.14 "	"	"	15.09 "
0.85 "	"	"	0.15 "	"	"	15.14 "
0.84 "	"	"	0 16 "	"	"	15.19 "
0.83 "	"	"	0.17 "	"	"	15.23 "
0 82 "	"	"	0.18 "	"	"	15.28 "
0.81 "	"	"	0.19 "	"	"	15.31 "
0.80 "	"	"	0 20 "	"	"	15.35 "
0.79 "	"	"	0.21 "	"	"	15.39 "
0.78 "	"	"	0.22 "	"	"	15.44 "
0 77 "	"	"	0.23 "	"	"	15.48 "
0.76 "	"	"	0.24 "	"	"	15.53 "
0.75 "	"	"	0 25 "	"	"	15.57 "
0.74 "	"	"	0.26 "	"	"	15.61 "
0.73 "	"	"	0.27 "	"	"	15.66 "
0.72 "	"	"	0.28 "	"	"	15.70 "
0.71 "	"	"	0.29 "	"	"	15.75 "
0.70 "	"	"	0.30 "	"	"	15.79 "
0.69 "	"	"	0 31 "	"	"	15.83 "
0.68 "	"	"	0.32 "	"	"	15.88 "
0.67 "	"	"	0.33 "	"	"	15.92 "
0.66 "	"	"	0.34 "	"	"	15.97 "
0.65 "	"	"	0.35 "	"	"	16.01 "
0 64 "	"	"	0.36 "	"	"	16 05 "
0.63 "	"	"	0.37 "	"	"	16.10 "
0.62 "	"	"	0.38 "	"	"	16.14 "
0 61 "	"	"	0 39 "	"	"	16.19 "
0.60 "	"	"	0.40 "	"	"	16.23 "
0.59 "	"	"	0.41 "	"	"	16.27 "
0.58 "	"	"	0.42 "	"	"	16.32 "
0.57 "	"	"	0.43 "	"	"	16.36 "
0.56 "	"	"	0.44 "	"	"	16.41 "
0.55 "	"	"	0.45 "	"	"	16.45 "
0 54 "	"	"	0.46 "	"	"	16.49 "
0.53 "	"	"	0.47 "	"	"	16.54 "
0.52 "	"	"	0.48 "	"	"	16 58 "
0.51 "	"	"	0.49 "	"	"	16.63 "
0.50 "	"	"	0.50 "	"	"	16.67 "
0.49 "	"	"	0.51 "	"	"	16.71 "
0.48 "	"	"	0 52 "	"	"	16.76 "

Mixture of carbonate of potash and carbonate of soda.								Amount of nitric acid required for one gramme of the mixed alkalies.	
0.47	grm.	KO,	CO_2 +	0.53	grm.	NaO,	CO_2	16.80	ccm.
0.46	"	"	"	0.54	"	"	"	16.85	"
0.45	"	"	"	0.55	"	"	"	16.89	"
0.44	"	"	"	0.56	"	"	"	16.93	"
0.43	"	"	"	0.57	"	"	"	16.98	"
0.42	"	"	"	0.58	"	"	"	17.02	"
0.41	"	"	"	0.59	"	"	"	17.07	"
0.40	"	"	"	0.60	"	"	"	17.11	"
0.39	"	"	"	0.61	"	"	"	17.15	"
0.38	"	"	"	0.62	"	"	"	17.20	"
0.37	"	"	"	0.63	"	"	"	17.24	"
0.36	"	"	"	0.64	"	"	"	17.28	"
0.35	"	"	"	0.65	"	"	"	17.33	"
0.34	"	"	"	0.66	"	"	"	17.37	"
0.33	"	"	"	0.67	"	"	"	17.41	"
0.32	"	"	"	0.68	"	"	"	17.46	"
0.31	"	"	"	0.69	"	"	"	17.50	"
0.30	"	"	"	0.70	"	"	"	17.55	"
0.29	"	"	"	0.71	"	"	"	17.59	"
0.28	"	"	"	0.72	"	"	"	17.63	"
0.27	"	"	"	0.73	"	"	"	17.67	"
0.26	"	"	"	0.74	"	"	"	17.71	"
0.25	"	"	"	0.75	"	"	"	17.76	"
0.24	"	"	"	0.76	"	"	"	17.80	"
0.23	"	"	"	0.77	"	"	"	17.84	"
0.22	"	"	"	0.78	"	"	"	17.89	"
0.21	"	"	"	0.79	"	"	"	17.93	"
0.20	"	"	"	0.80	"	"	"	17.97	"
0.19	"	"	"	0.81	"	"	"	18.02	"
0.18	"	"	"	0.82	"	"	"	18.06	"
0.17	"	"	"	0.83	"	"	"	18.10	"
0.16	"	"	"	0.84	"	"	"	18.15	"
0.15	"	"	"	0.85	"	"	"	18.19	"
0.14	"	"	"	0.86	"	"	"	18.23	"
0.13	"	"	"	0.87	"	"	"	18.27	"
0.12	"	"	"	0.88	"	"	"	18.32	"
0.11	"	"	"	0.89	"	"	"	18.36	"
0.10	"	"	"	0.90	"	"	"	18.40	"
0.09	"	"	"	0.91	"	"	"	18.45	"
0.08	"	"	"	0.92	"	"	"	18.49	"
0.07	"	"	"	0.93	"	"	"	18.53	"
0.06	"	"	"	0.94	"	"	"	18.58	"
0.05	"	"	"	0.95	"	"	"	18.62	"
0.04	"	"	"	0.96	"	"	"	18.66	"
0.03	"	"	"	0.97	"	"	"	18.71	"
0.02	"	"	"	0.98	"	"	"	18.75	"
0.01	"	"	"	0.99	"	"	"	18.80	"
0.00	"	"	"	1.00	"	"	"	18.84	"

If the hydrochloric and the sulphuric acids in the chloride of potassium and sulphate of potash respectively have been ascertained, it may also be proceeded with thus: by neutralizing a measured portion of the filtered potash solution with tartaric acid, then adding the same quantity of these acids once more, and then evaporating the whole of it in a porcelain saucer in a water-bath till dry, dissolving the residue, after it has assumed the temperature of the room, in a solution of tartaric acid which has been saturated in the same temperature, then drying the same also over a water-bath and weighing it. There are formed, when the neutral solution of the tartaric acid salts are mixed with the second equivalent of tartaric acid, acid tartrate of potash and acid tartrate of soda, of which, when they are dried and dissolved in the solution of tartaric acid, only the alkali becomes dissolved, while tartar becomes the residue, and after drying is calculated with the alkali. If from this is deducted the potash which is combined with the hydrochloric and the sulphuric acids, then the remainder will be that portion which is combined with carbonic acid. Perhaps this latter method deserves the preference, since here at least the potash is directly fixed, but, on the other hand, it is somewhat more intricate.

To avoid the calculation of potash in hydrate of potash and carbonate of potash, we give the following table, which has been calculated for this purpose, viz.:—

Potash = KO.	Hydrate of potash = KO,HO.	Carbonate of potash = KO,CO$_2$.	Potash = KO.	Hydrate of potash = KO,HO.	Carbonate of potash = KO,CO$_2$.	Potash = KO.	Hydrate of potash = KO,HO.	Carbonate of potash = KO,CO$_2$.
1	1.19	1.47	35	41.68	51.40	69	82.17	101.37
2	2.38	2.93	36	42.87	52.87	70	83.36	102.83
3	3.57	4.40	37	44.06	54 33	71	84.55	104.30
4	4.76	5.87	38	45.25	55.70	72	85.74	105.77
5	5.95	7.33	39	46.44	57.17	73	86.93	107.23
6	7.14	8.80	40	47.63	58.73	74	88.12	
7	8.33	10.27	41	49.82	60.20	75	89.31	
8	9.52	11.73	42	50.01	61.67	76	90.50	
9	10.71	13.20	43	51.20	63.13	77	91.69	
10	11.91	14 67	44	52.39	64.60	78	92.88	
11	13.10	16.13	45	53.58	66.07	79	94.07	
12	14.29	17.60	46	54.77	67.53	80	95.26	
13	15.48	19.07	47	55.96	69.00	81	96.45	
14	16.67	20.53	48	57.15	70.47	82	97.64	
15	17.86	22 03	49	58.34	71.93	83	98.83	
16	19.05	23 47	50	59.53	73.40	84	100 04	
17	20.24	24.93	51	60.72	74 87	85	101.23	
18	21.43	26.40	52	61.91	76.33	86	102.42	
19	22.62	27.87	53	63.11	77.80	87	103 61	
20	23.82	29.34	54	64.30	79.27	88	104 80	
21	25.01	30.80	55	65.50	80.73	89	105.99	
22	26.20	32.27	56	66.69	82.20	90	107 18	
23	27.39	33.73	57	67.88	83.67			
24	28.58	35.20	58	69.07	85.13			
25	29.77	36.67	59	70.26	86.60			
26	30.96	38 13	60	71.45	88.14			
27	32.15	39.60	61	72.64	89.61			
28	33.34	41.07	62	73.83	91.10			
29	34.53	42.53	63	75.03	92.57			
30	35.73	44.04	64	76.22	94.03			
31	36.91	45.53	65	77.41	95.50			
32	38.10	47.00	66	78.60	96.97			
33	39.29	48.47	67	79.79	98.43			
34	40.49	49.93	68	80.98	99.90			

We also append a table for soda :—

Soda NaO.	Hydrate of soda NaO HO.	Anhydrous carbonate of soda NaO,CO_2.	Crystallized carbonate of soda $NaO,CO_2,10HO$.	Soda NaO.	Hydrate of soda NaO HO.	Anhydrous carbonate of soda NaO,CO_2.	Crystallized carbonate of soda $NaO,CO_2,10HO$.
1	1.29	1.71	4.61	51	65.81	87.19	235.29
2	2.58	3.41	9.22	52	67.10	88.90	239.87
3	3.87	5.13	13.83	53	68.39	90.61	244.48
4	5.16	6.82	18.44	54	69 68	92.32	249.10
5	6.45	8.55	23.05	55	70.97	94.03	253.71
6	7.74	10 26	27 66	56	72.26	95.74	258.32
7	9.03	11.97	32 29	57	73.55	97.45	262.94
8	10.32	13.64	36.88	58	74.84	99.16	267.55
9	11.61	15.39	41.49	59	76.13	100.87	272.16
10	12.90	17.10	46.13	60	77.42	102.58	279.77
11	14.91	18.81	50.74	61	78.71	104.29	281.40
12	15.48	20.52	55.35	62	80.00	106.00	286.01
13	16.77	22.53	59.87	63	81.29	107.71	290.62
14	18.06	23.93	64.58	64	82.58	109 42	295.23
15	19.35	25.64	66.19	65	83.87	111.13	299.85
16	20.64	27.35	73.80	66	85.16	112.84	304.46
17	21.93	29.16	78.42	67	86 45	114.55	309.08
18	23.22	30.77	83.03	68	87.74	116.26	313.69
19	24.52	32.84	87.64	69	89.03	117.97	318.30
20	25.81	34.19	92 26	70	90.32	119.68	322.90
21	27.10	35.90	96.87	71	91.61	121.39	327.52
22	28.34	37.63	101.48	72	92.90	123.10	332.18
23	29.68	39.32	106.10	73	94.19	124.81	336.74
24	30.97	41.03	110.71	74	95.48	126.52	341.36
25	32.26	42.74	115.32	75	96 77	128.23	345.97
26	33.85	44.45	119.94	76	98.06	129.94	350.58
27	34.84	46 16	124.55	77	99.35	131.64	355.20
28	36.13	47.87	129.16	78	100.64	133.35	359.81
29	37.42	49.58	133.78	79	101.93	135.07	364.41
30	38.71	51.29	138.39	80	103.25	136.77	369.03
31	40.00	53.00	143.00	81	104.51	138.48	373.64
32	41.29	54.71	147.61	82	105.80	140.19	378.26
33	42.58	56.92	152.23	83	107.09	141.90	382.87
34	43.87	58.13	156.84	84	108.38	143.61	387.48
35	45.16	59.84	161.45	85	109.67	145.32	392.09
36	46.45	61.55	166.07	86	110 96	147.03	396.71
37	47.74	63.26	170.68	87	112.25	148.71	401.32
38	49.03	64.97	175.29	88	113.55	150.45	405.43
39	50.32	66.68	179.90	89	114.84	152.16	410.55
40	51.61	68.39	184.51	90	116.13	153 87	415.16
41	52.90	70.10	189.13	91	117.41	155.38	419.77
42	54.19	71.81	193.74	92	118.70	157 29	424.34
43	55.48	73.42	198.35	93	120.00	159.00	429.00
44	56.77	75.23	202.97	94	121.29	160.71	433.61
45	58.06	76.94	207.58	95	122.58	162.42	438.22
46	59.35	78.65	212 19	96	123.86	164.13	442.84
47	60.64	80.35	216.81	97	125.15	165.84	447.45
48	61.93	82.06	221.42	98	126.74	167.55	452.06
49	63.22	83.77	226.03	99	127.03	169.26	456.67
50	64.52	85.48	230.64	100	129.44	170.79	461.28

Analysis of Lime.

It might scarcely appear admissible to judge from the nature of a small piece of lime—such as is needed for its investigation—and to draw conclusions as to the value of the entire bulk from which this fragment was taken. An average sample should therefore be chosen. This is done by taking from a number of pieces small portions, and pulverizing and mixing them well. From this mixture of lime are weighed off 2.8 grammes (43.21 grains) of lime, which are placed in a 100 cubic centimetre (3.38 fl. ozs.) measuring flask, slaked with water, mixed with 5 grammes (77.15 grains) muriate of ammonia, and then the flask filled up to the mark with water. After the ensuing decomposition, and when the liquid has cleared off, 10 cubic centimetres (0.388 fluid oz.) standard nitric acid are placed in a porcelain saucer, mixed with tincture of litmus, and by means of a pipette—graduated to $\frac{1}{10}$ cubic centimetre (0.027 fluidrachm) divisions—titrated with the normal ammonia liquid until the appearance of the blue color. Of this 12.7 cubic centimetres (0.427 fluid oz.) are used. Inasmuch as the consumption is the larger the more diluted the liquid is, so becomes the proportion in this instance reversed.

In order to find the percentage of caustic lime, we must divide by 12.7 in $10 \times 100 = 1000$; and thus obtain 78.74 per cent.

In the case of another lime, treated in the same manner, there were used for 10 cubic centimetres (0.338 fluid oz.) of nitric acid 11.6 cubic centimetres (0.391 fluid oz.) of the ammonia liquid; the same contained therefore $\frac{1000}{11.6} = 86.2$ per cent. caustic lime.

SECTION IX.

THE APPLICATION OF SOAPS.

SOAPS have so many uses and are so well known that it may be superfluous to attempt to give all the different uses to which they are applied, but they may be divided into several classes; thus soaps for domestic and laundry purposes and those most in common use, as the tallow and rosin soaps. Soaps for toilet purposes are a numerous class, and of great variety for bathing, shaving, etc., and the soaps for manufacturers or for technical purposes, and those used for dyeing, for fulling, wool-washing, etc., and also for lithographic colors and numerous other purposes in the arts.

The soaps for wool-washing and fulling should be those that lather well and have a slight excess of alkali and be free from starch or resin; the better classes of soft soaps are made for these purposes. The soaps used in dyeing establishments should be of a still better class, free from all adulterations, entirely neutral and without any free alkali; those for the lithographic tints as perfectly made as possible, and without any culinary salt; while the toilet soaps should receive especial care in the selection of the purest materials, and in their manipulation great regard to the correct equivalents of the fat with the bases to insure their neutrality, and the admixtures they may contain should be such as are entirely harmless in using, or such as would improve their quality for the purpose they are designed for.

The action of soaps in washing is but little understood, and is based upon their decomposition in a large excess of water. When a diluted solution of the sebacic acid with alkali is decomposed into an acid salt, that being insoluble floats away while the alkali dissolves the grease and dirt.

We have explained that soaps are really acid salts, as stearic acid salt, oleic acid salt, etc. Thus, if we take one part of these salts to 500 parts of cold water, the diluted caustic potash or soda, becoming free, acts as a solvent of the dirt or grease, without injuring the fabric or the skin of the hands as a solution of pure alkali would do. It thus appears that the separated acid salts afford to sebacic acids a certain protection at the same time that they are themselves useful for cleansing, because many substances especially the fats suspend themselves as emulsions in the water and can be rinsed off with additional water.

A further advantage that soap has in its applications over other detergent matters, is in its form, which admits of its being used in any desirable quantity. When applied with water and assisted by friction, we make an emulsion of the dirt, then by adding more water the alkali is set free and exerts its effects, yet by the large quantity of water it is so diluted that it cannot act destructively.

SECTION X.

THE ESTABLISHMENT OF A SOAP FACTORY WITH THE NECESSARY PLANT.

MUCH might be said and many instructions given on this important subject which perhaps would find but little direct application by the person intending to establish a factory for making soaps, for they might not suit the conditions of his case; yet there are general maxims founded upon just principles which may apply to nearly all, such as—

The location;
The building;
The water;
The plant;
The machinery, etc. etc.

Of the location it would naturally be of advantage to have such an one that the raw materials might be readily and cheaply obtained, as well as that the products of manufacture might with facility be sent to market. The location will also depend upon the kind of soap made, for certain kinds may be needed for certain localities or certain materials can be procured to advantage in others that would be a saving in the cost of production. All this cannot be a matter for discussion, as each manufacturer must naturally be the best judge of where to establish himself and what to make in order to suit the wants of his customers. But wherever located it is our province to give such hints as may improve his facilities, control his expenses, raise the quality of his work, and above all enhance his profits.

This industry is an eminently progressive one, and there are being constantly invented many new kinds of machinery and labor-saving appliances, which tend to a more economical and improved manufacture. This is particularly the case in the United States, where new and convenient appliances have done much to improve the quality of soaps generally, while they serve to economize time and labor and so cheapen the production.

Concerning the building much must depend upon the space and usually a good deal is required, as well as a large yard. The building had better be of an oblong or square form. That part where the soap is boiled should have extra facilities for carrying off the steam and the vapors that are not agreeable to people generally. It is best to have the large chimney situated in the centre of the building, that the kettles may surround it. If they are to be heated by an open fire, the furnace is usually in the basement, while the rim of the kettle is extended above the first floor sufficiently high to facilitate the stirring. This arrangement also holds good for the heating by open fire or by super-heated steam.

Two large kettles answer in most cases for a large business, so that two other kettles may serve for making the lye. The tanks for preserving the caustic lyes are best made of cast iron, and are very frequently inserted in the ground. This arrangement is in itself convenient, room is economized and the lyes are always on hand. They must be well covered and it is best to cover them with cast-iron lids. The taking out of the lyes is much more easily performed if the tank is somewhat elevated so that the lye may be drawn by siphons or by spigots. We prefer the so-called water levels, since between these and the lye kettle the apparatus for filtering the lyes may be fixed. These water levels or pits may consist of walled and well-cemented vats. It is much cheaper to use barrels sunk into the ground and well cemented inside.

Adjoining the boiling house, there should be on the one side rooms for storing the raw materials, the potash, soda, and lime, and the oils and fats. The first room must be tolerably warm; the room for the fats as cool as possible. To keep the fats in the cellar is, on account of taking them up and down, not advisable, and in the building of a new factory is easily avoided. On the opposite side are situated the rooms for the soap, where it is cut into bars after it comes out of the forms, is dried, and finally packed for transportation. The upper rooms are most desirable for drying the soap.

Since, for the producing of lyes, the application of the purest possible water is of the greatest advantage, the building should be supplied with roof-gutters, in order to receive all descending rain-water into a cistern, which should be situated adjacent to the factory, and, by means of a force-pump, the water should be carried to the respective places. Besides this, there should be in the yard a well of good water.

The following is a description of the soap manufactory for Marseilles Soap of Gontard in St. Quen, near Paris (France).—Although in Marseilles, which is favored by local conditions, the soap manufacture is carried on on a very extensive scale, nevertheless that industry does not there excel in especially good appointments. A more complete soap manufactory is at St. Quen. This establishment is situated in an open field, in the immediate neighborhood of the railway depot and the canal basin of St. Quen, and is in immediate connection with the Paris belt-road, and this with all other French roads. There are high airy rooms on the ground-floor. The kettles are of wood with bottoms of wrought-iron plates, and fixed in the ground, extending to subterranean vaults, that their lower parts may be easily reached to discover every spot which may leak. The soap is boiled therein with surcharged steam, which is admitted by serpentine pipes fixed in the bottom. Steam is furnished from three boilers of 25 horse-power, then carried through a system of drawn tubes (or conduit pipes) which, by a special fire, are heated almost to a red-heat.

All labor being carried on on even ground, besides water and lye pumps, there is no especial lifting apparatus necessary. Gontard manufactures only solid (grain) soap, and its composition which in 100 is 60 per cent. sebacic acid, 6 per cent. soda, and 34 per cent. water, is kept very constant. This soap is perfectly neutral, and therefore for the washing of the hands and for technical operations is excellent. Especially olive-, sesame-, and ground-nut oil are worked into soap; the latter oil is pressed in the establishment itself, the former brought from the south of France.

Caustic soda lye is preserved of various degrees of strength in five large, immured, water-tight kettles. By mixing, a lye is obtained of the medium strength, which is = 10° B., and the dry alkali used is usually 30 per cent. caustic soda, about 9 per cent. sulphate of soda, 6 to 8 per cent. sulphite of soda, 4 to 7 per cent. carbonate of soda, and 6 to 10 per cent. culinary salt, while the rest consists of water.

Two kettles are always used for boiling the soap at the same time. In each are filled 1500 litres (330 gals.) lye of medium strength, which is gently heated by the steam worm. Thereupon the barrels, which contain in the aggregrate about 3500 litres (770 gals.) of oil, are rolled over a conduit lined with lead, which is inclined towards the boiler. They are tapped, the oil runs into the canal, and flows thence into the kettles.

Here it meets the tolerably warm lye, and now the formation of soap-paste soon takes place. In this manner the combining of the sebacic acids with the alkali progresses, the mass thickens, and, if after 24 to 28 hours, the saponification proves sufficiently advanced and the caustic soda amply bound, they proceed with the first cutting of the pan or separation. On this first operation of saponifying (*empâtage*) success mostly depends.

The boiling is now interrupted, and 600 to 800 litres (132 to 176 gals.) salted lye are put into the kettle, while the soap is pushed together with a square piece of board of about 90 centimetres (3.51 inches) long, which is fastened to a long stick, and thus is the lye incorporated. The mass becomes grainy, the superfluous water, the separated glycerine, and the uncombined salts separate as sub-lye. The steam is completely turned off, and the mass is left for a few hours to settle, whereupon the lye, by means of the opening of a conical valve situated on the bottom, is permitted to run off. It may be condensed, and, after separating the salts, worked up for glycerine, by distilling it with surcharged steam. Should the soap not yet be sufficiently pure and solid, the "cutting of the pan" is to be repeated, with a stronger salted lye.

Now the process of boiling is proceeded with. The soap receives the addition of 1200 to 1400 litres (264 to 308 gals.) of good and strong lye, and is left boiling for several hours. The soap grains, which are insoluble in this strong lye, thicken still more and more, and they absorb alkali and separate water. The culinary salt and the surplus water remain in the sub-lye. It is permitted to settle, and thus but a very weak alkali is drawn off, in order to renew the addition of fresh and strong lye. This is proceeded with until the soap no longer absorbs any caustic soda, and the lye, by the longer boiling and evaporation, becomes specifically heavier, while the soap, by absorption of water and the solution of alkali specifically lighter. The soap, thus finished boiling, has a characteristic smell. It dissolves in hot water without separating any oily drops, and gives, when pressed between the thumb and index finger, a solid touch, and shows in this condition a dark blue-black color of sulphuret of iron.

If fitted soap is to be produced from it, it must be made more fluid by adding more water. A workman climbs over a platform, which is placed over the boiler, and pushes the above-mentioned paddle down to the bottom. In the opening formed thereby, a second workman pours a few litres of weak lye or water. The first workman withdraws his paddle and pushes down in another place, and so on until 800 litres (176 gals.) water have been consumed, then a little less steam is admitted; the grains dissolve, and the muddy impurities fall to the bottom.

To produce the peculiar marbling of the grain soaps, about 1½ kilogramme (3.3 lbs.) of iron red or "kalkothar" are mixed with just as much strong lye as is necessary to dispose the formed precipitate into the peculiar division of flames and stripes. For this marbling a peculiar skill is required. If the soap is too watery or if it cools off too slowly, the precipitate settles too easily and the marbling is lost.

The finished soap is poured by means of copper scoops into the canals which lead to the frames, large basins which are about 75 centimetres (29.4 inches) high. The lye settles on the bottom, and the hardening occurs in 5 or 6 days. The soap mass is cut with long knives into large blocks which are divided by wire into smaller pieces. The soap, being still soft, is not yet suitable for shipment, and in order to make it hard without the loss of the latent water or to suffer too much shrinkage, it is dipped into a very strong lye, after which the hardening is accomplished by 12 or 14 days' drying. The soap is now finished and ready for shipment. The establishment in St. Quen possesses 8 soap boilers of 15,000 litres (3300 gallons) capacity, 24 basins for filtering the lye, and 30 receiving vessels. Every day 14,000 kilogrammes (30,800 lbs.) of soap are finished, which amounts to 4,000,000 kilogrammes (8,800,000 lbs.) annually. The workmen, 40 in number, cost daily for wages but 200 francs ($40), while the value of the soap daily produced amounts to at least 12,000 francs ($2400).

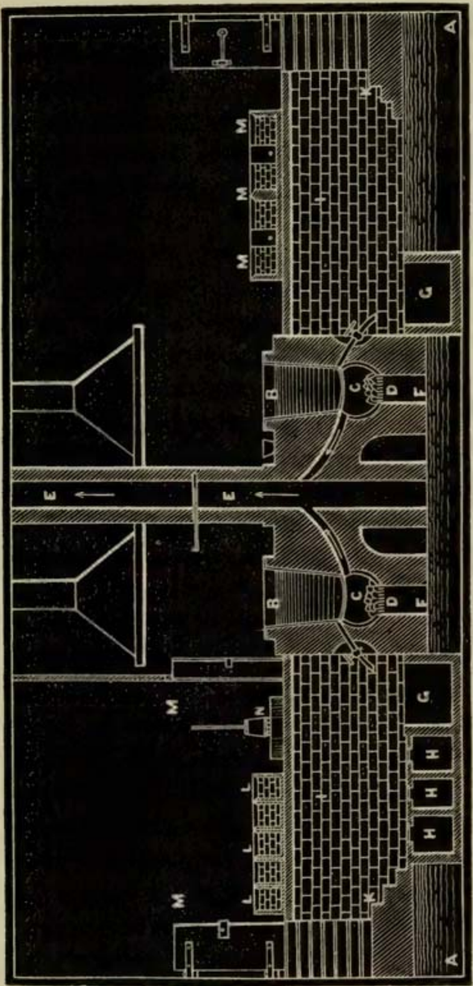
The market of Paris is nearly one-half supplied by this manufactory, while the northern provinces are almost entirely furnished by it. The proprietor of this establishment receives his orders six months in advance.

Of course it is not in the power of many manufacturers to possess such extensive establishments, yet there is so much of interest and instruction in this description, that for this reason we give the details.

We have often mentioned the importance of pure water in this manufacture, as well for soap as for the solution of the lyes as the usual impurities of water cause a waste in both; for a fuller treatise on this matter the reader is referred to another part of this work, in the section on materials.

In the arrangement of the plant of a soap manufactory, much must depend upon the means at hand, yet so much depends upon the completeness of the different implements and machinery, for the rapid and economical production of the soaps, that we must endeavor to describe all the most useful and the latest inventions for conducting the different processes with the greatest facility. We will precede this with illustrations of two French soap factories which may prove useful as hints.

Fig. 13.



First, one for making the mottled Marseilles soap, with an open fire.

A A. *Factory Building.*—This building has the form of a parallelogram, the dimensions of which vary according to the importance of the manufacture. It is divided into three compartments; the middle one is occupied by the kettles, frames, and lye vats. That on the left contains the lixiviating apparatus. That on the right is employed as a store-room. A basement about 9 feet below the first floor forms passages and cellars, a part of which is occupied by the furnaces and reservoirs of masonry to receive the waste lyes drawn from the kettles during the boiling of the soaps. The communication with the first floor is by the stairways K K.

B B. *Kettles.*—It is in these kettles that oils and fatty matters are saponified, by means of caustic lyes of soda. They are placed on a parallel line; below these kettles are passages and arched cellars, in which are placed the furnaces and masonry vats, to receive the waste lyes, which collect at the bottom of the kettles below the soap. Their capacity varies from 1250 to 5000 gallons. Their upper level is about 3 feet above that of the floor of the cellar, which is ordinarily paved with bricks or hard flagstones.

C C. *Fireplace.*—The fireplace is the space which separates the grate from the bottom of the kettle. The space varies from 13 to 20 inches, according to the capacity of the kettles. The inside of the fireplace is constructed of good refractory bricks, and has the form of a truncated cone.

D D. *Grate*, or the part of the fireplace destined to support the fuel. It is composed of cast-iron bars placed near each other, at the distance of about one-third of an inch. These bars are generally one inch in thickness, so that the grate presents a surface of draught equal to one-fourth of its total surface. Experience has shown that these proportions are the most convenient for producing a complete combustion of the fuel.

E E. *General chimney* into which all the products of the combustion are discharged. The higher the chimney the better the draft. Its inside diameter must always be proportioned to the total opening of the flues of the furnace. To hasten or slacken the combustion in the furnaces, each chimney is provided with a good register.

F F. *Ash-pan.*—The ash-pan is the vacant space between the ground and the grate. It has two different objects. First, it gives passage to the air between the bars of the grate, an essential condition to keep up the fire; secondly, it is a kind of magazine for the ashes. Its dimensions are variable, but it is ordinarily as wide as the grate. It is important not to let the ashes accumulate in it, for in this case the obstruction to the entrance of air under the grate would retard the combustion.

G G. *Cisterns in masonry* placed under the kettles. They are used to receive the waste lyes. A pump placed in each cistern is employed to raise the lye they contain, into a large masonry or sheet-iron vat placed on the first floor.

H H H. *Large masonry vats* in which are kept separately the different qualities of oil used in the saponification. Their capacity is very variable—from 2500 to 12,500 gallons. They are ordinarily covered by an arch of bricks, in the middle of which there is a large opening closed by a wooden trap-door.

I I. *Cellars* below the first floor.

L L L. *Basins* of brick or stone. They are used to lixiviate the crude soda for the preparation of caustic lyes. Their number, like their capacity, varies according to the importance of the manufacture. They are located on the first floor, and parallel with the kettles; immediately below, large cisterns are constructed, from six to nine feet deep, specially intended to be used as receivers for the different lyes obtained by the lixiviation of the crude soda.

M M M. *Frames* constructed of brick and cement, which have the form of a parallelogram, and their height varies between seventeen and twenty-three inches. The upper part must always be lower than the edges of the kettles, so that by means of a wooden trough, inclined towards the frames, the soap, after being boiled, may be run into them. Their capacity varies according to the size of the kettle. Generally each kettle requires three frames, which are simultaneously employed.

M M. *Store-rooms* containing the crude sodas. It is also in this room that the sodas are pulverized and mixed with the proper proportions of lime to form the carbonate into caustic soda.

The pulverizing of the soda is done in N. The powder must not be too fine, for in such case the lixiviation would be impossible or very difficult.

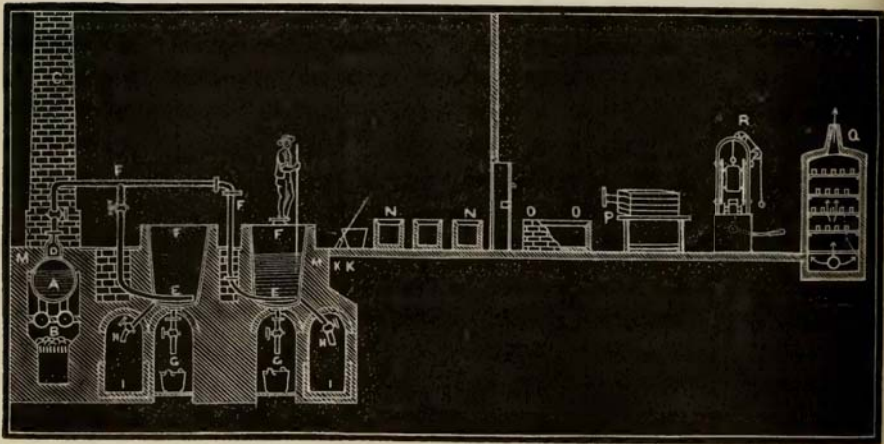
Description of a General Plan for a Manufactory of Soap Heated by Steam.—The application of steam to the fabrication of soaps has become nearly general. This system presents advantages so evident, over the heating by open fire, that it is now very generally adopted. In the following figure we give the plan of a manufactory in which all the kettles are heated by steam.

A. *Boiler* to produce steam.

B. *Fireplace* provided with a cast-iron grate, in which the fuel is burned.

C. *Chimney* for the discharge of the products of the combustion.

Fig. 14.



D. *Dome* from which the steam is discharged by means of the pipe F F, into flat coils, placed at about one inch from the bottom of the kettle. This dome is necessary to prevent the boiling water from entering the pipe, and thence passing into the coil.

F F. *Kettles* to boil the soap. Their shape is the same as the ordinary kettles, only at the bottom there is a horizontal worm in which steam continually circulates during the boiling of the soap. Each worm is provided with a waste pipe, which traverses the bottom of the kettle to discharge the water of condensation. The worms are designated by the letters E E, and the waste pipes by G G. These pipes are provided each with a valve which is opened or closed at will.

H H. *Pipes*, to draw off the lyes from the kettles.

I I. *Cisterns* of masonry, used to receive the old lyes drawn from the kettles.

K K. *Cellars*, communicating with the cisterns and the furnace by a stairway.

M M. *Foundation* of the kettles. This foundation is made of brick and cement; and its object is to render the kettles more solid, and prevent the loss of heat.

N N. *Sheet-iron* vats, used to receive new lyes.

O O. *Frames*, into which the soap, when finished, is drawn. These frames are of wood, and open in four parts. P. *Table* on which the soap is divided into bars and cakes. Q. *Drying-room*, using hot air in which the soap is dried. Illustrated and described elsewhere. R. *Ram*. This machine is used to mould the soap by means of a copper matrix. A heater for superheating the steam is now very customary, and has its advantages.

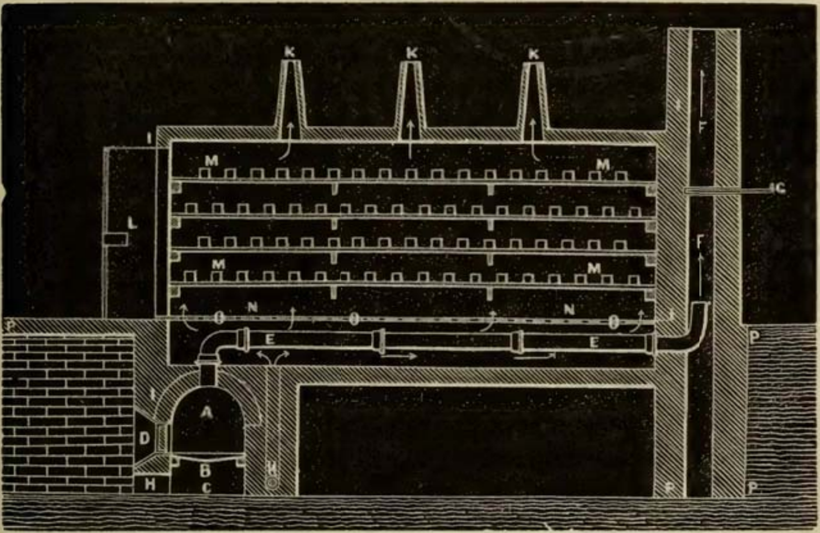
The advantages of the system by steam may be summed up in the following points: 1. Economy in fuel, since several kettles can be heated by the same fire. 2. Facility and rapidity in the work. 3. Products of a quality superior to those obtained by heating with an open fire. 4. Economy of labor.

The indispensable necessity of water in soap factories, either for the preparation of lyes, or the cleaning of the apparatus, must determine the manufacturer to establish his factory near a stream of clear and limpid water. This condition ought to be attended to, whenever circumstances will permit it, for it is of great importance in the fabrication. In case well water has to be used, it will be more economical to use a pump than to draw by hand. Then it will be convenient to prepare a large cistern below the surface of the ground, and to have it full at all times, for the various uses of the manufacture.

The *drying-room* mentioned we here illustrate in the annexed cut, and remark that all soaps do not require drying, but many do, and a drying-room is very necessary—one with warm air or a steam heat, or one well ventilated by air. The latter does not require any heating apparatus, but can be used only in fine weather. It is generally established in the upper story of the building, where the air circulates freely. Shelves or racks, on which are placed the pieces of soap to be dried, are fixed in the room, eight or ten inches apart, one above the other; this separation has the advantage of accelerating the drying of the soap, by putting it in contact with a greater mass of air; the desiccation is more rapid when the temperature of the air is elevated. This mode of drying is incontestably the most economical, because it does not require either apparatus or fuel; it is also the most regular and the best for the drying of soaps, and it may be used whenever circumstances will permit; unhappily it is subject to the variations of seasons and weather so frequent in our climate. The drying-rooms with warm air have the advantage of being used at all seasons. In many manufactories, the drying-room consists of a more or less large room around which shelves provided with trays are disposed, and upon which are placed the pieces of soap to be dried. In the middle of the room is a stove heated with wood or coal. The temperature must not be above 26.6° C. (80° F.); openings must be made in different parts of the room to permit the air, saturated with moisture, to escape freely. This arrangement quickly hastens the drying of the soap. A temperature of 26.6° C. (80° F.) is sufficient to dry in fifteen or twenty hours pieces of olein soap destined to be moulded.

Drying-room with Warm Air.—The drying of soaps in the free air cannot be practised at all seasons, and has to be stopped in rainy or damp weather. As for the drying in a room heated by a stove—while this mode is generally employed, it presents the inconvenience of localizing and causing an unequal distribution of the heat. Some shelves are remote from the source of heat—being *but little affected by it*—from which it results that the soap does not dry equally in all parts of the drying-room. This is not the only inconvenience; stoves often smoke, especially when first lighted, and the smoke stains and blackens the pieces of soap. These different inconveniences, and particularly that of the smoke, have obliged some manufacturers to use drying-rooms heated by hot air. By this system, they completely utilize the heat produced by the fuel, and the hot air which flows into the room is always pure, without either odor or smoke. What distinguishes this system from all others is, that the desiccation of the soap is rather produced by an energetic ventilation, occasioned by the abundance of the hot air continually renewed in the room, than by a high temperature; and experience proves that, in rooms heated by a good stove, it requires twenty-five to thirty hours to

Fig. 15.



dry the soap, while with a much smaller expense of fuel a treble quantity of soap can be dried in eight or ten hours in a room heated by hot air. Fig. 15 presents a longitudinal section of a drying-room with hot air.

A. Furnace in which the fuel is burned.

B. Grate.

C. Ash-pan.

D. Door of the fireplace.

E E. Cast-iron flue through which the fire and smoke pass to the chimney.

F F. Chimney for the exit of the products of combustion.

G. Register in the chimney, used to regulate the draft of the fire, and thus control the temperature of the hot air in the room.

H H. Opening for the introduction of cold air; this air grows warm by circulating round the furnace A, and passes into the room by means of proper apertures.

I I I I. Walls of the room which must have the thickness of a brick.

K K K. Chimneys by which the air escapes, more or less saturated with the moisture of the room.

L. Door by which the trays, full of soap, are introduced into the room.

M M M M. Squares representing the pieces of soap to be dried.

N N. Vacant space between the trays and the bottom of the room.

O O O O. Vent holes in the masonry which traverses the room in all its length, and which is provided with many openings to allow the hot air to pass into the room.

P P P P P. Stone or brick foundation on which the room is built.

The manner of using this drying-room is very simple. After filling the trays with pieces of soap, they are introduced into the room by the door L; the door is closed, and the fire lighted. The cold air enters by the openings H H, grows warm by circulating around the furnace, and flows continually into the room by the openings O O O. The temperature must not be too high but must be kept between 26.6° C. (80° F.) and 30° C. (86° F.). With an ordinary room, it is possible to dry 20,000 pounds of soap in a day.

Kettles.—In our description of the necessary plan, the first item should be the kettles, which are of various kinds. Kettles are vessels in which, by means of heat, the manufacturer combines fatty bodies with lyes of potash or soda to form soap. Their dimensions vary according to the quantity needed. It is always advantageous to operate with large kettles, because they present a greater economy of labor, fuel, and lyes than the small ones. As for the capacity, we have ascertained that, for the treatment of every 100 pounds of fatty matter, we require a capacity of about 37½ gallons, thus: to saponify 1000 pounds, a kettle of a capacity of 375 gallons; for 2000 pounds, 750 gallons; and for 3000 pounds, from 1000 to 1125 gallons, which represents the ordinary size of the kettles of Marseilles. Whatever are their dimensions, these kettles have always a circular form, and gradually widen up to the top, so as to form a cone. Some have flat bottoms, others have convex or concave bottoms. Experience has shown that the latter arrangement is the best, and the most convenient for the work. Whatever is their capacity, they are always provided at their lower part with a pipe, with valve used to draw off, after each operation, the sub-lyes collected under the soap.

Masonry Kettles.—At Marseilles nearly all the kettles of soap manufacturers are made of masonry, except the bottom, which is of copper or sheet iron. The most essential condition for the construction of such a kettle is to establish it on a good solid foundation. This foundation is covered with a thick mass of masonry, constructed of good materials, which is rendered tight with hydraulic mortar, a little soft, so that it may penetrate into all the interstices of the mass; by which means the infiltrations of liquid are rendered impossible. The kettle is afterwards built on this mass, beginning at the hearth and the surrounding walls, to which a thickness is given proportioned to the capacity of the kettle. When the level is reached on which the bottom of the kettle has to rest, it is important to employ materials of the best quality, and the least apt to be destroyed by the action of heat and lyes. Some stones are not good for these kinds of construction, because the heat quickly injures them. Good stone must be used for the outside walls. As for the inside of the kettle, it is always formed of a thick counter wall, of hard and well-burned bricks, and of pozzuolana cement, employed with a certain quantity of fine sand. It is very important to fill all the interstices exactly, for, independently of the loss of material, they would have the effect of accelerating the destruction of the masonry. To preserve the kettle, it is surrounded outside with hoops of very thick iron.

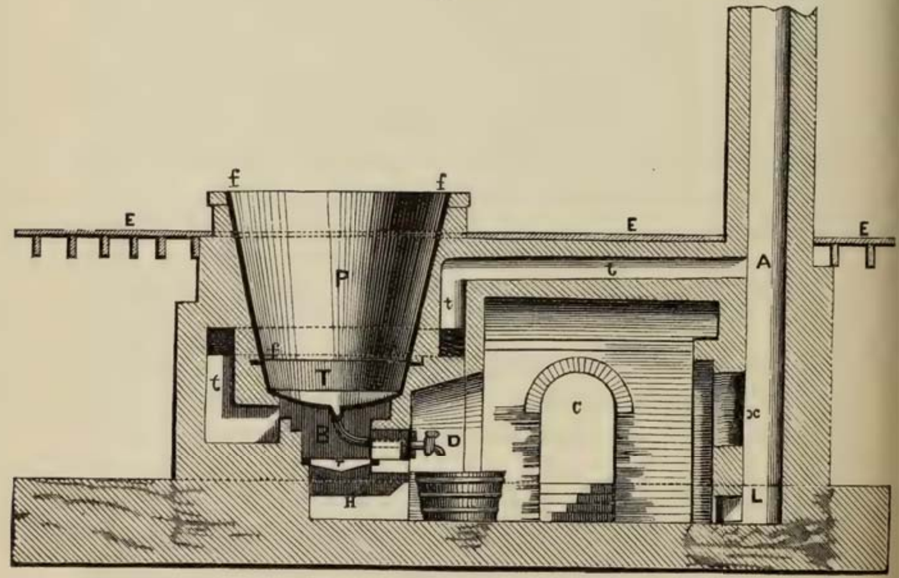
It is by these precautions that great solidity is given to these kettles. It is true, their construction is costly, and they require frequent repairs, but these inconveniences are well repaid by the advantages they present. The superiority attributed to these kettles over those made of metal, is generally recognized by the manufacturers of Marseilles, who use no others. Besides the advantage of better retaining the heat of the mass during the saponification, they are said to have that of not coloring the pastes, as is done by metal kettles. We do not know if there be any foundation for this assertion, but we can affirm that very white soaps are prepared in cast-iron or sheet-iron kettles; then, if the alteration of the whiteness and purity of the pastes were due to the use of metallic kettles, necessarily colored soaps would have been obtained, since these kettles were the only ones used; but it is not so—it is sufficient to see fine white soaps manufactured in such kettles, to be assured that there is no foundation for the statement. The only condition to be observed, is to keep the kettles always clean and dry, to prevent the formation of oxide of iron, which, by combining with the soap, would communicate to it a yellow coloration.

Cast-iron Kettles.—Cast-iron kettles are not much used in soap manufactories, because they are more costly than those of sheet iron, and also, because it is very difficult to have them of a large capacity, made of a single piece. In France they are used only in small manufactories, but in Belgium and England their use is more general. The first care to be taken in purchasing such a kettle, is to choose it without defects, and as thin as possible, for experience has shown that in this state it resists the action of fire better than when thicker. For the same reason soft cast iron must be preferred to hard. The first has a fine and soft grain, and can be more easily filed. It presents less inconvenience than the hard, brittle cast iron, and is capable of lasting much longer than the latter Indeed, a soft cast-iron kettle may last a very long time when well managed, besides, when warm, it requires very little fuel to keep up the heat.

Sheet-iron Kettles.—These kettles are now generally used in nearly all the soap manufactories. For a long time it was difficult to construct them, but since the progress in the mechanic arts, they have been constructed with great perfection. When a sheet-iron kettle is made, the dimensions must be calculated according to the quantity of soap to be manufactured. As we have said before, for every 100 lbs. of fatty matter, it requires a capacity of 37½ gallons; starting from this base, the maker will always succeed in giving to the kettle the capacity necessary for the work for which it is intended. As for the thickness of the metal, it varies according to the capacity of the kettle. For a kettle of 750 to 1000 gallons, the iron should have 3 millimetres (0.11 inch) of thickness for the lateral sides, and 4 to 5 millimetres (0.15 to 0.19 inch) for the bottom. All the solidity of such a kettle depends entirely on the riveting; however, as well riveted as a kettle may be, it often happens that the first time it is used it allows a little liquid to escape, but soon the soap, by stopping all the crevices, completely prevents the leaking.

Heating of Kettles by Fire.—In the heating of ordinary kettles by fire, the furnaces are constructed so as to absorb the most of the heat produced by the fuel, by applying at first the heat under the bottom of the kettle, and directing it afterwards around the sides, before losing it in the chimney. In soap kettles, on the contrary, a great part of the heat developed 'by the fuel is lost, because these kettles can be heated only at the bottom, so as not to burn the soap, which would be the case if the heat circulated around the sides. Notwithstanding the imperfection of this kind of construction, and the enormous loss of fuel, experience has demonstrated that it cannot be modified without great inconvenience. To diminish as much as possible the loss of heat, it is necessary: 1. That the fireplace should be right in the central axis of the kettle. 2. That the lining of the hearth should be of refractory brick, in order that the heat may be thrown back below the bottom of the kettle. 3. That the fuel which produces the most intense heat with the least flame should be used; hence hard coal should be selected. 4. That the openings through which the products of the combustion enter the chimney should possess together the same surface as the grate, experience having shown that this is the best arrangement for obtaining a good draft and effecting a complete combustion of the fuel. It is by fulfilling these conditions that the greatest amount of coal is utilized

Fig. 16.



in heating the kettles. But to obtain this result, it is essential to have a well-constructed furnace, with all the recent improvements. The furnace must be very dry before using it.

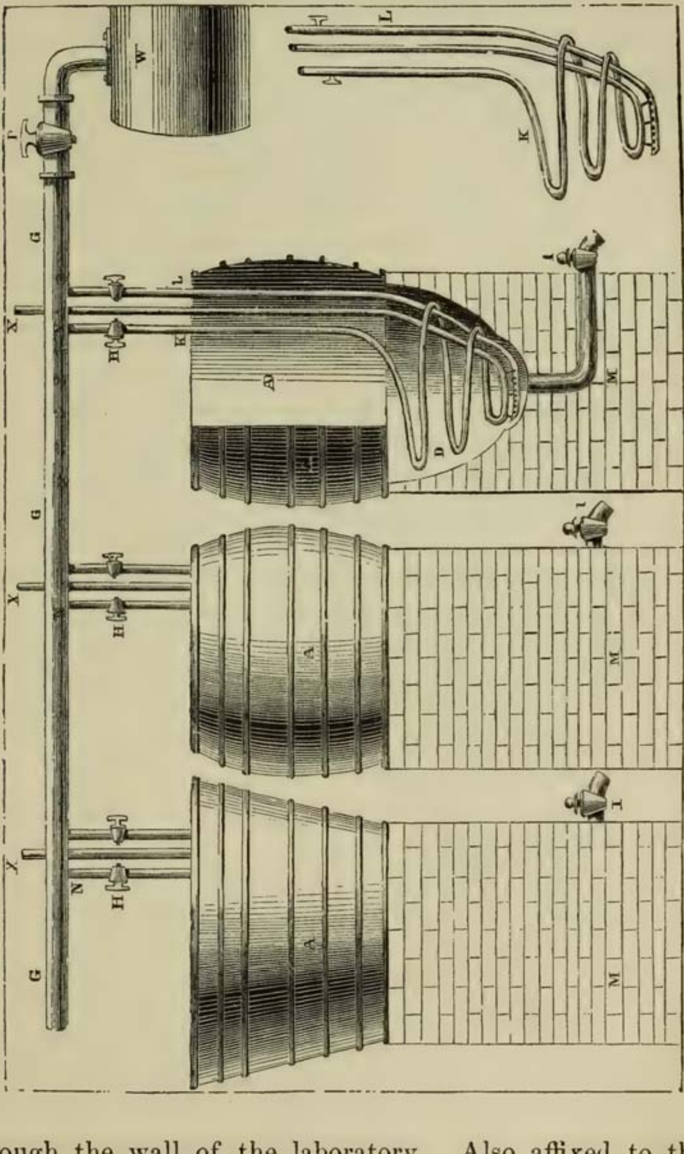
The figure (Fig. 16) represents a kettle heated by an open fire.

The sides are composed of brickwork erected and lined with cement. The upper part *f*, *f*, *f*, *f*, which never comes in contact with the fire, and is intended to afford space for the soap to rise, expands in the form of a cone. The fireplace B, is separated from the ash-pit H, by the grate *r*. The fire, after having heated the bottom of the pan, passes by the flue *t*, *t*, *t*, half round the side of the pan into the chimney A. This is accessible for the purpose of cleaning by the door *x*; the soot is thrown into the pit L. A tube with a cock leads from the lowest part of the pan for the removal of the spent lye. The whole of the pan is sunk into the floor of the boiling house, which is made of planks, stone, or iron plate, in such a manner that the brickwork of the upper part projects to about three feet above the floor.

Heating of the Kettles by Steam.—The most important invention introduced into the heating of the kettles, is incontestably the heating by steam. For a long time numerous experiments were made, but it is only within about fifty years that this new system has been advantageously applied. The first manufacturers who used steam discharged it directly into the mass of the soap; the result was that the water produced by the condensation of the steam considerably lowered the degree of the lyes used to saponify the fatty bodies. They were then under the necessity of using more concentrated lyes. Soon after, other manufacturers—to obviate the above inconveniences—conceived the idea of causing the steam to circulate in the kettle, within a double casing, in such a manner that water produced by the condensation of the steam should not mix with the lyes, and weaken their degree. This system is still followed in some manufactories, but it has the inconvenience of heating the sides of the pan too much, and the bottom not enough. The result is that the ebullition is never very regular, and is more pronounced on the sides than in the centre. Now, in new manufactories, pans with a double casing are suppressed, and the soap is heated directly by means of a flat worm of strong wrought iron, placed at about 3 to 4 inches from the bottom, and in which the steam circulates. This arrangement—as simple as it is ingenious, produces the best results, and the heating is so rapid that it requires only half an hour to boil a kettle containing 1000 pounds of soap, while the heating by an open fire will require from 3 to 4 hours. This advantage is not the only one this system presents; it enables us to heat with a single boiler, and consequently with the same furnace, several pans at a time, which presents a notable economy in fuel, time, and labor. There is no chance to burn the soap, as in heating with an open fire.

The use of superheated steam presents greater advantages than those obtained by ordinary steam. Experience has shown that, by the use of superheated steam, the operation is more rapid, and the expense in fuel greatly diminished. We give a representation of the whole arrangement, consisting of three caldrons, one for white, another for yellow, and a third for palm, and the finer soaps. G designates the main pipe or feeder, which is attached to the steam boiler W, of the establishment. It is stationary, and generally fitted against the wall, immediately above the kettles. The boiling caldrons are partly of iron and partly of wood—the upper portion or curb A being of wood, well hooped round by iron rings, and the lower portion D of cast iron, and so shaped that the worm may hug closely to the sides without loss of room, and the "blowpipe" fit snugly to the bottom. For the convenience of drawing off the spent lyes, there are attached a pipe and cock I. Each of these kettles, resting upon a hollow pile of circular mason work M, is furnished with a welded wrought-iron worm, which connects with the main feeder at N, and serves as the boiling medium of the soap paste. The steam is let on or off, by opening or shutting the cock H, and the waste steam is conducted through the other end of the worm X, which passes upward by the side of its inlet, and thence out in any convenient way

Fig. 17.



STEAM SERIES.

through the wall of the laboratory. Also affixed to the main feeder is another pipe, with a stopcock attached, and leading immediately downwards to the bottom of the kettle, where it is affixed to a circular iron tube, pierced around its circumference with holes. It is set immediately below the worm, and is called the "blowpipe," serving to give additional heat occasionally to the contents of the kettle, as well as to stir it up when necessary—an operation more effectually executed in this way than by a crutch in the hands of a workman. The whole interior arrangement of the boiling pan is seen at the figure AD, the worm detached at K, and the "blowpipe" at L. These kettles are worked much in the same manner as the ordinary fire caldrons, except that they require less attention. The charge of material is put in and melted by a rush of steam through both the blowpipe and worm, the cock of the latter being shut off when it is necessary. The cock P serves to regulate the current of steam from the generator. We have inserted three caldrons in our figure. In large factories it is convenient to have this number; one, however, will answer in a small laboratory, though there will necessarily be a loss of time in cleansing it always, when the charge is to be changed from yellow to white soap. The curbs of conical form are preferable, though other shapes are used. Some manufacturers dispense with the iron bottoms entirely, and boil in water-tight vats, or tubs, made wholly of wooden staves, hooped together with strong iron clamps. This series of kettles is well adapted for bleaching palm oil.

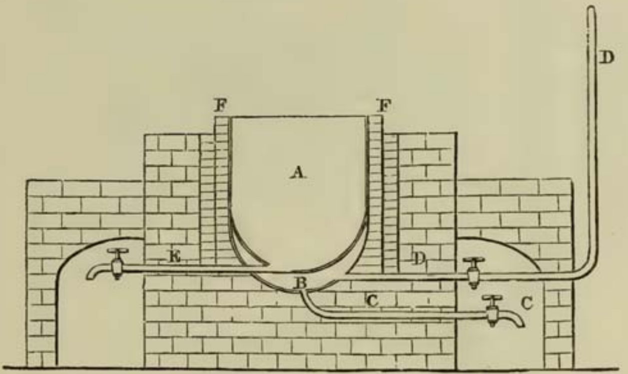
In the steam series above described, the steam is introduced directly into the material.

But as it is desirable for some soaps to apply the steam upon the outer surface of the kettle, we present below (Fig. 18) a suitable arrangement for that purpose.

A is the interior of a cast-iron kettle, surrounded by brickwork. B is the outer cast-iron caldron, which should fit to the inner kettle tightly, so as to prevent any escape of steam. D D is the tube leading from the steam boiler, and conveying the steam to the kettles. It is fitted with a cock, which is opened or shut, according as the steam is to be let on or off, for accelerating or retarding the boiling of the soap. C C is the tube by which the condensed vapor is discharged.

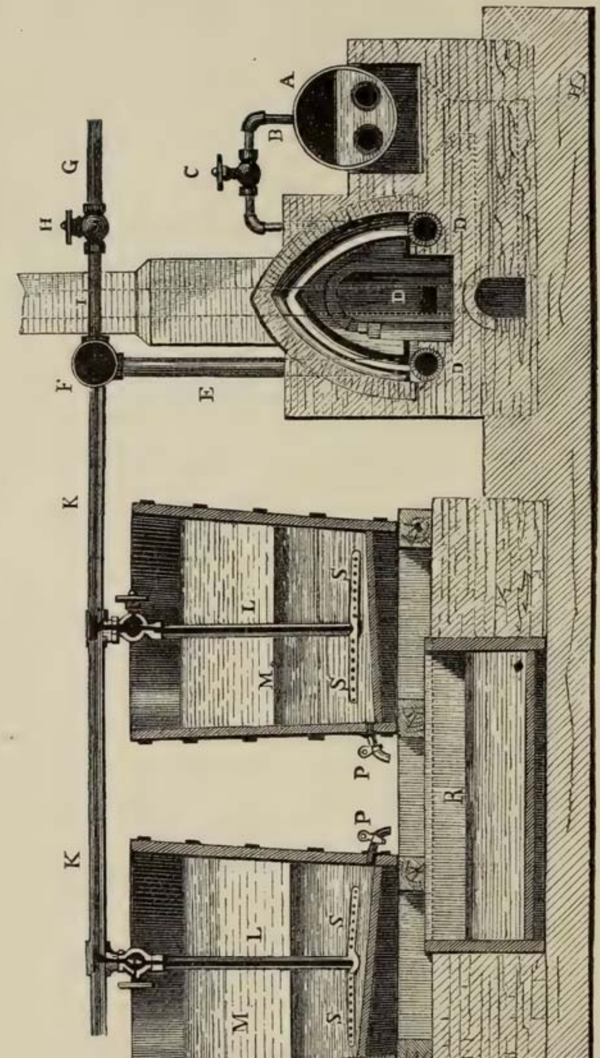
The cock in this tube can be left slightly open so as to operate as a safety-valve, when one of these necessary appendages is not fixed to the apparatus. The tube E is the discharge-pipe of the caldron. The brick-work F F is similar to that for other furnaces.

Fig. 18.



Hubert's Apparatus for Boiling Soap by Means of Surcharged Steam.—This apparatus, represented in Fig. 19, was patented by Mr. H. G. Hubert. "A is a steam boiler of ordinary construction. B is a steam pipe provided with a stopcock C. D is a steam super-heater. E is a pipe leading from the super-heater D to the receiver F. G is a pipe supplying air from a force pump. H is a valve for regulating the introduction of air into the apparatus through the pipe I. F is a receiver, where the steam and air are mixed together. K is a pipe conveying the mixed air and steam to any number of soap-boiling apparatus. L L are pipes conveying the steam and air to the bottom of the vats M M; S, S, S, S, are radiating pipes perforated with holes, turned in opposite directions, so that when the air and steam issue from them, they will cause a rotating motion of the whole mass of supernatant liquid in the vats M M. R is the tank for receiving the lye drained by the cocks P P. The operation of this apparatus is easily understood. The lye and fats being introduced into

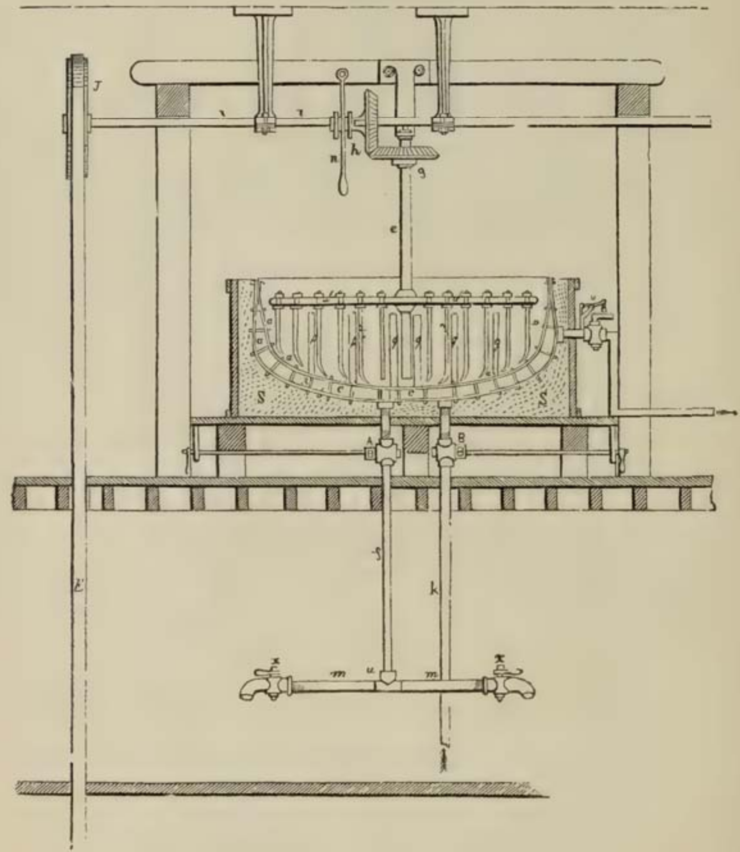
Fig. 19.



the vats M M, steam is allowed to escape gradually into the apparatus D, where it becomes super-heated, and is carried over and injected through the mass in the tanks MM. When it is required that the mass be stirred, then air is introduced into the apparatus by turning the valve H. It will be observed that the workman has perfect control of the operation, being able by simply turning the cock C or H, to increase or diminish the heat, and to stir or leave the pasty contents of the vats M M at rest."

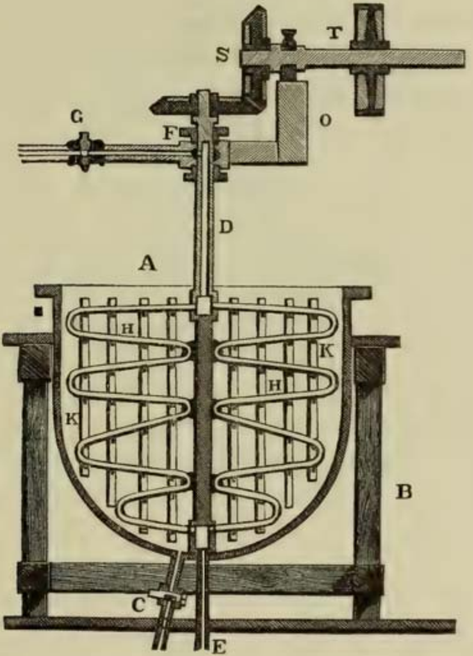
St. John's Steam Jacket.—This apparatus accomplishes the mixing and boiling of the soap ingredients simultaneously. As the steam circulates around the kettle, and through tubes, instead of being admitted directly into the paste, a uniform temperature may readily be established. The whole arrangement is shown in longitudinal vertical section, by Fig. 20. The boiling pan *a a* is enveloped by a steam casing or jacket *b*, adjusted to which is a tube *k*, communicating with the steam generator, and leading the steam into the space *c c*, between the pan and outer casing. The exit pipe *u*, with its stopcock *x*, is for drawing off the condensed steam, as may be necessary; and the safety valve *v* is a protection against excessive pressure. The stirring is accomplished by means of the revolving, horizontal arm *d d*, carrying teeth *f f*, and mounted upon a perpendicular shaft *e*. The stirring apparatus is put in motion by suitable gearing, consisting of the bevel wheel *g*, mounted horizontally on the vertical shaft *e*, and working into a similar wheel *h*, on the horizontal shaft *i*, which has a pulley *J* on its other end, driven by a band or strap *E*. When the boiling is completed, the contents of the kettle or pan are drawn off through the pipe *f*, and its branches *m m*. The tubes *p p p*, closed at their upper ends, and communicating with the space between the pan and jacket, by conveying the steam throughout the contents of the pan extend the heating surface of the latter. They also serve the purpose of stops for breaking the mass as it is carried around by the stirrers *f f*. The swivel or T joint *u* is so constructed that the arms *m m* may be turned horizontally in a circle, so as to bring the cocks *x x* over a range of receivers. *A* is a cock for letting the charge into the branch pipes *m m*. Another cock, *B*, is for regulating the admission of steam to the chamber *c*, and the tubes *p p*. The clutch lever *n* is for adjusting the cog-wheel *h* with the cog-wheel *g*, when the stirrers are to be put in motion. *E* is a driving-band, connected with the pulley *J* on the shaft *i*. *F F* are stay bolts for coupling the kettle and jacket.

Fig. 20.



Morfit's Steam Jacket.—This jacket produces the same effects as the above. The following figure represents a vertical section of it. A is the soap kettle, which may be made of any shape and of any material, having a waste-cock C, and mounted upon a frame B. D is an upright shaft, hollow both in its upper and lower parts, but solid in the middle. F is a stuffing box in which the shaft D runs, and is provided with suitable packing and a circular chamber, so that steam from the pipe G may be admitted through openings in the hollow top part of the shaft D. The lower end of the shaft D runs through the bottom of the kettle A, fitting sufficiently tight to prevent the soap and lye from escaping, yet loose enough to be easily turned. Two, three, or four pipes H, so bent as to take the configuration of the kettle A, are connected at both ends with the hollow part of the shaft D. K K K are a number of slats fastened to the pipes H H, to strengthen them, and at the same time to offer more resistance to the materials to be stirred. A set of gearings S, and

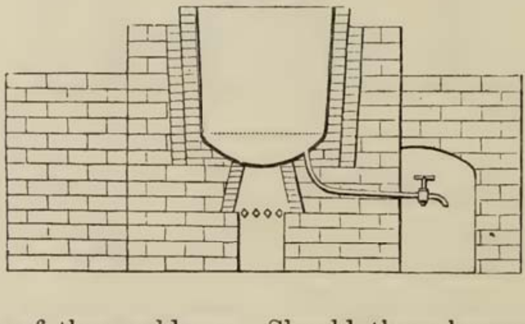
Fig. 21.



a shaft T, mounted on the beam O, are so arranged as to give motion to the shaft D. The advantage derived from this arrangement is obvious, as the steam entering the pipe D finds no other outlet than the pipes H H, through which it rushes, following their sinuosities, till it reaches the bottom of the shaft D, where the condensed water is drawn off at E. The heat thus conveyed into the pipes H H, is communicated to the materials contained in the kettle A, which being continually stirred, have the heat more uniformly distributed throughout their mass than could be effected by the ordinary methods. This is a most useful kettle for the extempore soaps.

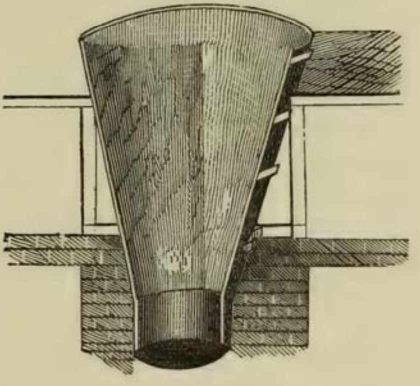
Caldrons or Boiling Pans.—In smaller factories the old mode of boiling soap by the naked fire may be employed, and we proceed to give a description and drawing of the kind of kettles most advantageous for the purpose. The size of the caldrons should be proportioned to the amount of soap intended to be made at each boiling. The bottom pan may be of cast iron, but in England they prefer Swedish wrought-iron plate. This bottom pan is built in brick masonry, so that the heat acts solely upon its bottom. Fig. 22 shows one of these caldrons. Should there be several, they are placed on a line with each other, and over a furnace beneath. To the caldron a tube of about two inches diameter is adapted, which serves as an outlet for the sub-lye which remains under the boiled paste. The furnace is made in the usual manner. The arrangement of the mason work

Fig. 22.



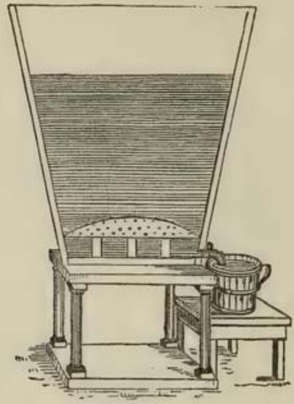
is generally, however, left to the skill and ingenuity of the bricklayer. These soap pans or caldrons are cast with a flange at their top, so that, when necessary, an adjunct cylinder of wood, in the shape of a cone, may be fastened to them. This is called the *curb*, Fig. 23, or upper part of the caldron. It is nothing more than a hollow cone of iron-bound staves, made to fit the flange of the iron kettle. It can extend as high as desired, and is made of wood, so as to save the cost of metal, and the mason work necessary to inclose it. The cones stand erect, but they should be strongly and tightly fastened, and jointed to the lower pan. In this way a pan may be enlarged at much less cost than for a caldron wholly of iron requiring to be entirely inclosed within mason work.

Fig. 23.



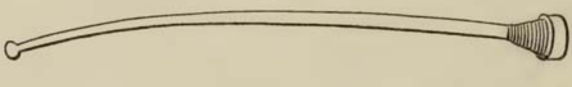
Lye Vats.—The lye vats, in very extensive factories, are made of brickwork, smoothly cemented within; but much the better material would be lead; for then one set of vats would answer for all kinds of soaps, as the lye prepared in them, not being acted upon by the metal, will be perfectly clean. Large tuns lined with sheet lead, and with cullendered false bottoms, Fig. 24, are perhaps the best and most durable fixture of this kind that could be put up. In this case there is a cock fitted near the bottom of each tun, and through it the clear lye collecting in the lower part of the tun, between the diaphragm and the bottom, can be drawn off into tubs below for use, as may be wanted. Close by these vats there must be a pump or hydrant, with its outlet spout conveniently arranged for a supply of water, in quantity as required.

Fig. 24.



An excellent substitute for the cock is a long-handled plug of wrought iron, Fig. 25. Its conical tip must be tightly and smoothly wrapped with tow, so that when in use, it may make a tight joint. It is placed in the hole from the interior of the vats, so that being always in position, it is only necessary to give the handle a push when it is desired to draw off the lye, and draw it outwards again when the flow is to be stopped. In large establishments, where there are a number of lye vats in constant operation, it is necessary to have a tightly covered reservoir for the reception of the lye as fast as it runs through; for there is not space enough below the false bottom for any great accumulation of liquid. There are generally several vats to each laboratory, but the

Fig. 25.



number depends entirely upon the amount of soap manufactured, and consequently the proportion of lye necessary for the steady prosecution of the work.

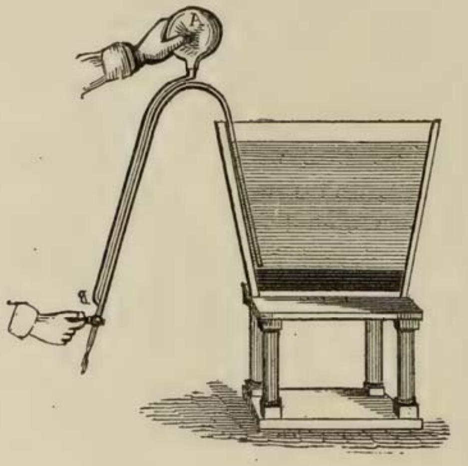
In a Marseilles soap house, the lye vats are in sets of four. No. 1 is the *fresh vat* which receives the fresh mixture of alkali and lime; the next one, or No. 2, being the *avancaire*, or an advanced stage. No. 3 is the small *avancaire*, being two steps in advance, and, therefore, containing *weaker* liquor; and No. 4 is the *water-vat*, because into that the water is directly introduced. Into No. 3 the moderately exhausted or somewhat spent lyes are thrown. From No. 3 the lye is pumped into No. 2, to be strengthened, and in like manner from No. 2 into No. 1. Upon the lime paste, in No. 4, which has been taken from No. 3, water is poured, and the lye thus obtained runs upon the paste of No. 3, which has been taken from No. 2. No. 3 is twice lixiviated, and No. 2 once. The receiver under No. 1 has four compartments, into No. 1 of which the first and strongest lye is run; into No. 2, the second lye; into No. 3, the third lye; and into No. 4, the fourth lye, which is so weak as to be used instead of water, for lixiviation. The lime in vat No. 4, when exhausted, is emptied out of the window near which it stands, in which case the water is poured upon the contents of No. 3; and upon No. 2, the somewhat spent lyes. No 1 is now the *avancaire* of No. 4, because this has become, in its turn, the fresh vat, into which the fresh soda and quicklime are put. The lye discharged from No. 3 comes then upon No. 2, and after having been run through it, is thrown upon No. 1.

In some factories iron vats in the form of inverted cones are used, the outlet for the lye being through an opening at the apex of the cone. Then it is judicious to have, also, a lead-lined vat for the finer qualities of soap; as it is requisite, especially for toilet soaps, to have the lye perfectly clear and colorless, and free from iron.

In the apartment containing the lye vats there should be two pieces of auxiliary apparatus for the preparation of the lye materials. These are a mill for grinding the alkali when lumpy; and a drum sieve for thoroughly mixing it with the lime. Both are to be driven by steam power.

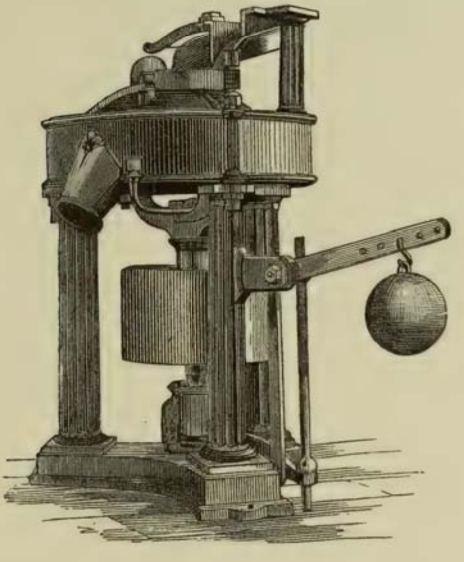
The siphon should be of half-inch lead pipe, and may be made after Coffee's pattern, for moderate volumes of liquid, as it possesses many advantages over the usual forms in delivering the liquid without any inconvenience to the operator. It is shown by Fig. 26, and consists of a bent tube, one leg of which is longer than the other, and a smaller lateral tube B, capped with a large, hollow India-rubber ball A. The long leg has also a stopcock near its lower end. It is put in operation by closing the cock, compressing the bag, and quickly immersing the short leg in the clear lye, to within an inch or less of the subsident carbonate of lime, as represented in the drawing. The act of compressing the ball produces diminution of the elastic force of the internal air by expelling the most of it, so that as soon as the hand is removed from the ball, the outward pressure of the air drives the liquid up to the highest point of the bend, whence it drops, by the force of gravitation, on the opening of the cock, and flows out in a continuous stream, as long as the mouth of the short leg is covered by it.

Fig. 26.



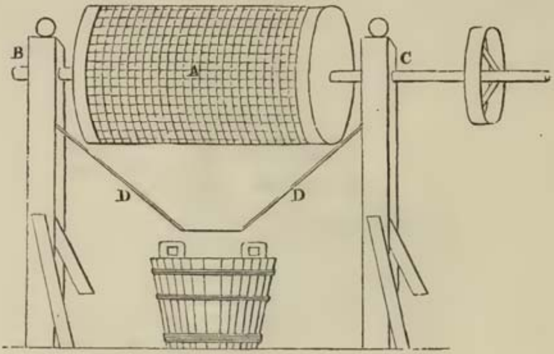
The best form of grinding apparatus is Bogardus's eccentric mill, Fig. 27; for it does its work economically, both as to time and cost; and, moreover, is not an expensive machine. It is so constructed that "both plates revolve in the same direction (with nearly equal speed) on centres, are apart from each other one inch more or less. The centre ot the one, or axis thereto affixed, rests and revolves upon a stationary point; whilst the prime mover, by means of a belt or gearing, communicates motion to the other plate. The circles which are cut in the plate act like revolving shears by cutting every way; and when the mill is in operation, they cause a peculiar wrenching, twisting, and sliding motion, admirably adapted for every species of grinding. The ground substance is delivered promptly without clogging the mill."

Fig. 27.



The drum sieve, Fig. 28, is merely a wooden framework cylinder A, covered with wire gauze, the meshes of which are larger or smaller, according to the degree of fineness which it is desired to give the mixture of alkali and lime. They should not, however, exceed the eighth of an inch. It is mounted upon uprights B, and is made to revolve by means of the shaft and pulley C. The shelf D is an inclined platform for the delivery of the mixture into tubs, as it passes from the seive.

Fig. 28.



Soap Frames.

This name is given to square reservoirs made of masonry, iron, or wood, into which the soap is run, when drawn from the kettle, in order that it may cool.

Frames of Masonry.—The first thing to do when building a masonry frame is to carefully level the ground on which it has to be established. This done, a platform of good masonry is constructed on it, at about four or five inches above the level of the ground, and the dimensions of which exceed, in every direction, from seven to eight inches the outside line of the walls of the frame. To build the walls, employ well-burned and very smooth bricks. For large frames, the walls have generally from twelve to fourteen inches of thickness, their height varies between twenty-four and twenty-six inches above the level of the platform. In the front of the frame leave a lateral opening of about two feet, in which is fixed a kind of movable door, which is used for removing the soap after its cooling. The mortar used in the construction consists of three parts weight of good cement, and one of fine sand. When the walls are raised to the proper height, and have stood for two or three days, the joints are cut down smooth, and the walls are thoroughly washed with a broom. The next day they receive a perfectly smooth coat of cement, about one inch in thickness. As for the bottom of the frame, a coating of cement is applied about one or two inches thick; and then suffered to dry for a few days; on this coating of cement a floor of hard bricks is laid; these bricks are laid flat, and well cemented with mortar. It is proper to give a slight inclination to the bottom of the frames in the direction of the door, so as to permit the lye to run off into a small tank, also built of masonry, and sunk in the ground below the door of the frame. The dimensions of a frame are generally regulated by the capacity of the kettle for which it is destined. It has been ascertained that for regular and continued work, three frames are required for the service of each kettle, so as to have no interruption in the different operations. Frames of masonry are completely water-proof, and do not allow the escape of any liquid, when properly prepared. Good frames last very long; they are used principally in the manufacture of marbled soaps; their employment is general at Marseilles.

Frames of Iron.—These frames generally have nothing remarkable in their construction. They ordinarily have the form of a parallelogram; their dimensions vary according to the quantity of soap to be run into them. They are formed of strong iron plates, so firmly riveted together as to render impossible the loss of liquid. These frames have on one of their sides a vertical opening from top to bottom, the width of which is from 16 to 20 inches; this opening is closed by a sheet of iron and is used as a door to the frame. It is by this opening that the soap is taken out after its cooling. The construction of these frames is costly, but they have the advantage of being perfectly tight, and of not allowing any leakage of soap or lye.

They are of the same form as the wooden frames; but differ in size. The sides are of wrought-iron plate, and the remaining portions of cast iron. Fig. 29 presents a side view, Fig. 31 the bottom, and Fig. 30 a top view of them, as made by Poole & Hunt, engineers and machinists, Baltimore; and the clamp, which fits on the ends, and holds them together, is shown by *a*. They are drawn to a scale of three-eighths of an inch to a foot. Being mounted on wheels, these frames can readily be moved from place to place. The good conducting power of the metal promotes the cooling and solidifying of the soap paste.

Fig. 29.

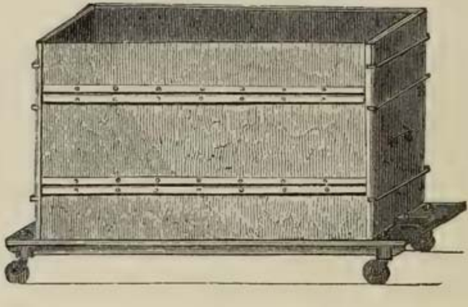


Fig. 30.

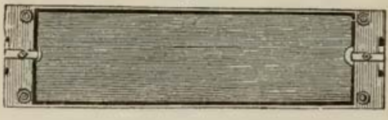
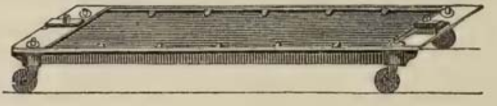


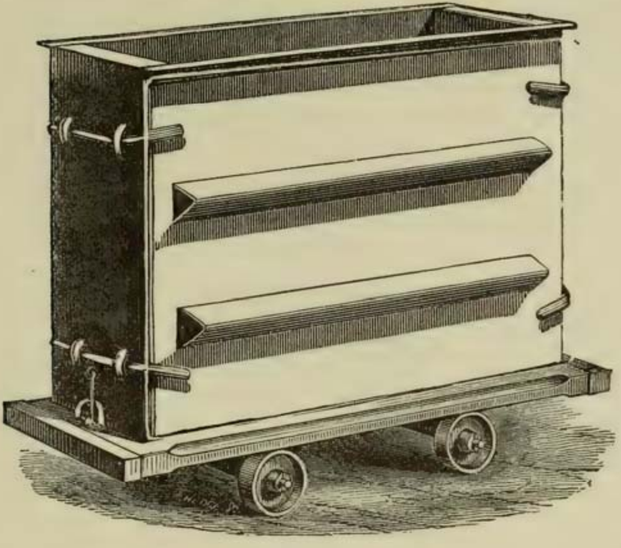
Fig. 31.



a

Whitaker's Patent Soap Frame.—One of the most approved forms is that made by Messrs. Hersey Brothers, of Boston, Mass., Whitaker's Patent Soap Frame. It consists of two sides of plate iron, flanged at their upper edges, and strengthened by ribs of corrugated plate iron, riveted to their outer surface, running in the direction of their length (Fig. 32).

Fig. 32.



These corrugations prevent the bending or twisting of the side plates, and the soap cools into the exact rectangular shape of the frame. The trouble and expense of the ordinary stays and supports are here avoided, as the frame is self-sustaining. The sides are connected by ends of two-inch plank, secured by clamps. The frame is very light, easily managed, and can be adjusted and unadjusted by one workman almost momentarily. The soap cools very rapidly—ordinary soap cooling sufficiently to strip in twenty-four hours in cold, and in forty-eight in warm weather.

Frames of Wood.—These frames are made of oak or pine. Those of oak are costly, and have the disadvantage of coloring the soap; the others do not present this inconvenience, and are to be preferred. Nearly all the frames are constructed of four movable parts, which are made of boards of pine wood, about two or three inches thick. To preserve the wood from alteration the inside is lined with very thin sheet iron, fixed to the wood with tacks about half an inch long. By this means these frames may be used five or six years without repair. The floor is of wood or brick. When the soap is cold and ready to be taken off, the sides of the frames are removed, and the cake of soap remains standing on the bottom. In this country, frames are made of pine wood, for light-colored and fine soaps; and of cast iron for common yellow soap. The iron frames need not exceed half an inch in thickness; but those of wood should be made of two or three inch stuff. The shape is that of a parallelogram, as shown by the drawings; and the dimensions of the opposite sides and ends are respectively 36 and 12 to 15 inches. They should be about 36 inches deep, and smoothly jointed, so that when they are placed on top of each other in piles of three,

Fig. 33.

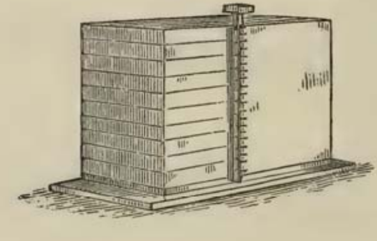
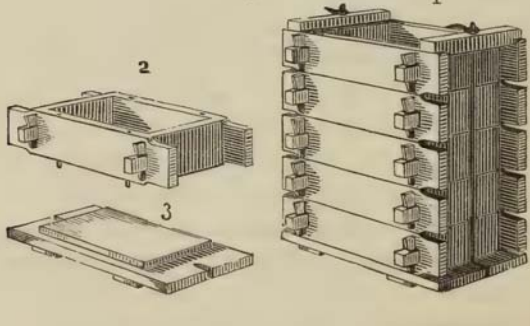


Fig. 34.



four, or five (Fig. 34), they may form a water-tight well, which will hold the hot paste without leaking.

The wooden frames are lifted off, one at a time, and the soap remains upon the movable bottom ready to be divided into bars, as shown by Fig. 33. Fig. 34, No. 1, shows the well of five frames, ready for receiving the soap paste. A single frame and the bottom of the well are severally presented in Nos. 2 and 3.

The German frames, like those of this country, are also constructed so that they may easily be separated into pieces, being set up by nuts and screws, as shown in Figs. 35 and 36. Their floor is also movable; and is shown in longitudinal section by Fig. 37, and in breadth by Fig. 38. It consists of two layers of deal boards, in the upper of which are four grooves, fitting with the projections in the sides. The two narrow sides are also supported on the inside by cross-pieces. All the sides are strengthened by supports. When the several parts are put together, the bolts, screw cut at the other end, have only to be inserted through the projecting parts of the longer sides, and made fast by the nuts at the ends, to form the whole into a solid box. A cloth spread over the bottom prevents any soap from passing the holes, through which the lye drains off. A frame with its sides and ends down is shown by Fig. 39. By the side of it is the clamp used for holding the different parts in position when

Fig. 35.

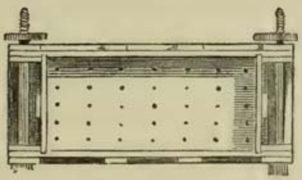


Fig. 36.

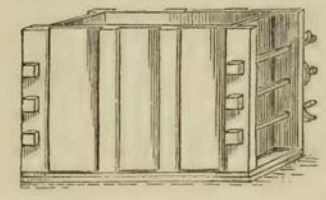


Fig. 37.

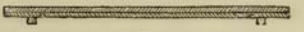
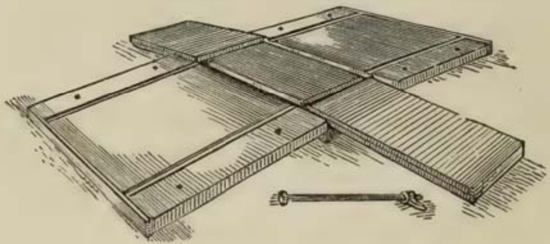


Fig. 38.

the frame is set up. Many, to prevent the too rapid cooling of the soap, are covered with a mattress of soft material on the outside, etc.

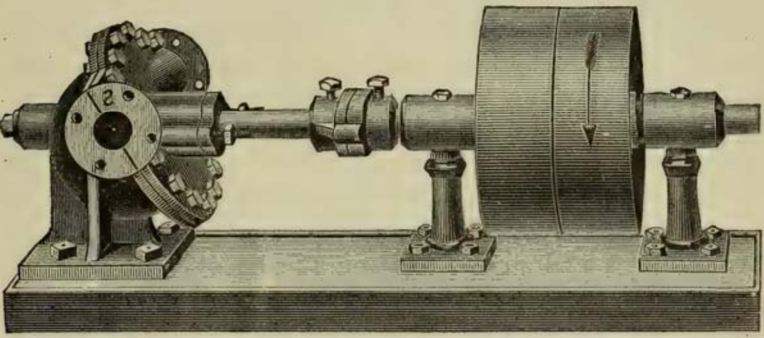
Fig. 39.



The *Hersey's Patent Rotary Soap Pump* of Hersey Brothers, of Boston, combines in itself more excellences and is better adapted to the requirements of the trade than anything of the kind ever presented, and there are now very few large manufacturers in the United States who use any other appliance for taking off soap. The pump may be set up in any convenient position adjacent to the kettle, and not over ten feet above the bottom of the same, and connected to it by means of a two-and-a-half-inch iron pipe tapped through the iron plate at a distance of about two feet above the worm or coil. Each kettle is thus connected with the pump by the iron pipes, which have valves placed upon them on the outside (of the kettle) so that any one of them may be readily pumped off and framed without disturbing the others. The pipe inside of the kettle has a suitable swing-joint so arranged that it can be raised or lowered at pleasure. The cuts represent the pump—perspective and sectional. Fig. 40 represents the pump complete; when the pump is rotated in the direction of the arrow, the outlet marked S is the suction; when rotated in the opposite direction, the opposite outlet becomes the suction. This is an important feature, as it enables the discharge pipes to be emptied of their contents in stopping, by giving a few revolutions by hand in the opposite direction. Fig. 41 is a view of the interior of the pump when the cover is taken off.

When turned in the direction of the arrow, the blade F sweeps around, drawing the fluid in at I and forcing it out at H, the contents of the pump being twice emptied during

Fig. 40.



each revolution. The blade F swings on a pivot; the end F, when reaching the point B, at the lowest point, gaining the position there shown, and gradually returning to its former position on completing the revolution. The fluid is prevented from passing from one side to the other by the contact of the cone with the cover. The set screw, shown in Fig. 41, bears against a step at the end of cone, and keeps the cone forced against the cover, and is screwed up to compensate for any wear that takes place. Fig. 42 shows the cone

Fig. 41.

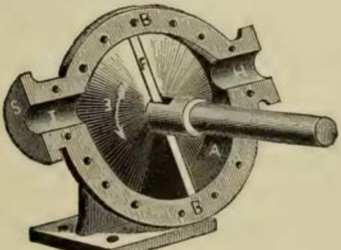
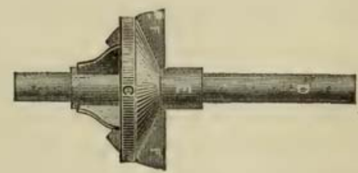


Fig. 42.



and blade, and forms the entire working part of the pump; no valve being used, there is no chance of any derangement in the operation of the pump By means of the pump the soap can be forced any distance or height. The soap can be pumped from one kettle into another, which is a special advantage when it is necessary to transfer the "nigre," either in the state of a soft curd, or in the unseparated state into another kettle, to make room for a fresh boiling with clean stock, and thereby keep up a uniform quality of first-class soap. By lowering the pipe attached to the swing-joint inside of the kettle, the lye of the "strengthening change" can be pumped from the very lowest point in the bottom of the kettle, while still hot, into another in which stock is being saponified, thereby economizing steam. In certain cases where it is undesirable to pump the lye over the curb into the kettle, because of the froth which it may occasion, another plan can be adopted, which admirably brings into play the whole system of pump, valves, and swing-joints of the two kettles, from the bottom of one of which it is required to pump the hot lye, and force it through the iron piping down to the bottom of the other. Lye of any kind, whether spent lye, or strengthening change lye, strong caustic lye, either hot or cold, grease or thick oil can be easily and quickly pumped by this pump. The pump is 10 inches in diameter and 2½ inches in outlet, revolutions 120 per minute, capacity 6000 gallons per hour.

Cutting Operation.—When the soap sets firmly, the frames, according to their construction, are either lifted off or unbound, by loosening the clamps, and removed, so as to leave resting on the bottom a solid mass of soap, corresponding in size with the interior of the wells, as shown in Fig. 33. It is then divisioned off on the sides by means of a scribe, Fig. 43, which is a wooden slat, carrying on its smooth side a number of slender iron teeth. The workman, then taking a brass wire, Fig. 44, directs it in the track of the teeth, and thus cuts off one slab of the pre-arranged thickness, as shown by Fig. 45. When the whole block is thus divided into slabs, the latter are in their turn reduced to bars and lumps of smaller dimensions, the usual size of the bars being 12 to 14 inches long, by 3 inches every other way. The pound lumps are about 5 or 6 inches long, 3 inches deep, and the same width. The size of the slabs must, therefore, be regulated accordingly; and, therefore, it is convenient to have a scribe with several sets of teeth, as shown in Fig. 33.

Fig. 43.

Fig. 44.

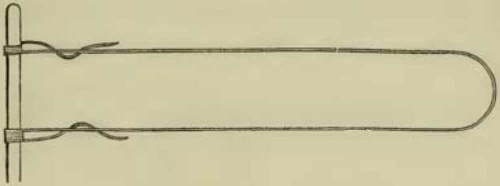
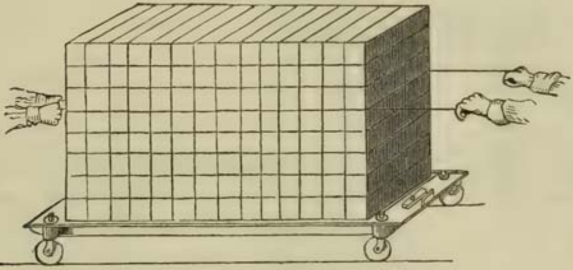


Fig. 45.

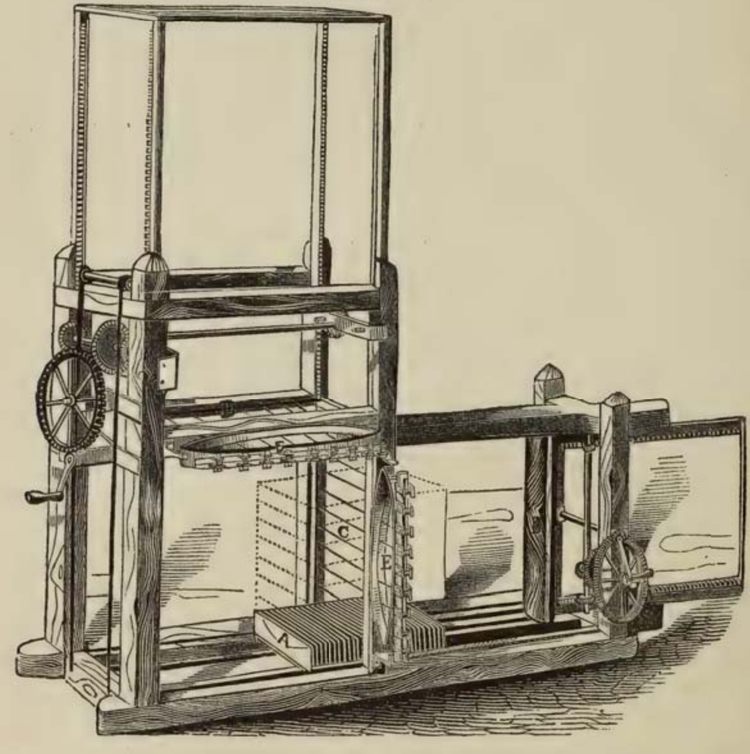


Such an instrument is used in the factories, and is nothing more than a piece of hard wood, about two inches square, with each of its four sides smoothly planed, and bearing slender teeth. On one side they may be set 1 inch apart from each other; on the second, 2 inches; on the third, 2½ inches; and on the fourth, 3½ inches; care being taken, however, that the distance between the teeth of the respective sides is uniform. In this manner, slabs and bars may be smoothly and accurately cut, according to the size traced out upon the block by the teeth of the scribe.

A much more rapid method of dividing the blocks into bars, is that invented by Van Haagen, of Cincinnati, and which requires the use of two pieces of machinery, as shown by Figs. 46 and 47. The first is called the *slabbing and bar-*

ring machine, and consists of a carriage A, which is so grooved at the top as to allow the wires to pass entirely through the block of soap. This carriage is then moved back to the driver B, and on it is placed a whole block of soap as it comes from the frame. This is done by a peculiar truck, as shown in diagram No. 46, made and constructed expressly for the purpose. The block of soap having been first cut loose from the bottom of the frame; this truck is run to the side of it, and, by means of rack and pinions worked with a lever, the block of soap is slipped on the truck, brought to the machine, and, by the same power, thereupon placed. All this is done with great ease and despatch, and by the same power.

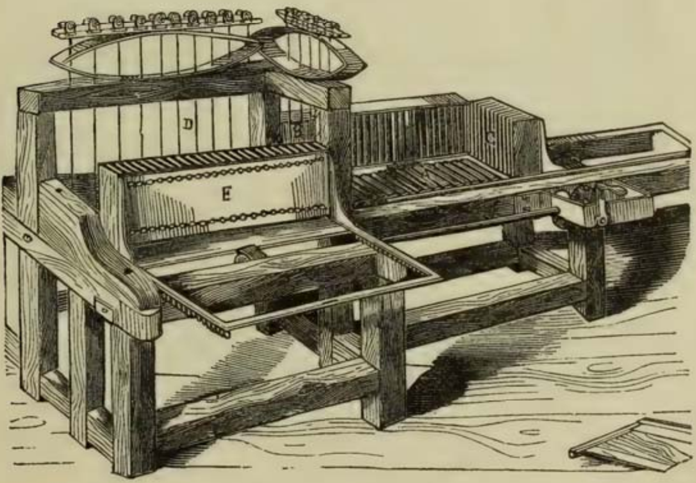
Fig. 46.



The range of wires C is regulated by corresponding gauges in the upright posts, which allow it to be set to cut slabs of any desired thickness. The block of soap is forced up to those wires by the driver B, propelled by means of racks and pinions and a winch. It will be seen that in this way the block will be converted into slabs. There is a similar horizontal arrangement of cutting-wires D, and confined to a vertical motion by the posts of the frame. These wires are also arranged as above, so that any desired bars may be cut. It is caused to descend by the action of the rack and pinions and winch as above; and with this part of the machine the slabs are converted into bars without handling the same. They, consequently, are much neater and smoother than they could be cut otherwise.

The wires, being fastened at one end to a spring E E, will easily yield and form the required loops at the beginning of

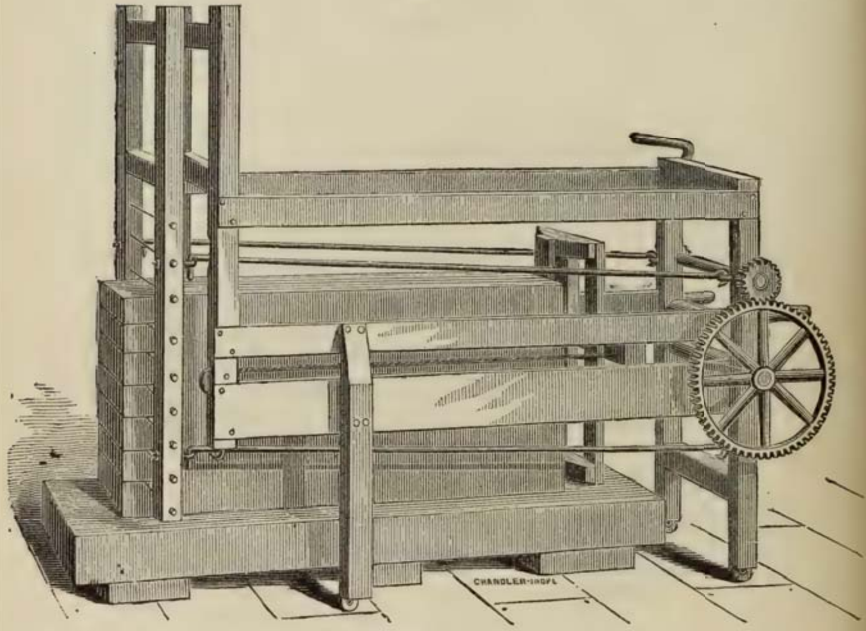
Fig. 47.



the operation; and then both ends become fixed, so that the loops cannot get any larger, if the soap be very hard; in which case the long loop is more apt to warp and cut uneven. The steady motion of this machine permits the use of much smaller wire than will do for hand-cutting, and consequently the work is much smoother. This apparatus cuts the blocks of soap into bars as long as its width. To make pound lumps or small cakes and tablets, the slabs must be transferred to the second, or *caking machine*, Fig. 47.

The slabs are placed in as great number as can be got on, upon a range of rollers A, and forced through the range of wires B, by the driver C, which is propelled by racks and pinions and a crank. The soap having been forced through lengthwise, and the crank being shifted, it is then forced through the range of wires D, by the driver E. Both the drivers are connected with the same crank, and, by displacing it from the one, it gears itself into the other. The wires are arranged in the same manner as in the slabbing machine. They may be readily shifted so as to cut any desired shape or size.

Fig. 48.



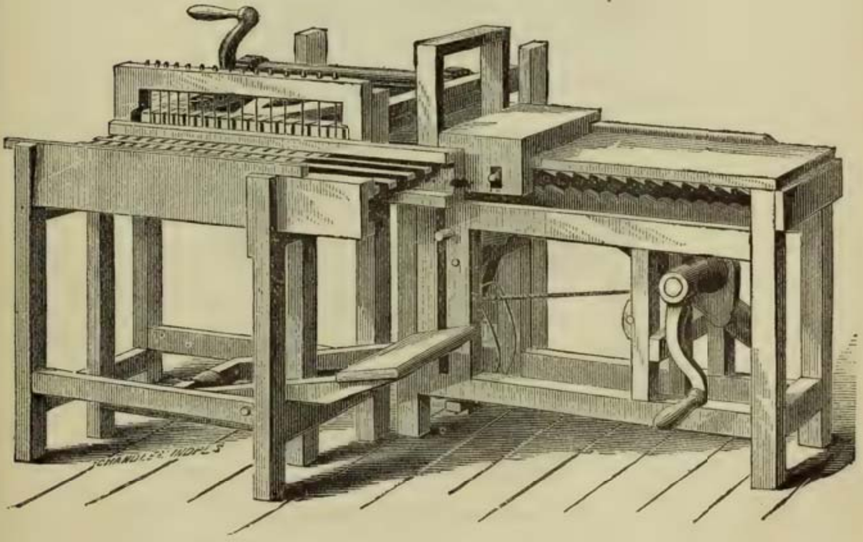
Champion soap slabber.

This mode of cutting gives great smoothness and uniformity of weight and size to the bars and lumps, saves handling, scratching, and bending, and effects a larger gain over the usual method, in time, labor, and expense.

Two of the most recently invented machines for cutting soap are those made by Hersey Brothers, of Boston, Mass., and here illustrated by Figs. 48 and 49.

The Champion Slabber (Fig. 48) is similar to that of Van Hagen, already described, with some improvements that make it more rapid in its working. Ralston's cutter (Fig. 49) has an attachment for spreading and stamping, so that the cakes are furnished ready for packing; it is simple and fast in action, and large quantities of soap can be cut and stamped in a working day.

Fig. 49.

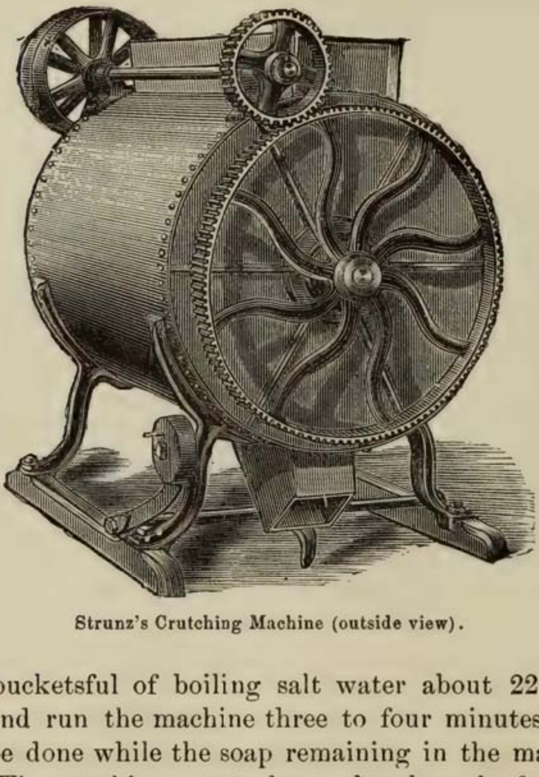


Ralston's patent cutter with stamping and spreading attachments.

Crutching Machines. Stephen Strunz's Soap-crutching machine, also made by Hersey Brothers. (See Figs. 50 and 51.) This machine is simple in construction, and perfect in its action. It crutches the soap completely within three minutes, and gives it a smoothness and transparency which can never be obtained by any other machine. Size, 1200 pounds.

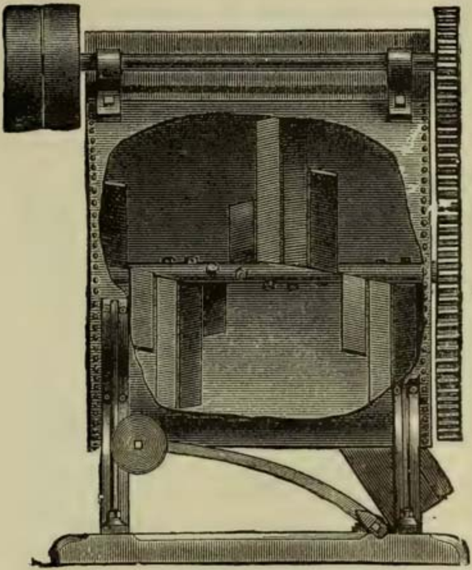
The speed of main shaft, with the working paddles on, should be forty-five to fifty revolutions per minute, and should turn so as to work the soap to the valve and pump it out. When the machine is charged, the soap should cover the paddles two inches before the machine is started. When running the soap into the frame, the machine should be stopped until the soap commences to run slowly, otherwise it will force it out too rapidly. Very little power is necessary for this machine. To clean the machine, put in four or five bucketsful of boiling salt water about 22 degrees strong, and run the machine three to four minutes; which should be done while the soap remaining in the machine is warm. The machine must always be cleaned after using.

Fig. 50.



Strunz's Crutching Machine (outside view).

Fig. 51.



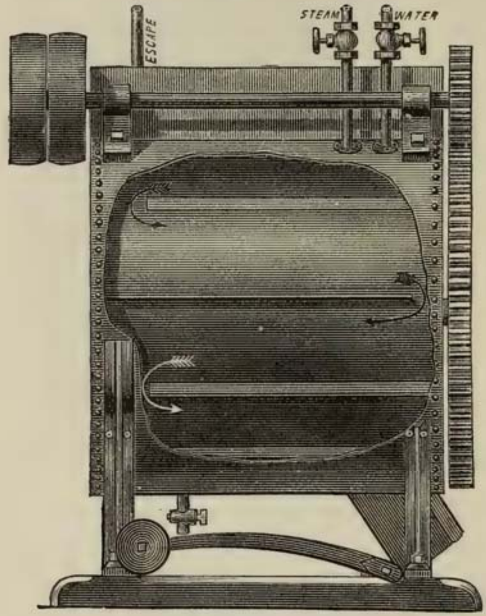
Strunz's Crutching Machine (working part of machine).

The Jacket Crutching Machine (Fig. 52).—The jacket on this machine is a circulating one, and is said to have no equal in its rapid heating or cooling power. There is no dead point in the jacket as in other jackets where the warm water remains for a long time outside of the current. The drawing shows two pipes on one side; one is to be connected with steam and the other with water. The escape should be left always free, and no cock or valve should be on the escape pipe. The little cock on the bottom is to let the water out of the jacket to prevent it from freezing, or else the jacket would burst. The steam should never be let on unless the jacket is free from water, otherwise it may strain the machine. These crutching machines are very useful for mixing the colors and perfumes of toilet soaps.

We have now left little to add to the needed implements except the minor ones, as hand stirrers, or paddles and crutches, which are too well known to need description, scales, weights, shovels, and spades for cutting out tallow, etc.

Almost all soaps are now stamped, and many wrapped; for stamping there are numerous presses in use, the most important have a full description in our chapter on toilet soaps.

Fig. 52.



Strunz's Jacket Crutching Machine.

Minor Implements.—The minor implements of the soap laboratory are, a crutch, Fig. 53, composed of a long wooden

Fig. 53.

handle adjusted at the end to a board, and used for stirring the soap paste in the operation of "*mottling;*" large, cullendered, iron ladles, with long, wooden handles (Fig. 54) for dipping out the hot paste from the kettles, and copper buckets (Fig. 55) for conveying it to the frames.

Fig. 54.

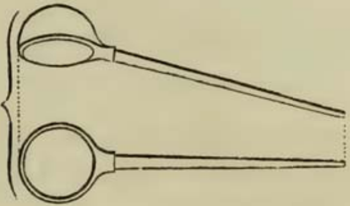
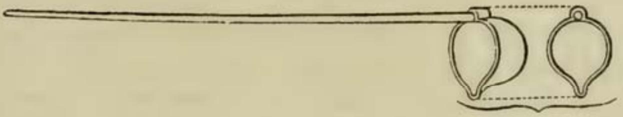


Fig. 55.

Copper dippers, with handles of two or more feet in length, Fig. 56, are used for dipping the soap into frames and for many other purposes.

Fig. 56.



SECTION XI.

THE FABRICATION OF SOAPS.

Soaps by Boiling.—The suitable preparation of the lyes for the decomposition of the fatty bodies is beyond doubt the most important process in the art of making soap, and it therefore requires the closest attention and study, for without the knowledge and experience this study gives, much loss of time and material may result.

We here repeat that the alkalies of commerce are never pure, and in our previous sections we have described these impurities and the modes of analysis. We will now give instructions for the proper preparation of the lyes for use, with suitable tests for strength and purity. For ordinary purposes the caustic lyes of soda as now received are generally of sufficient purity when freshly prepared for making common soaps, though there are none of them that do not require an investigation before entire confidence can be given to them. With potash the soap-maker will find still more difficulty as it is usually still more impure, as has also been shown, though in making soft soap with the potash lyes the process is quite different from that in use for the hard soaps from soda lyes. Yet a pure and caustic alkali is essential to nearly all methods. Whether we need a potash or a soda lye it is necessary in almost all cases to render them caustic, that is, to remove their carbonic acid by means of lime, and this lime should be reliable and be tested to discover if it contains any impurities or at least such an excess of them as to make it unfit for use. These tests are also shown elsewhere. The action of the lime is to remove the carbonic acid, by the power it has of great affinity for that acid, causing a decomposition by absorbing it and forming an insoluble carbonate of lime which is precipitated, after giving a greater part of its oxide to the alkali.

Of the quantity of hydrate of lime necessary to make caustic a given quantity of alkali, there is great diversity of opinion, yet there is a rule which must be studied, for an alkali may work wrong that has too little or too much lime, or, as is technically called, too low or too high in lime. Thus it is necessary to give due regard to the properties of lime and to its action in strong or weak lyes which is quite different, as lime will not act in strong solutions of alkali.

We have heretofore given the proper instructions for the alkalimetric tests for these materials, and they should receive attention to aid the necessary calculations, yet we will give an example as a further guide.

The carbonate of potash is a combination of 1 equivalent potash = 47.11, and 1 equivalent carbonic acid = 22, and its equivalent is therefore 69.11. If we desire to change this into caustic alkali, we must extract the carbonic acid. This is done by offering an equivalent of caustic lime, which, when changed into carbonate of lime, will absorb likewise 1 equivalent of carbonic acid. Since, however, the equivalent of the caustic lime is = 28, it follows that to 69.11 parts in weight of carbonate of potash 28 parts in weight of caustic lime must be applied, to make the former completely caustic. To 50 kilog. (110 lbs.) of pure carbonate of potash, therefore, 20.3 kilog. (44.66 lbs.) of caustic lime are added.

We, however, have never to do with pure carbonates of the alkalies, nor with pure caustic lime, so that in practice other corresponding proportions are required than are just given by theoretical calculation. Supposing, for instance, the potash for preparing the caustic lye contains 72 per cent. of carbonate of potash and the lime contains 82 per cent. pure caustic lime, then we must in the same ratio, as the potash contains less than 100 per cent., take less lime; while in the same proportion as the burned lime contained less caustic lime, apply more of the lime. In the suggested example the calculation would be rendered thus: X (that is the necessary quantity of lime) = $\frac{40.6 \times 72}{82} = 35.65$; that is, we would apply 100 kilog. (220 lbs.) of a 72 per cent. potash

35.65 kilog. (78.43 lbs.) of slaked lime of 82 per cent. pure caustic lime in order to obtain a perfect caustic lye.

The pure carbonate of soda contains also to 1 equivalent = 31.0 parts soda, 1 equivalent = 22 parts carbonic acid, and for its separation again 1 equivalent lime = 28.0 parts would become requisite. 100 kilog. (220 lbs.) of pure carbonate of soda require, therefore, for its change into caustic soda 52.83 kilog. (116.23 lbs.) of pure caustic lime. The weaker a soda is the less lime, and the more inferior the lime, the more is to be used in order to make a certain quantity of soda caustic. The following calculation is exactly the same as under the same proportion of the potash. Supposing we have a soda of 92 per cent. and a lime of 80 per cent., we have the following equation: $X = \frac{52.83 \times 92}{80}$, where X again represents the necessary amount of lime, and thus is found 60.76 kilog. (133.67 lbs.).

According to this the tables below are calculated; they contain the respective changeable quantities of the lime to be applied in proportion to the contents of potash and soda to pure carbonate of alkali, and the contents of the pure slaked lime, each from 5 to 7 per cent. This is for practice sufficiently accurate; meanwhile the tables may be easily changed if other proportions occur by means of interpolations.

I. *Table for Potash.*

100 kg. potash of appended degree require	Of lime if the same contains								
	90	85	80	75	70	65	60	55	50
100 per cent. potash,	45.11	47.77	50.75	54.01	58.00	62.46	67.67	73.82	81.20
95 “ “	42.86	45.38	48.21	51.43	55.10	59.34	64.28	70.12	77.12
90 “ “	40.60	42.99	45.67	48.96	52.20	56.22	60.90	66.44	73.08
85 “ “	38.35	40.60	43.14	46.01	49.30	53.15	57.52	62.75	69.01
80 “ “	36.09	38.21	40.60	43.31	46.40	49.97	54.13	59.06	64.96
75 “ “	33.83	35.82	38.06	40.60	43.50	46.85	50.75	55.36	60.90
70 “ “	31.58	33.44	35.53	37.90	40.60	43.74	47.37	51.68	56.84
65 “ “	29.32	31.05	33.00	35.19	37.70	40.60	43.98	48.00	52.78
60 “ “	27.06	28.66	30.47	32.48	34.80	37.48	40.60	44.31	48.72
55 “ “	24.81	26.27	27.92	29.77	31.90	34.36	37.22	40.60	44.66
50 “ “	22.56	23.88	25.37	27.06	29.00	31.23	38.83	36.91	40.60

II. *Table for Soda.*

100 kg. soda of appended degree require	Of lime if the same contains								
	90	85	80	75	70	65	60	55	50
100 per cent. soda,	58.70	62.18	66.21	70.44	75.47	81.28	88.05	96.06	105.66
95 " "	55.77	59.02	62.93	66.91	71.70	77.21	83.64	91.25	100.38
90 " "	52.83	55.93	59.43	63.40	67.92	73.15	79.24	86.45	95.10
85 " "	49.90	52.83	56.13	59.88	64.15	69.10	74.84	81.65	89.81
80 " "	46.73	49.72	52.83	56.35	60.37	65.02	70.44	76.84	84.53
75 " "	44.02	46.61	49.52	52.83	56.60	60.95	66.03	72.04	79.24
70 " "	41.09	43.51	46.25	49.30	52.83	56.89	61.63	67.24	73.96
65 " "	38.15	40.41	42.92	45.78	49.05	52.83	57.23	62.42	68.68
60 " "	35.22	37.20	39.62	42.26	45.29	48.77	52.83	57.26	63.39
55 " "	32.28	34.30	36.32	38.67	41.51	44.70	48.42	52.83	58.11
50 " "	29.35	31.07	33.02	35.22	37.73	40.64	44.03	48.03	52.83

While we insist on the maintenance of the proper proportions between the carbonate of alkali and the lime, we do not merely look to a saving of the latter, because the slaked lime can be had cheaply everywhere, so that the greatest overplus of lime will not influence the expense of making caustic lyes. The advantage of accurately maintaining the equivalent proportion of the materials which come into consideration, rests on the fact that a carbonate of lime is obtained, which may be lixiviated with the greatest ease so that not only is time saved, but also nearly all the alkali is recovered, without being compelled, in order to reach the same object, to be overburdened with a mass of weak lyes, as their storage often occasions more inconvenience than the alkali contained therein is worth.

Of scarcely less importance for preparing pure lyes is the proportion between them and the water necessary for solution. In this respect the carbonate of alkalies seems not to be proportionately equal, since, according to the experiments of Liebig, carbonate of potash to become perfectly caustic must be dissolved in at least twelve times its weight of water, while for carbonates of soda (anhydrous) about seven times the amount of water is required. We have, however, for finding out this proportion made some experiments, and found that carbonate of soda, even if dissolved in thirteen times its weight of water and boiled with a small overplus of lime, does not yet impart all its carbonate to the lime. The following are the results of these experiments:—

By 1 part anhydrous carbonate of soda and 5.8 parts water, remain undecomposed	15.62	p. c.	$NaO.CO_2$.
" 1 part anhydrous carb. of soda and 8.2 parts water	8.78	"	"
" " " " 11.3 "	4.19	"	"
" " " " 13.3 "	1.29	"	"

Even by the application of thirteen and one-third parts its weight of water to that of carbonate of soda, and the required amount of lime, there were 1.29 per cent. remaining undecomposed; it also made but a trifling difference when a larger overplus of lime was applied. Since it is known by experience that lyes which contain 9 per cent. of their contents in carbonate of soda will saponify the neutral fats, those who deem this an advantage, may dissolve the soda in eight or nine parts its weight of water, and then add the necessary quantity of lime and boil it. Meanwhile the solution becomes somewhat weaker by changing the lime into hydrate of lime, which imparts its water to the lye, because the carbonate of lime retains no water. To acquire a perfectly free carbonic acid lye, we would, according to the above experiments, probably have to apply fifteen times the amount of water of the weight of the pure carbonate of soda, and obtain hence a lye of 3.9 per cent. caustic soda, which, of course, is tolerably weak. But a lye of from 5 to 7 per cent. is in most cases suitable, *i. e.*, such as is obtained by dissolving carbonate of soda in ten times its weight of water.

For pure carbonate of potash, the same proportion must be used, and a lye is thus obtained of nearly 7 per cent. caustic potash. By these calculations it is self-evident, that we should only consider the contents of pure carbonate of alkali, so that for instance 50 kilogrammes (110 lbs.) of a potash, which contain but 65 per cent. pure carbonate of potash, we dissolve in 325 kilogrammes (715 lbs.) of water, and a soda of 35 per cent. pure carbonate of soda in 425 kilogrammes (935 lbs.) of water.

After having in this manner made the solution, and having brought the entire quantity to a boil, we begin with the addition of the previously weighed and slaked lime (milk of lime) in gradual portions, while the liquids are kept slowly boiling, and continue thus for a short time, after having added the last portion of lime. By this operation the lime which at first was of a gelatinous consistency is changed into the crystalline or grainy state, and may then be lixiviated with the greatest ease. When the boiling has lasted about half an hour, the fire is removed, when the carbonate of lime will soon settle on the bottom and the finished lye stand clear above it. After having cooled off so far, that the finger may be placed in it without scalding, the drawing off is commenced. This is best performed by means of a copper siphon, or in place of such by one made of tin-plate. The siphon is filled with water and boths ends are closed with the thumbs of both hands, which as they have to come into contact with the lye are previously rubbed with fat, or still better with paraffine. The residue, the carbonate of lime, is carried into the filtering apparatus, which has a sieve bottom, covered with coarse canvas, or cotton cloth, in such a way that none can escape spreading, the pulpy mass as evenly as possible thereon, to allow of a complete filtration, and fill the space above it with pure water, until it forms a layer equally as high as the carbonate of lime, and filters completely. If the necessary care and attention have in every particular been given, the lixiviation may be considered as finished, and the lime exhausted; but for a second time pure water may be poured upon the lime, and this very weak lye may be used for preparing the lye in the next operation.

Preparing Potash Lye from Wood-ashes.—Where there is opportunity to purchase large quantities of good wood-ashes cheaply, their use offers, for the preparation of potash-lye, immense economical advantages over the use of potash.

The manipulation is somewhat different from that of potash. After having, in the manner heretofore described, ascertained the contents of carbonate of alkali of the wood-ashes, the required amount of lime is calculated that is necessary to change it into caustic potash. The lime is slaked to powder and mixed with the wood-ashes as thoroughly as possible. This mixture is placed in a wooden, or still better in an iron vat, in which is inserted a sieve bottom covered with straw, now adding sufficient water to it so that a thick paste is formed which is left at rest for 24 hours. It must be observed that the layer is everywhere of equal height, and no gutters are formed, through which the water might flow off without having previously absorbed the caustic potash. Now pour water into the yet empty part of the vat and permit the lye to draw off. The space between the blind and the real bottom must have an opening immediately under the former, so that the air can escape. The lye which collects between the two bottoms is drawn off by means of a stopcock, and carried to a second vat, which is prepared in the same manner as the first. It may also be passed into a third vat, but in every case the quantity of water must be so proportioned, that only lyes of 7 per cent. caustic potash are produced. Of this strength, the lyes may be used for saponification of the fats; but they contain as a rule such large amounts of sulphate of potash and chlorate of potash that muddy soft soaps would be obtained. It is therefore necessary to condense them to 22 to 25° B., when after cooling off the greater part of these foreign salts crystallize. For use the lyes are again diluted with water till they reach the desired strength.

Preservation of the Lyes.—Although it is not common to prepare large quantities of lyes in advance and to preserve them for a longer period, yet it may be advantageous under certain circumstances, especially if the necessary vessels are at hand, to lay up a supply of caustic lyes; to avoid the absorption of carbonic acid, and to lose thereby more or less of their efficacy. Strictly hermetically tight vessels would be necessary, the constructing and acquiring of which would not only be very expensive but also difficult. We have in order to reach this end used paraffine, of which we have caused to be thrown according to the size of the vessel a sufficient quantity upon the yet warm lye. The paraffine melts, spreads upon the lye and forms upon it a cover, which completely shuts out the carbonic acid. For this no special vessels are needed, and it may be placed in tanks or in the so called pits;—as thereby the paraffine is in no wise changed, we can always make renewed use of it.

In testing the strength of lyes, formerly an egg was used—and in many instances this is yet done—for the approximate estimation, whether a lye possessed the necessary strength for the paste or preliminary operation, the lye had to attain such a density that a hen's egg would float upon it. At a more progressive period hydrometers were used for this purpose and are yet frequently applied. There is no doubt that the latter instrument would show with sufficient accuracy the quantity of alkali dissolved in the water if for the production of lyes pure carbonate alkalies were used. But as such is not the case, and the potash as well as the soda contains larger or smaller quantities of foreign salts, soluble in water, this method of testing, based upon the specific gravity, can never furnish positive results, and there may be lyes which although they prove themselves *high* on the scale of an hydrometer, yet may be proportionately weak in caustic alkali.

On the other hand, the alkalimetric test offers the most perfect security, and the *modus operandi* is similar, as we have already related, in the case of testing potash and soda. The main thing is, that a correct testing acid be provided, and it would be best to prepare it for the purpose, and, moreover, such an one, as may be applied as well for potash as for soda-lyes. We have, heretofore, for a testing acid, recommended nitric acid; but its treatment offers to those who are not chemists certain difficulties, and for this reason we would recommend to soap manufacturers crystallized oxalic acid. It has in its crystallized state always the same composition, and can, as it is dry, always be accurately weighed. 63 grammes (2.2 ozs.) of purified oxalic acid (in case of necessity the commercial oxalic acid may be used) are dissolved into 1 litre of water. It corresponds to 47.11 grammes (1.65 ozs.) caustic potash, and 31 grammes (1.09 ozs.) caustic soda, each cubic centimetre, therefore, 0.047 grammes (0.725 grains) potash and 0.031 grammes (0.478 grains) soda.

If a lye is to be estimated, take into a beaker glass, or still better, in a porcelain cup 10 cubic centimetres (2.70 fluidrachms) thereof, then add about 10 drops of litmus tincture, and then by means of a $\frac{1}{10}$ cubic centimetre (0.027 fluidrachm) graduated pipette, add the oxalic acid solution until the blue color of the liquid has changed into an onion-red. Supposing now we had by this transaction used upon a potash lye 10 cubic centimetres (2.70 fluidrachms) oxalic acid, then there are in the 10 cubic centimetres of the applied lye 0.47 grammes (7.25 grains) potash, or, if soda lye had been estimated, 0.31 grammes (4.78 grains) soda contained in the lye; the one lye contains, therefore, 4.71 grammes (72.7 grains) or per cent. potash, the other 3.10 grammes (47.83 grains) per cent. soda. To show at once that in such like tests it is not important to obtain the highest degree of accuracy, that is to have absolutely pure oxalic acid, we will suppose the applied oxalic acid had contained but 95 per cent. pure oxalic acid, an amount of impurity hardly ever found. In fact there would in such a case as is shown above if 10 cubic centimetres (2.70 fluidrachms) oxalic acid had been used, not 4.711 grammes (72.69 grains) potash, or 3.10 grammes (47.83 grains) soda, have been the proper contents of the lyes, but only 4.711 : 0.95 = 4.4 (67.9 grains) potash, respectively 2.945 per cent. soda, so that the difference in both cases amounts to about $\frac{1}{4}$ per cent. But another test of the lye can be made in this manner, by placing with a pipette 4.71 cubic centimetres (1.27 fluidrachms) potash-lye, or of a soda lye 3.1 cubic centimetres (0.84 fluidrachm) in a cup, bluing it with litmus tincture, and then by means of normal oxalic acid solution titrate until an onion-red color appears. In this case the cubic centimetre of acid used, multiplied by 10, gives the content of the caustic alkalies without further calculation.

But it is always best for such tests to apply purified oxalic acid, for which purpose the crude oxalic acid is dissolved in double its weight of heated distilled water and the solution filtered, when after cooling off, the acid will crystallize in a sufficiently pure condition. It is then brought upon a filter, and dried in the open air upon tissue paper without warming it, until a crystalline powder is formed.

Whenever the application of oxalic acid seems too troublesome, the test acid may be sulphuric acid, of which 55 grammes (1.93 ozs.) are weighed off and diluted with water to 1000 cubic centimetres, one litre (2.1 pints). To have this acid mixture correct, dissolve 5.3 grammes (81.78 grains) fresh heated pure carbonate of soda in 100 cubic centimetres (3.38 fluid ozs.) liquid; of this transfer 10 cubic centimetres (2.70 fluidrachms) by the pipette into a porcelain cup, adding tincture of litmus, and also from a graduated pipette so much sulphuric acid until the liquid has assumed an onion-red color, and by warming again does not again turn blue. If the sulphuric acid had been correctly mixed, then 10 cubic centimetres of it would have been accurately used; to occasion that change of color, generally, however, there will be—according to the above proportions between water and sulphuric acid—less than 10 cubic centimetres used of the testing acid, and the deficiency must be made up of pure water. Supposing, instead of 10 cubic centimetres (2.70 fluidrachms) but 9 cubic centimetres (2.43 fluidrachms) had been applied, then to the litre of testing acid, 99 cubic centimetres (3.34 fluid ozs.) water must be added.

We have already explained, that in order to determine the strength of a lye with some degree of accuracy, we cannot depend upon a hydrometer, but will prove by an example what differences may ensue under certain conditions. Thus a lye containing 14.52 per cent. of caustic soda of the specific gravity of 1.255 = 29.5° B., and according to this should have contained 16.635 per cent. of soda. If the requisite quantity of the lye for decomposing the neutral fat had been determined by means of a hydrometer in this case, we should have applied 2 per cent. of soda less than was necessary for a complete saponification. The soda from which that lye had been prepared contained 72 per cent. anhydrous carbonate of soda, hence we have an inferior article. Under certain conditions a hydrometer may, of course, be used for determining the value of alkali contained in certain (equal) sorts of potash or soda; that is when large quantities thereof are on hand and have to be worked up. In such case the contents of the alkali are discovered in the alkalimetric way and compared with the specific gravity or the degrees Baumé or those of another scale. Then as long as that supply holds out the alkalimetric tests may be dispensed with and the hydrometer may be used.

In order to obtain a certain basis for this, there have been found by experiment—for soda lye—the results indicated in the two following tables, from which it may be seen about how much of the caustic soda has to be deducted from the degree of Baumé's hydrometer.

One of the tables contains experiments with 86 per cent. soda, the other with 72 per cent. soda.

I. 86° Soda.

Specific gravity.		Degrees Baumé.	Should contain.	Contains.
1.2332	=	32.15	14.554	13.890
1.1166	=	24.20	7.635	6.945
1.0583	=	9.60	4.231	3.472

II. 72° Soda.

Specific gravity.		Degrees Baumé.	Should contain.	Contains.
1.2548	=	34.5	16.636	14.360
1.1274	=	19.5	8.646	7.180
1.0637	=	10.2	4.574	3.590

If the estimations of the hydrometer have been compared with the results of the alkalimetric test, we can as long as the same sort of soda is worked, for approximate determination of the lyes of caustic soda, apply the hydrometer also. This is done by deducting according to the degrees of soda a certain portion from the per cents. shown by the scale of the hydrometer. We do not wish to recommend this method, but there are many soap factories where the hydrometer cannot be dispensed with, and for such the statements above may have some value.

Table of the contents of Anhydrous Potash with the corresponding specific gravities and degrees of the hydrometer according to Baumé (calculated by Tünnermann) at 15° C. (59° F.).

Specific gravity.	Degrees according to Baumé approximate	Per cent. of potash.	20 l. (5.29 gal.) contain kilogr. NaO.	Quantity of fat which in 100 l. (26.5 gallons) of the corresponding lyes will saponify.
1.3300	36°	28.290	7.52	228 kg.
1.3131	34	27.158	7.09	215 "
1.2966	33	26.027	6.75	205 "
1.2803	32	24.895	6.37	193 "
1.2648	30	23.764	6.02	182 "
1.2493	28	22.632	5.66	171 "
1.2342	27	21.500	5.30	161 "
1.2268	26	20.935	5.14	156 "
1.2122	25	19.803	4.80	145 "
1.1979	23	18.671	4.50	136 "
1.1839	22	17.540	4.15	126 "
1.1702	21	16.408	3.84	116 "
1.1568	19	15.277	3.53	107 "
1.1437	18	14.145	3.22	99 "
1.1308	17	13.013	2.94	89 "
1.1182	15	11.822	2.64	80 "
1.1059	14	10.750	2.38	72 "
1.0938	12	9.619	2.10	64 "
1.0819	11	8.437	1.85	56 "
1.0703	10	7.355	1.57	48 "
1.0589	7	6.214	1.32	40 "
1.0478	6	5.022	1.05	32 "
1.0369	5	3.961	0.82	25 "
1.0260	3	2.829	0.58	18 "
1.0153	2	1.697	0.34	10 "
1.0050	1	0.5658	0.11	3.6 "

The second and fourth columns are added by Perutz, and the latter is especially calculated for the convenience of soap boiling establishments, and is valuable for reference.

Dalton has likewise furnished a table respecting the potash contents of lyes, according to their specific gravities, which, however, differs 2 per cent. from the above. But as it extends also to lyes of greater specific gravities we deem it desirable to add it here.

Specific gravity.	Degrees according to Baumé.	Per cent. of potash.	Quantities of fat which in 100 kil. (220 lbs.) of the lyes are saponified.
1.68	58	51.2	307 kg.
1.60	54	46.7	280 "
1.52	49	42.9	258 "
1.47	46	39.9	240 "
1.44	44	36.8	222 "
1.44	43	34.4	206 "
1.39	40	32.4	194 "
1.36	38	29.4	176 "
1.32	35	26.3	157 "
1.28	31	23.4	140 "
1.23	27	19.5	117 "
1.19	23	16.2	97 "
1.15	19	13.0	78 "
1.11	14	9.5	58 "
1.06	8	4.7	26 "

In the above table it is supposed that 141 parts potash, on an average, saponify 860 equivalents of fat; but we can operate more accurately when the equivalents for the different fats are the basis for this calculation. The figures in the fourth column are then changed in the same ratio as the equivalent becomes greater or smaller than that accepted by Perutz, viz., 860.

Table of the contents of Anhydrous Soda with the corresponding specific gravity and hydrometeric degree of Baumé, according to Tünnermann, to which Perutz has likewise added the quantities of the fats, which are saponified by lyes of various strengths.

Specific gravity.	Degrees Baumé.	Per cent. of soda.	20 l. (5.29 gals.) contain kilgr. soda.	100 l. (26.5 gals.) of the lye saponify kg. fat.
1.4285	43	30.220	8.63	416.7
1.4193	43.5	29.616	8.41	406.5
1.4101	42.0	29.017	8.18	395.7
1.4011	41.0	28.407	7.96	385.0
1.3923	40.5	27.802	7.74	374.3
1.3836	39.7	27.200	7.53	364.0
1.3751	39	26.594	7.31	353.7
1.3668	38.5	25.989	7.10	343.6
1.3586	38.0	25.385	6.89	333.5
1.3505	37.3	24.780	6.69	323.7
1.3426	36.7	24.176	6.50	314.0
1.3349	36	23.572	6.30	304.3
1.3273	35	22.967	6.08	294.1
1.3198	34.5	22.363	5.90	285.4
1.3143	34.2	21.894	5.75	278.3
1.3125	34	21.758	5.70	276.2
1.3013	33.5	21.154	5.52	267.1
1.2982	33	20.550	5.53	258.0
1.2912	32.4	19.945	5.16	249.0
1.2843	31.6	19.341	4.97	240.2
1.2775	31	18.730	4.79	231.4
1.2708	30.5	18.132	4.61	222.9
1.2642	30	17.518	4.43	214.2
1.2578	29	16.923	4.26	205.9
1.2515	28.5	16.319	4.09	197.5
1.2453	28	15.714	3.92	189.3
1.2392	27	15.110	3.74	181.2
1.2280	26	14.506	3.56	172.3
1.2178	25	13.901	3.38	163.7
1.2058	24.5	13.297	3.21	155.0
1.1948	23	12.692	3.03	146.6
1.1841	22	12.088	2.88	139.4
1.1734	21	11.484	2.70	130.3
1.1630	20	10.879	2.53	122.3
1.1528	19	10.275	2.37	114.6
1.1428	18	9.670	2.21	106.8
1.1330	17	9.066	2.05	99.4
1.1233	16	8.462	1.91	91.9
1.1137	15	7.857	1.75	84.6
1.1012	13.5	7.253	1.59	77.4
1.0948	12	6.648	1.46	70.4
1.0855	11	6.044	1.31	63.4
1.0764	10	5.440	1.17	56.6
1.0675	9	4.835	1.03	49.9
1.0587	7	4.231	0.89	43.3
1.0500	6	3.626	0.76	36.8
1.0414	5.6	3.022	0.63	30.4
1.0330	4.2	2.418	0.50	24.1
1.0246	3	1.813	0.37	17.9
1.0163	2	1.209	0.25	11.8
1.0081	1	0.604	0.13	5.9

For finding the contents of soda in the lye, Dalton has also furnished a table, showing the various specific gravities of soda contained in the lyes. The results vary materially from those stated by Tünnermann, which perhaps have their reason, because the latter may not have used a perfectly pure —carbonic acid free—lye, for his analysis.

Specific gravity.	Degrees Baumé.	Contents of soda.	100 kg. (220 lbs.) of the lye (in the margin) saponify fats.	Specific gravity.	Degrees Baumé.	Contents of soda.	100 kg. (220 lbs.) of the lye (in the margin) saponify fats.
2.95	70	77.8	720 kg.	1.40	41	29.0	270 kg.
1.85	66	63.6	596 "	1.36	38	26.0	242 "
1.72	60	54.8	498 "	1.32	35	23.0	224 "
1.63	56	46.6	431 "	1.29	32	19.0	168 "
1.56	52	41.2	381 "	1.23	27	16.0	149 "
1.50	48	36.8	346 "	1.18	22	13.0	121 "
1.47	46	34.0	314 "	1.12	16	9.0	83 "
1.44	44	31.0	287 "	1.06	8	4.7	44 "

The fats and oils and the fatty acids as they are received by soap manufacturers, are usually in a condition for immediate use, but occasionally there may be impurities of such a character that they will require to be removed before they are made into soap. If they are merely foreign substances a melting and straining may prove sufficient, or there may be adulterations. This falsification we have pointed out and given some tests for in another section; should the tallows, greases, or oils prove very impure they can be improved very much by melting to about 40° C. (104° F.), and adding about two per cent. of strong alkali, say 38° B., stirring gently at this temperature for about a quarter of an hour and then allowing to rest and cool. The impurities will fall to the bottom, and the purified grease can be removed therefrom.

It is generally conceded, and in our judgment very truly, that there is no oil or fat, though in itself containing several constituents, which used alone makes a faultless soap. Thus tallow or curd soap becomes in drying too hard and almost insoluble, and so with olive oil soap, which has the same property, and on the other hand, soaps made with the drying oils (linseed, poppy, etc.) are too soft and cannot be made sufficiently hard for use as solid soaps, and are consequently mostly made into soft soaps with potash lye, which, by its hygroscopic property, always remain soft and when exposed to the air absorb water and are constantly getting softer.

So that knowing the different properties of the fatty bodies with their behavior when combined with the alkalies, it is necessary so to mix the different oils and fats, and in such proportions that considering the different properties of each, by judicious mixture, may be produced a soap having properties suitable for its intended uses. The mixtures of the different ingredients will be given when we discuss the manufacture of each kind of soap and with them several formulas if necessary.

In making soaps by boiling with an open fire, with steam, or surcharged steam, or by whatever appliance or methods the manufacturer may possess, it is necessary in the first place to determine the proper proportions.

According to the information already given as to the equivalents for the fats, we suppose that 50 kilog. (110 lbs.) pure fat (which must not be mixed with cocoa-nut oil) demand about 6 kilog. (13.2 lbs.) caustic soda or 8.5 kilog. (18.7 lbs.) caustic potash. This is indeed somewhat in excess of the real necessity, but a little surplus is not injurious, as the lyes are seldom perfectly free from carbonate, and carbonated alkali does not easily combine with neutral fats. On this supposition, we will answer the question, How many kilogrammes of fat might be saponified by 1000 litres (265 gallons) of a soda lye of 20° B. = 1.163 specific gravity = 10.879 per cent.? 1000 litres weigh 1163 kilog. (2559 lbs.); with 10.879 per cent. soda, the same contain 126.5 kilog. (278.3 lbs.) caustic soda; since according to our supposition 6 kilog. (13.2 lbs.) of this 50 kilog. (110 lbs.) fat saponify, hence 126.5 kilog. saponify $\frac{126.5 \times 50}{6} = 1054.2$ kilog. (2319 lbs.) fat.

If, on the other hand, we have 1000 litres (265 gallons) potash lye of 20° B. or 1.163 specific gravity, which according to the table (heretofore given) contains 15.842 per cent. potash, and suppose, that 50 kilog. (110 lbs.) fat require 8.5 kilog. (18.7 lbs.) for saponification, then those 1000 litres (weighing 1163 kilog.) contain 184.2 kilog. (405.24 lbs.) potash and hence $\frac{184.2 \times 50}{8.5} = 1083.5$ kilog. (2384 lbs.) fat would be saponified.

Although in the two preceding examples we have supposed the quantity of the lye according to weight, yet it is more convenient for all operations on a larger scale to measure the liquids instead of weighing them. But the proportions thereby become the more varied the stronger the lyes are. Though 500 cubic centimetres (16.9 fluid ozs.) water weigh also ½ kilog. (1.1 lbs.), yet 500 cubic centimetres of lye weigh so much more than ½ kilog., as this lye is stronger. It is therefore easier and more to the point in question to give the contents of a lye as to its value of caustic alkali, according to its measure than its weight. The figures in the tables as to the contents of the lye relate, however, to weight proportions; but they can be easily changed into volume per cent. by multiplying the former by the specific gravity of the lye. In the preceding examples, there would hence be in the case of soda of 10.879 weight per cent. 12.67 volume per cent., and of 15.842 weight per cent. potash, we would have 18.42 volume per cent.; hence in 1000 litres (265 gallons) are contained 126.5 kilog. (278.3 lbs.) soda, or 184.2 kilog. (405.24 lbs.) potash, the same as above. The measuring method at once commends itself for this reason, because we obtain directly by the investigation of the lye the volume per cent.

If in this manner the supply of lye is made the issue for determining the quantity of a boiling, we will never be in a quandary on account of the want of lye during the operation of boiling. That we may also proceed in a reversed way, as soon as we are sure of having a sufficient supply of lye, and as soon as we are acquainted with the strength of the same, and how much of this lye is required to saponify, for instance 500 kilog. (1100 lbs.) fat, will thus become obvious. Supposing it is intended to make a boiling of 375 kilog. (825 lbs.) fat by means of soda, then we would need of pure lye, which contains 6 per cent. caustic soda for each 50 kilog. (110 lbs.) fat 100 kilog. (220 lbs.), and hence for those 375 kilog. fat 750 kilog. (1650 lbs.) of this lye would be required.

We use for these calculations the tables of Perutz, which we have given on pages 259 and 261, and, for the sake of convenience, we have here also added the weight of potash or soda contained in 10 litres (2.6 gallons) lye—and have recalculated into measures. These tables containing all sorts of lyes, from the strongest to the very weakest, it is by their aid very easy to find the correct quantities of alkali, even if we are compelled to apply lyes of various strengths.

A few examples will make this still more apparent. Supposing we had 2000 kilog. (4400 lbs.) fat to boil into soft soap, it would require, if 8.16 kilog. (17.95 lbs.) potash saponify 50 kilo. (110 lbs.) fat $\frac{16.32 \times 2000}{100} = 326.4$ kilog. (718 lbs.). Of lye we have one of 21° B. and another of 10° B.; each of the lyes is to furnish one-half of the requisite potash; hence 163.2 kilog. (359 lbs.).

In the table for potash we find that in 20 litres (5.29 gallons) of the lye of 21° B. 3.84 kilog. (8.45 lbs.) potash are contained, hence we have the rate $3.84 : 163.2 = 20 : x$; $x = 950$, and we have therefore to take 950 litres (251 gallons) of this lye. Of the lye of 10° B., 20 litres (5.29 gallons) contain 1.57 kilog. (3.45 lbs.) potash, hence $157 : 163.2 = 20 : x$; $x = 2079$; of this lye there are consequently to be measured off 2079 litres (550 gallons). If $\frac{5}{7}$ of the strong lye is to be taken and $\frac{2}{7}$ of the weak, the calculation would be fixed as follows: $\frac{5 \times 326.4}{7} = \frac{16,320}{7} = 233\frac{1}{7}$ kilog., and $\frac{2 \times 326.4}{7} = \frac{652}{7} =$ 93.2 kilog. (205 lbs.); we have hence to take $3.84 : 233.14 = 20 : x$, 1214 litres (321 gallons) of the strong, and of the weak $1.57 : 93.2 = 20 : x = 1187$ litres (314 gallons).

In the same manner the calculation is carried out if the point in question is the saponification of, for instance, 1000 kilog. (2200 lbs.) fat, by means of caustic soda. To do this 107.4 kilog. (236.28 lbs.) caustic soda would be requisite, whereof one-half is applied for the so-called process of boiling the paste (preliminary operation) with a weaker lye. On hand are: a lye of 30° B. and another of 12° B. The former contains in 20 litres (5.29 gallons) 4.43 kilog. (9.75 lbs.) of caustic soda (one-half of the entire quantity) take $\frac{53.7 \times 20}{4.43} = 250.4$ litres (66 gallons).

The weaker lye of 12° B. contains in 20 litres (5.29 gallons) 1.46 kilog. (3.21 lbs.) caustic soda, and to obtain also in this case 53.7 kilog. (118 lbs.) caustic soda, we will have to apply $\frac{53.7 \times 20}{1.46}$ = 736 litres (194 gallons).

These few examples will suffice to show how to use the tables, and also how, by means of the same, the correct proportion between fat and alkali may be calculated in advance.

HARD SOAPS (SODA SOAPS).

We begin with the fabrication of the solid (curd or grain) soaps made with soda lye. They are such soaps as in the process of boiling are cut, or freed from their superfluous water by means of culinary salt, and are the white, yellowish, or marbled soaps.

To make a good *Marbled or Marseilles Soap* the operation is divided into the following different parts.

1. The pasting or empâtage.
2. The separation or relargage.
3. The clear boiling or coction.
4. The mottling or marbling.
5. The framing.

In making the paste, only one-half of the quantity of caustic soda is applied, which is necessary for a perfect saponification of the fat which is taken to be worked up; but this quantity is also divided into two lyes of different strengths, and for the first application the weaker lye is used, so that the boiling commences with the fourth part of the entire quantity of caustic soda.

A certain quantity of lye is now placed in the kettle to be boiled, and then the fat is added, and for marbled or Marseilles soap olive oil with about 10 to 20 per cent. of a drying oil is put in. After a short time the mass is again brought to a boil, whereby it bubbles up under ebullition. For checking the boiling over the fire is diminished, and while the mass is being gently stirred it is permitted to continue to boil until all frothing has ceased, and the so-called paste is formed. The mass has, in this condition of the operation, a yellowish white appearance, and if a sample of it is taken out with a spatula, it can be drawn into long threads of a white color. The soap after continuous boiling having assumed a greater consistency, receives a gradual addition—at intervals of about half an hour—of the second portion of lye, and the boiling is kept up during several hours, the better to perfect the combination of the soda with the fat. In order to facilitate this combination, a little carbonate of soda is occasionally added; much better suited for this purpose, however, is a small portion of finished soap, which causes the formation of an emulsion-like mixture, a condition which greatly hastens the saponification. When a perfect union of the fat and the alkali has taken place the second operation, called *the cutting of the pan or the separation of the surplus water from the soap*, thereby to make the same more consistent, is attended to, when after the preliminary boiling a perfect union of the fat with the lye has taken place. For this operation we take either a strong salted soda lye or culinary salt. The latter, for reasons stated when this subject was under discussion, must be refined. It is applied dry or in solution, and of the one or the other we add as long as the soap and the lye become separated, which is ascertained by noticing when the soap begins to boil into broad and smooth plates, and upon the spatula separating from the lye in pieces, and a sample of it, being cooled off on a glass plate, is no longer soft and smeary, but can be removed tolerably dry. Another sign of the complete separation is that the hot, clear lye after cooling off does not congeal to a jelly-like mass. There is generally no danger that the soap will not completely separate, because a little surplus of culinary salt does not injure it. How much of salt is necessary, in proportion to the materials which are being worked up (fat and alkali) to cause separation, cannot be reckoned in advance, since this is dependent on the concentration of the lye applied and the greater or less time required for boiling, whereby it concentrates. The surest mode is repeated proving, whereby we convince ourselves of the state of the mass.

The action of the culinary salt does not always succeed at once, even if it is applied in soluble form, although it may thus cause a somewhat quicker operation. The more diluted the lye is, the more culinary salt will be needed for separation. Then, when, in consequence of an increased boiling, a greater concentration of the lye has been produced a separation will ensue; for as has already been stated, the separation of the soap does not so much rest upon the absolute quantity of culinary salt to a given quantity of soap, as upon the insolubility of the latter in a lye containing culinary salt, of a certain concentration. The manner in which the soap boils, is likewise a criterion as to whether the separation is complete. If instead of a smooth, lustrous surface, which is furrowed into small sections and circles, larger and rough divisions are visible, which are broken by steam under formation of bubbles, whereby the soap begins to rise, it may be presumed that the separation of the soap is completed. Moreover, the sub-lye must on no account have a touch or caustic taste, nor will this occur if the operation has been correctly performed, because the oil on hand is in double the quantity that the alkali present can absorb for forming a neutral soap. But if there should despite all this be some unsaponified oil therein, then a mistake has been made, the cutting of the pan has been premature, and must now, after the soap has been again rendered into paste by adding water, again boil until all the alkali becomes bound, and the sub-lye assumes a sweetish-salt taste. A further addition of culinary salt is not needed, and the soap reseparates without this, when the sub-lye, by the evaporation of water is again so concentrated, that it will no longer dissolve any soap. After a complete separation having ensued, the soap must remain a few hours longer in the kettle, during which time, the lye settles on the bottom, and is then drawn out by means of the waste pipe, which is in the bottom of the kettle. Where such a pipe is not present, the removal of the sub-lye is by a portable pump, which has its barrel on the lower end, or the soap is ladled from off the sub-lye into the cooling vat, which stands close to the boiling kettle. The soap is now prepared for the third operation of the coction or

Clear-boiling.—For this operation, after removal of the sub-lye, the necessary lye is added to the soap, or if this is still in the cooling vat, then it is placed in the kettle, adding the soap from the cooling vat to it, and heating the entire mass till it boils. Some manufacturers divide even the lye necessary for a perfect saponification, and boil the soap first with one-half of the same, and allow all the sub-lye thus produced—having imparted all its alkali—to flow out, whereupon the same operation is repeated with the other half. This may be suitable in those cases where a very impure fat is worked up, but whenever the fats are pure, such a custom is at least superfluous. It would be best, from the start, to pay more attention to a careful cleaning of the fat by remelting and depositing, a process which under all circumstances is much easier than a boiling upon the so-called second, third, and fourth waters. Pure fats may even be boiled and finished upon one water, so that the letting off of the sub-lye, or a repeated scooping of the soap into a cooling vat, becomes entirely superfluous. Only if dark colored fats are used, which in a great measure impart their color to the sub-lye, and partly also to the water which is contained in the soap, it may be necessary to boil in two or three waters. This of course is dependent on the color, which each withdrawn lye should show.

During the clear-boiling, the soap should boil as tenaciously as possible, that is, it should slip off with difficulty, when a sample is taken out with a spatula. It must become almost pasty, and whenever this does not take place at once, after adding a new quantity of lye, then the mass must have so much water added thereto, till it again returns into a glue-like substance. In this state, the lye acts upon the not yet completely saponified mass, and the process of saponification takes place much faster. It may hardly be necessary to remark, that, even if by a too abundant addition of water, the soap has turned into a real paste, this fault may be easily remedied by the addition of a little more salt. The boiling is continued, until all the caustic soda is bound, and a perfectly neutral soap is produced. This is ascertained, by separating a small sample of the soap-mass with a solution of culinary salt, that is by refining the soap, and then dissolving it in a little distilled water. Thereby a clear, opalescent, on no account milky solution must result; otherwise there is surely yet some unsaponified fat.

After a complete saponification of the fats, the soap will become thicker and opaque, boiling with little bubbles, by continuous, not too violent boiling. The more water evaporates, the more lye collects upon the bottom, and the soap becomes hard, and shows even at this high temperature an inclination to become solid; deep furrows are formed on the otherwise nearly smooth surface. Large and shiny bubbles appear, and the soap now boils into slabs. By taking a sample and placing it in the palm of the hand, and rubbing it until it becomes cold, it will harden into dry and glistening scales, which must show no adhesion, and may even be ground into powder. Should these characteristics be wanting, should it yet have a smeary touch, then the soap is either deficient in alkali, or the alkali used is not sufficiently caustic, or it has not yet been boiled long enough. The first case could hardly occur if the proper proportion of oil and alkali had been applied from the start, but if such is the case, we should not endeavor at once to mend this, by a fresh addition of alkali, but by continuing the boiling for a longer period of time. Thus even the carbonate of soda is bound—if its quantity is not excessively large—with the fat, and thus a neutral soap is obtained. If longer boiling proves insufficient, then carefully add some caustic lye until the object is reached. Frequent investigation of the soap, as to its solubility in distilled water, should not be omitted. Many manufacturers, especially when they think that the unpropitious result is caused by an insufficient causticity of the lye, add some lime-water. This, however, is for reasons heretofore stated most emphatically to be reproved. Although a complete saponification may thereby be reached, the lime-soap formed in this manner impairs the quality of the soap far more than the small portion of unboiled fat would. In how far, by a continued boiling, a good result may be attained, can be observed by the appearance of the sub-lye. For this purpose a portion of the soap is taken out of the kettle, placed in a saucer, the lye completely separated and cooled off, and the lye tested as to its contents of alkali. If by this test, no free or carbonated alkali, or at least but very little of it, is found, we may presume that the soap is yet wanting in it, if it does not show as yet the normal condition. A slight touch, which the sub-lye may have, does not injure the soap, since it is almost impossible to finish the boiling of soap, without any touch at all. This is quite natural too, since entirely caustic lye rarely or never is applied. At the first, the free alkali is bound; much more difficult and slower is the combination of the fat with the carbonated alkali, so that to hasten the process more caustic lye is added. In this manner nearly all the carbonated alkali remains uncombined and passes into the sub-lye. When taken out it appears upon the tongue as being too caustic, and this touch must not be deadened by the addition of fat.

The soap boiling correctly into slabs, is now kept boiling until it becomes *grainy*. This last operation is the real *grain* or *clear-boiling*. The soap now loses all superfluous water, and unites into a small grain-like homogeneous-curdle—while all froth vanishes, and when filled into the frames, produces the common grain—(curd) soap. But if the curdle by adding water or weak lye, is again changed into a mass of a gelatinous consistency, which, however, remains separated from the sub-lye, then the so-called ground (or filled) soaps are produced.

The Grinding or Filling of the Soap, whereby the soap is again changed into the semi-liquid or gelatinous state, has for its object the purification of the soap from its yet mechanically combined dross. This is done by imparting greater liquidity to it, and by allowing it before casting it into the frames to remain for several hours in the no longer heated kettle. This grinding is performed by two different modes, but is always carried out with water or a very weak lye.

Either the lye still in the kettle from the clear boiling remains in it, and so much water is added until the soap grains become liquid—for this water may be used, as has been noted above—there will still retain in most cases a touch (this is termed "the grinding from above);" or the salt lye is drawn off and the necessary lye or water with a little salt is added to perform the grinding, which is termed "the grinding from below." The adding of salt is to avoid the formation of paste. The grinding from below is only necessary when very impure materials have been worked up.

The operation of grinding is undertaken over a very hot fire so that the lye is constantly thrown up, and the boiling is continued until broad slabs appear, the surface shines in a honey yellow color or turns up in rosettes, and a sample taken out of it will prove the correct quality of the soap. The fire is now extinguished, and while the kettle is covered with the lid the soap is allowed to settle for a few hours and is then poured into the frames.

The Marbling of the Soap.—To impart to the soap the peculiar clouding or marbling, we add to it during the preliminary process of boiling, sulphide of sodium and sulphate of iron. Thus sulphate of iron and iron-soaps are formed, which admix with the soap and impart to it, when quickly cooled off, a greenish-black color. If allowed to cool off slowly the colored and insoluble soaps contract into smaller points and give to the soap a granite-like mottled appearance. If the cooling off is still more prolonged and the manipulation while stirring (an operation by which the soap before cooling off is stirred with an iron rod) is conducted with a certain regularity, we obtain a beautiful marbled soap. This is espeecially to be done with tallow soap, the crystallized grain of which has a great inclination to separate, and which consists essentially of stearic soda soap that at first congeals into a solid mass.

If it is intended to increase the marbling, we add, towards the end of the boiling, Frankfort-black or bole Armenian—of the former for 500 kilog. (1100 lbs.) grain soap 16⅔ to 33½ grammes (0.57 to 1.14 oz.), and we obtain in this way a black-grayish marble; and of the latter to the same quantity of soap 100 to 133⅓ grammes (3.52 to 4.69 ozs.), and a brownish-red marbling appears.

To attain a handsome marbling the operation must be performed with the purest possible sub-lye which contains at the utmost but ½ per cent. of the alkali and is of about 14° B. strength, and we must not add enough weak lye or water to liquefy the grain—that is, no more than is requisite to diffuse the dyeing matter equally through the soap. Finally it must be observed that the temperature during the running out, does not vary much below or above 100° C. (212° F.).

The marbling will be imperfect or does not take place at all, when the soap mass is too thin, or the temperature is too high. Therefore the adding of lye must be attended to with care, commencing with the stronger and leaving off with the weaker. The operation is ended, when the soap shows flakes of a greenish color, which float upon the lye, and when the grain becomes semi-liquid without losing its rounded form. The marbling may, however, become faulty by running the soap into the frames when too much cooled off, as it solidifies too fast without giving the various combinations (stearic and oleic soda soap) time to separate by crystallization of the former. Because as the stearic and palmitic acids solidify at 69° C. (156.2° F.) and 62° C., (143°.6 F) respectively, while the oleic acid is still liquid at 15° C. (59° F.), so also the soaps of the former acids harden much sooner than the oleic acid soap. The more cooled off the soap is when run into the frames, the sooner the moment of congealing of both soaps is found to be reached, and only an imperfect separation of the same takes place, and the coloring matters, which are especially absorbed by the elaidin soap, remain likewise divided in the entire substance. If on the other hand the temperature is too high, then the elaidic soap impregnated with coloring matter precipitates, and after the stearic acid and palmitic acid soaps have crystallized the marbling does not ensue.

As marbled Marseilles (Castile) soap is now made nearly everywhere, and is no longer confined to Marseilles, we will note the different proportions that obtain in various localities. The calculations are for about a ton of fats. In England are used of—

Olive oil,	550	pounds, or	Olive oil,	700	pounds.
Palm oil, bleached,	1000	"	Lard,	700	"
Tallow,	350	"	Cocoa-nut oil,	200	"
Cotton-seed oil,	350	"	Tallow,	650	"
	2250			2250	

or,

Palm-kernel oil	1500	pounds.
Sesame oil	450	"
Tallow oil	300	"
	2250	

In the United States the usual formulas are—

Olive oil,	700	pounds, or	Palm oil (bleached)	1000	pounds
Ground-nut oil,	700	"	Cotton-seed oil,	500	"
Lard,	850	"	Tallow,	750	"
	2250			2250	

In Marseilles we have noticed that the proportions also vary with each manufacturer, and the olive oil is in greater quantity, though there are in addition more or less ground-nut oil, poppy oil, hempseed oil, sesame oil, etc. etc.

White Marseilles (*Castile soap*).—This truly fine soap may be considered a standard as to what a pure soap should be, and has with the mottled Castile soap given character and popularity to the soaps of France and particularly to those of Marseilles. While the mottled soap cannot be well made to retain its proper marbled appearance with an excess of water, the white soap from the difference in the manner of manipulation contains more water, though nearly all impurities have to be removed to obtain the proper whiteness.

White Castile soap is now made in almost all countries, and generally with the artificial sodas, and even in Marseilles these sodas are now being used. Yet in some factories the barilla is still used as the base; this alkali, containing a certain percentage of potash, gives a plastic consistency to the soap which has added to its popularity. This effect is now usually produced by the addition of a drying oil, such as hempseed, sesame, ground-nut, poppy or cotton seed oil to the amount of 15 to 25 per cent. of the olive oil. These oils, instead of being a sophistication, may be considered a benefit, as they prevent the soap, which if made with olive oil alone becomes too hard in drying, from having that undesirable property.

This soap is the purest to be found in commerce, when it has been prepared and purified according to the proper rules of the art. It is very much used in industrial operations, particularly in the bleaching of raw silk. By its extreme purity and its nearly absolute neutrality, it does not alter the brilliancy and elasticity of the silk, which renders it superior to all the other kinds of soap.

When prepared in all its purity, it has for its basis, with the additions above mentioned, pure olive oil, saponified by caustic lyes of artificial soft soda. These lyes are prepared in the same manner as indicated for marbled soap; but as the presence of salt would render the soap less soluble in water, the lyes must be prepared only with soft soda free from salt and containing as little as possible of sulphuret of sodium. By this precaution too much coloration of the paste is avoided, and the operation is much more easy.

In Belgium, soda ash is substituted for crude soda in the preparation of the lyes. The soap thus made is of a fine pure white color. Thus by using a colorless and a purer alkali, the refining of the soap is easier, and the amount obtained much larger than with lyes made from crude sodas. This is rational, and we have seen soaps of olive oil thus prepared, which were perfectly white and as pure as the best Marseilles soap.

Independently of the purity of the alkali, the nature of the oil employed to prepare this soap exercises a remarkable influence on its consistency and whiteness. To obtain good results, the whitest and most limpid oils must be used.

Experience proves that oils much colored have the property of communicating their shade to the soap. Sometimes a proportion more or less considerable of another oil is mixed with the olive oil, especially earthnut oil; this oil, being white, has no influence on the color of the soap, but it changes its consistency and renders it more soluble and lathering.

PASTING. (*Empatage.*)

We suppose a saponification made with 2250 pounds of oil. For this quantity use a kettle of a capacity of from 1000 to 1250 gallons. Pour into the kettle from 175 to 200 gallons of caustic lye of soft soda at 8° to 10° B., which is heated. When the lye begins to boil, pour on the oil, and to facilitate its combination with the lye, stir the mixture all the time; the stirring may be continued for half an hour after the last portion of oil has been introduced.

This being done, boil the mixture. The ebullition must be very gentle to prevent the formation of too much foam. If, notwithstanding this precaution, the mixture rises, the heat is to be slackened, then the ebullition becomes less rapid, the foam diminishes, and the mixture boils regularly; but it is essential to watch the operation, for in the state of dilatation the paste is in, it would soon boil over. A gentle ebullition has also for its object to facilitate the combination of the oil with the lye. It is known that the paste is quite homogeneous, when neither oil nor lye is seen at the surface.

This result being obtained, pour into the kettle lyes at a higher degree than the first, at 12° to 15° B., for example. The quantity of lye to be added is not well determined, but from six to eight gallons may be added without inconvenience every half hour, to take the place of the evaporated water. A slight excess of weak lye in the pasting is not injurious, and has the only inconvenience of making the operation a little longer and more expensive; but as a compensation, the oil is better saponified, and more completely deprived of its coloring and mucilaginous matters, and the soap is finer and better.

After a gentle ebullition of eight or ten hours, the paste becomes thicker, and more homogeneous. To finish, introduce 25 to 50 gallons of lye at 5° B., and after stirring for half an hour, stop off the heat, and proceed to the separation, or cutting of the pan.

SEPARATION. (*Relargage.*)

This operation is conducted in the same manner as indicated for marbled soap, that is, by pouring little by little into the kettle perfectly limpid lyes of coction, *i. e.*, salted lyes at 20° to 25° B. During the introduction of the lye, a man stirs the mass all the time. It is known that the quantity of lye is sufficient, when the soap separates from the lye, and acquires a clotted appearance. The more concentrated the lye, the less the quantity to be used to effect the separation.

The operation being finished, cover the kettle, let it rest five or six hours, and then draw off the exhausted lye. If not sufficiently pure in color, this cutting of the pan can be repeated, when proceed to the coction.

CLEAR-BOILING, OR COCTION.

1. *First Service of Lye.*—To begin the operation, pour at first into the kettle from 125 to 150 gallons of soft lye, at 15° to 18° B., heat gently, and when the soap is very warm, stop off the heat. This done, the soap is briskly stirred for three-quarters of an hour or an hour. By stirring thus, the soap is brought into contact with the lye, and by combining with the alkali it acquires more consistency, at the same time that it is deprived of the larger portion of the foreign salts that it has absorbed during the saponification and separation.

Rendered purer by this first washing, the soap is more fit to combine with the concentrated lyes which bring it to the proper point to be purified. After a settling of a few hours the lye is drawn off.

2. *Second Service of Lye.*—For this second service, pour into the kettle 100 gallons of caustic and concentrated lye, at 22° to 25° B. Boil the mixture gently for eight or ten

hours, adding every hour six gallons of pure lye to take the place of the evaporated water.

During the ebullition, a very abundant foam is formed on the surface of the soap, but its development is moderated by slacking the heat or beating it down with the stirrers, when during the ebullition the soap is entirely granulated, and floats in the lye. By pressing it between the fingers, it is found to have more consistency, but it is yet greasy, because it is not yet completely saturated with alkali. To bring it to the state of saturation, the heat is stopped off, and the mixture left to settle for a few hours; then a third and last service of new lye is given.

3. *Third Service of Lye.*—For this service, use a new lye marking 28° or 30° B. Pour into the kettle 110 gallons of the lye and then heat. After an ebullition of five or six hours, the grain of the soap is well developed, and when pressed between the fingers forms hard and dry scales. Continue the ebullition for a few hours, and when the soap is saturated, the foam which covered it disappears almost entirely, and that which is left is very light and white. If the oil used is of a good quality, the kettle emits an odor somewhat similar to that of the violet; the heat is stopped off, and after resting for a few hours, the lye is drawn off. This lye, by being passed over a mixture of soda and lime half exhausted, becomes clear, limpid, and caustic, and may be used anew to separate the soap in a subsequent operation.

When thus saturated, this soap contains only 16 per cent. of water, and is very alkaline and caustic. Its coloration is due to the use of crude sodas, and especially to the presence of the sulphurets of soda and iron, always existing in these sodas, which combine with the oxide of iron, also existing in them, and give rise to a sulphuret of iron which colors the soap. To refine it, it is necessary to submit it to a last operation called *fitting* and by the French soapmakers *liquidation*.

FITTING.

To transform into a pure white soap the mass of soap which has a bluish-gray color, it has to be dissolved by degrees in weak lyes with the aid of heat. To begin, pour into the kettle from 125 to 150 gallons of soft lye at 8° to 10° B. and apply heat. When the soap is very warm, stir it briskly. Under the influence of the heat, of the lyes, and the stirring, the grain dilates, softens, and looks as if half melted in the lye. When in this state slacken the heat, and after a few hours' rest, draw off the lye.

By this first operation, the paste begins to be deprived of the coloring matter and the excess of alkali it contains, but it is still caustic. To complete its refining, pour into the kettle from 50 to 60 gallons of soft lye at 5° or 6° B. and heat gently, stirring the paste all the time from the bottom to the surface. By agitation and heat, the paste becomes more and more fluid, and is yet separate from the lye. As its refining can take place only when completely liquefied, to obtain this result, add from time to time a few pailfuls of lye at 2° or 3° B., continuing the heat and the stirring. When it has become fluid, and the liquid, brought to the surface by the stirring, has a blackish color and is viscous, the operation is finished, because the coloration is due to the precipitation of the alumino-ferruginous soap—and the viscosity to the complete liquefaction of all the parts of the paste.

When in this state, stop off the heat, cover the kettle and surround it with woollen blankets, so as to retain the heat as long as possible. By resting and the heat of the mixture, the metallic soap, *i. e.*, iron oxide soap, and the excess of alkali precipitate to the bottom of the kettle, as well as the excess of weak lyes used in this operation.

After a rest of 36 to 40 hours, uncover the kettle, and take off carefully the scum formed on the surface. Dip off the soap with large iron ladles into frames. When the black soap begins to appear, the operator must be careful not to disturb it, since its mixture with the white soap would render it less neutral and less pure. When all the soap is in the frames it is well stirred so as to have it perfectly homogeneous; if not stirred it would present veins and even spots of color.

When the soap is completely solidified in the frames, it is flattened by beating it with large wooden beaters. This operation renders the soap more compact and heavier, it is useful also to fill the vacant spaces due to the air in the soap. In conclusion, the beating of the soap fulfils two essential conditions: 1. It increases its specific gravity; 2. It destroys its porosity.

A few days after the frames are uncovered, and the soap is divided into bars or cakes by the usual methods.

Recently manufactured, this soap is always a little soft. To give it the firm consistency required in commerce, it is exposed for a few days to the air in the drying-room, then it becomes solid enough to be packed in boxes. Exposure to the sun, or to too elevated a temperature, must be avoided, for heat always communicates to it a more or less yellow shade. Another method of hardening is to dip the bars of soap into a very strong lye, which hardens the surface and makes them the sooner marketable.

When the soap is not to be sold immediately, the boxes containing it are stored in a cellar. A few weeks after it will have acquired the whiteness and solidity which distinguish fine Marseilles soap.

Well-prepared *White Soap from Olive Oil* constitutes, as we have before said, the purest soap of commerce. One hundred parts of this soap are composed of:—

Fatty acids	50.20
Pure soda	4.60
Water	45.20
	100.00

By operating under favorable circumstances, that is, using the purest and whitest olive oil, and the best quality of artificial soda, the 2250 pounds of oil will give:—

Soap of scum	157 to 225
Pure white soap	2925 to 3040
Black soap	675 to 790

We see by these numbers that 2250 pounds of oil give as a maximum 3040 pounds of soap, or 135 pounds of soap for every 100 pounds of oil. The black soap left in the kettle as a residuum of the operation is separated, while warm, from the weak lyes with which it is combined, by means of salted lyes at 20° to 25° B. It is then run into a frame and allowed to cool. In a regular mode of working, this black soap is utilized in a new operation, and gives by refining a new quantity of pure soap by the precipitation of the coloring matters it contains. This method is not without inconveniences, because this mass of black soap introduced into each new coction impairs the whiteness and purity of the soap. It would be more rational to use this residuum in the fabrication of marbled soaps which are not required to have the purity of color of the white soap.

The formulæ for the marbled soap may apply to this soap, though there should always be a large percentage of olive oil.

White Castile (*Marseilles*) *Soap*, when made in countries where olive oil is not abundant and is high priced, is now usually made with but a small percentage of that expensive oil. Thus in England, Germany, and the United States are used bleached palm oil, palm-kernel oil, ground-nut oil, poppy oil, cotton-seed and hemp-seed oil, tallow oil or olein, tallow in combinations. Having a due regard to their purity and whiteness we give some suggestions of proportions:—

Olive oil	40 parts.	Olive oil	30 parts.
Ground-nut oil	30 "	Lard	30 "
Tallow	30 "	Palm-kernel oil	40 "
Olive oil	30 parts.	Palm oil (bleached)	50 parts.
Cotton-seed oil	30 "	Sesame oil	20 "
Tallow oil	40 "	Tallow	30 "

TALLOW SOAP. (CURD SOAP.)

The fabrication of this soap is in general the same as that of the olive oil soaps. When tallow is used it is freed from all admixtures and impurities by melting and depositing. Thus prepared, the soap may very well be finished in one boiling. When impure tallow of a brown color is used, it becomes necessary to finish the soap upon two or more waters. In this case also a lye of 2° B. at the most 6 per cent. soda is used which should be caustic and free from culinary salt. Since the tallow consists chiefly of stearin and olein with but little palmitin glyceryl oxide, the amount of materials necessary for saponification is calculated according to the heretofore mentioned equivalents of tallow, to wit, 887.0. According to this there are 100 kilog. (220 lbs.) tallow corresponding to 10.5 kilog. (23.1 lbs.) of soda (anhydrous), so that for a boiling of 2000 kilog. (4400 lbs.) 210 kilog. (462 lbs.) of soda are required. which in four portions of lye are separately brought into use. Since the first portion, or the fourth part = 52.5 kilog. (115.5 lbs.) is to be taken not above 6 per cent. lye, and whereas in 20 litres (5.29 gallons) of such a lye 1.31 kilog. (2.88 lbs.) soda are contained, there would have to be taken thereof $\frac{52.5 \times 20}{1.31} = 800$ litres (211 gallons).

The lye is placed in the kettle, heated to boiling, and then the tallow is added. The melting fat mixes immediately with the lye to a milky fluid wherein fat and lye can no longer be plainly discovered, although a real chemical combination does not yet ensue. The entire mass soon begins to boil, and at first it froths very much, but gradually begins to clear, becomes more translucent and also thicker. But if an open fire be used, the heat must be diminished, to avoid burning. The entire mass becomes turned into a translucent lustrous liquid, the soap paste runs from the spatula in fine threads, the lye and fat of which upon the paddle no longer appear separate.

Sometimes it takes very long before the fat and lye unite into a paste. Usually the reason for this is found :—

1. In a too concentrated lye. The mass boils at starts, very violently, since the lye, because it cannot mix with the fat on account of its concentration, settles upon the bottom,

becomes strongly heated and breaks with violence, the fatty mass floating above. This fault is remedied by weakening the lye with water, and constantly stirring the mass. The production of some soap causes a corresponding weakening of the lye as a consequence, and the process again proceeds in a regular way. 2. In a not sufficiently caustic lye. This is discerned when by testing the lye with acid it foams up very strongly. A gradual addition of caustic lye remedies this defect. 3. In too much lye. Here we may help ourselves by the addition of fat, or, still better, by an addition of scrap-soap.

After the first quarter of the soda has united with the fat or becomes pasted, the second quarter is added, for which a strong lye 15° to 18° B. will best serve. 20 litres (5.29 gallons) of such a lye contain about 2 kilog. (4.40 lbs.) soda, so we must therefore to reach 52.5 kilog. (115.5 lbs.) lye take of this lye 26.25 × 20, that is 525 litres (139 gallons) lye.

All further operations are entirely the same as in the case of Marseilles soap.

The soap must be run hot into the frames, and for the first two days be well covered with cloths. On the second day it is cut on the edges and pressed or stamped down, to avoid its becoming hollow in the centre by shrinking.

The touch or alkali of the sub-lye is removed by boiling it in a sufficient quantity of oleic acid, which also absorbs the carbonate of soda. Instead of oleic acid another fat can be applied, but the fat in this case must be previously made pasty. This is done by means of a small portion of weak caustic lye. The cutting of the pan is now performed with the still caustic sub-lye and adding ad libitum so much fat and salt to it until all trace of a touch in the lye has vanished. The last boiling is kept and applied to the next boiling of soap.

Many manufacturers use rosin for the removal of the touch, that is, for regaining the soda contained in the sub-lye, which is entirely rational, because the rosin combines as well with the carbonate as with the caustic soda. The rosin soap is to be, as usual, separated from the salt (cutting up of the pan) and afterwards added to another soap boiled in fat. It is self-evident that every other soap may be thus treated whose sub-lye still shows traces of a touch or presence of alkali.

Palm Soap.

In saponifying palm oil it is customary to mix it with other fats and oils, either in its natural state, or deprived of its strong yellow color which will remain unchanged in the soap and will stain linen and other fabrics. The process of decolorizing the oils has been fully described elsewhere. In England many of the soaps for domestic uses are made of this oil, though usually in combination with tallow, cocoanut oil, and rosin, while in other countries where the oil is not so abundant it is principally used for toilet soaps, but rarely by itself.

A *pure palm-oil soap* we will take for example: To 1000 kilog. (2200 lbs.) pure palm oil 110 kilog. (242 lbs.) soda are needed; this first, stronger lye must therefore contain 55 kilog. (121 lbs.) soda; lye of 18° B. is used, and, whereas such a lye contains in the litre 0.161 kilog. (0.35 lb.), we must for 55 kilog. (121 lbs.) soda take 342 litres (90.3 gallons) of lye. As soon as the fat combines with this lye, there should be added gradually 360 litres (95 gallons) of a 20° B. lye having a tolerably strong touch. Since the palm oil often contains a considerable quantity of free palmitic acid, a certain quantity of carbonate of soda may be applied at once, and when this becomes saturated with the palmitin, then the rest is to be saponified with pure caustic lye. This is, however, not the same as if a carbonated soda lye were to be used. In this case, the intention would not be fulfilled, since the free palmitic acid absorbs at first the soda, while the carbonate of soda remains uncombined. The soap having finished boiling is separated by culinary salt, boiled until all froth disappears, gently ground or fitted, and the soap is run hot into the frames, where it is well covered and left to stand. In this case too, the rims of the soap in the frames are cut on the second day, and the soap pushed together.

Palm-oil soap is always hard and brittle, and to divest it of this peculiarity, which is by no means desirable, 5 per cent. of the soda is substituted by potash, which makes it more plastic.

We submit a few of the combinations in vogue for palm soap.

Palm oil	50 parts.
Tallow	30 "
Resin	20 "

Palm oil	35 parts.
Cotton-seed oil	35 "
Pure tallow	30 "

Palm oil	40 parts.
Tallow	30 "
Cocoa-nut oil	30 "

Palm oil	60 parts.
Tallow	20 "
Cocoa-nut oil	20 "

Rosin Soap. (Yellow Soap.)

Rosin in soap may be styled an ameliorator, for, though in itself it will not form with alkali a useful soap, yet combined with fats, or when saponified added to other soaps made with the fatty bodies, it counts as so much grease, and contributes the popular qualities of being readily soluble and forming a copious lather when used for laundry and other domestic purposes.

The methods for forming this soap are various: Either the rosin is saponified separately, or it is melted with the grease and boiled with the lyes. The latter is the usual mode in England, where is also added to the better qualities of rosin soaps a portion of palm oil, which tends to improve both their odor and color.

Rosins in the United States are usually prepared for the soap boiler at the place of their production, and are of different qualities depending upon their color; of course the lighter and clearer in color the rosin is the better will be the quality and appearance of the soap. Yet it may be that the rosin at hand is dark and contains many impurities. If so, it is necessary to submit it to a purification, which is usually done by boiling it with a solution of common salt, when the impurities and much of its color are precipitated with the salt water. This is often repeated a second or a third time to insure a bright color.

Cocoa-nut oil is often added to rosin soaps, and is said to simplify the process and take less boiling; this oil moreover making the soap more solid.

The usual formula is:—

Palm oil	20 parts.
Cocoa-nut oil	20 "
Tallow "	30 "
Rosin "	30 "

The usual method used in England is, to charge the pan with 2000 pounds of tallow or soap grease, about 600 pounds of rosin, and 150 to 175 gallons of soda lye marking 10° to 20° B.; and, when the whole is melted and thoroughly combined, heat up the mixture to ebullition, being careful to stir all the while to prevent the adherence of the rosin to the bottom and sides of the pan. If the mass seems disposed to intumesce or swell, the fire must be lessened. This boiling should continue but two or three hours, because of the facility with which the union of the fat and alkali is effected. After six hours' repose, the exhausted lye is drawn off, and fresh is substituted, and the whole is again boiled for three hours more. Another repose of six hours is allowed, and the spent lye is again drawn off and renewed by fresh additions; the boilings are thus continued until the soap shall have acquired consistency—a fact determined by taking a sample, and when cool, squeezing it between the thumb and finger. If hard, thin scales are formed, it is finished, or nearly so; if greasy, clammy, and soft, it is, on the contrary, not perfect, and must have more lye, and another boiling. In the first case, give a brisk boiling to the paste, and then put out the fire. Cool the soap by adding three buckets of weak lye, and two hours after, draw off the sub-lye. Next throw in six or eight buckets of water and boil briskly, stirring the mixture until the soap is melted; then, with a wooden spatula, take a little of the boiling paste, hold it up and observe whether it runs from the lye clear; if it does, add water to the pan, and continue the boiling. If it does not run from the lye, too much water has been added already, and there must then be poured in half a bucketful of strong solution of common salt.

The most delicate part of the operation is that of finishing or fitting, and should, therefore, command the particular attention of the workman. If the fitting is perfect, the soap will, when the spatula is held obliquely, not run off, but shake and disperse tremulously like jelly. It is then that the fire may be withdrawn, and the soap be regarded as finished.

If it is desired to give a better color to this soap, about 20 pounds of palm oil may be added before finishing; and after two days it must be run into the frames, whence, after a week or less, it should be taken and cut into bars.

When cocoa-nut oil is added, it is best to saponify separately with a strong lye, and add at the finish.

By a still more simple process, the English now prepare this soap as rapidly as economically.

Take—

White tallow	800 pounds.
Palm oil	200 "
Powdered rosin	400 "
Caustic lye of soda ash at 25°	175 gallons.

The whole is introduced into a large Papin's digester, and the mixture submitted for one hour to ebullition under pressure, at a temperature of 122.2° C. (252° F.). After this time the soap is finished and run into the frames.

This seems to be all that is necessary to say about these useful soaps. Of course if a soap is wanted by the old methods, we can but refer to the tallow soap, adding the rosin soap which has been made separately.

RESINOUS GRAIN SOAP AND TURPENTINE SOAP.

The first is a dark brown soap, which with 100 parts fat are combined 80 to 90 parts brown rosin. Turpentine soap possesses a light-yellow color, and is obtained by saponifying 100 parts of fat with 25 to 30 parts light rosin. For the fat sometimes tallow or palm oil alone is used, or in connection with olein, *i. e.*, oleic acid. In the latter case an addition of about 5 per cent. cocoa oil is made; the soap thereby attaining the property of frothing very well. The rosin-grain soap is always produced with very caustic lye, which is best prepared by dissolving caustic soda in water. The rosin must be well pulverized, before it is placed in the kettle, and immediately well stirred, as the matter easily ascends and runs together into lumps, which can only be re-separated with difficulty. A preliminary boiling in this case is not necessary, though the lyes should be added in portions, the boiling being well sustained, care being taken to add weak lyes or water to make up for evaporation. When the soap has assumed the true gelatinous appearance, it can be separated from its superfluous water with salt, and afterwards fitted or ground to bring it to the proper consistency. This is often done with a solution of carbonate of soda.

OLEIN SOAP, OLEIC ACID SOAP, ELAIDIN SOAP.

Under these various names is the soap made from oleic acid (commonly known as "red oil") called. This acid, being a by-product in the making of stearic acid, stearin, and glycerine by means of lime, sulphuric acid, etc., though it is limpid at ordinary temperatures, contains some stearin and palmitin, but no glycerine, and as it is generally low in cost, it makes an economical and useful soap, either by itself or in combination with other greases, as tallows, cotton-seed oil, rosin, etc.

There are numerous modes of saponifying this valuable sebacic acid, and it is difficult to say which produces the best soap, yet we must confess to a preference for that made by the regular process of boiling as certainly the most reliable. We will, however, give what we consider the best processes for some of the others.

Owing to the presence of some free sulphuric acid and other impurities, the oleic acid requires generally more alkali for its saponification, though it need not be entirely free from other salts or carbonic acid. Thus owing to its easy saponification it is sometimes made in an extemporaneous way by simply adding the crystalline carbonate of soda to the olein, putting into an air-tight vessel having a stirrer, and under the pressure and agitation causing a rapid admixture, the water of crystallization being in sufficient quantity to form the soap. This process requires a close calculation of the several quantities and some experience to produce a good and uniform product.

Being a cheap material and comparatively pure, it can be economically combined with other greases, such as kitchen and bone fats and other refuse greases. It also makes one of the most useful soft soaps for manufactures.

For making a *pure olein soap* in a large way we will take say 6750 lbs. of oleic acid. The saponification is effected in a kettle of a capacity of 1870 to 2000 gallons, into which the oleic acid is introduced and melted with the help of a gentle heat. The acid being completely liquefied, pour into the kettle 125 gallons of new lye at 25°, and 250 gallons of lye of coction perfectly limpid at 25° to 30° B. It often happens that by the reaction of the lyes on the oleic acid, the mixture considerably thickens and forms a compact mass. This effect is due to the spontaneous formation of stearate and margarate of soda, but as the heat increases, the mixture becomes clear, the grains gradually disappear and the mass becomes fluid.

Continue to keep up a gentle heat, and when the ebullition begins a considerable quantity of foam is developed on the surface of the soap. This effervescence is moderated either by slacking the heat, or by stirring all the time, or by pouring a few pails of cold water into the kettle. This rapid reaction is due to the action of the carbonate of soda, which, in contact with the oleic acid, abandons its carbonic acid. But this effect would not take place if the lyes used were entirely caustic. When this first effervescence has ceased, increase the heat, and continue to boil quickly; care being taken to stir all the time. By continuing the ebullition, the lye becomes more and more concentrated by the evaporation. The nature of the paste is modified, and by a progressive saturation with alkali, it acquires consistency.

However, when the pasting is finished, the paste has not the consistency of the ordinary soaps, which difference is explained by the nature of the oil on which we operate—this oleic acid being almost entirely formed of the oily and liquid part of the tallows, that is, of the part the least apt to form hard soaps. It is only after the paste is completely saturated with alkali that it forms a very consistent soap. This remark may be applied, at least generally, to every fatty or oily substance in which olein predominates.

The time for the first operation, on 6700 lbs. of material, varies from ten to fifteen hours. It is ascertained that the pasting is terminated, when the grains of soap formed at the beginning of the operation are entirely dissolved; then the heat is stopped off, and after resting ten or twelve hours the lye is drawn off.

Observations.—The pasting being finished, it is important to let the mass rest for ten or twelve hours, to permit the lye not combined with the soap to separate as completely as possible. If much of it is left in the paste, it will be troublesome in the coction, for two reasons: first, on account of the great quantity of neutral salts it contains, and which would render the soap less hard; then because it would weaken the degree of the new lyes of the first service, in such a manner that the action of these lyes on the olein would be less efficacious than if the operation had been conducted with a paste less saturated with neutral salts.

Whilst colored, this sub-lye is generally limpid; but as it marks from 18° to 22° B., it has to be reduced to 8° or 10° by the addition of water. It is then left to settle for a few days, and passed through an old residuum of exhausted soda ash and lime. For 6700 pounds of oleic acid, the quantity of lyes drawn off after ten or twelve hours' rest, amounts to 175 to 200 gallons, and, though marking from 18° to 20° B., containing very little useful alkali but many other salts.

The coction is effected with new caustic and concentrated lyes of soda ash. Two services are generally sufficient to bring the soap to the point of complete saturation.

First Service of Lye.—All the lye of the first operation being drawn off, pour into the kettle from 225 to 250 gallons of fresh lye at 27° or 28° B. Heat and keep the mixture to boiling. At the beginning the ebullition must be gentle; too active boiling would dilate the mass considerably, or cause the soap to stick to the bottom of the kettle.

Thus, for the first hours the kettle must boil gently. It is true the soap is separated from the lye but slightly; its grain is not completely formed, and it is yet soft, flaccid, and dilated; but it is proper to have it so, for in this half-viscous state, the action of the lye on the oleic acid is more direct and more rapid than if the grain of the soap were prematurely formed.

During all this first stage of the operation it is very important, we repeat, to boil gently and uniformly. A more complete and equal saturation of the oleic acid by the lye is obtained. The formation of too much foam is also to be avoided. Later—that is, after five or six hours of ebullition—the heat is progressively increased; by evaporation the lye concentrates, and the grain of the soap becomes larger and firmer. While the lyes do not separate as completely as in the first service, it is easy to see that the soap is not so viscous, and is less greasy than at the beginning of the operation. To render the separation more complete, and to compensate for the loss due to the evaporation, add every hour, for the first six hours, from ten to twelve gallons of new lye at 27° or 28° B.; add also, towards the end of the first service, fifteen gallons of salted water at 25° B. This addition of salted water contracts the soap, and facilitates its separation from the excess of lye with which it is mixed.

Lastly, after twelve or fifteen hours of continual ebullition turn off the heat, cover the kettle, and let it rest eight or ten hours. This time is necessary to have a complete separation. Draw off the lye, which is strongly colored brown, and marks while warm from 22° to 25° B.; frequently, on cooling, the lye solidifies into a gelatinous mass. Alone, or mixed with new lye, it is used in the pasting of oleic acid.

Second Service of Lye.—This service, which is generally the last, consists of new lye at 28° or 30° B.

The lye of the first service being drawn off, pour into the kettle about 175 gallons of new lye at 28° or 30° B. Heat; very soon the mass begins to boil; at first moderate the heat; but when, by an ebullition of five or six hours, the paste has acquired more consistency, the heat is increased; then add every hour, for six hours, about twelve gallons of lye of coction at 28° to 30° B. These successive additions of strong lyes have for their object the complete saturation of the soap, and to replace the evaporated water.

Towards the end of the operation—that is, after an ebullition of twelve to fifteen hours, add, as in the first service, from twelve to fifteen gallons of salt water, at 25° B. By this addition, the paste becomes denser and harder; its great consistency presents obstacles to the ebullition, which then becomes tumultuous. The foam which covered the soap has entirely disappeared; the soap is then in hard and dry grains, of a brownish color. However, the end of the operation is indicated by the following signs:—

1. When a little of the warm soap is put into the hand and quickly rubbed with the thumb, it instantaneously forms thin and hard scales, which fall from the hand without leaving on it any adhering particles.

2. When the foam which covered the surface of the soap has disappeared.

3. When, after fifteen hours of continual ebullition, the lye is yet caustic. To obtain the soap well grained, it is necessary that the lye extracted from the kettle, at the end of the operation, should mark 28° to 30° B.

When these indications are well defined, the soap is completely saturated with lye. Turn off the heat, cover the kettle, and, after resting ten hours, draw off the lye.

Fitting.—For this operation, the lye of the pasting (empatage) or a new lye can be used. The first slightly colors the soap, but deprives it more completely of the excess of caustic alkali it contains; the second does not color it, but sometimes causes an efflorescence of carbonate of soda; it is then better to use the first. As it generally marks from 18°

to 20° B., it is reduced to 8° or 12° B., by diluting with water.

The operation is conducted as follows:—

Two men stir the paste continually, while a third pours in the lye at 8° to 12° B. Heat strongly, so as to keep the mixture very warm, for it is by the combined action of heat, stirring, and the successive additions of weak lyes that the grain of the soap is broken and refined, by depriving it of the excess of caustic alkali and saline substances it contains.

It is only when the paste is sufficiently impregnated with weak lye, and has acquired a temperature near the boiling point, that it becomes homogeneous and fluid; the soap has then the form of soft, dilated, and flat grains. Generally from 250 to 300 gallons of lye at 8° or 12° B., are used in the operation. When the soap is entirely melted and floats in the lye, boil the mixture gently for a few hours; and to prevent the soap from again becoming granular by the concentration of the lyes, add from time to time a few pailfuls of water or of lye at 2° or 3° B.

In consequence of the movement caused by the ebullition, an abundant foam appears on the surface of the soap; this foam consists of the most impure parts of the paste, and is strongly salted. It is known that the operation is finished, when the paste which is under the foam is smooth, fluid, and homogeneous; the density of the lye at the bottom of the kettle is also a sign to indicate when the paste has been boiled long enough. When cold this lye marks from 17° to 18° B., at the end of the operation. If below 15°, the soap would be less consistent and less firm; above 19° or 20°, it would be too hard. Thus, the proper degree of density of the lye ought to be, when cold, from 17° to 18° B.

This result being obtained, the heat is stopped off, and the kettle well covered, so as to retain the heat in the mass as long as possible—an essential condition for a complete separation of the saline matters and the lye. Indeed, if the cooling should be too rapid, not only will the soap not be deprived of its heterogeneous and saline parts, but it will contain a considerable portion of lye, which then renders the soap less neutral and less pure.

After resting forty to fifty hours, the kettle is uncovered, and the scum on the surface of the soap carefully removed. This scum is utilized in a new operation.

The soap which is fluid, syrupy, and well melted, is dipped or pumped into the frames. If an iron-wire sieve is placed above each frame, and the soap passed through it, the foreign substances contained in the paste will be separated. The bottom of the kettle being reached, care must be taken not to dip up any of the lye with the soap; the latter is always easy to recognize by its golden color, while the lye has a brown, blackish shade. As soon as the lye appears, manage the ladles in such a manner as only to remove nothing but the surface matters; but whatever be the care taken there is always a small quantity of the lye mixed with the soap. To prevent the inconveniences which would result from the mixing of the lye with the refined soap, it is better to pour the last portions of soap into a cylindrical vessel, provided with a cork at the bottom. By resting, the lye precipitates, and the soap specifically lighter floats on the surface. Then draw off the lye, and pour the soap into the frames.

Paris manufacturers slightly perfume this soap, to mask the generic odor of the oleic acid; they generally add two ounces of artificial oil of bitter almonds (oil of myrbane) for 100 pounds of soap.

Stirring the Soap in the Frames.—It would not have been enough to bring the soap to the proper point of coction and purification, if it could not be had perfectly homogeneous. It is true the soap would have the essential qualities which constitute a good oleic-acid soap. It would foam and be detersive, but by the slow and gradual cooling it experiences in the frames, irregular marblings would be formed. It might even be often spotted by the lye, which would give it a very defective appearance.

To obtain the soap in a smooth and homogeneous paste, it must be submitted to the stirring operation, which consists in agitating the soap in the frames. The stirring must be continued until the soap becomes nearly pasty, which is easily ascertained by the difficulty of moving the stirrer. The new crutching machine illustrated elsewhere is well adapted for this purpose.

The equality and perfect homogeneity of the paste, depend essentially on the stirring in the frames; the more complete the stirring, the finer will be the soap. This operation is performed on almost all soaps, except the marbled soap, the marbling of which would be destroyed by stirring. The time of the stirring varies according to the nature of the pastes, their more or less complete liquefaction, and their temperature at the time they are introduced into the frames. But, as a general rule, soaps composed of fatty matters in which stearin exists in small proportions, and the liquefaction of which has been pushed too far, require a longer stirring than those made of fatty matters very rich in stearin. The stirring of olive soaps run into frames of about 2000 pounds, lasts from eight to twelve hours, according to the season; the stirring may be discontinued when the temperature of the mass is reduced to 43.3° or 48.9° C. (110° or 120° F.). After eight or ten days the frames are opened, and the soap divided into cakes.

Thus prepared, this soap is brownish-yellow, but by being exposed to the air, it becomes white. At first its consistency is somewhat soft, but it becomes hard in a short time. When well prepared it is very detersive. In water it produces a very abundant lather, and is one of the best soaps.

By the saponification of 6750 pounds of oleic acid of good quality, the amount of soap obtained is 10,687 pounds, or 155 per cent. The viscous lye from which the liquid soap has been drawn off, being mixed with 10 per cent. of salt water at 25° B. and boiled for seven or eight hours, produces from four to five per cent. of its weight of a good soap, which only requires to be dissolved in a weak lye to get rid of the excess of saline substances it contains. This soap being mixed with the other increases the amount obtained from 155 to 158 or 160 per cent.

When the soap is to be moulded it is divided into cakes, usually weighing one pound, and dried in the open air in summer, and in a drying-room in winter.

We give rather full directions for this soap, as it is a very important article of commerce, utilizing a material that otherwise would find few uses, and we shall have occasion to refer to it again in describing the Swiss soaps and soft soaps.

Of soaps made by boiling we have given those chiefly known to commerce, with hints that any skilful operator can apply with the materials on hand and make any modification of the kinds given, calling them by whatever names he may choose. There are several boiled soaps known in Europe as *wax soap* or *bleaching soap* made from tallow and cocoa-nut oil, containing a larger percentage of water. *Almond-grain soap*, is a modification of the mottled soap of tallow, wherein the coloring is applied in a different manner, causing white lumps to appear, called almonds. The soaps made in this country as imitations of Marseilles soap or Castile soap are now made with a good deal of cotton-seed oil in combination with tallow, etc., and as they possess much interest we will here give the formulas for Castile soap, either white or mottled, made from cotton-seed oil as a base.

CASTILE SOAP FROM COTTON-SEED OIL.

In our Southern States, where cotton is grown in the greatest quantity and of the best quality in the world, the seed has long been known to have an abundance of oil, the extraction of which was very difficult on account of the adhering fibre. From this cause the seed was allowed to rot, and was used for manure. When, however, machinery was invented for hulling the seed, the oil could be extracted with facility. The large amount of hull and adhering fibre these seeds possess will be understood when it is known that it sometimes takes five bushels of seed to make one bushel ready for the mill. The hull and fibre are used for paper stock, and are, of course, very valuable.

When it was found possible to remove the hull and make the oil, another difficulty arose in the large amount of objectionable color the crude oil contained, and which was due to dark resinous spots contained in the seed; the color, however, has been overcome, for it is now refined by means of chemicals, caustic lye, etc., and bleached with sulphuric acid, and pressed to remove the large amount of stearine it contains, and which, with the oils, is used for a great many purposes, this latter being sometimes sold and bottled as salad oil from its sweet nutty taste when fresh and pure.

Cotton-seed oil, when well refined, is a bland, bright yellowish oil, very similar to almond oil, though it has some of the properties of a drying oil, but taking a very long time to dry. This drying property does not seem to deter the maker of cheap perfumery from bottling large quantities for common hair oil, or from buying it for that purpose under the name of olive oil, often not knowing from what source it is obtained.

To the soap-maker it possesses very valuable properties, for nothing has yet been discovered that is so good and economical a substitute for olive oil; and when a portion of lard and bleached palm oil is mixed with it, for making Marseilles or Castile soap, it is difficult to distinguish the imitation from the genuine soap. The importance of this oil in the manufacture of soap is, to us, so great that we deem it necessary to devote some space to its description, to give soap manufacturers some hints for its manufacture into a soap that may be called Castile soap, from its close resemblance to it.

In saponifying cotton-seed oil, there is no peculiar difficulty more than in making a good Castile soap from olive oil, though the soap is made somewhat sooner if the stearine is left in it, which stearine is generally pressed out to permit the oleine to remain fluid in the coldest weather.

To make a white Castile soap, take:—

Cotton-seed oil	80 pounds.
Lard, good quality	10 "
Olive oil	10 "

And prepare the lye by close calculation in this manner: 50 pounds to mark 15° B., 50 pounds at 21° B., and 50 pounds at 27°, making 150 pounds for this quantity of grease—the lye to be made of the English caustic soda, and rendered clear and caustic with about one-fourth of lime.

To the melted grease in the kettle pour the first 50 pounds of lye at 15°, keeping it stirred as the heat is raised to boiling, and as it froths beating it down quickly to prevent its overflowing; boil for three or four hours, when add by degrees the 50 pounds of lye at 21°, and boil for five or six hours longer, keeping up the stirring, and, when it becomes a perfectly smooth mass, turn off the heat and let it rest for the lye to separate. After some hours' rest the spent lye is drawn off, the heat is raised, and the last 50 pounds of lye at 27° are poured in, and allowed to boil briskly for four or five hours, when the soap ought to grain and appear flakey when pressed between the fingers; when again turn off the heat and allow the lye to separate, and draw off after some hours' rest.

In finishing or fitting a lye of carbonate of potash of 6° or 8°, say 25 pounds are stirred in with a gentle heat until the soap presents a perfectly homogeneous syrupy mass, when it may be left to divide—the scum to the top and the gray soap to the bottom, with the fine soap between, which is dipped into the frames, and the scum and dark soap kept to make the mottled soap.

The result should be about 150 pounds of the best soap having a fine white appearance, and 30 to 40 pounds of inferior soaps that can be mixed with the mottled Castile soap. To make a

Mottled Castile Soap from Cotton-seed Oil.

Cotton-seed oil	80 pounds.
Lard, good	10 "
Palm oil, bleached	10 "

The bleached palm oil improves the odor, causing a greater resemblance to Marseilles soap, and is cheaper than the olive oil. Sulphuretted soda lyes are preferred by the French soap-makers for their mottled soap; but, as we are using the English soft lye or artificial lyes, we will have to adopt a modified process. The sulphuretted crude soda forms the colored mottling, the sulphur combines with the iron of the kettle and other impurities, and forms the oxide giving the blue color, which turns red on all those parts exposed to the air.

To make this soap, proceed very much as for the white soap. To the melted grease pour on the 50 pounds of the weaker lye at 15°, gently raising the heat while they are mixing, which should be done by gently stirring, and keeping down the froth by beating, and regulating the heat to prevent too rapid boiling. After three or four hours, pour in the 50 pounds of lye at 21°, and continue the stirring, and as the froth subsides bring to a more rapid ebullition, and when it granulates shut off the heat and let it rest for four or five hours. Now draw off the sub-lye and proceed to the coction, by putting into the melted soap the third 50 pounds of lye at 27°, which is added while constantly beating and stirring. Stir in also 5 pounds of common salt, and continue the boiling for six or eight hours, as may be required, or until the grains separate, as can be seen by taking out a portion with a knife or pressing between the fingers, when a little experience will show a flakey scale free from the lye; let the heat be stopped and the soap allowed to settle until next day, when after drawing off the salted lye it can be finished. The soap is finished with weak sal-soda lye, or, if the soap is neutral, with water having a little salt in solution, for if it needs water the grains will appear hard and dry, when the soap will have to be boiled until it forms a smooth mass. The soap is again allowed to rest, and the next day again thoroughly stirred and put in the frame, when it is ready for the mottling. This is done by putting into a small watering-pot with a rose-spout about 4 ounces of sulphate of iron, dissolved in a pint of warm water, and pouring it from the rose on to the top of the soap in the frame, while the crutch is plunged up and down to give the streaky marbled appearance. Of course this requires some practice, as it should present a uniformity throughout the entire mass, but is not difficult to accomplish with a little experience.

If this soap is carefully made, it will be as good as most of the mottled Castile soaps we import, and should be made so economically as to yield a good profit while being sold at a less price than the imported article.

We have devoted some space to the description of the manufacture of these soaps from cotton-seed oil, believing that the cheapness and other advantages of the raw material will induce soap-makers to give it the consideration it seems to deserve for making a good and cheap soap, and that they may see a source of profit in its manufacture.

SECTION XII.

THE FABRICATION OF SOAPS (CONTINUED).

EXTEMPORE AND OTHER SOAPS.

EXTEMPORE soaps, as we term them, are called in France *little pan-soaps*, because they can be made in the smallest quantity. They differ from the boiled soaps in containing all the glycerine that may be in the neutral fat, which, as we have shown, is precipitated with the sub-lye in the process of separation with culinary salt, or by other means. Thus, soaps are made in several ways, but, by whatever mode it is necessary clearly to calculate the requisite quantity of alkali, for the saponification of a given quantity of fats, or the equivalents. When this is done, and the proper skill is used, the result is generally satisfactory, although such soaps are never so neutral as those made by boiling.

On the score of economy there are divers opinions, while much time is saved, and the necessary plant is not near so costly, there is some additional expense in the preparation of the lye, yet on the whole, we would say that they cost less to make, than the soaps made by boiling, particularly at the present time, when the alkalies are obtained with so much facility. These soaps are now made largely in nearly all commercial countries.

Under this head may be classed all these soaps called *half-boiled soaps*, which we consider better entitled to the name we propose, *Extempore soaps*, as they are made with rapidity and retain their glycerine. Thus, when cocoa-nut oil enters into their composition, it is customary to saponify it separately in strong lye, and add it to the previously boiled tallow, or tallow and palm oil, or rosin, which have been boiled in a lye of 15° to 21° B. They are also marbled in the frame by adding ultramarine for blue, vermilion for red, bole Armenia for brown, bone black for gray. This, when skilfully done, gives an attractive appearance, particularly when the soap is of a clear white color.

For all cold soaps, attention must be given to have the alkalies as pure and as caustic as possible, otherwise, a complete admixture of the material is almost impossible. As a rule, lyes of 38° B. are taken. Such a lye of soda contains 0.3445 kilog. (.758 lb.) of soda to each litre (2.1 pints); so for 100 kilog. (220 lbs.) of cocoa-nut oil we require 36.8 litres (9.7 gals.), and we obtain *about* 150 kilog. (330 lbs.) soap having but 25 per cent. of water. This is simply an example. A larger percentage of water may be taken, though of course the lye will be weaker, but when cocoa-nut oil is present, it is best to use strong lyes.

As mechanical aid in making cold soaps facilitates the process, there are made several styles of kettles and apparatus for the purpose. We illustrate two: one being like the ordinary soap kettle with a mechanical stirrer; the other a cylinder placed horizontally, having a shaft through the centre to which are attached a number of arms like a churn; this mode of usage needs no further description. (Figs. 57, 58.)

Fig. 57.

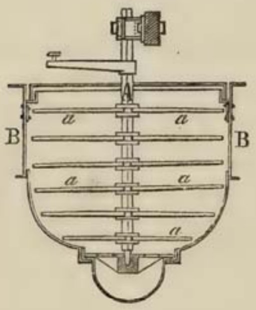
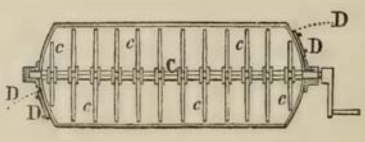


Fig. 58.



TALLOW SOAP BY THE COLD PROCESS.

Take, say, 1000 kilog. (2200 lbs.) of tallow, purified and cleared by rendering in a kettle, of twice its capacity, heated to a melting at about 37° C. to 43° C. (98.6° to 109.4° F.), and the 30° B. lye, being heated to attain the same temperature, is run from a vessel provided with a stopcock into the kettle. After having added all the lye, the entire mass is stirred gently, until it has thickened so that one part of it, spread out to a ribbon, no longer runs together with the other. The thin pasty mass is now run into the previously warmed frames, in which after a little while a tolerably strong heat takes place, which denotes the act of union between the alkali and the sebacic acid. As long as the soap is still soft, it shows a strong alkaline touch; but after the combination has taken place, this vanishes almost entirely, provided the proportions between the alkali and the fat have previously been correctly taken.

The soap thus produced is of brilliant whiteness, very hard and brittle, but will be more pliant, if about 10 per cent. of the alkali used is potash. This soap lathers very well, and is on occount of its hardness very economical for use; a little addition of cocoa-nut oil makes it lather still more freely.

COCOA-NUT OIL SOAP BY THE COLD PROCESS.

The operation is performed exactly in the same way, as has been stated in the case of tallow soap, in which case it is generally perfumed and artificially marbled. The latter is done in this manner. The soap is put into the moulds in layers, upon every layer some vermilion or other coloring, mixed with a little lye, is spread, until the last layer, when it is stirred in certain directions with an iron rod. To give the soap a blue flame-like appearance, ultramarine is used in lieu of vermilion. The soap remains for twenty-four hours well covered in the frames, during which time the real combination of alkali with the sebacic acids with evolution of heat occurs.

Cocoa-nut oil possesses in a high degree the property of forming soaps which are capable of retaining large quantities of water, without thereby losing much of their hardness. Thus water, or salted water may be added in the frame, to the amount of 50 per cent.

For the fabrication of all so-called *Cold Soaps*, the application of lyes entirely free from carbonic acid is a necessary condition, if a good product is expected, while only the absolutely required quantity of alkali needed for saponification is used.

ROSIN SOAP BY THE COLD PROCESS.

The quantity of rosin, which is applied to a given quantity of fat, is from 15 to 50 per cent. The more rosin is added to a soap, the more it attains a soft and pasty nature, if the quantity of cocoa-nut oil or other fats is not correspondingly increased. The number of rosin soaps, that is the names by which they are designated, is according to the kinds of fat used, extraordinarily large, and almost every large soap manufactory has its own receipts, after which the favorite soap is made.

For the saponification of the rosin suitably concentrated lyes are applied, because they furnish a firmer soap. Caustic soda could be substituted by carbonate of soda, but, for reasons already stated, one cannot well recommend this practice.

Rosin and fat are either saponified separately and afterwards stirred together, or the fat is first saponified when the pulverized rosin with the necessary quantity of lye is added to the soap and boiled until all froth disappears. So also of a mixture of 100 kilog. (220 lbs.) rosin, 55 kilog. (121 lbs.) cocoa oil, and 55 kilog. palm oil, a rosin soap may be manufactured in the cold way. These substances are melted together, adding gradually while constantly stirring 100 kilog. (220 lbs.) or 72 litres (19.0 gallons) of a 25° B. soda lye, until it becomes stiff, when it is put in the frames. The frames are now covered up and left to rest until the next day.

TRANSPARENT ROSIN SOAP.

For the fabrication of this soap Dr. Deite gives the following directions: 80 kilog. (176 lbs.) cocoa-nut oil, and 20 kilog. (44 lbs.) palm oil are saponified with soda lye of 24° B., adjusting it to a very weak "touch," and boiled until the froth disappears. Then 15 kilog. (33 lbs.) of pulverized rosin are thrown into it; he then dissolves 133½ grammes (4.67 ozs.) sugar of lead in 100 kilog. (220 lbs.) salt water of 10° to 20° B. which by adding soda has been enhanced to 20° B., stirs this among the soap, and then ceases the boiling. It is then run into the frames and well covered, and the result is a semi-translucent hard soap.

Another receipt for making this soap is as follows:—

70 kilogrammes (154 lbs.) cocoa oil
30 kilogrammes (66 lbs.) palm oil
20 to 25 kilogrammes (44 to 55 lbs.) rosin,

are saponified over a slow fire with a slightly carbonated caustic soda lye of 36° B. which adjusts it for a strong touch. When this is done, the fire is extinguished, pouring 20 kilog. of a solution of potash of 20° B. over it, stirring it well under, then adding under constant stirring 70 kilog. (154 lbs.) soluble glass (40° B.), which has previously been diluted with 3 kilog. (6.6 lbs.) alcohol and 3 kilog. of a weak lye, keeping the soap covered for a period of half an hour, run it into the frames and cover.

BORAX SOAP,

Now much in vogue, is generally made by the cold process. The soap is made with a weak "touch," and there is a portion of the alkali left out and substituted by a solution of borax marking about 12° B., of which about 10 per cent. is used. White greases are used, and the soap has a brilliant whiteness which is very popular. Soluble glass is also added to this soap by some makers, though it is quite likely to show in a white powder as the soap dries.

Swiss, or Half-boiled Soaps.

Among the various names given to this class of soaps, we prefer this title as distinguishing them, believing them to have been first made in Switzerland, where they are known as gluten soaps, a very unmeaning term and one calculated to mislead. They are soaps that by their characteristics claim a preference with many people. For illustration we will take for a

Swiss Palm Soap

1000 kilogrammes (2200 lbs.) bleached palm oil,
500 kilogrammes (1100 lbs.) cocoa oil,
1380 kilogrammes (3036 lbs.) 25° caustic soda lye,

and place in the kettle, and dissolve with a moderate fire.

1000 kilog. palm oil require for their saponification 110 kilog. (242 lbs.) soda.

500 kilog. cocoa oil require for their saponification 62.5 kilog. (137.5 lbs.) of soda; total = 172.5 kilog. (379.5 lbs.) soda.

A 25° soda lye contains 13.90 per cent. soda. We need therefore of such $\frac{172.5 \times 110}{13.9} = 1365$ kilog. (3003 lbs.); according to direction 1380 kilog. (3036 lbs.) shall be taken in consideration of the fact that the areometric degrees may also show the degree of foreign salts, hence indicate the soda somewhat too high. The work can also be commenced with one-half of the lye, and the soap must not cease to boil. As a substitute for the evaporated water, there must be added, in order to make the saponification perfect and cause the combination to take place, the other half of the lye which is added at five or six different times. It must also be observed that the soap does not fail to boil continuously for four or five hours. The soap must have but a very weak touch. Should it be strong add oleic acid carefully until the soap ceases to irritate the tongue. That the soap is sufficiently boiled is ascertained by its boiling up in large bubbles and being of apparently pasty consistency, while the surrounding portion forms a honey-yellowish bright ring when a sample of it is cooled and hardened upon a glass plate, and when, as soon as a spatula is placed in the mass and quickly withdrawn, dry spots become visible upon it and now and then knots of soap adhere. If the soap has a fat surplus it boils very dull, and in this case so much caustic lye is added until it shows a weak touch upon the tongue. Before testing a complete cooling off of the sample must take place, since the hot soap easily causes a poignant touch similar to that which caustic lye produces, nor must the biting taste of the cocoanut oil or the cocoa soap deceive us. The soap should only be considered as finished when it ceases to produce any foam at all, and is of a honey-like yellow, and telescoping slabs or rosettes are produced. The soap now boils in the kettle so that it can be heard, since the steam which originates upon the bottom of the kettle must break its way through the more consistent and dense mass of the soap and the bursting steam bubbles cause the loud noise which is called the "talking" of the soap. When the soap approaches a finish and is inclined to burn, it must be constantly stirred. If the soap now, as is stated above, falls off the spatula, becomes dry rapidly, and if a sample taken between the thumb and index finger draws no threads, then it is finished, and can, after removal of the fire under the kettle, be run into the frames.

This of course is a soap boiled in one lye, and where there is no separation of any of the materials, which should be well selected and purified before beginning the process, and it is particularly applicable to making toilet soaps, which will be more fully explained under that head.

So, in like manner, with modifications applicable to the nature of the materials, the various soaps of commerce can be made, of which we give a few formulas for a guide.

SWISS WHITE WAX SOAP.

Tallow (white),	50 parts.
Cocoa-nut oil,	20 "
Cotton-seed oil,	30 "

SWISS YELLOW SOAP.

Tallow oil,	30 parts.
Cocoa-nut oil,	20 "
Palm oil,	25 "
Rosin (pale),	25 "

Swiss Rosin Soap.

Palm oil,	40 parts.
Cocoa-nut oil,	30 "
Rosin,	30 "

Swiss Olein Soap.

Oleine (red oil),	50 parts.
Tallow,	30 "
Ground-nut oil,	20 "

These are merely hints, and the manufacturer like any one else must "cut his coat according to his cloth."

A very fine and very hard *Swiss rosin soap* is obtained as follows:—

Tallow	100 kilog.	(220 lbs.)
Rosin	50 "	(110 ")
Caustic soda . . .	37½ "	(82.5 ")

The soap is boiled in two waters and the fat substance is in the first place saponified, with a 13° or 14° B. soda-lye, then the rosin is added, and the boiling continued until a soap mass becomes visible; when the heat is turned off, and on the following day the sub-lye is drawn out. In the second operation it is boiled with a 10° B. lye, but, if it should show a smeary or weak condition, it can be remedied with a lye of 12° B. The boiling is now continued until no defect is visible, and after a rest of three hours, the soap is run into the frames.

Another modification of this process is, when the sebacic acids or fats are saponified with the requisite quantity of caustic soda, of about 20° B., in a moderate heat of about 49° C. (120.2° F.), the ingredients being slowly combined with constant stirring, the heat gently raised to a boil, and sufficient water added at times to keep up the due proportion of loss by evaporation. The combination is thus effected, and when the paste becomes too thick to stir it is framed and allowed to cool slowly for at least two days. This process involves some experience, and cannot be recommended to those who are novices in soap making.

The main feature in the fabrication of these soaps is, to keep up the correct proportion between alkali and fat. It may occur, that a little too much or too little lye is applied; because, on a larger scale the materials cannot be weighed or measured with the accuracy of an analytical test. But if we have manipulated as accurately as possible, it will only be an equalizing of a small overplus of fat or lye, and we must not always be too ready with ammunition of large calibre, and add large quantities of lye and fat all at once. This it is that leads to confusion, out of which it is difficult to correctly find our way again, and by which the soap instead of improving is made worse. All manipulations which are undertaken with extempore soaps amount finally to this, to produce the most neutral soap, and to fix the proper proportion between fat and alkali; since an overplus, be it of the one or of the other, works equally injurious.

Hard Soap from Potash Lye.

Prior to the introduction of artificial sodas, the lye from wood ashes was extensively used for making household soaps, and for making hard soap it was the custom to boil in potash lye, and cut with culinary salt, either directly, or in solution. Where wood is burnt as fuel, and wood ashes abound and are cheap, or where potash can be procured economically, this process may possess interest and be of useful application, although at present in commercial centres this class of soaps is rarely made. Yet it is necessary, for the reasons stated, to give a description of the processes.

Tallow Curd (grained) Soap.

To transform 1000 lbs. of tallow into grained- or curd-soap, 400 lbs. of potash have to be taken. The tallow is placed in the kettle, about 400 lbs. of lye of 10° B. added, and the fire is kindled. Within a short time of the commencement of boiling, the fire is kept well up, but then it is moderated. After the seething up, examination should be made as to whether the fat has united with the lye. This is perceived by the yellow-brown mass, which under gradual upheaving continues quietly to boil. What adheres to the spatula, when inserted and withdrawn, has a gelatinous, grayish-white appearance, without separation of lye. When lye and fat are not united, it moves in the kettle noisily to and fro, without rising upwards, only now and then pushing up in single places, with a bouncing noise. The reasons why fat and alkali do not at first combine, are in general the same as are stated in the section on soft soaps, and the remedy is the same.

When the combination succeeds there are added, at short intervals, in four to five portions, about 1100 lbs. of lye of 16° to 17° B. The boiling now becomes dense and languid, and the mass appears a yellowish-brown, and runs off the spatula in cohesive, long, translucent strings. The soap boils to a paste. If some of the soap is dropped upon a glass, and the sample while yet hot does not appear perfectly clear, lye is yet wanting. A small portion of lye should hence be added, until the soap while hot appears perfectly clear. As soon as this moment arrives the cutting of the pan begins.

The salt has here a double purpose to fulfil. It must transform the potash soap into soda soap, and must separate it from glycerine, superfluous water, lye, and dross. The entire portion of salt necessary for this purpose is not added all at once, but a repeated "salting out" should be performed. After each "salting out" the under lye is separated from the soap, and the latter is again brought into contact with water and salt. Such an operation is termed by the soap-boiler *a water*, and he speaks of a first, second, and third water. By a boiling of tallow and potash, when the materials are not very impure, the "salting out" is performed usually in three operations, hence the soap is finished boiling in three waters. In order to separate the under lye from the soap, the latter is either scooped from the kettle into a vessel which stands close by the kettle, and afterwards the first is removed; or the soap remains quietly in the kettle and only the under lye is removed therefrom. This may be done in two different ways, either the kettle is provided below with a stopcock, or a pump with a movable barrel at its lower end is used. The salt is either thrown into the boiling soap "dry," or what is better, previously dissolved in boiling water, and used as a solution of 20° B. When the salt is used in the dry state, it must be constantly stirred up from the bottom to prevent its burning.

To the quantity of fat taken for our example, we apply in the beginning 80 to 100 lbs. of salt. Whether the applied salt is sufficient, is discerned by the previously brown color of the soap now turning into white, and in the kettle there appear all round ebullitions of the size of the hand (the soap boiling "in slabs"), the soap beginning to rise with force, and the froth vanishing. Until these signs appear salt must be added. Hereupon the boiling should continue for another hour and be then stopped, in order to cause any impurities yet in the mass to have time to settle. The fire being extinguished, the separation of soap and the sub-lye follows.

When the sub-lye is removed from the kettle, 700 to 800 lbs. of water with 70 to 80 lbs. of salt are again put into it, and it is heated to the boiling point. After boiling up it should be investigated whether the "cutting of the pan" has been sufficiently attended to, which is discerned by the signs described above. Leaving the soap to boil for some time, the sub-lye is again removed.

Although the second water has greatly increased the hardness of the soap, yet this hardness is not yet sufficient, so the third water must be prepared to cause the hardness to become perfect. To this end 700 to 800 lbs. of water, and 50 to 60 lbs. of salt are again heated to boiling, and again put into it. When it begins to seethe up it should be critically investigated to find if the proper quantities of salt and of lye have been applied. If salt is wanting then froth appears upon the surface of the boiling soap, and the latter burns easily. In this case salt should be yet added, until it boils up in regular slabs of soap. If too much salt has been taken, or more correctly speaking, the salt solution is too concentrated, the soap appears upon the spatula without connection, the lye drops rapidly off, and little gutters are formed. This fault is remedied by adding a few buckets of water. The soap must yet be investigated by pressure. Upon the thumb of the right hand some soap is taken and rubbed on the palm of the left hand. The soap hardens there almost instantly, and now the thumb is pressed hard upon it and rubbed. If the sample there remains a cohesive slab, then the soap possesses the required firmness, is solid; but if the sample crumbles, it needs water; if smeary, then lye is wanting. Then lye and salt of 15° B. must be added till the proper state of the soap is reached. Thereupon commences the operation of clear boiling or fitting. To attain this the kettle is covered one half with planks, and a stirrer beats down the mass, so that it does not run over. The soap particles draw more and more together into globular grains—the soap "grains." The soap grains sink, and on the surface the kettle is filled with a light, flaky froth. To prevent the falling of the mass great heat is now needed. The fire is diligently kept up, the entire kettle is covered with planks and cloths spread over it. The soap seethes up with ebullition, and, to avoid running over, one of the boards is lifted and the froth is beaten with a long rod until it falls. Then the kettle is again tightly covered, a renewed ebullition ensues, and the overflowing is again prevented in the manner described. Gradually the violence of the ebullition diminishes, but in place of it a whistling sound is perceived in the kettle. From time to time one of the boards is lifted and the soap is watched. As soon as merely large perfectly translucent bubbles rise up, the soap is finished. After the fire is extinguished, the planks are removed, and for cooling the soap a few buckets of sub-lye are poured into the kettle. The soap is now ready to be run into the frames, when care should be taken that but very little of the sub-lye is transferred. After all the soap is in the frames they are covered with cloths. From time to time the sides of the soap in the frames are pressed back, as in becoming cold it contracts.

Boiling with wood ashes is very similar to that with potash, and differs only in so far that the lyes of ashes are less concentrated. In consequence of this it is not possible to saponify the fat in the first water completely, this succeeding only after the second and third waters. Therefore, for the second and third waters weak lye is taken, and not water, as in case of potash. In order to saponify 453 kilog.

(996.6 lbs.) of tallow, about 50 hectolitres (140 bushels) of wood ashes are to be put in.

The boiling with soda lye presents this advantage, that the soap may be finished in one water. The first lye is applied at a strength of from 10° to 20° B. The entire fat is placed in the kettle with one-quarter of the requisite lye for saponification, with proper attention to the fire. After boiling up, it should be examined as to whether the combination has taken place. This being the case, further portions of lye are added. Commonly this is taken of a strength of from 16° to 18° B. The adding of lye is continued, until a sample of the soap upon the glass plate appears perfectly clear. Thereupon the "cutting up of the pan" follows. This operation has here only the purpose of freeing the soap of glycerine and surplus water, hence much less salt is required than in the boiling with potash lye. For 100 lbs. of fat 10 to 12 lbs. of salt are required. The salt may be applied dry or in solution. After this the operations are the same as previously described.

Soda soaps made by the process above described have some advantages, principally because it is impossible to remove all the potash, and they are generally very neutral and plastic.

SECTION XIII.

THE FABRICATION OF SOAPS (CONTINUED).

SOFT SOAPS.

SOFT soaps are essentially a combination of the sebacic acid soap in a solution of potash with glycerine. On account of the great affinity of potash soaps for water, these soaps do not dry in the open air, but always retain their soft consistency; and the glycerine dissolved therein to a certain degree adds to this peculiarity. In its fabrication linseed oil, hemp-seed oil, sesame oil, cotton-seed oil, oleic acid of the stearic acid manufactories, with or without the addition of tallow or palm oil, are used. For winter soaps, the more liquid fats are chiefly used, such as linseed oil, hemp-seed oil, etc., since these do not congeal so easily; while in summer principally south sea train oil and rapeseed oil are applied in varied proportions.

A good soft soap (except the so-called Elaidin soap) must appear as a clear mass, in which at times, especially if it has been standing for a long period, white grains are formed—crystalline separations of stearic acid potash or soda. It must possess the requisite consistency, not draw into threads like rosin, but when taken between the finger and thumb break off short like butter or lard. According to temperature it should be somewhat more consistent than these latter articles. It may have a somewhat sourish touch when tasted with the tongue, but not too strong, *i. e.*, have a little overplus of potash. A large surplus is denoted by the dulness of the soap. When the soap is in want of alkali, it does not appear clear, has, however, in that case no sourish touch; so that it may be easily discerned, whence the surplus or the want of alkali originates.

Until lately, all soft soaps were manufactured only by saponification of the neutral fats with caustic potash, and contained therefore only the small portions of soda that are naturally in the potash. But later, caustic soda was used simultaneously in a fixed proportion to the potash, partly to obtain a somewhat more consistent soft soap, and partly too, in order to enhance the yield, in a certain given quantity of ingredients. *Gentele* has given a certain proportion for this, where, without a muddiness of the soap occurring, the maximum yield is reached. For this purpose 5 parts neutral fat are boiled with 3 parts of potash and 2 parts of soda. There are 3 equivalents of potash and 2 equivalents soda, or 7 weight parts potash, about 3 weight parts soda; and the soft soap thus produced consists, therefore, of 3 equivalents sebacic acid potash and 2 equivalents sebacic acid soda, besides the glycerine and water. A very advantageous result was obtained by Gentele by the application of the following weight proportions:—

1420 kilogrammes (3124 lbs.) 73 per cent. potash.
970 kilogrammes (2134 lbs.) pure crystallized soda.
3753 kilogrammes (8256 lbs.) hempseed oil.
40 kilogrammes (88.0 lbs.) tallow.
102 kilogrammes (224 lbs.) oleic acid.

These materials yield 9720 kilog. (21384 lbs.) of good soft soap, hence almost 250 kilog. (550 lbs.) soap from 100 kilog. (220 lbs.) fat. It must, however, be remarked, that this soap contains a great surplus of alkali; for the 3895 kilog. (8569 lbs.) fat taken, to be worked up, require when they are saponified with $\frac{3}{5}$ potash and $\frac{2}{5}$ soda, of the former 658 kilog. (1448 lbs.), of the latter 201 kilog. (442 lbs.), whereby it is supposed that to saponify 100 kilog. (220 lbs.) fat for soft soaps 19.6 kilog. (43.12 lbs.) potash or 12.75 kilog. (28 lbs.) soda are necessary. But since 1420 kilog. (3124 lbs.) of a 73 per cent. potash correspond with 706.5 kilog. (1554 lbs.) caustic potash, and 970 kilog. (2134 lbs.) crystallized carbonate of soda correspond to 210.3 kilog. (463 lbs.) soda, it follows that Gentele has applied 2486 kilog. (5469 lbs.) potash and 9.3 kilog. (20.5 lbs.) soda too much. With such an overplus nearly 1300 kilog. (2860 lbs.) more fat could have been saponified. There is of course no account taken as to loss ensuing in the preparation of the lye. But the deviation is, however, too great not to suppose at once an error in the hypothesis; perhaps if the oleic acid were to be increased tenfold a near correspondence of the common proportions between fat and alkali would take place in the soft soaps. We have ourselves, by investigating these soaps, repeatedly found in 100 kilog. (220 lbs.) fat as much as 21 kilog. (46 lbs.) potash. By applying 2 equivalents soda to 3 equivalents potash, the soap remains clear, if otherwise the right proportions are maintained, and alkalies of a high degree are used in the making of lyes. With equal equivalents of potash and soda, however, the soap becomes muddy; the same occurs when the soda contains much culinary salt, and the potash much sulphate of potash or chloride of potassium.

Calculating the proportion, when the fats are to be boiled with ⅗ potash and ⅖ soda. As we have already stated, that all soft soaps must be adjusted with a certain "touch," *i. e.*, with a surplus of alkali, which on an average amounts to ⅙ more than if we had to do with the production of a neutral soap, consideration of this matter should be taken from the first. To boil 100 kilog. (220 lbs.) into soft soap we apply 12.8 kilog. (28 lbs.) soda, or 19.5 kilog. (43 lbs.) potash. These proportions are based on the calculation made for saponification of 5000 kilog. (11,000 lbs.) fat for 3000 kilog. (6600 lbs.) with potash saponified.

$\frac{3000 \times 19.5}{100} = 585$ kilog. (1287 lbs.) caustic potash and 2000 kilog. (4400 lbs.) with soda saponified $\frac{2000 \times 12.8}{100} =$ 256 kilog. (563 lbs.) soda will be required.

The potash lye applied is ¾ at 20° to 21° B. and ¼ at 25° B.; the first contains $\frac{3 \times 585}{4} = 438.75$ kilog. (965 lbs.) potash, the latter $\frac{1 \times 585}{4} = 146.25$ kilog. (322 lbs.) potash.

The 20° B. lye contains 16.408 per cent. potash; there are hence to be taken of it $\frac{438.75 \times 100}{16.408} = 2674$ kilog. (5883 lbs.) or 1630 litres (431 gallons.)

The 25° B. lye contains 19.803 per cent. potash, and of it should be taken $\frac{146.25 \times 100}{19.803} = 740$ kilog. (1628 lbs.) or 610 litres (161 gallons).

The soda is only applied as 20° lye, and since it contains 10.88 per cent. of soda there are required of it $\frac{256 \times 100}{10.88} =$ 2353 kilog. (5176 lbs.) or 2028 litres (536 gallons). The total quantity of lye contains therefore:—

Potash lye	at 20°	2674 kilogrammes	or 1630 litres
" "	at 25°	740 kilogrammes	" 610 litres
Soda lye	at 20°	2353 kilogrammes	" 2040 litres
		5767 kg. (12,687 lbs.)	4280 litres (1132 gals.)

Whereas from 5000 kilog. (11,000 lbs.) fat (100 : 250) 12,500 kilog. (27,500 lbs.) soft soap are to be realized, there must needs be added to the soap mass in the kettle 1737 kilog. (3821 lbs.) of water, that is, the lyes must be diluted to the amount of 7500 kilog. (16,500 lbs.) and the evaporating water during the process of boiling must be replaced. Great competition often compels the manufacturer to enhance the yield (100 : 250) by other means, filling with salt lye, carbonate of soda, etc. With such intention the fats are also augmented by adding four to five per cent. cocoa-nut oil, and by this means the yield is still further enhanced to 300 kilog. (660 lbs.) soap from 100 kilog. (220 lbs.) fat.

The Boiling of Soft Soap.—The fabrication of soft soaps offers no particular difficulties, if the proper proportions of alkali and fat are accurately calculated and applied. The lyes and all the fat can be taken at once into the kettle, the mixture heated to boiling, and kept thus, until a perfect saponification ensues, and the soap has attained its correct consistency. More to the purpose it appears, however, either all the lye, or perhaps one-half of it, is stirred together with the fat in a temperature of 30° to 40° C. (86° to 104° F.) and to leave the mixture stand overnight. By this operation a certain emulsion is formed, and on the day following, the further union advances extremely fast. If at first only one-half of the lye had been taken, then during the continuance of boiling, the other half must be added. From time to time, the soap is tested as to its nature, whether it has an overplus of fat or alkali, whether it has steamed or not. This is ascertained by placing a small sample upon a glass plate, upon which it is cooled off in a temperature not exceeding 8° C. (46.40° F.). The soap is good if a sample of it, held up to the light, is clear and translucent, and when the soap dropped upon the glass, after a lapse of from 12 to 15 minutes, shows but a very small ring. It must not glide or be slippery upon the glass, and when taken between two of the fingers, it must not draw into threads when the fingers are extended.

Particular Remarks.—Should the soap at the commencement become thick, then it is wanting in lye, which must be added at once. If the soap turns muddy from the first, when placed upon the glass, and runs like water from the spatula, then the lye is excessive and must be relieved by adding some fat. If the soap runs out of the trial-spoon in flakes, it is too much evaporated, and must then be diluted with a corresponding quantity of potash lye of about 4° B., and again be somewhat condensed.

The ring of lye and the gray fat, by the trial upon the glass, the first as a rim encircling the soap-drop, the latter as a muddy point in the centre of the drop, appears only after the soap is so far boiled that it is out of the paste, hence almost finished boiling. A small ring of lye, every soft soap must show, because every soap must needs have a certain surplus of caustic potash. On the other hand, all fatty gray (a gray spot in the centre of the soap-drop) must be removed by adding potash lye.

If this is not done, then the soap after a short time turns in the kegs or barrels into a thick, slimy, and thready mass. The barrels into which the soft soap is placed must be entirely clean and dry, or the soap will easily turn, that is, will become thin and muddy. It is filled while yet hot into the barrels, which are closed only after the soap has cooled off. The magazines or storehouses for the finished soaps must not be too warm.

The soaps made of hempseed-oil possess a more or less greenish color; all other fats furnish a brownish soap. But since hempseed-oil soap is now very much favored, it is sought to impart also to the soaps made of other fats a greenish hue. This is done by dissolving finely powdered indigo in the sixfold part of its weight of fuming sulphuric acid, and this solution is stirred into the soap. Instead of this indigo solution, indigo carmine (indigo-blue hyposulphide, potash or soda) may be applied. So much of this is taken until the desired shade is attained.

The soft soaps are likewise filled, and for this various means are applied. Some add rosin soap to them. Such a mixed soft soap cannot be used for washing wool nor in fulling-mills; besides the profit which the soap manufacturer thus obtains is very doubtful, because the soaps have to be boiled more in order to attain the proper consistency. A frequent mode of filling is that with starch dissolved in weak lye. By this operation a transparent, and almost colorless gluten, is stirred into the soap, which must be done with great care, if not, little lumps will form.

Others fill with alum and a solution of salt; of the first 1 kilog. (2.2 lbs.) dissolved in water, and 30 to 40 kilog. (66 to 88 lbs.) salt lye of 5° B. are taken to 700 kilog. (1540 lbs.) finished soap. On the one hand, clay is separated by this operation, which partly dissolves again in caustic potash; on the other, some soda soap is produced. The filling is added after the soap has attained its proper consistency. Of this soap, worsted spinning manufacturers can make no use, which is to be well noted.

The filling with carbonate of soda in a lye of 5°, to which, upon 100 kilog. (220 lbs.) finished soap, 2 to 4 kilog. (4.4 to 8.8 lbs.) are added. In this case it is the formation of a small quantity of hard soda-soap, which makes the soap more consistent, so that it need not be boiled so long.

In more modern times, much filling is also accomplished by the use of soluble glass. This is carried out by taking 36 kilog. (79 lbs.) soluble glass, for 100 kilog. (220 lbs.) oleïc acid or fat. Inasmuch as the soluble glass contains an overplus of silicic acid, it becomes necessary to admix to each 25 kilog. (55 lbs.) soluble glass, 1 kilog. potash lye of 25° B., since the soap may otherwise become too weak. The mixing of the soap with the soluble glass is performed by stirring in well, without heat.

Grained Soft Soap. (*Fig Soap.*)—By this appellation such soaps are known whose brown, transparent mass is more or less filled with smallish white grains, crystals of stearic acid, or palmitic acid, potash or soda. The formation of these soaps succeeds best in a temperature of between 9° and 18° C. (48.2° to 64.4° F.). Below 9° C. (48.2° F.) the mass congeals too rapidly, so that no crystalline separation will ensue; above 14° C. (57.2° F.) the crystals all remain dissolved. To produce this soap, the purest potash-lye must be applied. The potash from which this lye is prepared must not exceed 5 per cent. of carbonate of soda, and must also be free from other foreign salts. Otherwise, the entire mass becomes muddy, and the grains can no longer be discovered therein.

There are various directions for producing this soap, of which a few are here given:—

I. 55 parts palm oil and 45 parts oleïc acid, or
II. 55 " " " 15 parts tallow and 30 parts linseed oil, or
III. 70 " " " 30 parts linseed oil.

These soaps are also adjusted upon a certain "touch"; just as the applied fats are more or less hard, the crystallizations are also more or less numerous, so that by the choice of the fats it is in our power to produce more or less crystals in the soap. Perutz communicates the following directions for the fabrication of an excellent fine soda-grain soap, which upon its clear green ground has but a few white grains. This soap is made of ⅔ oil of hemp-seed, and ⅓ tallow.

Artificial Grain Soap.—The above explained grain soft soap is also as to its exterior appearance, produced in an artificial manner, by admixing with the finished soap certain grainy substances. The so-called "artificial grain" consists usually of starch, lime, or clay, which is made into the shape of grains. The most suitable is clay, if we at all desire to assist in lending a helping hand to such a deception.

Elaidin Soft Soaps.—These soaps contain, in comparison to potash, a larger proportion of soda than the common soft soaps, in consequence of which they become muddy when cooled off, and when stirred again, assume a silvery or golden shiny appearance. According to the nature of the fat, they show a yellow or yellowish-white color; for their production, more hard fats are used than others. The first half of the fat boiled in potash, the other in soda, furnishes a good and smooth soft soap.

Numerous are the receipts for the fabrication of elaidin soaps, which differ partly on account of the various fats, partly on account of the proportions of the various mixed fats which are to be saponified. The manipulation is the same as in the case of the common soft soaps. They are adjusted until a sample, placed upon the glass plate, shows a small lye ring when cooled off. The disappearance of the froth in clear boiling here also designates the approaching end of the boiling. And this offers a tolerably sure sign that all the alkali has combined with the sebacic acids. For our ownselves, we have no doubt that the carbonate of alkalies, when the saponification does once take place, will to a certain degree decompose the neutral fats and change them into soap. At first the caustic alkali is absorbed while boiling, further also the carbonate of alkali is changed as long as fat is still on hand. This transformation ensues under the development of carbonic acid, which is really the cause of the frothing. The ceasing of frothing, or, what is the same, of carbonic acid development, is therefore a sure sign that a reciprocal influence of the materials no longer takes place. Inasmuch now as the lyes which find application in the manufacture of soap—as may be boldly asserted—are never perfectly caustic, we would, when the carbonate of alkalies in the presence of caustic alkali and finished soap were not decomposed in all cases from the beginning, have to employ a so much larger overplus of alkali, as the lyes contained carbonate of alkali. A certain limit, however, it seems must, in this case, not be transgressed, if we do not desire to run the risk of continuing the boiling very long, or until a perfect saponification ensues, and cause a loss of time and fuel.

The following receipts are effective for making good elaidin soaps:—

600 kilog. (1320 lbs.) palm oil (bleached),
300 " (660 lbs.) linseed oil,

saponified part with potash, part with soda, with say 3 parts potash and 2 parts soda. These are about the proper equivalents. Another formula is, 45 parts palm oil, 55 parts oleic acid; 40 parts palm oil, 30 parts oleic acid, and 30 parts linseed oil. The more the quantity of the soda is increased in proportion to the potash, the greater the consistency, the harder, but also the less clear the elaidin soaps appear. But in this respect we must govern ourselves according to the desires and the customs of the consumers. Many give to the elaidin soaps an addition of rosin; but in most cases there ensues from this no profit, either for the consumer or for the manufacturer.

White Soft Soaps.—By this name a soap is known in many places, which really cannot be counted among the soft soaps, since as to its main substance it is composed of a soda soap, filled with chloride of potassium. It is produced by saponifying 75 parts tallow and 25 parts cocoa oil with 2 parts caustic potash and 1 part caustic soda lye. The previously mixed lyes are added by degrees until the soap attains a strong "touch." Thereupon so much salt lye of 20° B. is stirred in, until a sample, when cooled off, forms a stiff paste, which by a pressure of the fingers, extends upon the glass plate. The soap is now finished and is to be filled into the barrels, where, after it becomes cold, it will be found to be so firm that it cannot—like other soft soaps—be taken out with the spatula, but must be cut out with a knife. 100 parts of the fats furnish 400 parts of a cheap, but very inferior soap.

A very pure soft soap, much esteemed by manufacturers, is the *English Crown Soap* (first quality). In England, the lyes are made perfectly caustic, and of two strengths, the weakest being 8° B., and the strongest 25° to 30° B. For eighteen barrels, prepare 400 gallons of lye, with good potash made caustic with lime; and put a third of it in the kettle, and then add 52 pounds of suet, and as much of lard. When the whole is melted, pour in 70 gallons of olive oil, and leave the liquor to settle for two hours; kindle the fire anew, and turn 19 gallons of lye into the kettle. As soon as ebullition commences, add from time to time a little lye in order to allay the frothing. Continue this addition until the liquor in the kettle has been reduced one-half. At this time examine whether the soap has been dosed too little or too much with lye. This test, or proof, should be made frequently during the saponification. It is merely to withdraw a sample from the kettle upon a spatula and to examine it. If it becomes whitish, and falls in short pieces, it is too alkaline, and requires oil; if, on the contrary, lye is needed, it drops in long, ropy strings. If it is proper, that is, deficient neither in lye nor in oil, the sample should be viscid, white, and semi-transparent. Then the fire must be extinguished, and the soap run off into barrels. It may be as well to say that, after the second time the fire is kindled, the soap should be kept in lively ebullition, until its preparation is well advanced; and, at that point, it must be carefully managed until the soap has acquired its requisite clarification.

Crown Soap (second quality).—For this soap, take 286 pounds of suet or tallow; lye, 135 gallons; sperm oil, 80 gallons. Place in the kettle, first, 94 gallons of lye and the tallow, and when the latter is melted, add the oil, and put out the fire. Two hours after kindle it anew, add 19 gallons of lye, and carry the whole to boiling, and keep it so until the soap becomes half made. Then dose with 9 gallons of lye, and finally resume and continue the ebullition, taking care to add the remaining 9 gallons of lye to finish the soap.

Green Soft Soap.—Two hundred and seventy-three gallons of whale or cod-liver oil, and 400 pounds of tallow are put into the soap pan with 250 gallons of potash lye, containing 250 pounds of dry caustic potash. Heat being applied to the pan, the mixture froths up very much as it approaches the boiling temperature, but is prevented from boiling over by being beaten down on the surface. Should it soon subside into a doughy-looking paste, it is to be inferred that the lye has been too strong. Its proper appearance is that of a thin glue. There should now be introduced about 42 gallons of a stronger lye, containing 55 pounds of potash, and after a short interval an additional 42 gallons; and thus successively till nearly 600 such gallons have been added in the whole. After sufficient boiling to saponify the fats, the proper quality of soap will be obtained, amounting in quantity to 6400 pounds, from the above quantities of materials.

SECTION XIV.

THE FABRICATION OF SOAPS (CONCLUDED).

SILICATED AND OTHER FILLED SOAPS.

THE filling and the sophistication of soaps is conducted to a greater or less extent in all business centres, and when the materials used are harmless and do not detract from the detersive power of the soap, they may be somewhat excused from that censure which all adulterations should receive. The materials generally used are water, soluble glass, dextrine, starch, clay, silica, sand, salt, etc., and there are many common soaps made from offal fat, bones, etc., in which are retained the many impurities natural to these substances.

In regard to water it may be stated that the soaps made from cocoa-nut oil have the property of absorbing large quantities of water, without essentially losing thereby their hardness. This property the cocoa-nut oil transfers also to the soaps in which, in combination with other fats, it appears. The common soaps contain 35 to 50 per cent. of water, but there are some cocoa-nut oil soaps in the market, which contain as much as 75 per cent. of water. Such soaps shrink greatly in drying, and are covered—when they contain an overplus of alkali—with a crust of fine white crystals. Since the cocoa-nut oil soaps are not separated even by greatly concentrated solutions of culinary salt, they may be impregnated with a large amount of salt water, without injuring their exterior appearance in the least. This may also be done to a less extent with soaps which are fabricated with cocoa-nut oil and other fats. In relation to this, the action of the different soaps is this: pure cocoa-nut oil soaps bear a great deal of salt; those of palm oil very little, and those of olive oil and tallow no salt at all.

For filling these soaps there are applied, besides water and culinary salt, starch, offals (bones and greaves), chalk, clay, barytes, pumice stone, sand, soluble glass, and carbonate of soda. Of these substances, chalk is beyond dispute the very worst, because it does not merely make the soap thin, but in a great measure entirely destroys it, and causes it to be inefficient.

Common Cocoa-nut Oil Soaps.—1000 kilog. (2200 lbs.) cocoa-nut oil are boiled with 1660 kilog. (3652 lbs) of a 7.5 per cent. caustic soda lye into a clear paste and filled with 1000 kilog. of a salt solution of 22° B. The frames must be well greased, because the soap is very thin, and scarcely combines. It may be marbled in the frames, with some vermilion or ultramarine, and perfumed with essential oils.

Common Filled Rosin Soaps:—

1000 kilog. crude palm oil.	110 kilog. (242 lbs.) caustic soda.
1000 " cocoa-nut "	112.5 " (247.5 ") " "
1000 " rosin.	104.0 " (228.8 ") " "

The soda is applied as a lye of 20° B. = 10.677 per cent., and hence uses $\frac{326.5 \times 100}{10.677} = 3060$ kilog. (6732 lbs.) = 2240 litres (593 gals.), which, added in three portions, is boiled until the potash shows but a slight "touch." The boiling is continued until the paste becomes thick, and after cooling off upon the spatula becomes firm. When in the frames, 50 to 75 kilog. (110 to 165 lbs.) of a solution of sulphate of potash of 20° B. may be stirred in, which must be continued until the soap becomes tolerably cool, stiff and thick. The frames should not hold more than 200 to 250 kilog. (440 to 550 lbs.) of soap, and not exceed 60 centimetres (23.62 inches) in height. They can be also filled with clay, using for each frame 15 to 20 kilog. (33 to 44 lbs.). The stirring must be continued until the crutch draws furrows, and upon the surface partly dry spots make their appearance. Sometimes a solution of potash is stirred into the frames, *i. e.*, to 200 kilog. (440 lbs.) add 15 to 20 kilog. solution of 20° B., which makes the same very plastic.

Soluble Glass Soap (*Silicated Soap*).—The manufacture of soluble glass soap became a real necessity when, some years ago, rosin became so expensive on account of the war, that it could no longer be used for making soaps, and manufacturers were compelled to substitute other ingredients.

The directions for making this soap vary, principally as to the quantity of soluble glass which is to be incorporated into a soap, and which is from 25 to 60 per cent. The method of manufacture consists in adding to the hot soap paste the desired quantity of soluble glass, which must be thoroughly stirred under, up to the moment of congealing. The soluble glass must also be saturated as much as possible with silicic acid, because a salt which is poor in silicic acid combines but in small proportions with the soap. This soluble glass soap, when made with unbleached palm oil, attains a yellowish color. It often contains 60 per cent. of soluble glass, and has a tolerable consistency, is not sticky like rosin soap, is free from the disagreeable smell of the latter, and foams like common soaps. It is deserving of especial mention that these soaps are frequently sold for rosin soaps, although they contain no trace of rosin. The crutching machines illustrated elsewhere are used for the mechanical admixture of the soluble glass and other filling.

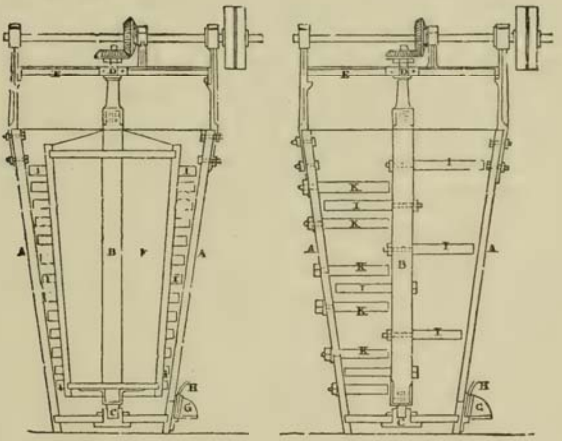
Silicated soaps are also a numerous class of soaps now found in all markets under a great variety of names, as sand, crystal, diamond, etc. They are simply a common soap usually containing rosin, as that appears, by its tenacious consistency, to have the power to best hold their heavy materials. We give several processes.

Gossage's Process.—This method consists in the mechanical mixture of soluble glass with the soap paste. The soluble glass is a thick, viscid liquor, made by fusing together, in a reverberatory furnace, 9 parts of 50 per cent. soda ash, with eleven parts of clean sand, or powdered quartz, for hard soaps; or equal weights of dry pearlash and sand, for soft soaps. When the mixture has combined, it is drawn off into moulds, quenched with water, ground in the eccentric mill, and boiled with alkaline water. The solution, when complete, is next evaporated until it reaches 49° B. It is then ready to be mixed with the soap paste in the pan, and just as it has reached the condition in which it is generally transferred into the frames. The temperature of both glass and soap paste should be about 71.1° C. (160° F.) at the moment of mixing, which must be thorough, to promote perfect homogeneity of the soap paste. This is accomplished by machinery described below, or with the crutching machine. When the mixture has cooled to 65.5° C. (150° F.) it is put into the frames and again stirred with the crutch until it begins to stiffen.

Rosin soap which is to be treated by this process may contain rosin in as large proportions as one to two of fatty matters. The solution of glass must, for this soap, mark 51° B., and be added to the paste when it is "fitted" and ready to be "framed."

The apparatus referred to consists of a circular tub or vessel (Fig. 59), marked A in the drawings hereunto annexed, having the shape of an inverted cone, and an internal diameter of about two feet two inches at its lower part, and three feet six inches at its upper part, and a depth of about six feet. Adapted to this vessel is a central upright shaft, marked B in the drawings hereunto annexed, supported by a foot-step C, fixed to the bottom of the tub or vessel, and by a journal D, adapted to a metallic bridge-piece E, which is fixed over the tub or vessel, and secured by screw-bolts to the sides thereof. A bevelled cog-wheel to the upper part of the said upright shaft, and a horizontal shaft, supported by suitable bearings attached to the said tub or vessel, and on such horizontal shaft another bevelled cog-wheel in such manner that its cogs will work in gear with the cogs of the bevelled wheel on the said upright shaft. A driving pulley on the said horizontal shaft, runs by means of a band passing around such driving pulley, also around another driving pulley, which is caused to revolve by some mechanical power, which communicates a revolving motion to the driving pulley on the said horizontal shaft, and through this to the bevelled wheels and upright shaft. The speeds and diameters of the pulleys and wheels employed, are so that the said upright shaft may be caused to make from sixty to eighty revolutions per minute. Fixed on the said upright shaft is a closed tub or vessel (marked F, in Fig. 59, 1), which said tub or vessel is of such diameter as to admit of its being placed in the larger but or vessel A, and to leave a space of about two inches between the said two vessels at their lower part, and a space of about six inches at their upper part. Attached to the outside of such inner tub or vessel (by means of screws or otherwise) are a number of projecting blades marked I I, made by preference of sheet-iron, of such length as to approach within about half an inch of the inside of the larger tub or vessel A. G is a spout, having a movable stopper H, to the lower part of the vessel A, through which to run off the contents of the vessel. In place of fixing a smaller tub or vessel on the upright shaft B, on which to attach projecting blades, can be attached projecting blades to the said shaft as shown in Fig. 59, 2. When this arrangement is adopted, other projecting blades, marked K K, are attached to the inside of the vessel A, which projecting blades, K K, are so placed as to admit of the blades I I revolving between them,

Fig. 59.

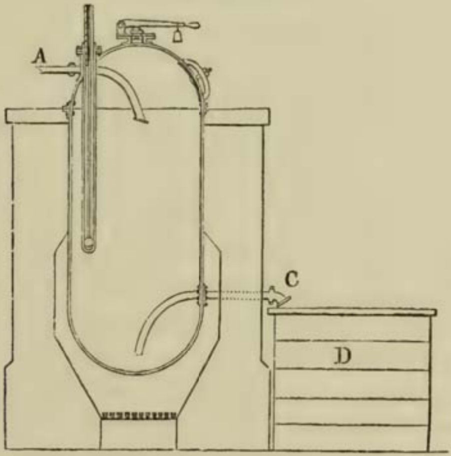


1. 2.

as shown in Fig. 59, 2. When about to use this apparatus for the production of compound soap by mixing genuine soap with viscous solution of soluble glass, it is well to ascertain previously the highest temperature at which the mixture of such genuine soap, with the proportion of the viscous solution employed, will become too thick to admit of its flowing from such mixing apparatus. It is then preferable to make a preparatory mixing, by means of paddles or crutches, of the genuine soap with the viscous solution employed, in such a tub or vessel as will contain about half a ton of soap, adding the soap and viscous solution at such temperatures as will yield a mixture, having a mean temperature about ten degrees higher than the previously ascertained temperature hereinbefore referred to. Then transfer the soap, which has undergone a preparatory mixing, into this apparatus, and cause rapid revolving motion to be given to its vertical shaft, which communicates corresponding motion to its projecting arms or blades. Then withdraw the sliding stopper of the said spout to such extent as to allow the compound soap, in the state of perfect mixture, to flow from the mixing apparatus, and then put further quantities of genuine soap and viscous solution of soluble glass, which have undergone a preparatory mixing, as hereinbefore described, into the said mixing apparatus. The mixed compound soap produced is conveyed to the ordinary 'frames' in which it becomes solid by cooling. In mixing viscous solution of soluble glass with genuine soap (whether such mixing may be subsequently completed by 'crutching' in frames or by means of the improved mixing apparatus), it is best to commence such mixing by adding a portion of such solution at a specific gravity of about 1.300, and to add the remaining portions required for the mixing at increasing specific gravities, so that the average specific gravity of the whole solution used may be equal to that which has been found (by previous trials) to be suitable to yield a compound soap of proper hardness when using a genuine soap of the composition employed. When it is desired to produce a compound soap, having less detergent power than the compound soaps obtained by mixing genuine soaps of ordinary quality with solution of soluble glass, let a portion of the alkali contained in such solution be combined with rosin or with fatty or oily acids obtained from tallow or oil by well-known processes. Such combinations are effected by boiling rosin or fatty or oily acids with solution of soluble glass, in the same manner as rosin and other soap-making materials are combined with alkali in the ordinary process of soap-making, and we use the product thus obtained to mix with genuine soap, and thus produce less detergent compound soap containing solution of soluble glass.

Dunn's Silicic Soap.—In this process, the silicic matter is made to combine with the soap under pressure. Mr. Dunn, the author, says that it is as applicable to all other kinds of soap, even where silica is not an ingredient; and with the advantage over the usual mode of boiling soap materials, of effecting a more perfect union of the ingredients, in a shorter time, with less waste, and at a diminution of expense.

Fig. 60.



Take the materials for soap in the usual proportions, say for *yellow* soap, 7 cwt. of tallow, 3 cwt. palm oil, 3 cwt. of rosin, and 140 to 150 gallons caustic soda lyes, 21° B., and place the whole in a steam boiler, such as is represented by

Fig. 60. The boiler should be furnished with a man-hole, safety valve, and all the ordinary appendages of such an apparatus, with a thermometer plunged into a mercury chamber. There should be a feed pipe as at A, and a discharge pipe as at C, through which the soap may be discharged into a pan or frame as at D. The fire being kindled, the pressure on the valve should be such as to allow the temperature in the boiler to rise gradually to about 154.4° C. (310° F.). When it has remained at this height for about an hour, the ingredients may be discharged from the boiler into the pan or frame, and allowed to cool down, when the process of saponification will be found to have taken place.

When silica is to be added, it must be put through a preparatory process, which is as follows: Crushed flint or quartz mixed with caustic soda or potash lye, in the proportion of one cwt. of silica to 100 gallons of lye of 21° B., is placed in a steam-tight boiler, or apparatus, such as above described, and the whole heated to a temperature of about 154.4° C. (310° F.), and kept at this pressure for about three or four hours, when it is discharged and cooled down, and a silicate is thus obtained, of potash or soda, according to which alkali has been used in solution; and this solution is added in the proper percentage to the soap paste in the pan, after the saponification is complete, and before it has cooled down.

Guppy's Process.—To the above invention, in its application to ordinary or silicic soaps, a gentleman by the name of Guppy has proposed certain improvements, such as the introduction of stronger lyes and in separate portions into the boiler or steam-tight vessel, to be injected from a reservoir by a force-pump, properly appropriated and arranged, and in connection with both the boiler and reservoir. For every 24 pounds of tallow, 10 pints caustic soda lye, of 17° B., are added to the boiler, and the mixture heated to 148.9° C. (300° F.); and by means of a force-pump about 30 pints of soda lye, of 25° B., to every 24 pounds of tallow, are then injected or thrown in, and the mixture maintained for two hours at 148.9° to 154.4° C. (300° to 310° F.). At the end of that time the saponification will be complete, a fact determinable by drawing out samples through a try-cock fitted in the boiler for the purpose. The stronger lyes are kept at hand in a special reservoir, and from thence drawn by the pump, through pipes suitably connected, and forced in through other tubes. The advantages gained by this mode of operating seem to be a saving of time and fuel; but whether these expectations are to be realized in practice, must be determined by experiment.

Davis's Alkalumino Silicic Soap.—This soap is a patent invention, by which, as the patentee says, the cost of the soap is diminished, whilst its detergent and normal properties, instead of being impaired, are much improved. The plan consists of a combination of fuller's earth, pipe-clay and pearlash, with the soap as soon as it is poured into the cooling frames. When pearlash or soda is employed, it is necessary that it should be calcined and then ground together with the clay and earth so as to form as intimate a mixture as possible. In this mixed state it is incorporated with the soap. To every 126 pounds of soap already made and in paste, take 56 pounds of fuller's earth, slaked or dried, 56 pounds of dried pipe-clay, and 112 pounds of calcined soda or pearl-ash, all reduced to powder, sieved as finely as possible, and thoroughly incorporate the whole by stirring or crutching. The mixing must be very perfect, and done as quickly as possible before the paste soap cools. To obviate any objection against the use of this soap for washing white linens, a modification of the above process is proposed, by which the use of fuller's earth is entirely omitted, leaving the proportions then for every 120 pounds of soap, 112 pounds of dried pipe-clay, and 96 pounds of calcined alkali. A soap produced by these quantities, the patentee says, is useful for general purposes at sea, and for washing white linens in salt water. For washing white linens in fresh water, the process is still further modified by using 112 pounds of soap, 28 pounds of dried pipe-clay, and 36 pounds of calcined soda; and as a toilet soap, either for fresh or salt water, by employing 28 pounds of fuller's earth, slaked or dried, and 20 pounds of calcined soda to 112 pounds of perfumed curd soap.

Sand Soap is made with the admixture of fine sand to the amount of 20 or 25 per cent. in weight, which is best added to the hot soap when in the frames, being crutched in until the soap is too stiff to stir.

Quartz Soap is also known by various names, as diamond soap, crystal soap, etc., and is made by crutching into the still hot soap in the frames about 20 per cent. of finely powdered quartz or spar, as in the manner for sand soap.

Poncein Soap is also a useful detergent much used for cleaning the dirty hands of those engaged in mechanical trades. The process is the same as for sand soap, using a very finely powdered pumice stone. This soap is also made of very select materials, and used as a toilet soap with the requisite amount of perfume.

For the mechanical admixture of these various substances with soap there are a number of new crutching machines that greatly facilitate the filling of all soaps; we have illustrated the one lately invented by Mr. Stephen Strunz.

Greaves or Crackling Soap.—For the manufacture of this soap, we use the offals and remnants of rendered tallow, hogs' lard, etc.

When for the melting of the tallow sulphuric acid has been employed, the greaves must at first be washed out with water. For 100 kilog. (220 lbs.) greaves place 100 to 110 kilog. (220 to 242 lbs.) of 20° B. soda-lye in the kettle, which is to be heated to boiling, and leave this mass to rest for 48 hours, during which time the greaves dissolve into a gelatinous mass. The boiling is then continued until it becomes pasty; add cocoa-nut oil with the requisite alkali to it, and boil until it becomes a paste soap; after the disappearance of froth, or, if this takes too long, and the soap proves to be firm, it is run into the frames, after previously skimming off the froth.

Bone Soap.—By this name we designate a mixture of common soap, for instance tallow, palm-oil, or rosin soap, which has by soda-lye been loosened of decomposed animalic gelatinous matter or bones, and has been so treated that a solid mass (soap) is produced. With regard to the soap made of bones, this can be performed by two different methods. According to the one, the bones are manipulated with concentrated muriatic acid, and they need not be previously broken up. This acid dissolves the carbonate and phosphate of lime, while it leaves the animal gluten as a strong transparent mass, in the form of the bones. By repeated washing it is entirely freed from the muriatic acid; this gluten is added to either of the above-named fats during the process of saponification.

According to the other method the entire mass of bones is embodied with the soap, and not the jelly or gluten alone. For this purpose, the previously bruised bones are softened by pouring a strong caustic lye over them in an iron vessel. The lye dissolves the gluten, and leaves the earthy paste as a residue, in the shape of a powder. After a period of two or three weeks, the bones are perfectly loosened and are easily reduced to a pulp. The finely ground mixture is now boiled in the kettle for one hour, in order to saponify with this caustic liquid the fat, for instance cocoa-nut oil, in the same manner as is done with common lye. Such an article was formerly produced and sold under the name "Liverpool Poorman's Soap," and much used. By the presence of the gluten and the bone clay, the soap loses but little of its firmness and its property of foaming. It shows, however, nothing of that which is termed "*grain*," and it appears, when cut, of dark-brown color, and is not as transparent as the rosin soaps.

Other Filled Soaps.—By a change of the proportions between cocoa-nut oil and the other fats and rosin, and these again among themselves, and by applying a solution of salt-soda or potash for the filling of the soaps, the number of the variety of these filled soaps may be multiplied indefinitely; but all of them resemble each other in this one particular, that of having more the interest of the manufacturers at heart than that of the consumers, and, to say it plainly, they are inferior and only apparently cheap. The following are a few more formulæ for making these soaps:—

I.

Cocoa-nut oil	2000 kilog.	(4400 lbs.)
Palm-kernel oil	2000 "	(4400 ")
Crude palm oil	630 "	(1386 ")
Tallow	370 "	(814 ")
Caustic soda-lye 28° B.	5350 "	(11,770 ")
Solution of potash 25° B.	350 "	(770 ")
Salt solution 25° B.	5200 "	(11,440 ")

II.

Cocoa-nut oil	1000 kilog.	(22,000 lbs.)
Tallow	500 "	(1100 ")
Caustic soda-lye 20° B.	960 "	(2112 ")
Solution of potash 30° B.	360 "	(792 ")
Salt solution 25° B.	1680 "	(3696 ")

III.

Cocoa-nut oil	2720 kilog.	(5984 lbs.)
Caustic soda-lye 25° B.	750 "	(1650 ")
Solution of potash 12° B.	1760 "	(3872 ")
Solution of potash 20° B.	960 "	(2112 ")
Salt solution 30° B.	2000 "	(4400 ")

IV.

Cocoa-nut oil	1680 kilog.	(3696 lbs.)
Caustic soda-lye 40° B.	600 "	(1323 ")
Solution of potash 30° B.	300 "	(660 ")
Salt solution 25° B.	860 "	(1892 ")
Water	630 "	(1386 ")

SECTION XV.

NEW SOAPS BY NEW METHODS.

INNUMERABLE new soaps by new processes are constantly seeking notice, and for many of which patents are granted more for their novelty than for their intrinsic merit, for often in their composition they set at defiance all chemical rules and are worse than useless. There are, however, many others that being based on science may be considered as improvements, and have a useful application in our art.

As we have said, there are many other means of saponification besides soda and potash, and these have been utilized to decompose the neutral fats, for various uses in the art. Yet, in as far as a detersive soap is concerned, they have not been successful in practice. But for making the stearic acid for candles many of these new processes have found a practical use. Thus, we have the saponification by lime, by a small portion of lime assisted by surcharged steam, by water and distillation, by water under high pressure, by sulphuric acid, by sulphate of soda, etc. When we come to treat of the manufacture of candles these processes will receive that attention which they deserve. Yet, there are some of these processes that here claim our attention and are of interest.

Saponification of Fats by means of Carbonated Alkalies.—Under ordinary conditions, the carbonated alkalies do not possess the power to separate the glyceryl oxide from the neutral fats, and to combine with the sebacic acids. By an increased temperature, however, a lively reaction ensues, whereby the carbonated alkali does lose its carbonate, while the sebacic acid and the base combine for a real soap. When, for instance, a mixture of 100 parts tallow and 22 to 25 parts anhydrous carbonate of soda is gradually heated, vigorous action takes place, at 260° C. (500° F.), and the mixture becomes much puffed up, in consequence of a great development of carbonic acid gas. Towards the end, the temperature must be somewhat increased, in order to decompose the last portions of neutral fat.

After a few hours a semi-liquid, yellowish mass is obtained, which, during its cooling off, becomes more consistent. In water it dissolves gradually to an opalescent liquid, which in every respect acts like a solution of common soap. The carbonated alkalies, as also culinary salt, cause therein a separation of soda-soap, which collects upon the surface of the liquid.

Saponification of Fats by Sulphuretted Alkalies.—This method has been proposed by Pelouze. Despite this authority, we have not been able to discover in this new method any special advantage; for although an equivalent of sulphide of sodium, where this, like the soda, is produced on a large scale, may be cheaper than an equivalent of caustic soda, there are nevertheless other inconveniences which are much greater, since the alkalies form in themselves a proportionately cheap ingredient of the soap, and there is therefore caused, by the cheaper sulphide of sodium, no essential reduction in the prices of the soaps.

In the practical performance, the fats are treated in exactly the same manner with a solution of sulphide of sodium, as the common method with soda-lye. The saponification ensues by means of sulphide of sodium very quickly and under a development of sulphuretted hydrogen gas, which, on account of its very disagreeable smell and its poisonous properties, must be made harmless. This may be done most advantageously by burning it, and the sulphurous acid which is produced by the process of burning may be applied in the fabrication of sulphuric acid. But this presupposes a very extensive and complicated business, such as would hardly be suitable for many soap-manufactories. Moreover, according to Dullo, the soap made with sulphide of sodium retains a bad smell, which cannot be removed, and finally the manufacture of white soaps with sulphide of sodium would become entirely impossible, on account of the unavoidable admixture of coloring substances.

The Process of Mege Mouries.—This process requires a particular notice here, as when first made known it attracted great attention, which has however subsided, though it has resulted in suggestions which have been utilized particularly in France, especially for making the sebacic acids in the manufacture of candles. He found that the neutral fats in the oil seeds during germination, as well as in the animal organism during life, are in the condition of movable globules, which offer a great surface to the action of reagents. In this globular state, fats exhibit some peculiar properties of which we shall only notice such as are interesting to the soap-maker. Fat, as for example tallow, in the ordinary state, becomes rancid by exposure to the air; in the globular state, in a milky form, or in a dry state, or in the form of a white powder, it remains unaltered any length of time. In practice it is obtained by mixing melted tallow at 45° C. (113° F.) with water at the same temperature, holding in solution 5 to 10 per cent. of soap. It is difficult to combine tallow, in its ordinary state, with hot salty caustic lyes; but in the globular state the lye is immediately absorbed in proportions varying with the temperature. Each globule, as it is attacked by the alkali, quickly gives up its glycerine, and in a very short time each globule of fat is transformed into a globule of perfect soap. This result is obtained in two or three hours. These saponified globules heated to 60° C. (140° F.) give up the excess of lye with which they are charged, and retain only water sufficient for ordinary soap. They become eventually transparent, and by stirring form a layer of melted soap above the lye. The saponification is so complete, that to prepare commercial stearic acid, it is only necessary to add a corresponding quantity of diluted sulphuric acid, and the fatty acids may be separated from the solution of sulphate of soda. By melting with steam, crystallizing and pressing when cold, a commercial stearic acid is obtained perfectly pure, melting at from 57.7° to 58.8° C. (136° to 138° F.), while the oleic acid flows off nearly colorless. This latter acid is of a better quality than many fixed oils, and more useful to manufacture white soap of first quality either alone or mixed with some other fatty substances. By using it alone, it has only to be neutralized by weak lyes; the formation of the soap takes place immediately, and it can be melted at once. If mixed with some other fat, this fat has to be transformed into the globular state and the saponification is effected in six hours; and in twenty-four hours a soap may be prepared which is as neutral and nearly as good as the best olive oil soap. Thus not only is time saved, but there is no loss of fat as in the ordinary process of boiling soap.

Knapp attributes the great efficacy of the globular state not so much to the globular form as to the microscopic size of the tallow globules, which may be attacked to their centre by the lye, while a large lump of tallow, under the same circumstances, would soon be coated with a stratum of soap of a thickness which would render it impossible to penetrate it. As to the saponification in the kettle, there is, strictly speaking, only an emulsion of fat obtained, a homogeneous milky mass, formed by the union of the melted tallow with the lye; moreover, soap is simultaneously produced by the first contact of these substances. This emulsion, after standing a few hours in the cold, becomes gradually saponified. It might be expected that the process would be more rapid under the influence of heat and agitation, but this is not the case, and the hypothesis is that, in the boiling, each fat globule is immediately enveloped in a coating of stearate of soda, which protects the nucleus from further saponification. In like manner, and upon the same principle, heated soap bubbles are only denuded of their gelatinous coating, and the mass becomes a thickish soap solution rather than a chemical compound.

Again, concentrated soap in the heated mass will retain a considerable quantity of fat in solution, consequently diminishing the action of the alkali. This may be remedied by the addition of a middling strong lye; but in any case, cooling and quiet are found to promote the combination of fat with alkalies, after having been heated for a sufficient length of time to effect as minute a division of the molecules as possible in the characteristic form of an emulsion. For this purpose a temperature greater than 48.9° C. (120° F.) is not required.

Perutz affirms that the facts discovered by Mege Mouries have been successfully applied in soap making. "To every rational nanufacturer," he says, "it must be known that saponification is produced with greater ease when the fat is stirred for about an hour under a slight heat—about 60° C. (140° F.)—with the so-called combination lye, and suffered to remain undisturbed for one night." As this mixture never reaches the boiling point, it follows that the globular emulsive state must be produced and saponification expedited.

With the view of improving this discovery, and shortening the time of boiling, Perutz proposes to add to the fat the whole quantity of lye necessary for the saponification, and then proceed according to Mege Mouries' plan, leaving the mixture quiet all night. Until now, soap boilers have not, at the beginning, added the entire quantity of lye required, because experience has shown that saponification is thereby rendered more difficult; but, on the other hand, it has also been ascertained that the saponification is more rapidly effected at a low temperature. Whether this process of fabricating soap, as Mege Mouries asserts, is essentially cheaper than the usual method, could only be decided by experiment on a large scale, but that, if we work only with pure materials, a very beautiful pure soap is obtained, we have satisfied ourselves by experiments.

Methods of M. D'Arcet.—These suggestions have an interest here as they throw some light on our subject and have a scientific basis, and may be a guide to new methods. He remarks, there are two very distinct operations in the fabrication of soaps; the first has for its object to chemically combine the alkali with the fatty bodies, while in the second, the formed soap must be made to contain the proper quantity of water, by the processes of liquefaction or mottling if a white soap containing 50 per cent. of water, or a marbled soap containing only 33 per cent. is to be manufactured.

The first operation, called saponification, presents numerous difficulties; it is important to add to the fatty body the necessary caustic lye, little by little, and of a proper density. so that the soap when formed will not dissolve in the liquor, nor be transformed into too large and too hard grains. If the soap dissolves in the boiling lye, the whole will soon form a mass, the soap will burn at the bottom of the kettle, and the operation thus conducted will be impossible. If, on the contrary, the saponification is effected by using too much of, or too concentrated a lye, the ebullition will with difficulty bring about a sufficient contact between the fatty bodies and the lye, which will retard the saponification, and increase the expense in fuel, work, etc.

The necessity of keeping the soap during all the time of the saponification in a state of half solution in the boiling lye, presents great difficulties of execution, and renders the operation much longer and too costly.

The saponification being finished, the soap is boiled down, that is, until the lye on which the soap floats is concentrated by evaporation to the density at which the grain contains just the necessary quantity of water. It is thus, that after the saponification, the soap contains more than 50 per cent. of water, while towards the end of the coction the grain of soap contains only about 16 per cent.

This operation has for its principal object to leave in the grain of the soap only the proper quantity of lye, but it presents at the same time the advantage of completing the saponification, if this first operation has not already been completely effected, and besides, of rendering the soap homogeneous in all its parts. After the coction of the soap comes its liquefaction, if it is to be converted into white, or its mottling, if it is to be manufactured into marbled soap.

The liquefaction or fitting has for its object to soften the grain of the soap, to introduce into it as much as 55 per cent. of water, instead of the 16 per cent. that the coction has left in it, to render the paste nearly liquid, and to favor thus, during the cooling of the soap in the frame, the precipitation of all foreign substances that the grains may contain, which contributes to bleach this kind of soap, and to give it much homogeneity, and a great degree of purity.

As for the marbling of the soap, it might be improved. It is true that soap has been marbled at Marseilles for many years, and when the art of soap-making is well understood it strikes me that since the origin of the art, the manufacturers have obtained soaps more or less well marbled.

At the time of the saponification, the iron which is held in solution in the lye of sulphuretted soda combines with the fatty bodies and the iron of the kettle, and forms a soap of iron, and the manufacturer is often obliged to add some green vitriol; on the other hand, the alumina and lime contained in the lyes are also converted into soaps of alumina and lime, and these three soaps dissolve in the nearly liquid mixture of oil and soap submitted to the saponification.

Later, when the saponification is finished, and even at the end of the coction, the soaps of iron, lime, and alumina are so uniformly divided in the mass, that it may be said that they are in a state of true solution. They color it a grayish-blue in all its parts, if the lye on which the soap boils has not ceased to be sulphuretted; and the soap, suddenly cooled and cut into thin plates, looks then like damp slate.

The soap, being finished and colored as we have just stated, is too dry on account of the high density of the boiling lyes on which it floats. It must be brought back to contain at the most 36 per cent. of water. This is done by the operation called mottling, which has for its object to swell and soften the grains of soap. (See Marseilles Soap.)

When this is done, the mass of soap ought to be evenly penetrated with water throughout; the grains must be soft and voluminous, hardly separated from the warm lye on which they float, and the greater part of which is interposed between the grains of soap properly softened. The soap is then run into the frame, and the operation is finished. Let us see what takes place in the frame.

If the soap is run into a thin dish, and if a portion of the soap, taken at the time it is run into the frame, is quickly cooled down, a soap uniformly colored blue like damp slate is obtained; the soap then is not marbled at the time; the mixture of the soaps of iron, alumina, and lime, colored by sulphuretted lye, is still in solution in the mass, but by degrees, and by the progressive cooling, the soaps of alumina and lime, being less soluble and less fusible than the soap of soda, separate and divide in the mass of soap, which is white for the greater portion, but is streaked with strongly colored runs, which are formed by those portions of the soap in which has concentrated the mixture of the soaps of iron, lime, and alumina, colored blue by the action of the sulphuretted lye.

The marbling of the soap is not an effect produced by a simple mechanical mixture of two soaps, one of which is colored; the cause which controls its formation belongs to a more elevated order, for the separation of soaps having different bases, during the cooling in the frame, is effected by the action of that force which separates alloys at the time of their solidification, the effect of which is known by the name of *liquation*, and to which we attribute the formation of granites, etc., and in general, that of all the primitive crystallized rocks.

In the fabrication of the bar soap by using sulphuretted lyes, a white soap is obtained, because the liquefaction is carried to the point where the paste is fluid enough to permit the whole of the blue colored soaps of iron, alumina, and lime being heavier to separate completely and fall to the bottom of the kettle.

The mixture of soaps of iron, alumina, and lime, dissolved in ordinary soap, and colored by the action of the sulphuretted lye, quickly loses its color in the air under the influence of water and the excess of alkali the soap contains; the blue color by disappearing leaves a yellow trace, so much darker when there is more iron in the soap, which is due to this, that the mixture of the soaps of iron, alumina, lime, and soda, being desulphuretted, is colored only by the iron soap which has an ochreous yellow color. These yellow lines are not wanted by the consumer, and they result in a loss to the soap-maker. It is required that the soap shall have a marbling of a fine dark blue, and that the part of the soap thus shaded shall become red in the air, by absorption of oxygen.

In conclusion, for the marbling of soap, the following conditions have to be fulfilled :—

1. To have in the mass the quantity of iron soap necessary to give the required degree of coloration.

2. That the iron soap shall be combined with a sufficient quantity of soap of lime and alumina, so as to produce a transparent, homogeneous, and properly shaded marbling.

3. To have all the time, but especially at the end of the coction, a proper excess of sulphuretted lye in contact with the soap.

4. That the cooling in the frame is managed in such a manner as to produce the required marbling.

Instead of saponifying with weak lyes, and in deep and conical kettles, I operate in large sheet-iron vats being three times as long as they are wide, heated below only by the waste heat of the ordinary kettles, and I use strong caustic lyes containing a little common salt, instead of using weak lyes and gradually increasing their density.

The heat communicated to the vats is not above 50° C. (122° F.), and may be sufficient only to keep the fatty body perfectly liquid.

Instead of stirring the mixture by ebullition, I use a mechanical stirrer conveniently fixed, which multiplies, more economically than the ebullition, the points of contact between the fatty body and the lye. The stirring is continued until the chemical combination which constitutes the soap is completed, which is ascertained by the strength of the lye, which must remain the same, and the complete solubility of the soap in boiling water. The soap is then converted into small round grains without adherency, and swimming on the excess of caustic lye; the saponification is then finished.

The vat in which this operation takes place has its edges elevated about three feet above the large, deep, and conical kettle in which the coction is finished. A wooden gutter is used to transfer the soap from the vat into the kettle; the old lye, remaining in the bottom of the vat, is drawn off, and a new operation may be begun. As for the soap in grains which has been introduced into the large kettle with new lye, its saponification is completed, and the coction is conducted as usual; it is also converted into white or marbled soap.

To manufacture white soap, it is not necessary to add coloring matter; but for the marbled soap, the mass must be colored in the vat at the beginning of the saponification.

This coloration is managed as follows:—

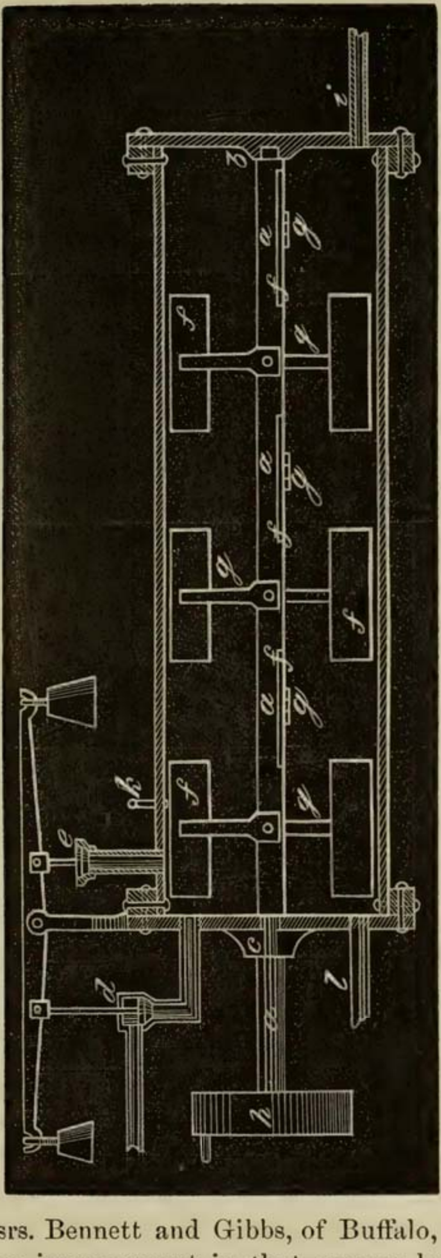
In a kettle, I prepare a mixture of soaps of alumina, lime, and lead, by decomposing in the order indicated below, by an excess of soap dissolved in water, solutions of acetate of lead, chloride of calcium, and alum. The mixture obtained is kept under water, and is used to color marbled soap, which is done by adding at the beginning of the operation enough of the mixture to give to the mass the proper shade. The sulphuretted lye used in the saponification quickly gives to the soap of lead the blackish-blue color necessary to color the marbling, and consequently, it is easy by different trials to obtain the required shade.

What we have said of the marbling of soap, proves that there is a necessary relation between the beauty or the perfection of the marbling of the soap, and the quantity of water it contains. A well-marbled soap cannot contain more than 33 to 34 per cent. of water, while white soap may receive more without losing its good appearance, and it is even whiter when it contains more water. To manufacture white soap containing, like the marbled soap, 33 per cent. of water, lyes free from sulphides must be used, which may increase the expense of fabrication. We have noticed this fact, because it is generally believed that the preference given to marbled soap is ridiculous and without foundation, while on the contrary, this preference is the result of a long experience.

Soaps by Steam Pressure.

In the processes for making soap by pressure and by agitation, using carbonated alkalies, we would call attention to

Fig. 61.



Bennett and Gibbs' apparatus

that of Messrs. Bennett and Gibbs, of Buffalo, N. Y., who have made an improvement in that process, by combining the two together, for which they took out a patent in 1865. Their process consists in agitating the saponifiable materials with caustic or carbonated alkalies in solution in water in a closed vessel while under heat and pressure, in such a manner as to cause a thorough mixing of the fats with the alkaline solution, and producing an instantaneous combination of the fatty acids with the base of the alkaline solution.

We suppose a quantity of fatty matter inclosed in a vessel with a solution of carbonate of soda in water, and heat applied to produce a pressure of 220 to 280 pounds per square inch, and a temperature of 176.6° to 204.4° C. (350° to 400° F.). A combination between the fatty acids and the soda of the solution will take place only at the upper surface of the solution when in contact with the under surface of the grease, the heavy lye occupying the lower part of the vessel, and soap will only be produced when the fat and alkali unite. If we now agitate in such a manner as to stir together and thoroughly mix the contents of the vessel, the whole will be instantly converted into a homogeneous and even quality of soap. It is advisable to use no more water than is wanted in the soap.

The inventors use a boiler or cylinder similar in shape to a plain cylinder steam boiler, resting horizontally and heated in any convenient manner; one or both heads of the cylinder is made so as to be removable, and is about the full size of the inner diameter of the cylinder, so as to admit of the insertion of a revolving shaft *a a a* (Fig. 61), which should be as long as the cylinder itself. The bearings of this shaft should be in the centre of the cylinder, and either or both ends worked through a stuffing box *c*, for the convenience of applying to the pulley *h*, power to revolve the shaft. On the shaft are fastened arms *g g*, with floats *f*, or stirrers, extending nearly to the sides of the cylinder; the arms, floats, or agitators on one side of the shaft when revolved carry the fat down into the alkali, while the agitators on the other side carry the alkali up into the fat, thus, while under heat and pressure, thoroughly mixing the whole and causing the conversion of the whole contents of the vessel instantly into a uniform, even, and good quality of soap. At the fire end of the cylinder are placed two safety valves, one *e*, on the top of the cylinder, the other *d*, on an outlet pipe inserted in the head of the cylinder; they also use a mercury bath *k*, of about four inches in length of gas pipe, and which is screwed into the boiler or cylinder in any convenient place for the insertion of the thermometer bulb. At the opposite end of the cylinder is an opening *r*, for the insertion of a supply pipe; at the fire end is also an opening *l*, for the insertion of a second outlet pipe, and which is intended to be used only when it is desired to draw off the whole contents of the cylinder. The contents of the cylinder when operated upon should be subjected to a pressure of about 220 to 280 lbs. per square inch, and under a heat of about 176.6° to 204.4° C. (350° to 400° F.).

When the shaft is revolved, all of the ingredients in every part of the cylinder are immediately and thoroughly mixed, and the same will take place by means of any other revolving machinery. Perfect saponification is at once effected, and the soap produced is of uniform and good quality. When the machinery is first put in operation, it is necessary to allow some carbonic acid gas to escape by one of the safety valves, if carbonate of soda is used, in order to prevent undue pressure by the liberation of the carbonic acid when combination of the fatty acids with the alkali takes place. If any of the liquids be allowed to escape before the temperature reaches 162.7° to 190.5° C. (325° to 375° F.), they should be returned to the cylinder.

The safety valve on the outlet pipe *d*, may be so loaded as to allow an escape of soap at a pressure of 250 to 270 lbs., and a quantity of lye and oil may be pumped in at the opposite end, the agitation by the revolving shaft being still kept up, and thus a continual stream of soap is kept up as long as the feeding is continued. The product may then be prepared for market by the cooling, moulding, and cutting processes in ordinary use.

By this process the soap is made in less than one hour from the time the ingredients are introduced into the boiler, but a uniform and thorough saponification is obtained at the instant that the heat and pressure arrive at the required degree, be the time long or short; if this degree is reached in five minutes, the soap is made.

The inventors use from 30 to 33 lbs. of carbonate of soda at —48°, and 100 lbs. water to 100 lbs. of lard, tallow, or oil; 27 lbs. of carbonate will make a neutral soap for soft water. The product obtained is 200 lbs. of soap for every 100 lbs. of grease.

Any kind of soap can be made by this process; soft soap is prepared with the same rapidity as any other, and is much more perfect and requires a less quantity of potash than by the open kettle process; four lbs. of potash being required for one barrel.

To conclude, we would state that the advantages claimed for this process are:—

1. The rapidity of manufacture. 2. The improvement in quality. 3. The increased quantity. 4. Economy in labor. 5. Saving of fuel. 6. The use of cheaper material. 7. The saponification of all the grease. 8. The uniform certainty of the results. 9. The saving of the valuable property of glycerine which greatly improves the quality of the soap. 10. The ability to use alkaline salts instead of caustic lye, obviating the necessity of using chloride of sodium, which is required by the common process, in order to get rid of the waste lye.

Professor Dussauce examined some specimens of soap made by this process, and found them perfectly neutral, and entirely saponified, without a trace of carbonated alkali, and not containing as much water as soap made by the ordinary process.

SECTION XVI.

SOAP ANALYSIS.

THERE are few articles of industry or commerce that are subject to so much falsification as soap, and it is partly because the public ignorantly wish a cheap one, hence there is always a desire to find a suitable and often an unsuitable substitute with which to adulterate it, to enhance the profits of unprincipled makers.

There are many methods of analyzing and appraising soaps, but they are not so easy or simple that every one can perform them with the necessary accuracy. Soaps differ according to their value in alkali and to their organic ingredients, *i. e.*, fat and rosin. Thus in the valuation of soap we have to consider: 1st. The contents of water; 2d. The proportion of sebacic acids to the alkali; 3d. The nature of the alkali and of the sebacic acid; 4th. The intentional or unintentional admixture of foreign substances.

Although the amount of water in a hard soap appears easily determined, it is nevertheless a somewhat difficult matter. This is easily seen when we know that each part of a cake or bar of soap contains a different amount, the outer part being denser than the centre, so a sample for testing should be a mixture of all parts to make an average. The sample obtained is to be scraped fine, the different parts uniformly mixed, and from this the quantity to be investigated weighed off; both operations, of mixing and weighing, must be carried out quickly so that the soap can neither absorb nor lose water. The sample, say about 10 grammes scraped soap, is placed in a small porcelain saucer, weighed, and placed over a water-bath and heated until the soap no longer loses in weight. At first the soap is left entirely untouched, and only when it has passed from the liquid into the pasty state the lumps are pressed with a glass spatula which has previously been weighed. If the two last weighings correspond, the soap is removed and weighed, and the loss is the weight of the water contained in the soap.

Determination of the Amount of Alkali.—For this purpose it is well to use the dry soap left by the determination of the amount of water. This is placed in a glass flask, the porcelain saucer and glass spatula are repeatedly washed off in strong alcohol, putting all the liquid of the rinsing operation into the flask, then add from 50 to 60 cubic centimetres (1.69 to 2.03 fl. ozs.) of the strongest alcohol, the whole heated in a water-bath putting the stopper loosely on. The soap is dissolved, allowed to precipitate, and to cool off. The liquid, having cleared off perfectly, is decanted carefully into another larger flask. Pour over the residue some alcohol, let it settle, and operate as in the first case. The residue is then placed upon a filter and completely washed out with alcohol. The residue left on the filter consists principally of carbonate and sulphate of alkalies, carbonate of lime, and other mechanical admixtures. The residue is dissolved on the filter and with distilled water, washed out, when test the carbonate of alkali in the filtration, by alkalimetry, as also the sulphuric acid present, by chloride of barium in the liquid soured with muriatic acid. The sulphate of barium is placed upon a filter, washed out with distilled water, dried, calcined, and weighed. We calculate thus the sulphuric acid present, respectively, in the sulphate of potash and the sulphate of soda: 116.5 parts sulphate of barium correspond to 40 parts of anhydrous sulphuric acid, 87.11 parts anhydrous sulphate of potash and 71 parts anhydrous sulphate of soda. The liquid filtered off from the sulphate of barium is mixed for assaying the surplus addition of barium first with ammonia, then with carbonate of ammonia, filtered and washed out. The filtered liquid is evaporated in a small porcelain saucer until dry, and the muriate of ammonia ejected by calcination. The saucer is now placed upon a sensitive scale and balanced, emptying its contents without loss into a 100 cubic centimetre (3.38 fl. ozs.) measuring flask, rinsing the saucer with water, drying it by warming, placing it again upon the scale, and by additional weights causing it to balance. The weights placed on after deducting the calculated sulphate of potash found in the sulphuric acid, show the alkalies present as chloride of potassium and chloride of sodium. We will designate this weight by A. To find herefrom the respective quantities of soda and potash, we determine the quantity of chloride in A, by dissolving the salt mixture to 100 cubic centimetres (3.38 fl. ozs.), then placing a certain part of this solution (10 to 20 cubic centimetres = 0.338 to 0.676 fl. oz.) in a white porcelain saucer, adding a few drops of neutral chromate of potassa, and then from a $\frac{1}{10}$ cubic centimetre graduated pipette so much standard nitrate of silver solution until the ensuing precipitate shows a reddish coloring. By determining, the chloride, the data for continuing the calculation are given. We know now, 1, the weight A, and, 2, that of the chloride contained therein = C. If the two unknown quantities are designated chloride of potassa with x and chloride of sodium with y, there is

$$x + y = A. \qquad \text{I.}$$

The chloride of potassa contains the 0.47552 of its weight of chloride, the chloride of sodium the 0.60657 part of its weight of chloride.

x parts chloride of potassa hence 0.47552 x parts chloride and
x parts chloride of sodium hence 0.60657 y " "

$$0.47552\,x + 0.60657\,y = \qquad \text{II.}$$

If we place of equation I. for x its value, to wit, x = A — y, and substitute it in the equation II., then we obtain:

$$0.47552\,A + 0.13105\,y = C, \text{ and herefrom}$$

$$y = \frac{C - 0.47552\,A}{0.13105}$$

$$x = \frac{0.60657\,A - C}{0.13105}$$

From the figures thus found for the chloride of potassa and the chloride of sodium, we calculate the potash and the soda according to the proportions.

74.56 parts chloride of potassa are = 47.11 parts potash and
58.45 " chloride of sodium " = 31.00 " soda.

These salts do not form a constituting ingredient of the soap, they are an intentional or accidental surplus present. The sulphuric acid is, in the first place, calculated as sulphate of potassium and a surplus as sulphate of sodium, the rest is carbonate of potassa or carbonate of soda. The alkaline chloride, and also the free caustic alkalies, are found in the alcoholic solution, and are determined in the following manner: This alcoholic solution is well and constantly shaken, with an accurately weighed quantity of bicarbonate of soda, or potash. By this process the caustic alkalies change into carbonates, which, as they are insoluble in alcohol, will precipitate to the bottom. Now we decant, rinse the residue with alcohol, and then place upon a filter, where it is fully washed out with alcohol. The residue upon the filter, dissolved in distilled water, determines in the filtrations by means of standard nitric acid the carbonate of soda, and deducting from the quantity thus found, the applied bicarbonate of soda, the rest is that surplus carbonate of sodium, which was present in the soap.

In the alcoholic soap solution now only remains for determination the chloride of potassa, as also the alkalies combined with the sebacic acids. For this purpose, the solution is divided into two equal parts. The one of these parts is analyzed by a measured quantity of standard nitric acid, which is warmed until the separated sebacic acid melts, separating them, after they congeal, melting them again in distilled water, and uniting the here obtained acidy liquids. The surplus of the acid is now titrated back, and finding now from the nitric acid neutralized by the alkalies, the alkalies present potash and soda. In the same liquid, after having been made somewhat alkaline by a few drops of carbonate of soda; and having colored it yellow, with neutral chromate of potassa, we determine by means of $\frac{1}{10}$ nitrate of silver, the value of chloride of potash.

A more simple, although less accurate, yet in most cases amply sufficient method, by which to determine the value of free alkalies (caustic as well as carbonate) contained in soaps, consists in weighing a portion of the soap, dissolving the same in distilled water, and separating it with culinary salt, which has no earthy salts, gypsum, chloride of calcium, or chloride of magnesium, etc., or rock-salt. We must not warm it, so that the soap separates grainy, and it is then washed out upon a filter with a concentrated solution of pure chloride of sodium. In the filtered liquid, the alkalies are found dissolved. In order to determine the carbonate and the caustic alkali separately, the solution is mixed with chloride of barium, gathering the precipitate upon a filter, washing it out, and putting it into a beaker glass, wherein it is dissolved in a surplus of measured standard nitric acid, and the surplus of the latter is then analyzed by means of the standard alkali. From the nitric acid used, the quantity of carbonate of potash or soda, or both together (specifically only the quantity of the carbonates) is ascertained. The liquid filtered off from the carbonate of barium, contains the caustic alkalies, which may then be determined by alkalimetry. In the testing of soda-soaps, as a rule no consideration need be taken as to their value in potash; but if this is nevertheless intended, one part of the liquid is to be concentrated and mixed with bichloride of platinum. If no yellow precipitate ensues then no potash is present.

It yet remains to determine the relative quantities of potash and soda, which have really formed the soap. To this end, the other part of the alcoholic soap solution is to be analyzed. This is done by muriatic acid, separating the sebacic acid from the liquids, washing it well with water, and finally evaporating the acidy lye with the washing water in a porcelain saucer, until it becomes entirely dry. Here great care must be taken, so that no loss is experienced. The porcelain saucer, while yet a little warm, is placed on the scale and balanced; it is then removed, emptied, rinsed, and dried by warming, and again placed while yet a little warm upon the scale and again weighed. Thus the aggregate quantity of alkaline chlorides is obtained, from which the chloride of potassa found in the first test is deducted, and from the rest, by the above stated process, the proportion between the potash and soda is calculated. The quantities thus found are to be doubled for the soap which is tested

We have yet to consider the residuum, which in dissolving in distilled water remains upon the filter. It consists of carbonate of lime, carbonate of dolomite, clay, and silicic acid. Its quantity is as a rule very small, and the determination of these substances can be taken simultaneously, by taking the dried precipitate from the filter, calcining in a platina crucible and burning the filter, and weighing the whole.

Another method for determining the alkalies combined with the sebacic acids, has the advantage that the potash is at least directly determined, and consists in this: The alcoholic soap-solution is evaporated by the volatilization of the alcohol, diluting with water; the solution is decomposed by oxalic acid to a weak acidy reaction, the sebacic acids are separated, the liquid evaporated to dryness, the residue calcined, and the coaled mass completely washed out with distilled water. It is now filtered, the coal washed out and determined in the filter, the value of the alkali by titrating with a solution of tartaric acid (75 grammes (2.63 ozs.) to 1000 cubic centimetres (1 litre = 2.1 pints) dissolved), then adding of the solution of tartaric acid again as much as had been used for neutralization, evaporating the liquid in the water-bath until dry, cooling to the temperature of the room, and treating the salt residue saturated at the same temperature with a solution of bitartrate of potassa. This now dissolves the foreign salts, and leaves the potash as bitartrate of potash, which is dried by a gentle heat, and then weighed. From the weight the potash contained therein is calculated.

100 parts of the dried bitartrate of potassa correspond to 25.04 potash. If the potash thus found is deducted from the aggregate quantity of the alkalies, obtained by titration with tartaric acid, then the rest is soda.

By the chloride of platinum also, the potash can be directly determined; this method is however rather expensive. For discerning the free alkalies in soap, Stein has proposed a very simple method, by which it becomes obvious, without further trouble, whether free alkali is present or not. Stein applies to this end corrosive sublimate (bichloride of mercury), which furnishes with the sebacic acid a white sebacic peroxyd of mercury combination, while in the absence of a free alkali (caustic as well as carbonate) red peroxyd of mercury is formed. Stass has proposed for this same purpose calomel, which, if free alkali be present, becomes black. The sublimate has however the advantage over calomel, that it can be applied in solution, and also that soaps may be tested with it without dissolving them, by moistening a fresh cut surface with a solution of sublimate. On the other hand, for determining the free alkalies in rosin soaps, binitrate of mercury is well adapted. By its application for testing rosin soaps, the heating of the liquid must be avoided, because by the resinous acid protoxyd of mercury may suffer a decomposition.

Determination of the Amount of Sebacic Acids and of the Rosin.—For this operation the sebacic acids may be used, as we have separated them by the two preceding methods. Especial care must be taken that no loss is incurred, which might easily happen, because the sebacic acid will adhere to the sides of the vessels, and from thence cannot be again removed by water and be regained. This is attained by washing with benzine, which by heat is entirely volatilized again. If by this means all sebacic acid has become reunited, the sebacic acids are melted, thus ejecting the adhering water and benzine. But these acids being mostly too soft to be accurately weighed, they are usually melted together, with dried white wax or stearic acid, which substances have been previously accurately weighed. The fat cake is placed upon a filter, and washed out with distilled water, until the washing water is no longer acid. The drying is performed under a glass cover with concentrated sulphuric acid. The drying may also be performed in a porcelain saucer over a water bath, and can be continued as long as the saucer no longer loses in weight, whereupon the melted acid is poured out, the saucer cleansed with a little lye, dryed off, and when thus empty is weighed. From the aggregate weight is deducted in the first place that of the wax or stearic acid. The rest represents the hydrates of sebacic acid, in case rosin soap is not investigated. The hydrates of stearic acid, palmitic acid, and oleic acid have nearly the same value of water, which with sufficient accuracy may be placed at 3.25 per cent. From the weight of sebacic acid found, 3.25 per cent. are therefore deducted and the rest as the sebacic acid is taken into the analysis. Very frequently it happens, that the hydrate of the sebacic acids is not deducted, and the hydrates of the same anhydrous sebacic acids calculated. By the error thus committed, the value of the sebacic acid in the soap appears too high.

Under certain circumstances the melting points of the various acids may give a basis as to the kind and derivation of the sebacic acids, especially if the point in question is to determine whether two samples of soap before us are equal or varying. For this experiment a small quantity of sebacic acid is melted and the temperature observed. While slowly cooling off, the mercury in the thermometer will be observed remaining somewhat longer at a fixed degree, whenever the point of congelation is reached, and the temperature thus indicated is the melting point. If but little of the sebacic acid is at our disposal, then according to Douis we operate as follows: A thin glass tube is taken, drawn out to a very narrow tube, and the narrower part, which is turned downward, is filled up with the melted acid. After the congealing has taken place, the apparatus is placed in water, which is slowly heated. At the moment of melting, the partly melted sebacic acid is forced upward by the pressure of the water. The temperature of the water, at which this observation takes place, is also the melting point of the acid.

According to Stöckhardt the sebacic acids congeal as follows:—

of pure tallow soap	at 44° to 45° C. (111.2° to 113° F.)
of pure palm oil soap	at 38° to 39° C. (100.4° to 102.2° F.)
of 1 part tallow and $\frac{1}{3}$ part cocoa oil	at 32° to 35° C. (89.6° to 95° F.)
of 1 part tallow and $\frac{1}{2}$ " "	at 29° to 30° C. (84.2° to 86° F.)
of 1 part tallow and 1 " "	at 27° to 28° C. (80.6° to 82.4° F.)
of 1 part palm and $\frac{1}{2}$ " "	at 27° to 28° C. (80.6° to 82.4° F.)
of pure cocoa-nut oil	at 23° to 24° C. (73.4° to 75.2° F.)

A less accurate, but for all common cases amply sufficient method to determine the value of sebacic acid in a soap, when the separated fat, instead of being weighed, is measured, has been proposed by Buchner. To this end is used an alembic of glass, with a long and not too wide neck in which is inserted a scale graduated into ⅕ cubic centimetres (0.054 fluidrachm). In this apparatus are placed 16⅔ grammes (0.58 ounce) soap, with diluted muriatic acid, and heated. If the decomposition is perfect, lukewarm water is used to fill up, until the division mark between the watery and the fatty layer reaches the zero point of the scale, or is somewhat above it. After leaving it to cool off to the temperature of the room, the height of the fatty layer is read. If the specific gravity of sebacic acid is calculated at 0.93 and multiplied by the indicated cubic centimetres, we obtain the weight of the hydrates of the sebacic acid, and can thereby calculate the quantity of fat which has been applied in the fabrication of the soap. According to Buchner, 50 kilog. (110 lbs.) fat furnish 77½ kilog. (170.5 lbs.) of the fine grain soap, and about $\frac{1}{16}$ glycerine. For an easy mode of calculation, Buchner furnishes the following table:—

The sebacic acid separated from 16⅔ g. soap measures in cubic centimetres	Specific gravity of the oils and fats.	The separated sebacic acid hence weighs in the mean in grammes.	The fat used for 100 kilog. soap.	The grain soap contained in 155 weight parts of soap.	100 weight parts soap contain of water, lye, and glycerine.	100 weight parts soap contain of real grain soap.
½	0.93	0.46	3.13	4.85	97	3
5	"	4.65	31.30	48.50	69	31
6	"	5.58	37.56	58.20	63	37
7	"	6.51	43.82	67.90	57	43
8	"	7.44	50.08	77.60	51	49
9	"	8.37	56.34	87.30	44	56
10	"	9.30	62.60	97.00	38	62
11	"	10.23	68.86	106.7	32	68
12	"	11.16	75.12	116.4	26	74
13	"	12.09	81.38	126.1	20	80
14	"	13.02	84.64	135.8	13	87
15	"	13.95	93.90	145.5	7	93

Determination of the Amount of Rosin.—Pure rosin soaps do not generally exist, and it would be easy if such were the case to distinguish the rosin soap from a fat soap. On the other hand the determination of the amount of rosin in a soap, particularly if the point in question is the investigation of an imitation, is very often of great importance, in order to find out the accurate composition of such a soap, to which as is self-evident the determining of the amount of rosin contained in such an imitation belongs. There are several methods, according to which the quantity of the rosin contained in a soap can be determined. Chemistry, however, must confess that it has not yet succeeded in finding a ready technical method.

The following method, which furnishes reliable results, originated with Sutherland. According to this, the soap is cut up into small pieces, weighing a certain quantity, for instance 33⅓ grammes (1.17 ozs.) accurately, and pouring over it, in a porcelain saucer, some strong commercial muriatic acid. The saucer is covered with a glass plate, and heated over an alcohol flame until all soap pieces are perfectly dissolved and decomposed, and the sebacic acid with the rosin floats above. Now 133⅓ to 166⅔ grammes (4.67 to 5.83 ozs.) warm water are added, and the saucer allowed to cool off. The now congealed fat-cake, thereupon, is carefully taken off, and can be already judged by its appearance, whether rosin is contained therein, or not. It is remelted with warm water, in order to remove all adhering acidy solution, and again cooled off, carefully dried with blotting paper, and melted again without water, until the boiling degree is reached. This is for the purpose of removing the last vestige of water. After cooling off, the fat-cake is placed upon the scale, to ascertain its exact weight. In all these operations, all loss must be carefully avoided.

If the soap were a pure fat soap, the fat cake thus obtained, after the deduction of 3.5 per cent. for the hydrate, would be 95.5 per cent. of the originally applied fats, and the latter can be easily calculated. But if rosin be present in the soap, it is found in the sebacic acid cake, and this must now be treated as follows. It is placed in a porcelain saucer, holding about ½ kilog. (1.1 lbs.) water, pouring strong nitric acid over it. Then it is heated very cautiously until the boiling point is reached. At this moment a violent ebullition will ensue, and thick red vapors will develop. As soon as this occurs, the lamp is immediately removed; and is placed under it again when the violence of the reaction has ceased. It is now left to boil a few minutes, while frequently stirring with a glass rod, adding now and then small portions of nitric acid, until no more red vapors develop. All these operations are performed in the open air, on account of the development of acid vapors. It is again cooled off, removing the cake of sebacic acid, which floats upon the strong acidy and deeply colored acid of the rosin, washing it off, and remelting it in nitric acid.

After cooling off it is finally dried, and once more melted, by itself at a gentle heat, until no more acid vapors appear, and then left to congeal. What remains is pure sebacic acid, and the difference in weight (the loss) against the weight of the cake first weighed, indicates the quantity of the rosin. The latter is thus obtained immediately, but the quantity of the pure sebacic acids found must, as was stated before, be calculated after the reduction of the neutral fat. This is done by deducting 4½ per cent., corresponding to the glycerine present.

If the soaps have been made with oil, *i. e.*, liquid fats or oleic acid, then the separated sebacic acids do not congeal easily into a solid cake, and it would then be difficult to weigh them accurately. In this case also the condition of an exactly weighed small portion of white dried wax serves to melt it together, in order to obtain a firm cake, which can be weighed without trouble, and from the weight of this, in order to ascertain the quantity of the sebacic acids, the weight of the added wax is deducted.

Of this mode of determination we have to remark, that too large a surplus of nitric acid must be avoided, nor should the same act upon the sebacic acid cake any longer than is necessary, since according to Heintz, a small portion of stearic acid or palmitic acid becomes easily oxydized.

Determination of Soap as to Admixtures.—To enhance the weight and quantity of soaps, they are frequently mixed with cheap, grainy bodies, such as clay, chalk, silicic acid, barytes, starch, etc. These substances remain—by treating the soap with strong alcohol—as a residuum, and may then be, as to their nature, further investigated. If the residue is boiled in water, and a thickish liquid is produced, which can be colored dark-blue by one or a few drops of tincture of iodine, then starch is present. If the liquid be strongly alkaline, it must, before adding iodine solution, be neutralized by acetic acid. To determine whether lime, silicic acid, or clay is in a soap, the residue is treated with muriatic acid, and evaporated over a water-bath to dryness. If silicic acid be present, this remains as a grayish, coarse powder. Clay is present in the liquid, if it precipitates with ammonia to a glutinous substance, which easily dissolves in caustic soda-lye; and if chalk be present, carbonate of lime is produced by the precipitate obtained of the filtered liquid. Oxalic acid produces a white precipitate of oxalate of lime.

The various kinds of soap have often been treated as to their compositions or combinations, and from these analyses is learned how much the soaps which are found in commerce differ from each other. We annex some of these analyses below. Moreover, it also appears, as if in these investigations and experiments *lime* and *dolomite* had not received that attention which they deserve as ingredients of a soap; since none of these analyses mention these minerals as ingredients of soap. And yet it is doubtful if there exists a soap in which they are not present. And in such a case, we may surely suppose, that they are present as sebacic acid salts, forming a portion of the sebacic acids.

Table of Analyses of Soaps.

Kind of soap.	Sebacic acid.	Potash.	Soda.	Lime.	Water.	Admixtures	Investigated by
I. *Grain (curd) Soaps.*							
Marbled grain soap of tallow boiled with potash, separated by culinary salt, after several years' keeping	81.25	1.77	8.55	......	8.43	......	Heeren.
White tallow grain soap	61.00	......	9.70	......	23.80	3.6	Stöckhardt.
The same fresh	58.00	......	8.40	......	28.80	2.3	"
Marseilles soap	66.99	......	7.80	......	21.24	4.0	Bolley.
Marbled tallow soap	72.30	......	9.70	......	14.80	0.8	Stöckhardt.
The same fresh cut	60.90	......	8.90	......	25.60	1.2	"
Castile soap, specific gravity 1.0705	76.50	......	9.00	......	14.50	......	Ure.
The same, specific gravity 0.9669	75.20	......	10.50	......	14.30	......	"
Palm-oil soap, unbleached	65.2	......	9.8	......	19.9	1.1	Stöckhardt.
The same bleached	61.2	......	9.7	......	24.8	1.3	"
Oleic acid grain soap from a manufactory in Rheims	67.3	......	10.9	......	17.3	......	Deite.
Bleaching soap from a Rheims factory	74.5	......	7.9	......	13.1	......	"
Wax soap from a Magdeburg manufactory	74.1	......	7.9	......	14.7	......	"
II. *Swiss (gluten) Soaps, etc.*							
White tallow soap	42.8	......	8.8	......	39.1	3.6	Stöckhardt.
Marbled tallow soap	47.6	......	8.7	......	35.0	3.5	"
Cocoa-oil soap	46.4	......	9.0	......	36.8	3.3	"
Palm-oil soap	49.6	......	8.0	......	35.4	1.1	"
London cocoa soap	22.0	......	4.5	......	73.5	......	Ure.
III. *Soft Soaps.*							
Common soft soaps	42.8	9.1	......	......	48.0	......	Chevreul.
London white soaps	45.0	8.5	......	Carb. of potash and caustic potash	46.5	......	Ure.
Belgian green soaps	36.7	7.0	......		57.0	......	"
Scotch white soaps	47.0	8.0	......		45.0		"
Green lustre soaps from Magdeburg	32.46	7.91	0.34	3.455	45.34	Sulphate of potassa 0.385	Grager.
So-called Elaidin soap from Magdeburg	40.00	0.69 bound 0.75 free	Chloride of potas'm free. 0.33	0.13	48.22	Sulphate of potassa 0.88	"
Elaidin soap, origin not known	40.12	5.10	2.75	......	52.02	......	"

Valuation of Soaps.—The value of soaps is determined generally, according to their contents of neutral fats or sebacic acids. Although soaps with a certain excess of free or carbonated alkali take better hold, that is, act stronger for the removal of dirt, it must not be overlooked that the free alkali not only hurts the hands, but also the textile fibres of the articles washed. For this reason, since soaps seldom are in the market with excess of fat, the sebacic acid value of a soap may be considered the correct rule and measure for the value of a soap. This however is subject to a limit, in so far, as the equivalents of the sebacic acids are somewhat varying, so that equal weights of various sebacic acids, require various weight proportions of alkali, in order to be changed into neutral sebacic salts. If in this manner the Grain (curd) and Paste (cold) soaps are compared with each other, they correspond (if the greatly filled soaps are excepted), in regard to their value of neutral sebacic acid soap, the former to the latter approximately as 15 : 11, and in regard to their value of sebacic acids as 10 : 7. In commerce the prices of grain soaps correspond approximately to the cold soaps, = 7 : 6. According to the sebacic acid—and sebacic acid soap value, the prices should compare as 8 : 6, and we find hence, that the cold soaps, in comparison with the grain (boiled) soaps, are sold too high.

If despite this in modern times the use of cold soaps has overtaken that of grain soaps, the reason of this is partly found in the fact, that the cold soaps, by dint of their contents of cocoa-nut oil, foam very much, on which property a certain value is placed, and for the reason that it is really thought they are cheaper; for the common consumer, who is not in a position to investigate or examine a soap more accurately, is constrained to regard such external, and in this case deceptive signs, as firmness and good frothing are. On the other hand, it has also happened that wool-washing establishments, whose demands for soap amounted to several thousand pounds per week, very soon made the observation, that they used $\frac{1}{5}$ to $\frac{1}{6}$ more of a good cold soap than of an equally good boiled soap. The proportion was also here more unfavorable than was stated above, or perhaps for the reason that the greater solubility of the cold soap brought with it a larger consumption.

CAILLETET'S PROCESS.

It may interest the manufacturer to read the details of this process, which we give in full from the *Bulletin de la Société Industrielle de Mulhouse* (No. 144, vol. xxix. p. 8).

Characteristics of the Aqueous Solutions of Soaps, Normal Acid, and Alkaline Liquor.—The soaps used in industry are formed of fatty acids, of soda and potash, and water. These acids, which are solid or liquid at the ordinary temperature, are extracted from fatty substances of animal or vegetable origin.

The soap of oleic acid often contains rosin.

The white soap obtained by the Marseilles process is formed of:—

60 to 64	parts of	fatty acids.
30 to 36	"	water.
6	"	soda.

Some white soaps are met with in the trade which contain from 40 to 50 per cent. of water. The marbled soap cannot contain more than thirty-four per cent.

When the soap separates from a saturated saline solution, it is formed of:—

Fatty acids	77
Soda	7
Water	16

When anhydrous the same soap contains:—

Fatty acids	91
Soda	9

In certain industries, soaps are used into which there enters more than six per cent. of soda. These soaps by their excess of alkali, and according to their mode of fabrication, may be hydrated enough to contain from 50 to 60 per cent. of water.

The fatty substances which enter into the composition of soaps are generally oleic, margaric, stearic, and palmitic acids. The more or less consistency of the aqueous solution of a soap is due to the presence of solid fatty acids, or to an excess of alkali.

To prepare an aqueous solution of soap, take ten grammes of the soap to be tested, introduce it into a wide-mouthed bottle and add 90 grammes (3.15 ozs.) of cold distilled water, and dissolve over a water-bath. Introduce this solution into a test tube of a capacity of 100 cubic centimetres (3.38 fl. ozs.), and one hour after, examine its consistency.

Hard soaps generally give a solution which by cooling forms an opalescent mass, in which crystallizations are often seen after it has been prepared for some time. Diluted with cold water, this solution divides into an acid salt which deposits, and an alkaline salt which remains in solution. The acid salt sometimes deposits in the form of a flaky substance, without consistency; it is ordinarily richer in solid acids than in liquid; sometimes, as with a solution of soap of cocoa-nut oil diluted with its volume of water, the acid salt which deposits assumes a crystalline form, and remains attached to the edges of the vessel in which the mixture has been kept.

A warm solution of 10 grammes (.35 oz.) of soap of olive oil, and 90 grammes (3.15 ozs.) of distilled water, is transparent as long as the solution is warm, but as soon as it cools down it becomes more and more opalescent, and lastly, when cold, it is entirely opaque. Its consistency has some anology with that of the white of egg; it can be drawn in threads, and a few days after preparation it has lost some of its consistency. If in the soap which has been dissolved, there have entered fatty acids due to a mixture of sesame and olive oils, olive oil and earth-nut oil, etc., the solution is less opaque and has not so much consistency as that produced with olive-oil soap alone. If in the composition of this latter there enters cocoa-nut oil, the solution is partly curded. A solution of soap of cocoa-nut oil diluted with its volume of water produces, after a rest of twelve hours, an abundant and crystalline precipitate; the liquor is colorless.

Generally, a solution made with 10 grammes (0.35 oz.) of soap and 90 grammes (3.15 ozs.) of distilled water gives, by cooling, a solution much more opalescent and with more consistency, when it contains more solid acids and alkali.

Soaps manufactured with solid fatty acids give a solution which is solid. Thus 3 grammes (46.29 grains) of soap of tallow, and 97 grammes (3.39 ounces) of water, produce a solid solution.

Soaps in which liquid fatty acids predominate give generally a colorless solution at a temperature of 85° to 100° C. (185° to 212° F.). When the fatty acids predominate, as in the tallow soap, the solution looks flocculent. If the soap contains rosin, the solution at 185° to 212° F. is very opaque, and after being prepared a few hours it separates into three parts. The upper part, which is nearly transparent, contains very little rosin and much alkali; the middle part is entirely opaque; the lower part is formed with a white substance which has deposited and which looks like pure rosin combined with very little alkali.

All soaps are heavier than water; they do not act in the same manner when in contact with warm water. If a piece of soap weighing 10 grammes (0.35 oz.) is introduced into a wide-mouthed bottle containing 90 grammes (3.15 ounces) of cold distilled water, and if the whole is heated over a water-bath, the soaps manufactured with olive oil, palm oil, tallow, oleic acid, etc., will float on the surface and become transparent from the circumference to the centre; soon by their contact with warm water, their transparency is complete. The contrary takes place, if the soaps have been manufactured with cocoa-nut oil or rosin; they remain at the bottom of the vessel and dissolve very easily.

The soaps of olive oil, tallow, etc., retain their transparency all the while they are in contact with warm water. If this transparent soap is taken from the warm water, it will retain its transparency for some time; but if the soap is half out of the water and is allowed to cool, the part in contact with the liquid becomes white and opalescent, while the other remains transparent.

Soap in contact with warm water loses at first a part of alkali, water, and fatty substance; it becomes richer in solid acids and is less aqueous. Its transparency is as much greater as it contains less water and alkali; afterwards its solution in warm water will be slower if it contains more stearic than margaric acid, and more of this latter than oleic acid. Lastly, each kind of soap by its solubility in warm water, by the transparency and consistency of its aqueous solution, presents to the observer shades more easily seen by the aid of a comparative examination.

After studying the characteristics of the aqueous solution of a soap, it is very easy to determine its composition by the following method: This process, which consists in measuring the constituent principles of a soap to ascertain its weight, is called *saponimetry*, by which the manufacturer may, in half an hour, test several specimens of soap, compare them, and select the best for his use.

To operate according to this method, it is necessary to prepare beforehand two liquors, one which is acid, the other alkaline. These two liquors ought to be kept in ground-stoppered bottles.

Preparation of the Normal Acid Liquor.

Take

Monohydrated sulphuric acid (66°) . .	189.84 grammes (6.64 ozs.).
Distilled water	same quantity.

and add, after the cooling of the liquor, enough water to make one litre (2.1 pints) at the temperature of 15° C.(59° F.).

10 cubic centimetres (0.338 fluidounce) of normal acid contain 1.8984 grammes (29.29 grains) of monohydrated sulphuric acid, and are equivalent, in forming a neutral salt, to 1.2 grammes (18.5 grains) of soda, or 1.825 grammes (28.16 grains) of potash.

The equivalent of monohydrated sulphuric acid is 612.5 (SO_3, 500 + HO, 112.5 = 612.5).

The equivalent of soda is 387.17.

The weight of sulphuric acid necessary to form a neutral salt with soda (1.2 grammes), is known by

$$\begin{array}{ccccccc} NaO & & SO_3HO & & NaO & & SO_3HO \\ 387.17 & : & 612.5 & :: & 1.2 : & = & 1.8984 \end{array}$$

The weight of this acid, which has to be mixed with a sufficient quantity of water to form one litre (2.1 pints) of acid liquor, is known by

$$\frac{1.8984\text{ grm.} \times 1000\text{ c. c.}}{10\text{ c. c.}}\ x = 189.84\text{ grammes (6.64 ozs.).}$$

To prepare 50 cubic centimetres of acid liquor, we have

$$\frac{1.8984\text{ grm.} \times 50\text{ c. c.}}{10\text{ c. c.}}\ x = 9.492\text{ grammes (0.33 oz.).}$$

Preparation of the Normal Alkaline Liquor.

Pure and dry carbonate of soda . .	41.046 grammes (1.44 ozs.).
Distilled water	enough to

dissolve the carbonate and obtain one litre of alkaline liquor at a temparature of 15° C. (59° F.).

50 cubic centimetres (1.69 fluidounces) of this liquor ought to contain 1.2 grammes (18.5 grains) of soda, a weight represented by 2.0523 grammes (31.66 grains) of carbonate of soda.

To ascertain the weight of the dry carbonate of soda which ought to represent 1.2 grammes of soda to saturate 1.8984 grammes (29.3 grains) of monohydrated sulphuric acid contained in 10 cubic centimetres (0.33 fluidounces) of the normal acid, knowing that 612.5 of monohydrated acid saturates 662.18 of carbonate of soda ($NaO\ 387.17 + CO_2\ 275 = 662.17$), we have

$$\begin{array}{ccccccc} SO_3HO & & NaO,CO_2 & & SO_3HO & & NaOCO_2 \\ 612.5 & : & 662.17 & :: & 1.8984 & : & x = 2.0523 \end{array}$$

We find 2.0523 grammes of carbonate of soda *without water*, representing 1.2 grammes of soda which, dissolved in a sufficient quantity of water, ought to give 50 cubic centimetres of alkaline liquor at a temperature of 15° C. (59° F.).

The weight of carbonate to dissolve in a sufficient quantity of distilled water to obtain one litre of alkaline liquor is known by

$$\frac{2.0523 \text{ grms.} \times 1000 \text{ c. c.}}{50 \text{ c. c.}} = x = 41.046 \text{ grammes (1.44 oz.)}$$

These normal liquids are used in—

SAPONIMETRY.

Soaps Composed of Solid and Liquid Fatty Acids.—The normal acid and the alkaline liquor being prepared, the question is to determine with rapidity the weight of the fatty matter, the alkali, and the water, without being obliged to use the balance.

To obtain this result, take a graduated glass tube of a capacity of 50 cubic centimetres (1.69 fluidounces) divided into 100 parts (alkalimetry), to which a cork is adapted. Introduce into it 10 cubic centimetres (0.33 fluidounce) of normal acid. This acid must be carefully measured. Afterwards, add to it 20 cubic centimetres (0.66 fluidounce) of spirit of turpentine carefully measured; then weigh 10 grammes (0.35 ounce) of soap divided into very thin shavings which is introduced into the tube; cork the tube; stir for a few minutes until the soap is dissolved and then let it rest. A quarter of an hour is sufficient to have a complete separation of the turpentine, of the dissolved fatty matter, and of the water.* The heaviest part, which is water, sulphate of soda, and sulphuric acid, falls rapidly to the bottom of the tube; the lightest part formed with turpentine and fatty matter occupies the upper part; lastly, a layer formed of an albuminous or animal matter occupies the middle. This latter layer, which is neither fatty matter nor water, is sometimes voluminous enough to occupy the whole of the capacity of the tube containing the normal acid. A slight agitation is sufficient to collect it into a very thin

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* The solution of the fatty matter in the turpentine takes place without dilatation or contraction of the volume; it is the same for the mixture of the normal acid with the water.

layer. In this state it is between the normal acid and the turpentine. When the soap contains rosin, this substance partly separates from the fatty matter, and forms a layer between the turpentine and the acid, but it preserves its volume whatever is done to unite it into a smaller space.

The volume of the turpentine with the fatty substance must be diminished by about ½ a division, or ¼ of a cubic centimetre (0.06 fluidrachm), and the volume of the water ought to be increased by that diminution. This correction must be made, because the water attaches itself to the edges of the tube and diminishes its diameter, which causes the lightest volume to be increased a little, and the heaviest to be diminished.

If soap made with olive oil is tried, the total volume is about 79.5 divisions; if the trial is made with oleic acid soap, the total volume is from 80 to 81; if the soap is made with greases or heavy oils, the volume is below 79.5 divisions. These volumes are very variable, because the soaps may contain more or less water, and the fatty substances may have a greater or less weight.

Let us suppose that by the trial of a white soap from olive oil the volume was 79.5 divisions, and the volume of the normal acid and water contained in the 10 grammes of the soap was 26 divisions, we have:—

Total volume	79.5 div.
Less the volume of acid and water	26.0
For the correction . . .	0.5
Which gives	53.0
Less the volume of turpentine .	40.0
Balance	$13.0 = \frac{13 \text{ c. c.}}{2} = 6.5$ c. c. (1.75 fldrm.).

As there has been used 10 cubic centimetres = 20 divisions of normal acid according to the composition of the soap, the volume of the acid water is 26.5 divisions, we have:—

$$\frac{26.5 \text{ c. c.}}{2} = 13.25 \text{ c. c.} - 10 \text{ c. c.} = 3.25 \text{ c. c. (0.88 fluidrachm).}$$

Which make:—

Fatty matter	6.50 c. c.
Water and soda	3.25 "
	9.75 " (2.63 fluidrachms).

The soap being heavier than water, the volume 9.75 cubic centimetres in soap represents the weight of 10 cubic centimetres (2.70 fluidrachms) of water.

To know the weight of the cubic centimetre of the fatty matter contained in various soaps, we remember that there have been introduced into the tube 10 cubic centimetres of normal acid, 20 cubic centimetres (0.66 fluidoz.) spirit of turpentine, and 10 grammes of soap. After the decomposition of the soap, the height of the total volume of the spirit, fatty matter, and acid water, being exactly taken, has been of 79.5 divisions, the volume of the aqueous part being 26 divisions. By making the correction spoken of before, 10 grammes of the soap contain in volume:—

$$\left.\begin{array}{ll}\textit{Fatty matter} & 6.50 \text{ c. c.}\\ \textit{Water and soda} & 3.25 \text{ c. c.}\end{array}\right\} = 9.75 \text{ c. c.}$$

On the other hand, the author has dissolved in a porcelain dish 10 grammes (0.35 oz.) of the same soap in a sufficient quantity of water, to which, afterwards, was added a sufficient quantity of the normal sulphuric acid; after the separation of the fatty acids 10 grammes (0.35 oz.) of dried white wax were added, which after fusion became incorporated with the fatty substance; and after cooling the cake was dried and weighed. The total weight was 15.97 grammes (0.56 oz.). From this weight, if we subtract that of the wax, which is 10 grammes (0.35 oz.), the balance 5.97 grammes (0.21 oz.) represents the volume 6.5 cubic centimetres (1.75 fluidrachms) found by the turpentine. To ascertain the weight of a cubic centimetre of the fatty matter contained in Marseilles soap, we have:—

$$\frac{5.97 \text{ grms.}}{6.5 \text{ c. c.}}\, x = 0.91846 \text{ gramme (14.17 grains).}$$

The weight of the cubic centimetre of the fatty matter contained in several specimens of Marseilles soap made by different manufacturers was 0.91846, 0.91875, 0.91921; the average of which is 0.91880 gramme.

The weight of the cubic centimetre of fatty substances from cocoa-oil soap is 0.940 gramme.

From palm-oil soap 0.922.

From tallow soap 0.9714.

From oleic-acid soap 0.9003.

The weight of the fatty matter being known, we have to analyze the soda and water.

Add to the tube which contains the mixture a sufficient quantity of distilled water to raise the level of the turpentine; this substance and the fatty matter are removed, the tube is corked and well stirred to dissolve the acid sulphate of soda which may have crystallized, and the acid mixture is poured into a test glass. Pour a little more water into the tube so as to wash well the last portions of acidulated water, and add it to the first acid solution. Put into this solution a few drops of tincture of litmus, and in the graduated tube introduce 50 cubic centimetres (1.69 fluidozs.) of the alkaline liquor; pour little by little a sufficient quantity of this liquor into the glass containing the acid, mixing the whole with a glass rod until the litmus passes to the onion peel color. The liquor has to be tried from time to time with litmus paper, and when this paper does not turn red, the addition of the alkaline liquor is stopped and its volume measured.

Let us suppose that the $\frac{30}{100}$ of the alkaline volume have been necessary to saturate the acid.

The alkaline liquor contains in 50 cubic centimetres (1.69 fluidozs.) 1.2 grammes (18.50 grains) of soda. This weight forms a neutral salt with the sulphuric acid contained in the 10 cubic centimetres (0.33 fluidoz.) of normal acid used to decompose the soap. If the operator has only used the $\frac{30}{100}$ of 50 cubic centimetres of alkaline liquor, it is evident that the soap contains the $\frac{70}{100}$ of 1.2 grammes (18.50 grains) of soda. Then the volume of the alkaline liquor which is not used contains exactly a weight of soda equal to that which is found in the 10 grammes (154.3 grains) of the soap.

To apply this process, if the operator has used the $\frac{30}{100}$ of the alkaline volume for the saturation of the acid, the soap contains the $\frac{70}{100}$ of 1.2 grammes (18.50 grains) of soda, or 0.84 gramme (12.96 grains), or 8.40 per cent.; if the volume used has been $\frac{50}{100}$ the soap contains 0.6 gramme (9.26 grains) of soda, or six per cent.

If the analysis of a soft soap has to be made, what is left of the alkaline volume not used will represent the proportional equivalent of the potash contained in the soap. The equivalent of the soda being 1.2 grammes, that of the potash is 1.825 grammes (28.16 grains). If the volume not used is $\frac{70}{100}$, it is evident that the soap contains in the 10 grammes $\frac{70}{100}$ of 1.825 grammes of potash; if the volume not used is $\frac{50}{100}$, it is manifest that the soap contains $\frac{50}{100}$ of 1.825, or 9.125 per cent. of potash.

The weight of the soda or potash being determined, it has to be subtracted from the water.

The analysis of a soap giving in volume:—

Fatty matter	6.50 c. c.	(1.75 fluidrachm)
Water and soda	3.25 "	(.88 ")

if the weight of the soda is 0.60 gramme, we have:—

Fatty substance 6.5 c. c. × 0.91846 grm.	= 5.9699 grms.	(92.16 grains).
Soda	0.6000 "	(9.00 ").
Water found by difference	3.4301* "	(52.84 ").
Soap	10.0000 "	(154.00 ").

If the soap contains glycerine, this substance remains in solution in the normal acid; if it contains flour, talc, clay,

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* If we take 10 c. c. of distilled water, and 5 grammes (77.15 grains) of potash, the volume of the solution at 60° is 11.75 c. c. (3.17 fluidrachms). Supposing that soda gives the same result as potash, we have to know the volume of 0.6 gramme (9.24 grains) of soda:—

KO		Vol.		NaO.		Vol.
5 grms.	:	1.75 c. c.	: :	0.60	:	$x = 0.21$ c. c.
77.15 grs.	:	0.47 fluidrachms.	: :	9.24	:	$x = 0.056$ fluidrachms.

Which gives for the volume of the water:—

3.25 c. c. — 0.21 c. c. = 3.04 c. c. of water.
0.87 fluidrachm — 0.05 fluidrachm = 0.82 fluidrachm.

all these substances fall immediately to the bottom of the tube.

Soap of Oleic Acid and Rosin.—If 10 grammes (154 grains) of rosin soap are treated by 10 cubic centimetres (0.33 fluidoz.) of normal acid; and 20 cubic centimetres (0.66 fluidoz.) of spirit of turpentine, the latter hardly dissolves any of the rosin. If a certain quantity of Marseilles soap, for example, enters into the weight of 10 grammes of rosin soap, all the fatty matter of the Marseilles soap is dissolved by the turpentine, and the rosin is dissolved only in the proportion of about the $\frac{15}{100}$ of a cubic centimetre (0.045 fluidrachm); it forms a voluminous layer below the turpentine.

This easy separation of the rosin ought to be attributed to a special state it acquires while in presence of the water when separated from its combination with potash or soda by sulphuric acid.

These results are described in the two following experiments:—

First Experiment.—10 grammes (0.35 oz.) of olive soap containing very little water have given for the volume of the fatty matter 8.25 cubic centimetres (2.23 fluidrachms).

Second Experiment.—8 grammes (123 grains) of the same soap and 2 grammes (31 grains) of rosin soap have given a volume of the fatty matter and dissolved rosin equal to 6.75 cubic centimetres (1.82 fluidrachms).

To know the volume from the 8 grammes of olive soap, we have:—

10 grms. : 8.25 c. c. : : 8 grms. : x = Vol. 6.60 c. c. (1.78 fluidrachm).

If from the volume of 6.75 cubic centimetres we subtract volume 6.60, the balance 0.15 indicates that the turpentine has dissolved only the $\frac{15}{100}$ of a cubic centimetre of rosin.

In some woollen cloth manufactories, they use a soap made with oleic acid and rosin. Let us suppose that 10 grammes of this soap have given by the wax process a weight of fatty matter and rosin = 6.45 grammes (99.52 grains), that by the treatment with the turpentine the volume of fatty matter and dissolved rosin = 6.25 cubic centimetres (1.7 fluidrachm), and that in saturating the normal acid the volume of alkaline liquor employed was $\frac{32}{100}$.

Subtract from the volume 6.25 cubic centimetres the volume 0.15, which gives for the oleic acid 6.25—0.15 = 6.10 cubic centimetres (1.65 fluidrachms), we have:—

Oleic acid 6.10 c. c. × 0.9003 grm.	= 5.49183	grms.	(84.74 grains).
Rosin by difference (6.45 *grms.* — 5.49183)	—0.95817	"	(14.78 ").
Soda 1.2 *grms.* × $\frac{68}{100}$	0.81600	"	(12.59 ").
Water by difference	2.73400	"	(42.21 ").
Soap of oleic acid and rosin	10.00000		(154.32 ").

The weight of the wax will give that of the fatty matter and rosin; the volume x cubic centimetre of the fatty matter —the volume 0.15 of the rosin multiplied by 0.9003 weight of a cubic centimetre of oleic acid will give the weight of that volume. By difference the weight of the rosin will be known; the volume of the alkaline liquor not used, will give the weight of the soda or potash; lastly, by difference, the weight of the water is obtained.

Mixtures of Potash and Soda.—In some soaps there is a mixture of potash and soda. The weight of each alkali is known by the following method.

Burn 10 grammes (0.35 oz.) of soap. Weigh the ashes and treat them by boiling distilled water: filter, wash the filter with a little warm water, and add the washings to the alkaline solution; then burn the filter, deduct the known weight of its ash from the total weight of the ashes, and by difference we have the weight of the potash and soda mixed in the state of carbonates.

Let us suppose that the mixture weighs 3 grammes (46.29 grains). The volume of normal acid necessary to saturate 3 grammes of the mixture is found by a direct experiment. Then the volume of normal acid necessary to saturate 3 grammes of carbonate of potash and 3 grammes of carbonate of soda is found by calculation. The volume of normal acid by which the three grammes of the mixture have been saturated will be intermediate between the volumes which ought to saturate 3 grammes of carbonate of potash, and 3 grammes of carbonate of soda. By a proportional division, we shall have fractions of potash and soda to compose the weight of the mixture examined.

Let us suppose that the volume of normal acid used directly for the saturation of the 3 grammes of the mixture is 13 cubic centimetres (3.51 fluidrachms).

The volume of normal acid to saturate 3 grammes of carbonate of potash and 3 grammes of carbonate of soda is to be ascertained; knowing that 10 cubic centimetres (0.33 fluidoz.) of normal acid contain 1.8984 grammes (29.29 grains) of monohydrated sulphuric acid, and that its equivalent is 612.5.

For the carbonate of soda, we have:—

$$\begin{array}{ccccccc} \mathrm{NaO,CO_2} & & \mathrm{SO_3,HO} & & \mathrm{NaO,CO_2} & & \mathrm{SO_3,HO} \\ 662.17 & : & 612.5 & :: & 3 & : & x = 2.774 \text{ grms. (42.80 grains).} \end{array}$$

To know the volume of normal acid which contains 2.774 grammes of monohydrated acid, we have:—

$$\begin{array}{ccccccc} \mathrm{SO_3,HO} & & \text{Vol.} & & \mathrm{SO_3,HO} & & \text{Vol.} \\ 1.8984 & : & 10 \text{ c. c.} & :: & 2.774 \text{ grms.} & : & x = 14.612 \text{ c. c. (3.94 fluidrachms).} \end{array}$$

In the same manner we ascertain the weight of monohydrated acid and afterwards the volume of normal acid which contains the weight of monohydrated acid necessary to saturate 3 grammes of carbonate of potash. We have:—

$$\begin{array}{ccccccc} \mathrm{KO,CO_2} & & \mathrm{SO_3,HO} & & \mathrm{KO,CO_2} & & \mathrm{SO_3,HO} \\ 863.93 & : & 612.5 & :: & 3 & : & x = 2.126 \text{ grms. (32.80 grains).} \\ \mathrm{SO_3,HO} & & \text{Vol.} & & \mathrm{SO_3,HO} & & \\ 1.8984 \text{ grms.} & : & 10 \text{ c. c.} & :: & 2.126 \text{ grms.} & : & x = 11.198 \text{ c. c. (3.02 fldrms.)} \end{array}$$

of normal acid, which contains 2.126 grammes of monohydrated acid.

By experiment 13 cubic centimetres (3.51 fluidrachms) of normal acid have been employed to saturate the alkalies found in the ashes of the calcined soap. It is evident that if the weight of alkali found in the ashes is formed only of carbonate of soda, the volume used should be 14.612 cubic centimetres (3.94 fluidrachms) of normal acid; if, on the contrary, the 3 grammes are only formed of carbonate of potash, the volume used should be 11.198 cubic centimetres (3.02

fluidrachms) of normal acid. But as the volume of normal acid used has been 13 cubic centimetres, this volume alone indicates a mixture of carbonate of potash and soda. By a proportional division we have the weight of the carbonate of soda proportional to a fraction of the volume 14.612 cubic centimetres of normal acid; we have also the weight of the carbonate of potash proportional to a fraction of the volume 11.198 cubic centimetres of normal acid.

To establish this division, we have:—

1. *The gain that the volume* 11.198 *ought to make to give volume* 13 *cubic centimetres which is* 1.802 *cubic centimetres* (0.49 *fluidrachm*).

2. *The loss that the volume* 14.612 *cubic centimetres ought to make to give* 13 *cubic centimetres, which is* 1.612 *cubic centimetres* (0.43 *fluidrachm*).

Which gives:—

$$\left.\begin{array}{ll}\textit{Gain} \quad . \quad . \quad . \quad . & 1.802 \\ \textit{Loss} \quad . \quad . \quad . \quad . & 1.612\end{array}\right\} = 3.414 \text{ (0.92 fluidrachm).}$$

To compose the volume 13 cubic centimetres, we take:—

1. *The* $\frac{1802}{3414}$ *of the volume* 14.612 *cubic centimetres, corresponding to the* $\frac{1802}{3414}$ *of* 3 *grammes of carbonate of soda.*

2. *The* $\frac{1612}{3414}$ *of the volume* 11.198 *cubic centimetres, corresponding to the* $\frac{1612}{3414}$ *of* 3 *grammes of carbonate of potash.*

We obtain:—

x = carb. of soda	1.5834 grms.	corr. to soda	0.9258 grm.	corr. to vol. of acid	7.7126 c. c.
y " " pot.	1.4165	" "	pot. 0.9656	" " " " "	5.2873
$x+y$ = mixture	2.9999 (46.29 grains).	" both	1.8914 (29.18 grains).	for volume found	12.9999 (3.51 fldrm.)

In this analysis, the following method due to Gay Lussac cannot be well used, because too much soap would have to be burned so as to operate on 50 grammes of mixed chlorides.

Operate as follows:—

Transform the two carbonates into chlorides and calcine to evaporate the excess of acid; take 50 grammes (1.75 ozs.) of the mixture which is finely powdered, introduce this mixture into a bottle weighing 185 grammes (6.48 ozs.), and containing 200 grammes (7.00 ozs.) of water, stir with a glass rod, and observe the falling of the temperature produced by the solution of the salt in water.

The chloride of potassium produces a falling of temperature of 11.4° C. (20.6° F.). Common salt in the same condition produces a falling of 1.9° C. (3.4° F.).

If we suppose that the thermometer marking 15° C. (59° F.) falls by the effect of the dissolution of the saline mixture to 10° C. (50° F.), we have a falling of 5° C. (9° F.).

By proportionally dividing 11.4° and 1.9° to give 5° C., we have: 1st, a fraction of 11.4° corresponding to a fraction of 100 grammes (3.52 ozs.) of chloride of potassium; 2d, a fraction of 1.9° corresponding to a fraction of 100 grammes of chloride of sodium. Therefore:—

$$\left.\begin{array}{ll}\text{1. Gain} & 5 \;\;\, - 1.90 = 3.10 \\ \text{2. Loss} & 11.4 - 5.00 = 6.40\end{array}\right\} 9.50$$

Which gives:—

1. *The* $\frac{310}{950}$ *of* 11.4° *corresponding to the* $\frac{310}{950}$ *of* 100 *grammes of chloride of potassium.*

2. *The* $\frac{640}{950}$ *of* 1.9° *corresponding to the* $\frac{640}{950}$ *of* 100 *grammes of chloride of sodium.*

The results are:—

Chloride of potassium	32.63	corresp. to temp.	3.72° C.,	6.7° F.
Chloride of sodium	67.37	" "	1.28	2.3
Total	100.000	falling of temp.	5.00° C.,	9.0° F.

The tests for determining the amounts of the alkalies of potash and soda are rather intricate; we have, therefore, given the reader the choice of methods by giving Caillette's also.

SECTION XVII.

RE-MELTING OF SOAP.

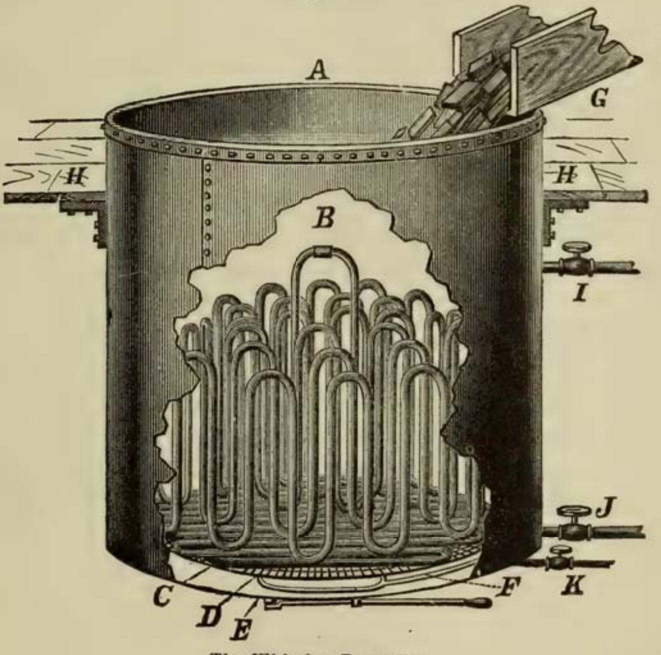
THIS operation to the inexpert is quite difficult, taking much time and being attended with some loss, but at the same time it is very important. In the manufacture of soap, in cutting, moulding, pressing, etc., a great deal of scrap soap accumulates, and it often happens, that, in the making of the soap, it may not turn out to suit, it may be discolored, may not be neutral, or may have too little alkali; or, from whatever cause, and these are many, the soap even with the best of care will not be salable and will have to be re-melted and adjusted.

To re-melt the scraps and soap there are several means. The simplest is where, in the case of having a steam jacket with cover, the soap is stripped or made into shreds and placed in the kettle with a limited quantity of water, covered closely, and the steam turned into the jacket, this operation taking much time and requiring some attention in stirring, etc.

Again, one of the best modes of re-melting by means of boiling and re-adjusting is to cut up the soap into small pieces; in which case it need not go into the stripper. Place it in the boiler with a suitable quantity of weak lye, say, of 2° or 3° B. (half the weight of the soap), and with a gentle heat gradually bring to a boil until all the pieces are dissolved, and a jelly like mass is obtained. Then add sufficient culinary salt, or a strong solution of it, to separate the soap—an operation frequently described—boil to a curd, turn off the heat, let it settle, and remove the sub-lye. If then the soap is too hard, it will be necessary to fit it. This is done by adding a portion of water, and again bringing it to a boil that it may again form into a gelatinous state and be subjected to the usual tests, so frequently described. If finished it is framed. If the soap was not good before this operation, the boiling and adjusting will have improved it, though it may not be as white as it was before. If it was much discolored, the process of separation may be repeated several times.

Soaps that have a filling with water-glass, sal-soda, or whatever substance should not be re-melted by the boiling process, as all the filling would be separated and lost. To re-melt such soaps, a valuable machine has been invented by Mr. Whitaker, and is made by Messrs. Hersey Bros., of South Boston, Mass., which has proved very successful.

Fig. 62.



The Whitaker Re-melter.

The following is a description of the above machine: A, wrought iron cylinder with dishing bottom. B, coil of continuous steam pipe. C, horizontal scroll pipe connecting with the upright pipe. D, wire diaphragm which serves to separate the soap. E, gate for discharging soap. F, small pipe for admitting direct steam through perforations into the body of the soap. K, inlet pipe and valve for direct steam. I, inlet pipe. J, discharge valve for condensed steam. H H, floor of building. G, spout for running in the cut soap.

Directions for Use.—Fill the re-melter with the soap, put on the cover, close the bottom slide, and let on the open steam, until the soap begins to melt, which will depend upon the dryness of the soap. When sufficiently melted shut off the open steam, open the bottom to drain off the condensed steam. Then let on the steam through the coils and put the frames in place to catch the melted soap. When in the frames stir well when half-full and also when full, in order to insure a uniform soap.

This machine will hold about 1000 pounds of soap, and can be used six or eight times a day. It is now used by many of our largest manufacturers both for domestic and for toilet soaps.

The re-melting of soaps is a very important part of soap manipulation, for independent of the scraps and faulty soaps, this re-melter might be used to re-melt the stock soaps for toilet soaps described in that section, especially if they should become with drying too hard and brittle to mill.

It may be unnecessary to say that with proper care in the first operation of making the soaps there will be less re-melting to be done, and in toilet soaps the various appliances of stripper mill and platter generally cause a thorough blending of color and scraps, and the mixing of the soap is attained much more speedily and with less expense.

SECTION XVIII.

MISCELLANEOUS USEFUL SOAPS.

Though we have given in our preceding pages the most important soaps known to commerce, there are many that have had a reputation more or less deserving or transient, that should receive some notice at our hands, and there are also soaps made in the household and for domestic and laundry purposes that have some merit and are economical.

Altenburge's Rosin Soap.

Cocoa-nut oil	100 kilog.	(220 lbs.)
Rosin	100 "	(220 ")
Soda lye, 28°	135 "	(297 ")

Make by the cold process, and before framing cut with a salt lye of 24° B.

Dresden Palm Soap.

Cocoa-nut oil	1600 kilog.	(3520 lbs.)
Palm oil (crude)	500 "	(1100 ")
Rosin	400 "	(880 ")
Soda lye, 28°	1304 litres	(353 gals.)

Melt together the fats and saponify the rosin separately, taking care to add the rosin soap before it becomes too thick to stir.

Offenbach Palm Soap.

Palm oil (unbleached) . . .	1000 kilog.	(2200 lbs.)
Cocoa-nut oil	400 "	(880 ")
Soda lye 15° B.	2800 "	(6160 ")

Place one-half the lye with the fats and let it boil gently to saponify slowly; when combined add the last of the alkali, keeping up the boiling until it becomes a jelly. If stringy, add a portion of 20° lye, and if too caustic correct with oleic acid.

WAX OR BLEACHING SOAP.

This is simply a good tallow soap or a mixed tallow, bleached palm oil, or cocoa-nut oil soap, but it must contain tallow, which, when it is boiled and nearly finished, is fitted or ground with a weak solution of carbonate of soda, the quantity depending upon the dryness of the grain soap after its separation with salt. It has a smooth wax-like appearance, and being highly detergent, is very popular on the continent of Europe as a laundry soap.

BRAN SOAP.

Bran is boiled with 2 per cent. of soda-lye in a large amount of water and strained. It is supposed to be useful for washing cotton cloths for printing.

OX-GALL SOAP FOR SCOURING WOOLLENS.

Purified ox-gall	1 part
White curd soap	2 "

The soap is cut into shavings and melted in the ox-gall at a moderate heat, evaporating until of proper consistency. The ox-gall is prepared by boiling it with 10 to 12 parts wood spirit and straining.

SCOURING BALLS.

White curd soap	16 kilog.	(35.2 lbs.)
Pearl ash	3 "	(6.6 ")
Oil of juniper	1½ "	(3.3 ")

Mixed together, having previously added a little water to the soap and pearl ash to dissolve them by a moderate heat; add the oil of juniper and mould into balls.

FRENCH SCOURING SOAP.

Curd soap	1½ kilog.	(3.3 lbs.)
Water	20 litres.	(5.3 gals.)
Oil of turpentine	16 grms.	(0.56 oz.)
Aqua ammonia	33 "	(1.16 ")

The soap is dissolved by heat in half the water, and the other ingredients added. This is used as a soft soap for the laundry.

SCOURING TABLETS.

Good rosin soap	16 kilog.	(35 lbs.)
Oil of turpentine	2 "	(4.4 ")
Sal ammoniac	1 "	(2.2 ")

Melted together and formed into cakes used for removing ink, wine, or vinegar stains.

ERASIVE SOAP.

Good rosin soap	16 kilog.	(35 lbs.)
Pipe clay, or fuller's earth, in powd.	1½ "	(3.3 ")

Melt the soap in a water-bath, and when perfectly melted add the powdered earth. This is used as an erasive for grease and other stains on clothing. It is usual to cut it into small cakes with printed directions.

LABOR-SAVING SOAP.

Good rosin soap	1 kilog.	(2.2 lbs.)
Sal soda	¾ "	(1.65 ")
Water	33 litres	(8.7 gals.)

One litre or 1 quart is added to each 5 gallons of water used in washing. It is particularly applicable for use with hard water.

COUNTRY SOAP.

This is a hard soap usually made on farms, using the kitchen or other greases to make a soft soap with wood-ash lye, boiling well to a clear paste, and cutting with culinary salt. The only art is in making a clear glossy paste before cutting, when the soap is generally allowed to cool and rest for a day, when the cakes of soap are removed from the surface and cut up and dried in the shade.

DOMESTIC SOFT SOAP.

Grease	3.64 kilog.	(8 lbs.)
Potash	2.7 "	(6 ")
Water	113 litres	(30 gals.)

The potash is dissolved in a portion of the water. About a third of the grease is added and heat applied. It is, when mixed, put into a barrel in the cellar and the rest of the water added in portions for seven days, and after repeated stirrings for a fortnight it is ready for use.

SHAKER SOFT SOAP.

Strong lye from wood ashes	45 litres	(12 gals.)
Grease	2.83 "	(6 pints.)

Water sufficient to make up the 113 litres (30 gallons). Manipulation is similar to that for the domestic soft soap.

BORAX SOFT SOAP.

White fats	45.4 kilog.	(100 lbs.)
Soda lye, 15° B.	45.4 "	(100 ")
Potash lye, 10° B.	27.3 "	(60 ")
Solution of borax, 10° B.	6.8 "	(15 ")

The soda lye is added to the melted grease and heated till it forms a clear liquid or is combined, when the potash-lye and borax solution are added. It should be a semi-solid translucent paste, and is usually sold in quart cans, and is quite popular.

LUBRICATING SOAP.

Palm oil, crude	2 parts.
Tallow	1 part.
Solution carb. soda, 15°	1 "

Melt together.

AGRICULTURAL SOAP (WHALE-OIL SOAP)

Whale-oil foot	2 parts.
Soda lye, 30° B.	1 part.

Made in the cold way. Whale-oil foot is the residuum left in refining the oil. This soap is useful for destroying insects on plants.

FIG SOAP

Is another name for the grained soft soap, so named because it resembles the seeds of figs.

PEARL SOAP POWDER.

Curd soap, dried and powdered	4 parts.
Sal soda, " " "	3 "
Silicate of soda " "	2 "

Made as dry as possible and intimately blended.

BORAX SOAP POWDER.

Curd soap,	in powder	5 parts.
Soda ash,	"	3 "
Silicate of soda,	"	2 "
Borax, crude,	"	1 part.

Each ingredient is thoroughly dried and all mixed together by sieving.

LONDON SOAP POWDER.

Yellow soap	6 parts.
Soda crystals	3 "
Pearl ash	1½ "
Sulph. soda	1½ "
Palm oil	1 part.

These ingredients are combined as well as possible without any water, and they are spread out to dry and then ground into a coarse powder.

Thus, in an infinite degree can the variety of soap powders be multiplied. They are adapted for hard waters, as their excess of alkali neutralizes the lime.

BELGIAN SOFT SOAP.

Tallow	350 kilog.	(770 lbs.)
Cocoa-nut oil	150 "	(330 ")
Palm oil, bleached	100 "	(220 ")

This quantity of fats is boiled in a caustic potash-lye of 20° B. until perfectly saponified. Water is added to keep the proper consistency. This is a favorite soap for manufacturers of cloths and woolens.

AMMONIATED SOAP.

To a good white soda cold soap yet warm add a solution of ammonia alum, say 10 per cent. of 8° B. solution, before putting in the frames. The ammonia will be set free and improve the detersive qualities of the soap.

MEDICATED SOFT SOAP.

Under this name a pure soap is made with oleic acid and caustic potash-lye, care being taken to obtain a neutral product. It is boiled with a moderately strong lye until the proper consistency is reached.

MARINE SOAP.

Cocoa-nut oil soap	100 parts.
Fuller's earth	50 "
Calcined soda ash	50 "

Make as usual. Used for washing in sea-water.

In our section on toilet soaps, we shall give a large number of formulas of soaps that properly belong to that department. From a great number of useful domestic and manufacturer's soaps, we have selected what we consider most reliable, and such as will give the intelligent manufacturer hints towards many more, should he have occasion to make them.

SECTION XIX.

TOILET SOAPS.

THE increased demand and production of this class of soaps, has made their manufacture one of the most important of which it is our office to treat and explain. The writer, in his connection with the fat industry for nearly forty years, can readily trace, in the United States, the different improvements made during that period in this art: from the time when the chandler made the tallow curd soap, and marbled it with vermilion, perfumed it with sassafras, formed it into squares or rounded it into balls, and when this was a standard for a domestic toilet soap. This soap, being made of tallow and soda-lye, soon became so hard that it was almost impossible to coax a lather from it, even after a previous soaking in water.

Then, later, the perfumer bought the different domestic soaps, remelting, perfuming, and forming into cakes with the plane, wrapping them in gorgeous wrappers, and applying to them names to suit the prevailing taste. Then again, when, some twenty years ago, toilet soaps were made by the cold or extempore process, the product was very inferior, the result of a very imperfect knowledge of the proper method and manipulation. But since, the progress has been a steady improvement to the present time, when we may be said to stand on nearly equal ground with the older nations, our products comparing favorably with any others.

Owing to the prestige of time and many local facilities, Europe may produce many superior soaps, and may be said to be without rivals in certain kinds; yet in as far as the usual toilet soaps are concerned, we are, owing to our many improvements in machinery, the abundance of superior materials, and the attention to the chemical rules of the art, producing goods that, for prices and quality, compete with any in the world.

The fabrication of toilet soaps presents but few changes from those already given in the making of domestic and manufactured soaps, except a greater care in the selection of the raw materials, which should all be of the best quality. The fatty bodies and the bases should be purified as much as possible, the oils and fats from all odor and impurities, the alkali from all foreign salts and carbonic acid, and made as caustic as possible.

For making a good and pure toilet soap, due care in purifying the fats and oils is perhaps the first stage of the process. When the manufacturer has the opportunity and the facility to render his own greases, there will be much advantage as insuring their purity and enhancing the quality of his soaps very much.

To Render and Purify the Grease.—Fat of good quality and very fresh must be selected, the membranes of which are carefully removed. This operation being performed, it is spread on a strong piece of oak wood and strongly beaten to open the adipose cells in which the grease is contained; by this means the grease is more easily and quickly extracted. The fat is then washed five or six times in cold water, the water being renewed each time. This operation is performed in large buckets two-thirds filled with water; the water of the last washing must remain clear and limpid. The object of these washings is to remove, as completely as possible, the coloring and bloody parts which are adherent to the grease, and which would color and alter it during the trying out, and would render its perservation uncertain and difficult. These washings being finished, the fat is drained on clean cloths, then melted in a copper kettle, in which is a quantity of water about equivalent to one-third of the weight of the fat. All being thus ready, heat the kettle, and, when the grease is melted, add from five to seven ounces of pure salt for every 45.5 kilog. (100 pounds.) Boil for eight or ten minutes, and as in boiling a scum is formed, it is carefully removed with a skimmer. The melting being finished, decant the liquid grease into large copper vessels having a conical form; but to have clean grease, pass it through a hair sieve which prevents the solid and insoluble substances from passing through. Let it rest for two or three hours; during this time the water separates, carrying with it the dirt contained in the grease. It is then carefully decanted and put back into the scoured kettle, and melted with water, to which are added a few quarts of rose or orange-flower water. Heat anew, and when the grease is melted, add to it two ounces of pure powered alum for 100 pounds of grease, boil gently for eight or ten minutes, and carefully remove the scum formed on the surface of the grease. Then turn off the heat, cover the kettle with care, which is essential for keeping the mass at an elevated temperature. Let this stand for eight or ten hours, or, what is surer, until the grease begins to whiten and solidify on the sides of the kettle. When in this state, decant it into clean barrels and keep for use.

As the last portions of grease which swim on the water are less white and pure than the first, they are kept separate to prepare soaps of second quality. The grease thus purified may be kept a long time without alteration, and forms the base of toilet soaps of the first quality. There are other methods for attaining this end. When the greases are obtained reasonably pure, one of the simplest is to melt in the kettle the requisite soap grease, and when at about 45° C. (113° F.) to add about two per cent. of strong alkali of 36° to 40° B., stirring some time and shutting off the heat. A soap will be formed of the impure fat, and will sink to the bottom, carrying almost all of the other impurities down with it, when the clarified grease can be carefully separated.

In boiling a soap and separating with culinary salt, fats less pure may be used, as the impurities are usually carried down with the sub-lye, which separation can be repeated till the soap is pure and colorless, and to the improvement of its quality. But in the soaps by the extempore processes, all the contents of the fats are retained in the soap as well as the glycerine, hence the necessity of a purified fatty body to produce a good and pure product.

Toilet soaps are now nearly all made by this latter (cold) process, for several reasons: first, because the alkalies are now obtainable in a much purer state than in former years; secondly, because, by the facilities of improved machinery, their quality is improved; thirdly, because they retain their form much better than boiled soaps, which in drying warp and become misshapen; fourthly, because by means of these new appliances they can be manipulated, milled, colored, perfumed, plotted, etc., in a cold state; finally their appearance is much more attractive. All these manifold labors tend to the improvement of a soap, as the more it is worked the more perfect is the union of its ingredients, and consequently the more perfect is the soap.

Cocoa-nut oil has for many years formed one of the chief constituents of toilet soaps on the continent of Europe, and, when its natural rancid smell is not objected to, is a valuable material, as it has some desirable properties, making a very white and emollient soap, but it is not possible to remove all its unpleasant odor. For this reason it is not used in the better qualities of soaps, nor in but a small proportion, and then the best quality of Cochin China oil is preferred.

Cotton-seed oil is another ingredient, that has lately claimed much attention as a material for toilet soaps, and has some peculiarities similar to the cocoa-nut oil without its unpleasant smell. We have used it in combination with tallow, castor oil, lard, etc., and the resulting soap was quite satisfactory. Being a cheap material, it would appear that it should attract great attention from the manufacturers of toilet soap.

Toilet Soaps by Boiling.

We have in this work given so many particulars, as to the processes of boiling soap, that it is scarcely necessary here to repeat them, as all of these methods apply equally to soaps for toilet purposes, but, as we desire to make this work as complete as possible, we will give some examples, remarking that nearly all the appurtenances heretofore given apply to this branch also, and repeating the necessity of securing pure and neutral products and materials.

In many large manufactories it is quite common to have the boiled soaps in stock in several kinds, which are mixed in certain proportions to form the various kinds; thus they make a white soap, a palm soap, a half-palm with rosin, a cocoa-nut oil soap, etc. These are usually kept in a cool room or cellar, and when wanted they are re-melted, or milled, colored, perfumed, etc. To make one of these soaps by boiling we give the formulas for the half-palm soap with rosin, and the process will apply to the rest except the cocoa-nut oil soap which is differently made.

Half-Palm Soap.

Either of the following formulas may be used:—

White tallow	900	pounds.
Palm oil	400	"
Cocoa-nut oil	200	"
Yellow rosin	100	"
	1600	"

Tallow	700	pounds.
Palm oil	300	"
Cotton-seed oil	400	"
Rosin	200	"
	1600	"

Lard	550	pounds.
Tallow oil	400	"
Cotton-seed oil	450	"
Rosin	200	"
	1600	"

The proportions of these substances are not fixed, and vary according to the uses for which the soap is destined. In England this soap is prepared with common tallows and an addition of rosin. In France where it is used only for toilet purposes, it is better attended to, and its purification is more complete. The above formulas give a soap of superior quality, and the use of which is very advantageous in the preparation of toilet soaps. The palm oil may be bleached or not, but must always be purified.

Pasting.—By a gentle heat, melt the tallow and oils in a kettle of a capacity of at least 2633 litres (696 gallons). When melted, pour into the kettle 378 litres (100 gallons) of new lye at 8° or 10° B.; heat slowly and gradually, stirring from time to time, and when the ebullition begins, moderate the action of the heat, to avoid too rapid a reaction in the mass. After continuing the ebullition for about four hours, pour little by little on the paste from thirty-five to fifty gallons of new lye at 15° or 18°, and incorporate it by stirring for fifteen minutes. This being done, continue to boil for three hours, or rather until the paste appears quite homogeneous and has acquired a certain consistency. Then a new quantity of thirty-five gallons of lye at 20° may be added, and after a new ebullition of two hours the first operation is finished.

Separation.—The pasting being finished, the heat is stopped off, and after a few hours' rest, pour into the kettle a limpid lye of coction, *i. e.*, salted lye at 20° to 25°, or a new lye containing salt in solution. While one man pours in the lye, another stirs the paste all the time. When the quantity of salt lye introduced into the kettle is sufficient, the soap is transformed into small grains, and the lye separates abundantly. After resting five or six hours, draw off the lye. About two-thirds of the lyes which have been used are drawn off; they have a yellowish color, and mark when cold from 15° to 16°. The pasty mass left in the kettle has a fine yellow color.

Coction.—The coction of this soap is very little different from that of pure palm-oil soap. Like the latter, it is effected with new and caustic lyes of soda marking 25° or 28°. When the operation is done in two services, lyes at 18° or 20° are used for the first service, and lyes at 25° or 28° for the second. When, on the contrary, the coction is finished in a single operation, lyes at 25° are used. This last process is the quickest and most economical.

The lyes being drawn off, pour into the kettle from 567 to 661.5 litres (150 to 175 gallons) of new lye at 25°; heat, and give a gentle boiling, for in the first hours the soap dilates and swells considerably. Its surface is then covered with an abundant scum, which gradually disappears only as the coction progresses. It is necessary to stir from time to time during the whole of the operation. This agitation is very important, for it accelerates the coction of the soap. When the soap has been gently boiled for three or four hours, the heat may be increased without fear of burning the soap. Generally, after eight or ten hours of ebullition with lye at 25° the soap is completely boiled. The scum has entirely disappeared, or there remains very little on the surface of the soap, which then has the form of hard and dry grains. When these grains are pressed between the fingers, they form thin and hard scales. The rosin has been added at the beginning of the coction, so as to saponify it completely. When the soap is sufficiently boiled, which is known when it forms scales, stop off the heat, let it rest a few hours, draw off the lye, and proceed to the fitting.

Fitting.—Two operations are necessary to completely refine the soap. The first has for its object to soften the grains of soap, and to separate the greater part of the free alkali and saline matters; the second has for its object to completely dissolve the grains of soap and precipitate the coloring and heterogeneous substances, and the excess of caustic lye it contains.

First Liquefaction.—When the lye has been drawn off, pour into the kettle 378 litres (100 gallons) of new lye at 8° or 9°, and heat gradually until boiling, being careful to stir the mixture well. When the grains of soap have become soft, cease the stirring; and, to complete the precipitation of the strong lye contained in the soap, boil for five or six hours, or even eight hours. As by such a long ebullition the grain of the soap has a tendency to be formed again, pour from time to time into the kettle a few pails of lye at

2° and even pure water. It is, however, necessary that the soap should be always separated from the lye; this is ascertained by pouring some into a glass, and if so, the lye precipitates at the bottom of the glass. It is important and essential to have, during the whole operation, the lye separated from the soap, to obtain the separation of the strong lye mixed with the paste. When this result is obtained, stop off the heat and cover the kettle. Let it rest six hours, then introduce the soap into another kettle and proceed to a second liquefaction.

Second Liquefaction.—Whatever has been the care taken in the first liquefaction, the soap has not been completely deprived of all its causticity—it always contains a certain quantity of caustic alkali, which must be eliminated to obtain a pure product. This is the object of the second liquefaction. But to obtain all the good results this operation may produce, substitute for the caustic lyes of soda ash, a *non caustic solution of crystals of soda.* By its extreme purity and the absence of causticity, this solution completely purifies the soap, depriving it of all its caustic parts. Pour into the new kettle about 136 litres (36 gallons) of a solution of crystals of soda at 4½° or 5°, and heat to a temperature near the boiling point. Then introduce the soap from the first kettle into the second, being careful not to draw any of the sub-lye. This being done, boil the mixture gently for four or five hours, being careful to stir from time to time. By the ebullition with weak lyes (aqueous solution of crystals of soda), the soap entirely loses its granular appearance, and becomes syrupy, fluid, and homogeneous. As in the first liquefaction, a scum is formed on the surface of the soap, and this scum is more considerable on account of the greater dilatation of the paste. As by evaporation the lye concentrates, add from time to time very small portions of water, so as to keep the paste always fluid. The heterogeneous coloring and saline impurities will be precipitated by resting. The soap must not contain too much water, for in this case it would be too long in hardening. The signs by which it is ascertained that the paste is sufficiently liquefied, are manifested by a slightly blackish coloration which proves that the black soap has been precipitated to the bottom of the kettle, and is brought up in the mass by the ebullition. When these characteristics have been observed, the operation is finished; stop off the heat, cover the kettle and let it rest eighteen or twenty hours. By resting, the black soap precipitates with the lye, and the pure soap is between it and the scum. After eighteen or twenty hours' rest, uncover the kettle and remove the scum on the surface of the soap. Remove the pure soap and introduce it into the frames, passing it through a metallic wire sieve; all the foreign bodies in the soap remain on the sieve:—

When all the pure soap has been introduced into the frames stir it well till cold; this manipulation is necessary to make it homogeneous. By operating as we have indicated, the above quantities of fatty matters generally give:—

Soap-scum, from	64 to 73 kilog.	141 lbs. to 161 lbs.
Pure soap, "	954 " 982 "	2100 " " 2160 "
Black soap, "	227 " 273 "	500 " " 600 "

The scum and black soaps are mixed in the next operation or used for a common soap. The half-palm soap has a very pure yellow color when manufactured with good materials. It has also a good odor, and is useful for making many kinds of soaps, such as honey, glycerine, marshmallow, etc.

For a palm soap for stock and for toilet soap, we refer to the formulas previously given for palm soaps, and for this purpose advise extra care in selecting the materials.

For a white soap for toilet purposes use the same processes for tallow, grain or curd soap, given elsewhere, using only the whitest and sweetest greases and purest alkali.

The cocoa-nut oil soap for toilet purposes should have a different manipulation. This oil not being saponifiable in weak lyes, it is always necessary to use lyes of 28° to 36° B. They need not be entirely caustic, as this oil can also be saponified in carbonated lyes, though it of course takes more of them and a longer time. For this soap it is now customary to use a portion of lard, cotton-seed oil, or any other white grease or oil, but the cocoa-nut oil for toilet soaps should be the best Cochin China oil. By using a certain proportion of potash lye the soap retains a more plastic consistency and is much improved. The amount is usually from 6 to 10 per cent.

WHITE SOAP FROM COCOA-NUT OIL.

To prepare 182 kilog. (400 lbs.) of this soap, introduce into a kettle of a capacity of 200 to 250 gallons 200 pounds of pure white cocoa oil; add afterwards 200 pounds of colorless and perfectly limpid lye at 30°.

All being ready, heat the kettle, and, to accelerate the combination of the substances, stir well from time to time. Under the influence of heat the material, which at first was in the form of grains, softens and becomes liquid. Continue to heat slowly and gradually until the combination between the oil and alkali is effected, which generally takes place when the ebullition begins.

When properly made, the soap has the appearance of a fluid, homogeneous, and syrupy paste. Its color is amber white. It is useless to boil it; stop off the heat and draw off the soap into the frame.

If, on the contrary, it happens when the mixture begins to boil that a certain quantity of oil swims at the surface of the paste, it may be combined with the saponified mass, by adding ten to twelve pounds of cocoa-nut oil soap. The same result may be obtained by adding eight or ten quarts of pure water. After stirring a few minutes, the homogeneity of the soap is re-established, and the combination of the substances is perfected. The heat is then stopped, and the soap drawn off into the frame. After five or six days, the soap is firm enough to be taken out of the frame.

Obtained by the above process, this soap is very white, does not contain any excess of alkali or oil, and may be employed for toilet uses. From the quantities indicated above, from 396 to 420 pounds of soap are obtained, according to the quantity of water added. The operation lasts about one hour.

It is not necessary to give further formulas for the different soaps that this useful oil may form in any judicious mixture with other fats, as they are almost without number, and, with the hints already given, any others may be manipulated. Where a colored soap is desired, palm oil is a very suitable combination.

The soaps here given may be called stock soaps; for from them nearly all kinds of toilet soaps can be formed, by a mixture of the different kinds in suitable proportions, milling, mixing, coloring, plotting, moulding, and perfuming to suit the kinds needed. As in our formulas these soaps may be frequently called for, it were well to give them some attention. But as we have before remarked, almost all toilet soaps are now made by the cold or extempore process, when the soaps are colored and perfumed in the kettle, or what is better, when they are run into the frames, or still better, when put in a crutching machine, such as we have described elsewhere.

SECTION XX.

TOILET SOAPS BY THE COLD PROCESS.

EXTEMPORE SOAPS.

THESE processes have become so universal for the fabrication of all toilet soaps, that they require special attention at our hands. Beyond what has been already given in the methods for making the cold or extempore soaps, there is but little to add, except in the care in selecting the purest materials, or making them perfectly pure before manipulation, and giving due regard to the proper equivalents of the fatty bodies with the alkalies to form a neutral soap.

For fine toilet soaps there are many desirable greases and oils, that can be used to much advantage, their price being usually too high for the ordinary soaps, but in this class of soaps, the price generally obtained justifies their employment. Thus almond oil, castor oil, olive oil, butter, lard, tallow oil, beef-marrow, cocoa-butter, bleached palm oil, palm-kernel oil, sesame oil, and other such like fats and oils of good quality could be advantageously used in a judicious admixture, for it seems that such a mixture produces a more desirable soap than any one used alone will do, the properties of one so blending with the other as to produce the most satisfactory results.

From the facility with which this soap can be made, it is quite unnecessary to make the stock soap as mentioned and described in our last chapter. For a small quantity can be made as well as a larger; indeed it is not convenient generally to make over five to eight hundred pounds at a time, and the kind of soap needed can be at once prepared, colored, and perfumed at the finish as described. Some manufacturers prefer to mill all their soaps, and color and perfume while milling;

there are many advantages in this. The color is better, more uniform, there is no loss of color or perfume by heat, there is a more complete blending of the materials in the soap, which, when finished, retains its form, color, and perfume for any reasonable length of time.

Again, for the superfine soaps of the finest odors, made from the oils or pomades perfumed with flowers by the process of enfleurage, elsewhere described, such as rose, jasmine, orange-flower, etc., this extempore process is indispensable, as a boiling heat would cause not only a loss of perfume, but an undesirable change in it.

Many mechanical appliances have been made to facilitate this process; which usually have a stirrer or twirl placed in the kettle or cylinder, and are a great advantage in manipulating; they are illustrated in our former chapter on cold soap for domestic use.

The use of filling in toilet soaps must not always be considered an adulteration, for there are some substances that may be regarded as an advantage, or at least in the light of ameliorators. Thus dextrine in moderate quantity gives smoothness without injury, while the mucilage of gum tragacanth gives both smoothness and emollience, which are desirable qualities in the best soaps. Soluble glass, while it cheapens the cost of soaps, does not, if used in moderation, and properly combined, injure its detersive quality or its value for use. It is, however, often used in such quantities as to become, with other adulterations, a means of unprincipled sophistication, giving a bad character to much of the toilet soap of commerce. Rosin, on the other hand, if added to other good materials, may have certain advantages, especially with a medium grade of soap, giving it a soluble and lathering property, which is always popular. A portion of potash lye also gives this soluble property.

The alkalies for toilet soaps, as we have said, should be of the purest, and should receive strict investigation (see Alkalimetry). While the caustic lyes of commerce are, as a rule, sufficiently pure for ordinary soaps if freshly prepared and made caustic, for the finer grade of soaps, it is most desirable to prepare the caustic lyes from the crystallized carbonate of soda; from its mode of manufacture having less foreign salts than any other form of soda. To prepare this alkali it is only necessary to extract the carbonic acid with the purest lime attainable, and form a solution of 12 to 15°, and then concentrate by evaporation to the desired strength, putting into well filled and stoppered bottles or carboys that it may not absorb any carbonic acid, and that it may be always ready for immediate use.

In making the soaps by the cold process our formulas generally call for a lye at 36° B. Now this is subject to some modification, as there are many circumstances and conditions where a lye of less strength would be more advantageous. When a weaker lye is used, there must of course be more of it (the tables given will show how much); and again the different greases act somewhat differently in connection with the weaker or stronger lye; all of this must be gained by experience, for it would be impossible without a knowledge of all the conditions and materials to give exact details.

With these preliminary remarks we think we can now proceed to give the necessary formulas, and begin with

White Soap by the Cold Process.

To obtain white toilet soap of the first quality, employ white grease. The following are the best proportions to use:—

Pure white grease	160 lbs.
Lye of crystals of soda at 36° B. . . .	80 "
	240 "

Saponify as follows: Melt the grease in a cast-iron kettle of a capacity of about 75 gallons. To operate with great precision, dip a thermometer into the melted grease, and when the temperature has reached from 45° to 50° C. (113° to 122° F.) pour in slowly the 80 pounds of lye at 36° B., stir the mixture all the time with an iron spatula until the entire saponification of the materials. It is important not to raise the temperature above 122° F., for in that event a part of the lye would separate from the fatty substances.

For the quantities indicated above, the operation lasts about two hours. When the saponification is finished, which is ascertained when the fatty matters are exactly combined with the lye, run the soap into a frame. While the soap is yet soft, if almond soap is wanted, it may be perfumed with 12 ounces of oil of bitter almonds, and 4 ounces of oil of lemon for each 100 pounds of soap. For the above mixture may be substituted 13 ounces of artificial oil of bitter almonds, but this last oil communicates to the soap a yellowish shade. This soap may be also perfumed with the following mixture for 100 pounds:—

Oil of vervain	2½	ounces.
" lavender	2	"
" bergamot	2	"
" lemon	2	"
" thyme	3	"

The oils must be added as soon as the soap is poured into the frame; and well crutched to mix.

A remarkable phenomenon, not produced with soaps boiled on the lye, occurs five hours after the soap is poured nearly cold into the frame; a spontaneous reaction takes place, which raises the temperature to about 82.2° C. (180° F.). Under the influence of this temperature the different constituent principles of the soap combine more directly and intimately, and the product is better. It is important to hasten that reaction by closely covering the frame.

A few days after the mass of soap is cooled and solidified, take it out of the frame and divide it into cakes, which are dried in the drying room, if necessary. The quantities of substances used give from 236 to 238 pounds of soap, or 149 per 100 of fat.

When well prepared, this soap is of a very pure white, not very alkaline, and produces an abundant lather with water.

Rose Soap.—The white soaps can be colored with four or five ounces of vermilion, and perfumed with

Oil of rose	2 ounces.
" geranium	4 "
" cinnamon	1 ounce.
" cloves	½ "
" bergamot	2 ounces.
	to each 100 lbs.

Windsor Soap can also be made of the white soaps or with the half-palm soap, coloring with caramel or other means, and perfuming each 100 pounds with

Oil of cinnamon	4 ounces.
" cloves	1 ounce.
" caraway	1 "
" sassafras	2 ounces.
" bergamot	2 "

Yellow Soap.—This soap, which has a fine yellow color, is obtained with tallow, palm, and cocoa oils. The following proportions give excellent results:—

White tallow	50 lbs.
Cocoa-nut oil	30 "
Palm oil	20 "
Lye of soda at 36° B.	50 to 52 "

Melt the tallow and other fatty substances in a sheet-iron kettle, add the lye, and operate as for white soap. If the color is not dark enough, add a solution of annotto, prepared by boiling one ounce of annotto or cadmium yellow, in one quart of lye of soda at 10°, boil five minutes and pass through a cloth.

Perfume this soap with the following composition, calculated for 150 lbs. of soap:—

Oil of lavender	10 ounces.
" lemon	2 "
" vervain	1½ "
" peppermint	¼ ounce.
" neroli petit grain	1 "

White Windsor Soap.

Take

White tallow	80 lbs.
Cocoa oil	40 "
Lye of crystals of soda at 30°	68 "
" " " potash at 30°	12 "

Melt the greases in a kettle of a capacity of about fifty gallons. When the fusion is complete and the temperature is at about 35° C. (95° F.), introduce the lyes little by little, stirring all the time, and continue until the substances form a homogeneous paste. The operation lasts about fifteen minutes. This soap is perfumed with

Oil of carvi (caraway)	4 ounces.
" bergamot	6 "
" Portugal	2 "
" cloves	½ ounce.
" lavender	4 ounces.
" thyme	2 "

Add the oils to the soap a few minutes before introducing into the frames. When the soap has become solid divide it into cakes weighing from two to four ounces, according to the size of the mould. The soap thus prepared is of a very pure white, and does not contain too much caustic alkali.

Honey Soap can also be made of the half-palm soap with rosin, by putting in the pan just before turning into the frame 8 ounces of citronella oil and 2 ounces of lemon-grass oil to each 100 pounds.

Glycerine Soap can be perfumed in the same way; for each 100 pounds take

Oil of cassia	2 ounces.
" caraway	1 ounce.
" lavender	4 ounces.
" mirbane	1 ounce.

Let both of these soaps be a bright yellow, the last of a somewhat darker shade to distinguish it.

Marsh-mallow Soap can be made by an admixture of the palm and the half-palm soap, and perfumed to each 100 pounds with

Oil of lavender	6 ounces.
" lemon-grass	4 "
" peppermint	½ ounce.
" petit grain	½ "

To make a good rose soap take equal parts of the white and cocoa-nut oil soap, and color 100 pounds with 12 ounces of French vermilion, and perfume with

Oil of rose geranium	4 ounces.
" rose	1 ounce.
" cinnamon	1 "
" bergamot	2 ounces.

OLD BROWN WINDSOR SOAP.

This popular soap, when properly prepared, is made in the following manner: Take of boiled palm soap and half-palm soap each 50 pounds; put in the stripper, and make into thin shavings, and spread upon sheets of strong paper to dry; when dry, melt in a marine bath with a small portion of an aromatic water, and when it is again hard enough proceed to cut it up and strip it as before, drying it again and remelting and adding caramel to color; and after the third operation add the following perfume to the 100 pounds:—

Oil of bergamot	4 ounces.
" caraway	2 "
" cassia	2 "
" lavender	8 "
" cloves	1 ounce.
" petit grain	1 "

Mould or cut into small square cakes, and wrap them in a neat paper wrapper.

Brown Windsor soap owes its fine emollient properties to the amount of labor employed in its manufacture, for it is almost needless to say that the more soap is worked and handled, and melted and remelted, the better it becomes. This soap is, in large establishments, often made of the scraps of all other kinds of soaps that accumulate from moulding and other manipulations, but of course these do not generally produce so good a soap.

HALF BOILED SOAP—SWISS SOAPS.

We employ the latter term to denote the soaps that are usually boiled in one lye and by one operation, and which not being separated retain all their glycerine and are classed among the extempore soaps. There are several ways of working more or less perfect; we will describe two. First, when a soap is composed of one part cocoa-nut oil and two parts of other greases, the cocoa-nut oil is saponified by the cold process separately, while the other greases are boiled with a weaker lye of 12° to 16° B., separated, and the lye withdrawn. The two soaps are then mixed and gently boiled, being careful that they do not separate, and that the due proportion of alkali and water is used to form a neutral soap.

By the second method the process is simplified, and with careful manipulation the result is equally satisfactory, and the yield is greater, 100 pounds of fats forming 210 to 220 pounds of marketable soap. It is customary to make these toilet soaps with a percentage of potash lye with the soda, say about 10 per cent. In this process the whole amount of fats or oils is at once placed in the kettle, and the lyes are made rather strong, 15 to 20° B. One half is put with the grease and heated to a gentle boil, which should cause a combination of the ingredients if the lye is not too strong. When this lye has been absorbed, the rest of the lye is added from time to time until all is taken up, and the froth disappears, and the soap has the proper consistency, and is of a gelatinous appearance, when it is run into the frames, crutched, colored and perfumed, while it is still soft. This operation occupies about four hours.

In forming the Swiss soaps a certain amount of skill is very essential, and various precautions must be exercised in having the due equivalents of fat and alkali, and the proper proportion of water that the soap is to retain, and the final adjustment of the soap at the finish to insure its proper admixture and neutral character. Having a portion of cocoa-nut oil in their composition, they will hold a large percentage of water, and can also be filled with salt water, silicate of soda, etc. etc. Care must also be taken that the soap does not grain; if it does, a few gallons of hot water stirred in will generally restore it to a pasty condition.

Kurten's Table.

Showing the composition and product of soap by the cold process from concentrated lye, and mixture of cocoa oil with palm oil, lard and tallow.

Soap.	Tallow.	Cocoa oil.	Palm oil.	Lard.	Lye.	Degrees.	Salt water.	Degrees.	Potash.	Degrees.	Product.
Cocoa-nut, No. 1 ..	..	100	..	..	56	36	..	..	..	..	153
Paris toilet, round	20	30	..	8	31	36	..	..	5	36	87
" " "	..	25	..	75	50–52	36	..	..	..	..	150
Windsor, square...	66	34	..	..	77	30	..	..	13	30	185
Shaving, No. 1	66	34	..	..	..	..	..	..	..	..	..
	or	or	..	..	120	27	..	..	..	..	214
	33	34	33	..	..	..	..	..	..	..	..
Shaving, No. 2....	33	34	33	..	120	27	12	12	..	..	226
Washing, No. 1 ...	60	40	..	..	..	..	..	..	..	..	..
	or	or	..	..	125	27	25	12	..	..	244
	30	40	30	..	..	..	..	..	..	..	..
Washing, No. 2 ...	40	60	..	..	..	..	..	.	..	..	..
		or	..	..	135	27	50	15	.	..	278
	..	60	40	..	..	..	..	..	..	..	..
Ordinary cocoa oil.	..	100	..	..	..	..	..	..	..	..	..
	or	or	..	..	..	..	..	..	..	..	..
	10	90	..	..	225	21	75	12	..	..	400
		or	..	..	..	..	..	..	..	..	..
	..	90	10	..	..	..	..	..	..	..	..

SECTION XXI.

MISCELLANEOUS TOILET AND MEDICATED SOAPS, WITH FORMULAS.

We have in our two preceding sections given the processes for forming the usual kinds of soaps used for making toilet soap, and those that are at once made, colored, and perfumed at the finish and are ready to be cut up and dried previous to moulding. We here give formulas for making the various soaps now known in commerce, with suitable hints towards many new styles.

As we have said, the manipulation of soaps for the toilet is an important part in the production; to make them marketable, good and uniform, well colored and smoothly finished, nicely perfumed, and neatly packed. To aid these operations, various appliances are used, and much apparatus is needed, and in our next section we will give a careful description with illustrations of all the latest machines now in use and which greatly facilitate the manufacture, saving time and labor, besides improving the quality and appearance of the products.

Many of the finer soaps have to be made from the raw materials, though most of them are made from the stock soaps before mentioned. The different formulas will show in some instances that the soaps can be remelted to produce the best results, though many and most can be mixed, colored and perfumed by repeated passage through the mill, and this kneading that they receive will tend to benefit them.

Cold Cream Soap.

White soap	30 lbs.
Spermaceti soap	20 "
Oil of almonds	½ lb.
Caustic potash, 6°	1 "
Gum tragacanth	2 ounces.

To manipulate, strip up the two soaps, place them in the hopper of the mill, dissolve the gum by previous soaking in a little water, mix with the oil and lye to a uniform consistency, then stir into the soap and grind in the mill until thoroughly combined. Care should be taken to have it as white as possible. Perfume the above with

Oil of bergamot	5 ounces.
" cloves	1 ounce.
" nutmegs	1 "
" thyme	2 ounces.
" bitter almonds	1 ounce.

Bouquet Soap.

White curd soap	60 lbs.
" cocoa-nut oil soap	40 "
Dextrine	3 "

Perfume with

Oil of cedrat	6 ounces.
" asarum	2 "
" cloves	2 "
" thyme	3 "
" petit grain	2 "

Color a light yellow with cadmium yellow, manipulate as for the cold cream soap, dissolving the dextrine in its weight of warm water.

Lemon Soap.

White soap	50 lbs.
Starch	2 "

Perfume with

Oil of lemon	4 ounces.
" bergamot	2 "
" lemon-grass	2 "
" cloves	1 ounce.

Color light yellow with cadmium yellow.

Orange Soap.

White soap	50 lbs.
Starch	2 "

Perfume with

Oil of orange peel	8 ounces.
" cinnamon	½ ounce.
" thyme	2 ounces.

Color dark yellow with naphthaline yellow.

Elder Flower Soap.

Half-palm soap	100 lbs.
Dextrine	3 "

Perfume with

Oil of bergamot	8 ounces.
" lavender	2 "
" thyme	2 "
" cloves	1 ounce.
" cassia	½ "
" almonds	½ "

Color light green with Guinet's green.

Heliotrope Soap.

White curd soap	80 lbs.
Palm soap	20 "
Starch	4 "

Perfume with

Oil of rosemary	4 ounces.
" thyme	2 "
" rose geranium	3 "
" cloves	2 "
" almonds	1 ounce.
Balsam of Peru	3 ounces.

Color light purple with a red and blue color.

Frangipanni Soap.

Palm soap	30 lbs.
White soap	20 "
Dextrine	2 "

Perfume with

Oil of bergamot	4 ounces.
" neroli	2 "
" santal	2 "
Tincture vanilla	4 "
" civet	4 "

Color light brown with tincture of catechu.

For toilet soaps made with other soaps, these recipes will give a proper idea and hints for any kind the manufacturer will desire.

SUPERFINE SOAPS.

We will now proceed to give the formulas for fine and superfine soaps, to which we would recommend the addition of a little wax as giving a consistency and smothness, besides improving their quality.

AMBERGRIS SOAP (Ambrosial Soap).

Grease perfumed with ambergris and musk	25 lbs.
Jasmine pomade of flowers, No. 24	10 "
Rose " " " "	10 "
Beeswax	1 lb.
Gum tragacanth	3 ounces.
Caustic soda lye, 33° B.	25 lbs.

Color light brown with caramel.

This soap is made of select materials by the cold process, and after being made is allowed a few days to dry before milling; the musk and ambergris have to be added to the grease some weeks before, frequently melting and stirring.

BENZOIN SOAP.

Lard with benzoin	30 lbs.
Cocoa-nut oil	10 "
Tallow	10 "
Soda lye, 35° B.	26 "
Gum tragacanth	2 ounces.

Perfume with

Oil of bergamot	8 ounces.
" lavender	3 "
" pimento	1 ounce.
Flowers of benzoin	3 ounces.
Tincture of benzoin	3 "

Saponify in the usual way. The lard with benzoin is made by infusing the lard with the powdered gum, two ounces to the pound for a month, occasionally melting and stirring. Melt and strain off the clear lard before using.

JONQUILLE SOAP (superfine).

Orange-flower pomade, No. 24	20 lbs.
Tuberose " "	10 "
Jasmine " "	10 "
Castor oil	10 "
White wax	1½ "
Gum tragacanth	2 ounces.
Caustic soda lye, 36° B.	27 lbs.

Saponify as carefully as possible, avoiding too much heat. This soap will be a light yellow. To enhance the color add a little anatoline.

MILLEFLEUR SOAP.

Lard with vanilla	20 lbs.
" ambergris	10 "
Rose pomade (aux fleurs) No. 24	10 "
Butter of cocoa	10 "
Chocolate	2 "
Caustic lye, 36° B.	26 "

Perfume with

Oil of orange (Portugal)	8 ounces.
" lavender	4 "
" cloves	2 "
" nutmegs	1 ounce.
Tincture of musk	4 ounces.

The chocolate will give the proper color. Operate with care, and you will have a very fine soap.

SAVON A LA MARECHALE (surfin).

Lard with musk	10 lbs.
" " ambrette.	10 "
Pomade (aux fleurs) No. 24 :	
Cassia, jasmine, and rose, of each	10 "
Olive oil	1 lb.
White wax	2 lbs.
Gum tragacanth	2 ounces.
Caustic lye, 36°	28 lbs.

Saponify carefully and color with a little caramel.

SAVON HYGIENIQUE (extra fine).

Orange flower pomade, No. 24	10 lbs.
Rose pomade, No. 24	5 "
Palm oil (bleached)	20 "
Cocoa butter	5 "
Olive oil	10 "
White wax	1 lb.
Caustic lye, 38° B.	24 lbs.
Gum tragacanth	2 ounces.

Perfume with

Oil of santal	2 ounces.
" geranium	2 "
" valerian (rect.)	1 ounce.
" melisse	1 "
" orange	4 ounces.
" thyme	2 "

Avoid too much color; the soap should have a yellowish-brown that needs no addition.

SAVON A LA VIOLETTE DE PARME.

Violette pomade, 24	20 lbs.
Rose " 24	10 "
Cassia " 24	10 "
Palm oil (bleached)	10 "
Soda lye, 36° B.	25 "
Gum tragacanth	2 ounces.

Give it a purple color, not too dark.

Lettuce Soap.

Lard with lettuce	20 lbs.
Cassia pomade, 24	10 "
Spermaceti	5 "
Castor oil	5 "
Palm oil (bleached)	10 "
Caustic lye, 36° B.	26 "
Gum tragacanth	3 ounces.

Perfume with

Oil of bergamot	6 ounces.
" thyme	2 "
" valerian	1 ounce.
" cloves	1 "

Color light-green with Guinet's green. The lard with lettuce is made by melting the lard with its own weight of lettuce leaves, keeping it at the melting point, about 32.2° C. (90° F.), for some hours, or until the leaves have parted with their color and juice, then strain off for use.

Cucumber Soap.

Operate as for lettuce soap, using the fruit.

Mousseline Soap.

Similar to marechale soap, using another color.

Savon de Muguet. Lily Soap.

Similar to jonquille soap, keeping it as white as possible.

Rose-leaf Soap (extra fine).

Rose pomade (aux fleurs) No. 24	20 lbs.
Lard	20 "
Cocoa-nut oil	10 "
White wax	2 "
Soda lye, 36° B.	20 "
Potash lye, 30° B.	12 "
Gum tragacanth	3 ounces.

Perfume with

Oil of roses	2 ounces.
" geranium	2 "
" rhodium	1 ounce.
" bergamot	2 ounces.
" cinnamon (Ceylon)	½ ounce.

Color with aniline (fast red) a light pink.

VIOLET SOAP (yellow).

Cocoa-nut oil	20 lbs.
Palm oil	20 "
Tallow oil	10 "
Soda lye, 36° B.	26 "
Orris root in fine powder	4 "

Perfume with

Oil of lemon	4 ounces.
" rhodium	2 "
" thyme	2 "
Tincture of musk	4 "

Color with cadmium yellow.

VANILLA SOAP (superfine).

Lard with vanilla	30 lbs.
Cocoa butter	10 "
Palm oil	10 "
Caustic lye, 36° B.	26 "
Wax	2 "
Starch	2 "

Perfume with

Tincture of vanilla	4 ounces.
" " musk	2 "
" " ambergris	2 "
Oil of rose	½ ounce.

Lard with vanilla is prepared by adding the vanilla to the lard (1 oz. to the lb.), keeping it at a moderate heat for some days, straining, etc.

ROSE WINDSOR SOAP

Is best made with the white soap as a body, coloring red, and perfumed nicely with any of the numerous formulas as here given.

Violet Windsor Soap.

Take any good soap, say a mixture of white and palm soap, color yellow, and perfume nicely.

Musk Windsor Soap.

A palm soap perfumed with the tinctures of musk, civet, and vanilla, and colored brown with malline brown and well milled. These Windsor soaps are usually wrapped in neat wrappers.

As French soaps have a just reputation for good quality, we append a list of names of some.

French Toilet Soaps.

Savon a l'ambre.
" au bouquet.
" a la fleur d'orange.
" a l'acacia.
" a la julienne.
" au narcisse.
" a la jacinthe.
" a la jasmine.
" a la jonquille.
" au vitevert.
" a l'œillet.
" a la mousseline.
" a la mignonette.
" aux fleurs d'Italie.
" a la palma rosa.
" a la rose-blanche.
" a la lavende.
" au chypre.
" a l'iris.
" a l'heliotrope.
" a la violette.
" au pois de senteur.
" a la noisette.
" a l'amande amare.

Savon a la verveine.
" a la tubereuse.
" a la limette.
" au lilas.
" aux millefleurs.
" au myrte.
" a la maréchale.
" orientale.
" occident.
" des Indies.
" a la balsamine.
" au geranium.
" a la dalie.
" a la campanule.
" a la camelie.
" aux fleurs de champ.
" a la rose.
" a la rose du Provence.
" a la rose de Bengale.
" a la giroflée.
" au patchouli.
" au santal.
" au musc.

MEDICATED SOAPS.

Soap is a valuable vehicle for the administration of many medicinal and curative substances, and, when the article is not altered or injured by the natural excess of alkali in all soaps, it is a useful means to that end. Many cosmetics are also added to soap.

CARBOLIC SOAP.

Half-palm soap	20 lbs.
Starch	1 lb.
Carbolic acid (crystals)	1 ounce.
Oil of lavender	2 ounces.
" cloves	1 ounce.

MEDICATED TAR SOAP.

Cocoa-nut oil	20 lbs.
Tallow	10 "
Juniper tar	5 "
Soda lye, 40° B.	15 "

The greases should first be saponified, and the juniper tar added at the finish; perfume can be added, though fine perfume would be lost in the strong odor of the tar.

SULPHUR SOAP.

Take any good hard soap, the half-palm for instance, and melt carefully with dissolved starch, and add about 12 per cent. of lac sulphur, color light yellow with naphthaline yellow. Perfume to fancy.

TOOTH SOAP.

Tallow soap, white	20 lbs.
Pumice stone (lixiviated)	½ lb.
Prepared chalk	2 lbs.
Starch	½ lb.

Perfume and color to suit. The soap can be melted or milled and the ingredients thoroughly incorporated. Any color, perfume, or name can be given it.

Thus the intelligent soap-maker can prepare any kind of medicated soap by using the proper proportion of the substance, taking care that the medicine may not be injurious to the skin or the health.

Tannin Soap with 3 per cent. of tannic acid.

Salicylic Soap with 2 per cent of salicylic acid.

Disinfectant Soap with carbolic acid, about 2 per cent.

Thymol Soap with 3 to 5 per cent. of thymol.

Croton Oil Soap with 2 per cent. of croton oil.

Benzoic Acid Soap with 2 per cent. of benzoic acid.

Castor Oil Soap with 20 per cent. of oil with the other fats.

Petroleum Soap with 20 per cent. of the petroleum oil added to the other fats before saponification.

Paraffin Soap: the wax is added to the amount of 10 per cent. to the fats before saponification.

Creasote Soap with 2 per cent. of creasote.

Bromine Soap with 2 per cent. of bromine.

Iodine Soap with 2 per cent. of iodine.

Turpentine Soap with 5 per cent. of oil of turpentine.

Alum Soap with 10 per cent. of finely powdered alum.

Borax Toilet Soap with 10 per cent. finely powdered borax.

Mercurial Soap with 6 per cent. of mercurial ointment.

Irish Moss Soap with 5 per cent. of Irish moss dissolved in a suitable quantity of water and strained.

Bran Soap with 10 to 20 per cent. of bran.

Cornmeal Soap with 10 to 20 per cent. of maize flour.

Oatmeal Soap with 10 to 20 per cent. of oatmeal.

Camphor Ice Soap with 5 per cent. of camphor—added to cold cream soap would be very suitable.

Wax Soap with 10 per cent. of wax added to soap. It has some good and useful properties.

Egg Yolk Soap.

Cocoa-nut oil	10 lbs.
Tallow	10 "
50 yolks added to olive oil to make	5 "
Soda lye, 38° B.	10½ "

Perfume with

Oil of lemon	2½ ounces.
" sassafras	1½ ounce.
" thyme	½ "
" cloves	½ "

Color light yellow. Supposed to be beneficial to the skin.

BORDHARDT'S HERB SOAP.

Olive-oil soap	30 lbs.
Palm-oil soap	20 "
Dextrine	2 "

Perfume with

Oil of rosemary	2 ounces.
" lavender	1½ ounce.
" thyme	1½ "
" sage	1 "
" magnolia	1 "
" peppermint	1 "

Color blue.

BEEF MARROW SOAP.

Beef marrow (purified)	25 lbs.
Soda lye, 36°	10 "
Potash lye, 30°	3 "

Saponify in the usual way, color yellow, and perfume to suit.

SPERMACETI SOAP.

Lard	30 lbs.
Castor oil	10 "
Spermaceti	20 "
Soda lye, 38°	25 "
Potash lye, 21°	8 "

Avoid all color, and let the perfume be good.

SHAVING SOAPS IN TABLETS

Are made with a perfectly neutral soap having a certain portion of potash in the lye. The walnut-oil military soap is made thus, using a portion of nut or poppy oil.

SHAVING COMPOUNDS,

Usually put up in china boxes or mugs, are made with well-selected soaps with some potash to keep them plastic, or a mixture of soda and potash soaps is made and perfumed in the mill. The variety of these soaps is so great that it is useless to give formulas; these hints must suffice.

FLOATING SOAPS

Are made from soaps that are composed of vegetable oils or greases, which are stripped and melted in a little water, the vessel being placed in a marine bath, which is water containing a portion of salt and which can be heated above the heat of boiling water. The kettle has a mechanical stirrer, which causes the soap to foam to twice its bulk, being filled with portions of air. It is then poured into shallow frames, and in about a week's time cut into cakes.

NYMPH FLOATING SOAP.

Palm soap	30 lbs.
Cocoa-nut oil soap	20 "
Perfume to suit	8½ ounces.

ROSE FLOATING SOAP.

Olive-oil soap	30 lbs.
Cocoa-nut oil soap	20 "
Color with vermilion	3 ounces.

Perfume with

Oil of rose	¼ ounce.
" bergamot	4 ounces.
" geranium	2 "

POWDERED SOAPS.

In this form very convenient kinds of cosmetics are made and used for a variety of purposes, as a dentifrice, for shaving, etc. They are made from any pure soap, which is cut into shavings and thoroughly dried, when they are ground and sieved into the finest possible powder, perfumed and colored in any way desired. They should be put up in well-stopped bottles, or they will absorb moisture and form into lumps again.

SOAP ESSENCES

Are usually made by dissolving a potash soap in a suitable quantity of alcohol of 85°, perfuming and coloring to suit; the colors should be transparent or they will precipitate.

TRANSPARENT TOILET SOAPS

Are among the most important now made, and owing to their neutrality and free lathering they find much favor. They are also attractive in appearance. They are usually made with tallow, cocoa-nut oil, and castor oil in varying proportions. Rosin also is added in the cheaper kinds, though it should be used with caution as it tends to give the soap a dark color. The cold process is now the usual mode of making these popular soaps, and requires great exactitude in the proportions, and some experience and skill to produce a favorable result. It is needless to say that the greases and alkalies should be in their purest condition.

TRANSPARENT SOAP BY THE COLD PROCESS.

Tallow, or a suitable mixture . .	95 kilog.	(209 lbs.)
Caustic soda lye, 40° B. . . .	43 "	(94.6 ")
Alcohol	50 "	(110 ")

To the melted greases add one-half the alkali, keeping the heat as low as possible or about 48.9° C. (120° F.); when, with constant stirring, the fresh lye is combined, add the balance of the lye, to which had been previously added the alcohol, the heat being well regulated; saponification will now ensue very rapidly; then add the perfume and color and pour into the frames, cooling very gradually.

The transparency will not be perfect until it has been exposed to the air for some days; this quantity of soap will require about a kilog. (2.2 lbs.) of mixed essences to perfume it. The coloring matter if added should be perfectly transparent. These soaps are seldom colored.

TRANSPARENT GLYCERINE SOAP.

Tallow (mutton)	20 kilog.	(44 lbs.)
Cocoa-nut oil	20 "	(44 ")
Castor oil	10 "	(22 ")
Glycerin, pure	10 "	(22 ")
Caustic lye, 40° B.	26 "	(57 ")
Alcohol, 96°	22 "	(48.4 ")
Water	4½ "	(9.9 ")

Melt the grease at 40° C. (104° F.), and add the alkali by slow degrees, keeping the heat low to prevent evaporation, and stir constantly. When the lye has been absorbed after three or four hours' stirring, add the alcohol, which should be warmed, stir till it becomes clear, then add the glycerine, and, when mixed, the water and perfume; turn into the frame pouring slowly. This soap if carefully made is a very superior one.

Transparent soaps by the older method were made by dissolving tallow curd soap in its own weight of alcohol 85°, having first cut the soap into shreds and dried it thoroughly. The ingredients were placed in a still, heated by a water bath, the head put on, and the condenser or worm attached and the greater portion of the alcohol recovered which can be used again for another operation.

There is a still simpler method of making transparent soaps, and which is generally applied to the cheaper kinds. Tallow and rosin soaps are stripped or planed into shavings and dried as much as possible in heated air, and alcohol of 95°, of which latter one-half the weight is taken and mixed in the water bath with the soap which is soon dissolved. The heat is continued for some time to evaporate the excess of alcohol, when it is perfumed and framed. This soap requires some time to dry before it becomes properly transparent.

TRANSPARENT SOFT SOAPS.

Oleophane or *Sapophane* is made in the same manner as the kinds above mentioned, substituting potash lye for the soda, and is valuable for shaving and other toilet purposes.

LIQUID GLYCERINE SOAP much in favor is made thus:—

Oleic acid	85 kilog.	(187 lbs.)
Cocoa-nut oil (best)	15 "	(33 ")
Potash lye, 35° B.	52 "	(114 ")
Glycerin	4.5 "	10 "

The ingredients are saponified at a gentle heat, and sufficient 95° alcohol added to make the soap clear, and it is then filtered.

SOFT TOILET SOAPS OF POTASH.

SHAVING CREAMS.

Soaps of potash are among the most valuable cosmetics prepared by the soap-maker or perfumer, and much care should be exercised in having the purest materials, the greatest cleanliness, and the true equivalents of the parts, as any carelessness in them particularly deteriorates the quality of the product.

WHITE SOFT SOAP.

To prepare this soap very white, operate in the following manner:—

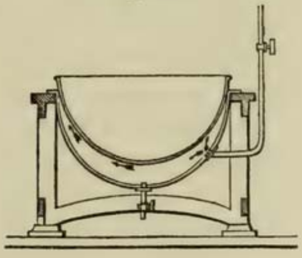
Melt in a sheet-iron kettle of a capacity of about 50 gallons, 50 pounds of white fat, and 13 lbs. of cocoa oil. When the fatty matters are entirely melted, add 50 lbs. of lye of potash at 20° or 21° B. Stir all the time, so as to aid the saponification, the temperature being kept at from 60 to 65.5° C. (140° to 150° F.). Under the influence of heat and stirring, the aqueous part of the lye evaporates and the mixture acquires a thicker consistency. Sometimes it happens that a part of the fatty matters separates; this effect is produced especially when the temperature of the mixture is raised near the boiling point, because at that temperature, concentrated lyes have little affinity for fatty substances. This effect may also be produced by the insufficiency of alkali in the mixture. In the first case the homogeneity is re-established by moderating the action of the heat, and in the other, by pouring into the kettle a portion of strong lye necessary to complete the saponification.

This first stage of the operation lasts about four hours. To obtain a perfect soap, add a new portion of 10 lbs. of lye of potash at 16° B., and be careful to keep the mixture very uniform by a continual stirring. Keep the temperature below the boiling point, and as much as possible between 60° and 65.5° C. (140° and 150° F.).

The saponification is finished when the paste has acquired a very thick consistency; at this point turn off the heat.

Many perfumers prepare this soap in iron kettles with a double bottom, heated by steam; some use silver kettles which are preferable, because the soap will retain in them all its whiteness.

Fig. 63.



The above figure represents a jacket or kettle with a double bottom, heated by steam. This kettle is of tinned copper, and may be used also to purify tallow and greases. The operation lasts in all from seven to eight hours. When the soap is entirely cooled down, pour it into large stone jars in which it is kept for use. Soft soap, as obtained by the saponification of fatty matters by potash, has not that bright and nacreous appearance required for the toilet. To obtain it in this state it is ground in a marble mortar, and aromatized with oil of bitter almonds.

Almond Shaving Cream.—Take a few pounds of the above soft soap, introduce it into a marble mortar, and strongly triturate with a wooden pestle. The operation is finished when the soap forms a soft and homogeneous paste; the more it is beaten, the finer it will be. To perfume it, incorporate from 1½ to 2 drachms of oil of bitter almonds per pound.

Thus prepared, this soap forms an unctuous paste very soluble in water. When it contains some cocoa-nut oil, it is yet softer.

Rose Shaving Cream.—To give this soap a slight rose color, when pearling add one-quarter to one-half a drachm of vermilion per pound of soap, perfume with otto of rose; it then takes the name of rose shaving cream.

Ambrosial Shaving Cream, Crême d'Ambrosie.—Perfume with liquid storax and benzoin, oils of bergamot and cloves, and color purple with tincture of archil.

SHAVING CREAM BY BOILING.

In some instances, a soap by boiling will prove more satisfactory, particularly when it is mixed and milled with a soda soap to form shaving tablets. The cream is rarely of so white a color as that made by the cold process. To proceed, take 30 pounds of white grease to 45 pounds of potash-lye of 17° B., and boil gently while stirring, until a paste is formed, when boil more briskly until the vapors nearly cease, and the soap forms into an almost perfect jelly when it is finished, and when cold it should be almost neutral.

NAPLES SOAP, OR SHAVING CREAM.

Take of the

Boiled soft soap	50 lbs.
Gum tragacanth	2 ounces.
Tincture of musk	2 "
" " ambergris	1 ounce.
" " balsam Peru	3 ounces.
Oil of geranium	2 "

Color a light brown.

SOAP BALLS OR SAVONETTES,

Often called wash balls, once very much used, are made of any good hard soap cut into squares and rounded in the hand with a brass tool until spherical. The mottled soap marbled with vermilion and ultramarine is the kind most used. The transparent soaps are also formed into balls and have a good appearence, and are still much in vogue.

GLYCERINE COCOA-NUT OIL SOAP.

Cocoa-nut oil	50 lbs.
Tallow	20 "
Soda lye, 38° B.	36 "
Starch	4 "
Soluble glass	10 "
Salt water	10 "
Glycerine, 26° B.	10 "

Perfume with

Oil of mirbane	1 lb.
" cassia	¼ "

A handsome white translucent soap.

We think it is unnecessary to extend the list further, as we have more than outlined the numerous soaps in vogue, and given examples that should be amply sufficient to any intelligent manufacturer. To give the formulas of all the different soaps of commerce would require space that would double the size of our volume. We must proceed to the more important subject of manipulating toilet soaps, for in the quality of the work bestowed upon them, depends much of their superiority and their good appearance.

SECTION XXII.

MANIPULATION OF SOAPS.

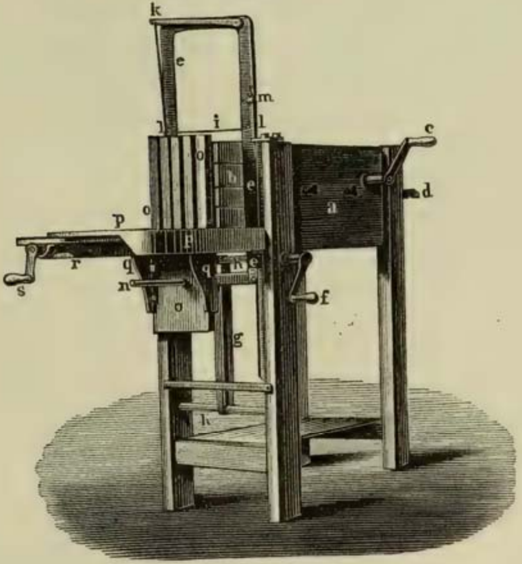
Machinery and Appliances, Perfuming, Coloring, Finishing, etc.

For this important portion of our work we must give many particulars with descriptions of all the newest kinds of apparatus that have been invented to aid in this useful manufacture. In the chapters on domestic soaps we have given descriptions of the usual appliances for this fabrication, which, in the making of the soaps, are equally applicable to toilet soaps, and a necessary part of the plant, though, if toilet soaps only are made, they need not be of so great a capacity or on so large a scale. It will not be necessary here to repeat these descriptions. But for toilet soaps many other and useful machines are requisite, which we will illustrate and describe.

Soap Caking Machine.

When the soap from the frames is submitted to the slabbing and barring machine, it is necessary still further to divide it into small cakes of a convenient size for moulding. For this purpose the machine here shown (Fig. 64) is very convenient. The case or box *a*, which has a width of about 12 inches, and whose length is dependent on the length of the soap-bars which are to be cut, serves for the reception of the bars *b*. The crank *c* moves the bars of a rack and pinion jack *d*, which is supplied with a thumb-screw. In front of it is affixed the cutting-frame *e*, of wrought iron, which by means of the crank *f*, moves several secure guides, thus, that two *girths g*, winding up and off around the two shafts *h*. Upon the frame *e* the cutting-wire *i* is placed across the case *a* about one centimetre below the level of the bottom of the case, that one of the ends is fastened to the spring *k*, while the other—after giving to the wire its guide over the two rolls *l*—is fastened to the pin *m*, which is supplied with a check appliance. With the frame *e* are furthermore connected, the round iron bar *n* and the measuring board *o*, which on its upper part is divided in fork-shape, so that by the movement of the frame *e* up and down, it must needs also make this same motion with the frame in the front part of the table *p*. The front table is likewise divided, so that the forks of the board may enter. The strict guidance of the vertical motion of the board is effected by the guiding ledges *q*. The measure-board *o* is furthermore connected with the screw *r*, which is turned by means of the crank *s*, thus carrying out the horizontal motion of the measuring board.

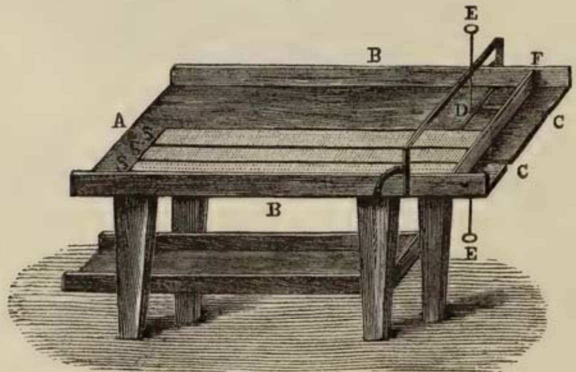
Fig. 64.



Soap Caking Machine.

The work with this machine is conducted as follows: Fill the case *a* with bars *b* and then by turning the crank *s* bring the measuring-board *o* the distance to the cutting-wire *i*, that the pieces are desired to measure in length. Thereupon turn by means of the left hand, with the crank *f*, the cutting-frame *e*, and with it the measuring-board *o* high up, so that the cutting-wire *i* is situated above the level of the bar *b* which is to be cut. Then turn by the use of the right hand, by means of the crank *c* and the rack and pinion *d*, all the bars *b* which are in the case *a* forward, and under the wire *e*, until they are pushed upon the raised measuring-board *o*. (In our representation the apparatus appears in this position.) Now, the cutting may begin, by simply moving the cutting-frame *e*, by applying the crank *f* downwards, and thereby cutting all the bars with the wire *i*. Whereas by descending of the cutting-frame *e* the measuring-board likewise descends, thus forming a surface or one plane with the surface of the front table *p*. The removal of the soap thus cut becomes very convenient.

Fig. 65.



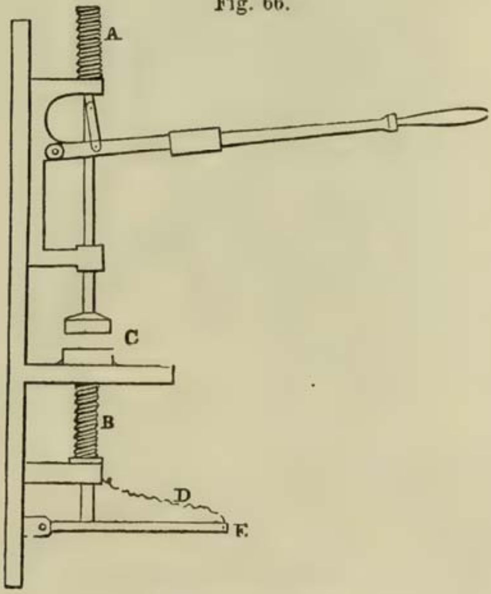
Cutting Table.

As the measuring board *o* can be placed at every desirable distance from the cutting wire *i*, the bars may be cut by this machine very accurately into pieces of any desirable length. Such a machine may be handled by a mere lad, and with it, 100 pounds of soap may be cut within about two minutes into pieces of any desired length.

Cutting Table.—We also illustrate a cutting table, Fig. 65, which by some manufacturers is preferred, in fact is handier for cutting the strips that are formed by the plotters, as they are too long for the cutter previously described. A detailed description is not necessary, as the illustration shows the manner of working, which is also very rapid. To work with this machine, the bars of soap *S S S* are laid upon the table *A* and cut by the wire *E*. The gauge-board *F* is fastened by thumb-screws *C C* beneath the table.

Hand Press.—When these cakes are to be moulded they are previously placed upon racks, which is an arrangement of latticed strips of wood either stationary or portable, and similar to those described elsewhere. After they are sufficiently dry it is often necessary to give them a form similar to that intended as a finish, which is often done in a hand press in a plain mould. This press is here illustrated, and there are many other similar ones made and used.

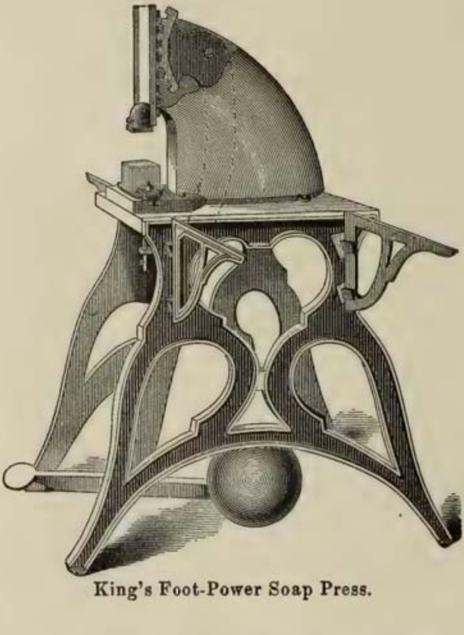
Fig. 66.



Hand Soap Press.

King's Foot Power Press.—A soap press worked by the foot is also used for this purpose, in fact for general use; and is a much more convenient and powerful press, and has been in common use; we illustrate it here. Among many similar foot presses this is we think the most powerful; one blow being usually sufficient to mould the largest size cake. It is made by W. H. King, of Philadelphia.

Fig. 67.



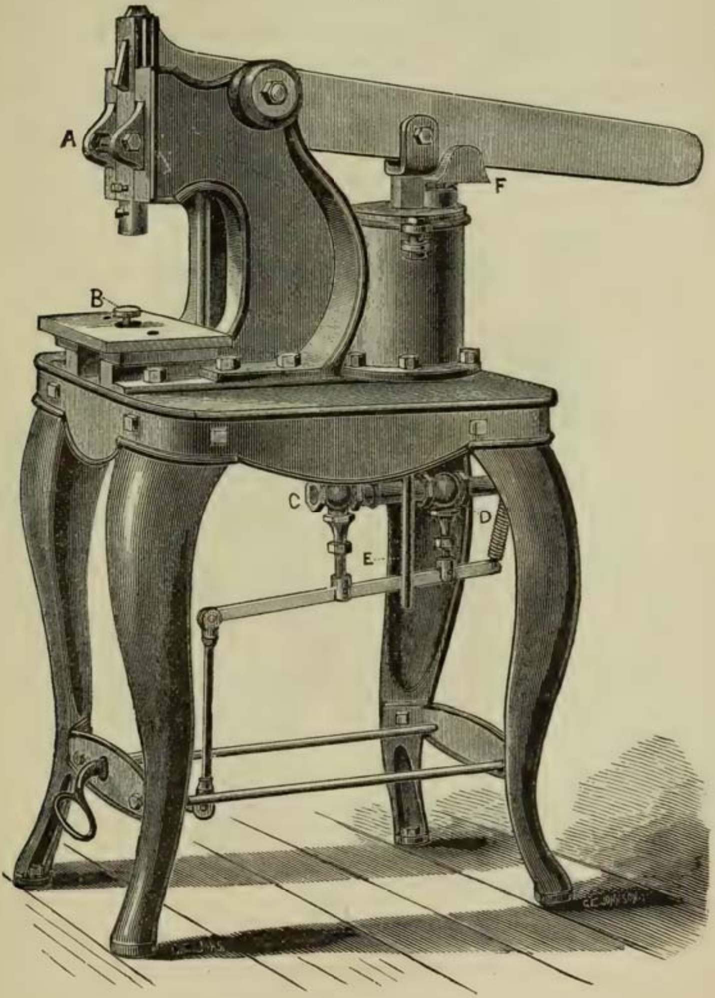
King's Foot-Power Soap Press.

Hersey's Patent Steam Press.—For an extensive business the steam press made by the Messrs. Hersey Brothers, South Boston, Mass., is the most useful one we know of, as a smart workman can upon it mould 2000 cakes an hour.

The *modus operandi* of the press is very simple, viz.:—

A gentle pressure of the foot upon the treadle fills the cylinder with steam, causing the die to descend with lightning rapidity upon the cake of soap, and the instantaneous return of the lever raises it out of the die-box ready for removal. The blow given by the steam soap press is so powerful that the soap pressed by it looks better, and is more solid than when operated upon by the old-fashioned foot

Fig. 68.

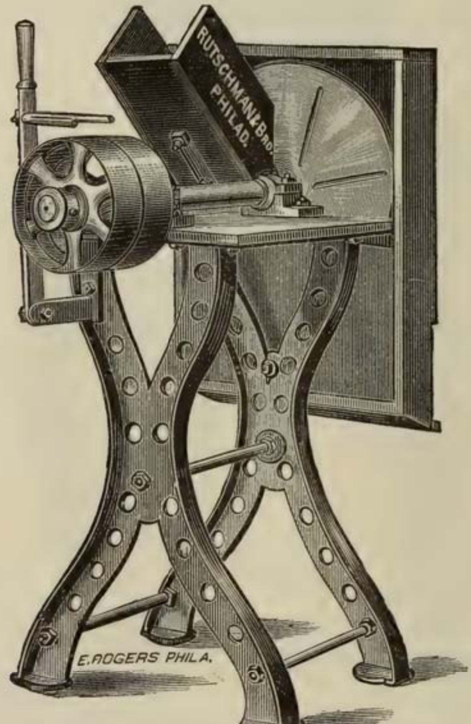


Hersey's Patent Steam Soap Press.

power press. The cost of running it is so trifling that the required amount of steam at twenty pounds pressure, conveyed through a one-inch pipe, would not be missed from a very small steam boiler. The entire press is constructed in a very substantial manner. It is ready for work at short notice, as it is only necessary to connect it with steam piping and commence pressing immediately. Cakes of soap, varying in weight from a few ounces up to the very largest sizes, are pressed with the greatest ease.

Stripping of Soaps.—In the manipulation of soaps, the stock soaps previously mentioned have to be cut into shavings or chips previous to receiving their color and perfume, and to being milled. For this purpose many machines have been invented and are of very simple construction, but all of them are an improvement upon the plane, the implement

Fig. 69.



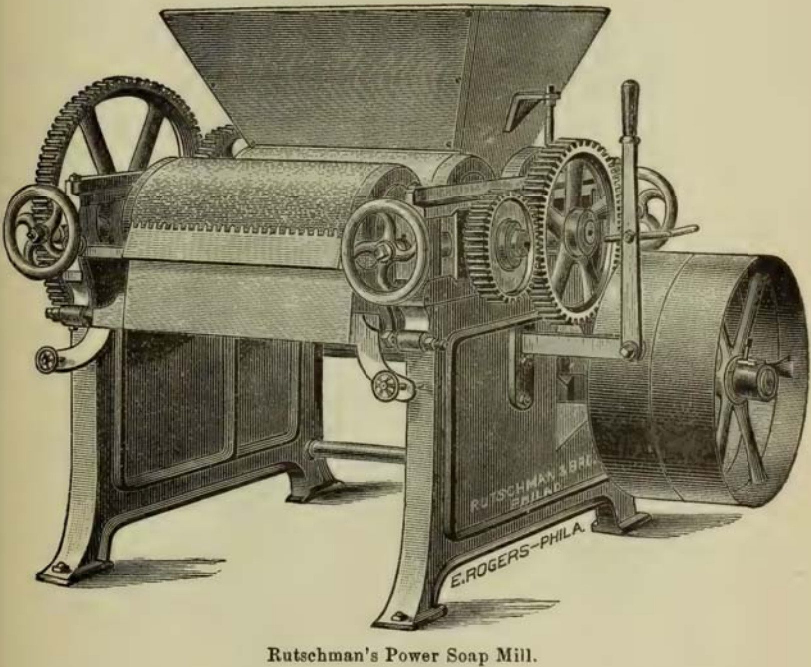
Rutschman's Stripping Machine.

formerly used. The latest and most approved machine for this purpose is that made by the Messrs. Rutschman and Brother of Philadelphia, which is given here.

This stripper or clipper works with great rapidity. The plate has six knives which can be regulated to cut the shavings of any thinness, and can be cleaned with ease. In working it is only necessary to lay the bars of soap in the hopper and set the machine running, and it will strip several hundred pounds an hour.

Soap Mills.—After the soap has been reduced to shavings by means of the stripper or clipper, and, as it is technically called, stripped, these are mixed with the requisite coloring (if to be colored), and perfume (if to be perfumed), and stirred together in the receiving box, when they are conveyed to the mill. Of the many soap mills in use none are so powerful

Fig. 70.



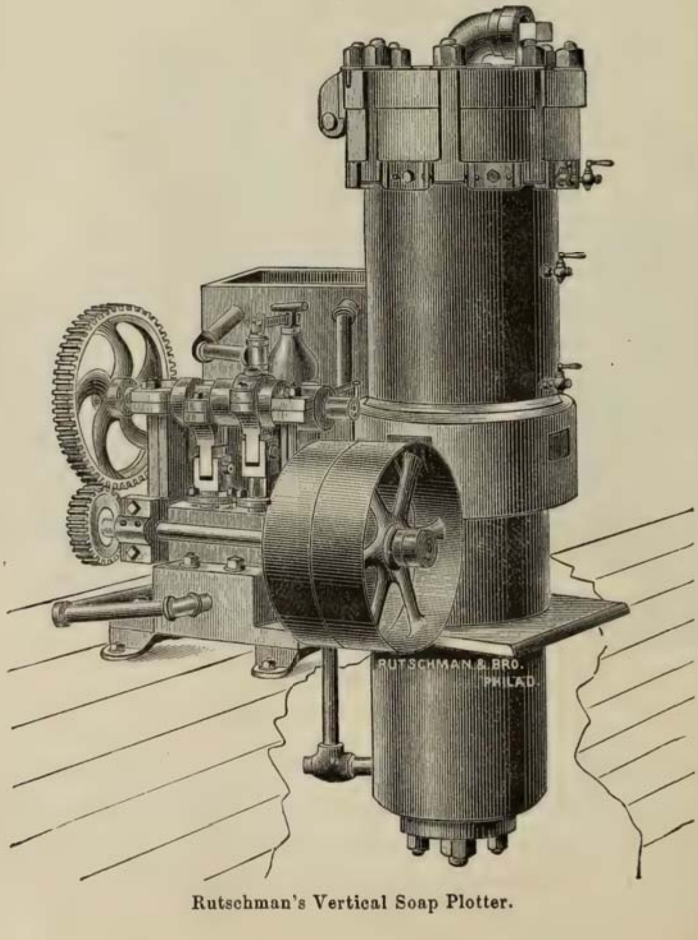
Rutschman's Power Soap Mill.

or so rapid as those now made by the Messrs. Rutschman of Philadelphia, here illustrated.

This is the largest size, and will mill 2000 pounds of soap in a day. It weighs about 1600 pounds, and is made so strong and well that it will last many years and do the work thoroughly.

By the action of this mill the soap is made into a homogenous mass, and the different soaps, the colors, and the perfumes completely blended, by repeatedly running through, until this object is attained.

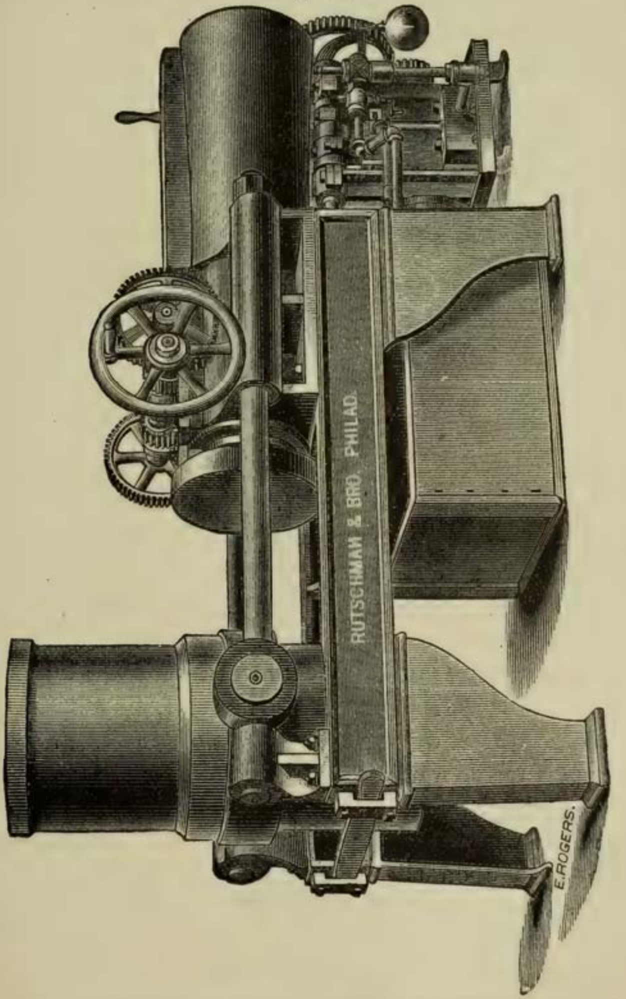
Fig. 71.



Rutschman's Vertical Soap Plotter.

Plotting.—When the soap paste is smooth and shows no grains or streaks, it is formed into balls or cakes of the required size; this is called plotting or *peloting.* This operation is now performed by another machine, and one of the most useful, for in this plotter the soap is pressed into a solid substance with great pressure, insuring the cake when formed

Fig. 72.



Rutschman's Hydraulic Soap-Plotting Machine.

against any interstices or any liability to crack and fall to pieces, when dry or when wet.

Rutschman's Vertical Plotting Machine.—This valuable labor-saving machine (Fig. 71), made by Messrs. Rutschman & Bro., Philadelphia, has a capacity for 100 pounds of soap, and is suitable for an ordinary business. Its working is similar to that of the larger machine also here shown.

Hydraulic Plotting Machine.—This new plotter (Fig. 72) is also made by the Messrs. Rutschman, who make a specialty of manufacturing soap machinery. It is of great power, and subjects the soap to a pressure of 3000 to 4000 pounds to the square inch. The machine here illustrated has a capacity of 200 pounds of soap, and can be charged and discharged five times a day, thus plotting 1000 pounds a day. It is made very substantially, and weighs about 5500 pounds. Smaller plotters are made, but they do not, of course, have the same power to press the soap so solidly, and are, therefore, not so suitable.

Finishing and Polishing the Soap Cakes.

The cakes of soap, after they are pressed and apparently ready for the market, are often dried before they can be packed. In this drying they may lose some of their lustre. This process is generally to scrape them off and rub them with a woollen cloth dipped in strong alcohol, a rather tedious process.

This somewhat troublesome process has been superseded according to Dupuis by another method, by exposing the soap before or after drying to a stream of steam. The steam can be perfumed with any fragrant odor, by passing it, before reaching the soap, through a cloth which has been impregnated with fragrant materials. The steam causes at once a change upon the surface of the soap pieces or bars, and forms, according to the fats applied, either a super-palmitinate, or super-stearic palmitin-soda combination. If this operation is carefully done, it closes up all the pores and uneven spots, and when dry forms a very lustrous cover, which does not suffer even under the moulding-press. No other method of polishing will give such a beautiful, even, and lustrous coating, as that caused by steaming. Further advantages for this mode of operating are economy in time, hand labor, and prevention of all loss. Especially will it preserve these soaps in damp magazines, on sea-voyages, and in the show-windows of stores, where they are exposed to the rays of the sun.

Coloring Toilet Soaps.

With the many other improvements in the manufacture of toilet soaps, there has been a corresponding advance in the character and nature of the coloring so necessary to their attractive appearance. While in former times, ochres, chromes, and metallic oxides of iron, as siennas, umbers, etc., were used with many other minerals, the object is now gained by other means, by substituting more soluble colors and such as are generally innoxious.

There are, however, necessary but a few primitive colors, as almost any shade can be produced by a suitable blending of them. Thus yellow and orange are made with the naphthaline yellow or cadmium yellow; red is still made with vermilion, and some shades with new aniline colors which are permanent and not affected by heat or light; blue with ultramarine; green with Guinet's green, which is the borate of chrome; browns are made with caramel, cutch, chocolate modified with red or yellow; anatoline is a good yellow or orange shade. There are also constantly occurring many colors used in dyeing, that may find application for soaps, which can, however, only be known by experiment.

In coloring soaps, it is almost always most desirable to color in the process of grinding in the mill, as it has several advantages. It prevents the color from being injured or altered by the heat; it gives the full brilliancy expected from the substance, and with much less trouble. Many of the cheaper soaps are cut from the solid, and not subjected to the milling and plotting processes. It is then necessary to color and perfume them in the kettle or in the frame.

THE PERFUMING OF TOILET SOAPS.

The perfuming of toilet soaps may be considered one of the most important branches of the art, as the object is to impart a pleasant and at the same time an economical scent. This rather difficult matter is attained only by good judgment, experience, and skill, all of which require some time to gain, unless there be an aptitude in the person, that is rarely met with. It is, therefore, very proper and suitable that we should give some hints founded upon an extensive experience in the art.

Many of the essences or essential oils may not be pleasant when used alone, but when used with others in certain proportions, may produce a fine perfume, and this blending or shading is where the skill is needed, and where the attention of the manufacturer of soaps should be given, for there are certain fine but expensive odors that are universally considered pleasant, but which to use in ordinary soap would enhance the cost too much; thus he should have the skill to give an agreeable odor without making his soap too costly. This subject requires more attention than it usually receives, and is very important to success in making of toilet soaps.

PERFUMES FOR HONEY SOAP.

For each 100 pounds of soap—

I.

Oil of citronella	220	grammes	(7.7 ozs.)
" lemon grass	110	"	(3.85 ")
" cassia	60	"	(2.1 ")

II.

Oil of citronella	200	grammes	(7 ozs.)
" thyme	100	"	(3.5 ")
" caraway	50	"	(1.75 ")

III.

Oil of lavender	120	grammes	(4.2 ozs.)
" cloves	45	"	(1.58 ")
" rosemary	65	"	(2.27 ")
" thyme	50	"	(1.75 ")
" lemon	65	"	(2.27 ")

PERFUMES FOR GLYCERINE SOAPS.

For each 100 pounds of soap—

I.

Oil of lavender	110	grammes	(3.85 ozs.)
" bergamot	80	"	(2.8 ")
" thyme	40	"	(1.4 ")
" cloves	30	"	(1.05 ")
" caraway	20	"	(0.7 ")

II.

Oil of rosemary	160	grammes	(5.6 ozs.)
" orange	80	"	(2.8 ")
" cassia	30	"	(1.05 ")
" thyme	30	"	(1.05 ")
" myrbane	20	"	(0.7 ")

III.

Oil of bergamot	120	grammes	(4.2 ozs.)
" lavender	60	"	(2.1 ")
" thyme	40	"	(1.4 ")
" wintergreen	30	"	(1.05 ")
" cassia	20	"	(0.7 ")

PERFUMES FOR WHITE WINDSOR SOAP.

For each 100 pounds of soap—

I.

Oil of lavender	210	grammes	(7.35 ozs.)
" cloves	40	"	(1.4 ")
" rosemary	80	"	(2.8 ")
" caraway	60	"	(2.1 ")

II.

Oil of bergamot	120	grammes	(4.2 ozs.)
" lavender	80	"	(2.8 ")
" cloves	30	"	(1.05 ")
" thyme	30	"	(1.05 ")
" peppermint	20	"	(0.7 ")

PERFUMES FOR ROSE SOAPS.

To each 100 pounds of unperfumed soap—

I.

Oil of rose	80	grammes	(2.8 ozs.)
" rose geranium	60	"	(2.1 ")
" cinnamon (Ceylon)	20	"	(0.7 ")
" bergamot	40	"	(1.4 ")
Tincture of ambergris	20	"	(0.7 ")

II.

Oil of rhodium	80 grammes	(2.8 ozs.)
" rose geranium . . .	80 "	(2.8 ")
" palma rosa	60 "	(2.1 ")
" cassia	20 "	(0.7 ")
Tincture civet	20 "	(0.7 ")

Perfumes for Elder Flower Soap.

For each 100 pounds of soap—

I.

Oil of lavender	120 grammes	(4.2 ozs.)
" orange	80 "	(2.8 ")
" thyme	40 "	(1.4 ")
" cassia	30 "	(1.05 ")
" wintergreen . . .	30 "	(1.05 ")

II.

Oil of bergamot	120 grammes	(4.2 ozs.)
" lavender	80 "	2.8 ")
" caraway	60 "	(2.1 "
" peppermint . . .	30 "	(1.05 ")
" thyme	20 "	(0.7 ")

Perfume for Cashmere Soap.

For each 100 pounds of soap—

Oil of bergamot	120 grammes	(4.2 ozs.)
" rose geranium . . .	80 "	(2.8 ")
" patchouly	40 "	(1.4 ")
" santal	30 "	(1.05 ")
" valerian . - . .	20 "	(0.7 ")

This must suffice for hints to the perfuming of any desired soap, and applies to the soap that has no perfume, the superfine soaps having a portion of their perfume in the previously perfumed greases. We have already given the perfumes with the formulas for the different kinds of soaps.

SECTION XXIII.

VOLATILE (ESSENTIAL) OILS AND SOME OTHER MATERIALS, USED FOR THE PERFUMING OF SOAPS.

THE fragrant volatile oils appear in commerce of very varying qualities, and are frequently intentionally adulterated. Unfortunately, the means which we possess to discover such falsifications are yet very imperfect, and the best guides at this juncture are always the properties and characteristics of an undoubted genuine oil, and it is the safest plan to purchase these very expensive materials from a source which is known to be reliable. We intend by the following to communicate the properties and the action of a few of these mostly applied to this art. According to the deviations which an oil shows, from the specimen oil which we have on hand, it may be judged with more or less probability, whether the same is genuine or adulterated.

Oil of Valerian.—This oil is produced by the distillation of the root of *Valeriana officinalis* with water. Made of fresh roots it is grassy-green, from older ones dark-brown. The fresh oil is a thin liquid, becoming with age somewhat thicker and yellowish-brown; it possesses a very disagreeable, penetrating valerian smell, and its strength and rankness increase with age. The rectified oil has not an unpleasant odor; its taste is camphor-like, spicy, and burning; it has an acid reaction in consequence of its contents of valerianic acid; forms at —29° C. (—20.2° F.) needle-shaped crystals, boils at 160° C. (320° F.), dissolves easily in alcohol. Its specific gravity varies between 0.94 and 0.96.

Oil of Bergamot.—From the rind of the *Citrus bergamia*, belonging to the family of *Aurantiaceæ*, furnished by pressing. It has a specific gravity of from 0.870 to 0.877. It is a thin liquid of yellowish-green color, when old brownish, has an agreeable odor, spicy taste, easily soluble in alcohol, and its solution opalizes. It is frequently adulterated with almond oil or alcohol; the first is discovered by heating the oil in a water-bath, where finally the non-volatile oil of almonds remains. The alcohol is detected when it is shaken with red sandal wood, which with a pure oil is not touched, but in alcohol is colored. From the other oils of the family *Aurantiaceæ* it differs by its ready solubility in alcohol; 1 part of oil in ½ part of alcohol.

Oil of Bitter Almonds.—This oil is made in the usual manner, by distilling the pulp made of bitter almonds with water. The re-distilled oil is of a golden-yellow, heavier than water, of fatty touch, and has a penetrating smell of bitter almonds and a burning bitterish aromatic taste, similar to prussic acid. It contains prussic acid, and acts as a poison. The fresh rectified oil of bitter almonds is a colorless, strong, bright-burning, thickish liquid, which left exposed to the air becomes yellow by absorption of carbonic acid and oxygen. Its specific gravity = 1.043, its boiling point 180° C. (356° F.). It dissolves in 30 parts water, and in every proportion of alcohol and ether. The oil of bitter almonds, for perfumers and soap manufacturers, is frequently adulterated, as is well known, with the so-called mirbane oil (essence de mirban, a mixture of nitro-benzole and nitro-tolu oil), and sometimes with enormous quantities, even as much as 60 per cent. To detect this adulteration a process has been made public by Bertagnani, which is based upon the easy solubility of the benzole-hydrure (mirbane oil) in an aqueous solution of bisulphate of ammonia, in which the mirbane oil easily dissolves. The combination which hereby ensues, and by a sufficient concentration of the bisulphate solution separates in the form of a crystalline mass, is combined according to the formula $C_{28}H_{16}Na_2S_4O_{18}$. From it, by treatment with a heated solution of carbonate of sodium, the benzole-hydrure can be again completely separated. Upon this action R. Wagner has based a method by means of which the quantity of mirbane oil contained in an oil of bitter almonds may be determined, which for all technical purposes is amply sufficient.

The genuine oil of bitter almonds has a specific gravity of 1.040 to 1.044, while that from aniline manufactories (mirbane oil) has a specific gravity of 1.180 to 1.201. If a bitter almond oil is suspected of an admixture with mirbane oil, it can be tested in the following manner: 5 cubic centimetres (1.35 fluidrachms) of the oil to be tested are accurately weighed. If composed of pure bitter almond oil, then it will weigh (at 12.50° C. = 54.5° F.) 5.205 to 5.220 grammes (= 80.3 to 80.5 grains), if mirbane oil only, then its weight will be 5.9 to 6 grammes (91.03 to 92.6 grains). From the weight of the above 5 cubic centimetres (1.35 fluidrachms), we can therefore approximately conclude as to the quantitative proportions of the two liquids contained in the sample, whereby the following table may be used.

5 c.c. m.	pure oil of bitter almonds (100 %) weigh							5.20 g.
5 "	of a mixture of	75	bitter almond oil and		25	mirbane oil	.	5.30 g.
5 "	" "	50	"	"	50	"	.	5.57 g.
5 "	" "	25	"	"	75	"	.	5.76 g.
5 "	of mirbane oil							5.90 to 6.00 g.

The 5 cubic centimetres oil are placed in a mixture flask with 35 to 40 cubic centimetres (1.01 to 1.35 fluid ozs.) of a solution of bisulphite of sodium of at least 1.225 specific gravity (= 28° B.), and well shaken. The volume of the mixture is by adding water brought up to 50 cubic centimetres (1.70 fluid ozs.) and placed in a burette, which is left to act undisturbed, until the mirbane oil has become separated upon the specifically heavier liquid, and appears as a clear oil stratum. The quantity is read off from the scale. If for a more exact measuring of the mirbane oil a pipette, divided into $\frac{1}{10}$ cubic centimetres, is applied, then the quantity of the addition to the bitter almond oil can be determined by 1 to 2 per cent. In order to lessen the consistency of the oil and to quicken the union of the oil drops, Wagner recommends shaking the entire liquid with 5 cubic centimetres (1.35 fluidrachms) of benzole or light petroleum, in order to ascertain by its increase of volume the quantity of the mirbane oil.

Oil of Lemon is procured by pressing or distilling the rind of the fruit of the *Citrus medica*. In its purest rectified condition it is a colorless, very thin oil. The oil as it appears in commerce is of a pale yellow, often somewhat muddy. It has a very strong, agreeable smell of lemons, and a sharp, spicy taste. Its specific gravity varies between 0.848 and 0.860. In time it will change, even in sealed vessels, into a thick liquid, and will crystallize. These crystals are called lemon stereopts, which are very similar to the stereopts of turpentine oil. It is sometimes adulterated with alcohol and turpentine. The former is discovered by means of red sanders; the latter by the change in its aptness to turn when exposed to an enhanced temperature, since lemon oil will withstand the influence of a higher temperature much better than oil of turpentine. To this end, the turning capacity of the suspected oil is determined. Heat it for one or two hours, to about 133° C. (271.4° F.), and determine again the turning point, which now appears altered, if the oil is adulterated. If the lemon oil contains French turpentine oil, the turning capacity increases, which by the influence of heat alone upon pure lemon oil does not happen.

Oil of Fennel is acquired by distillation of the bruised seeds of *Anethum fœniculum* with water. This oil is colorless or yellowish, and becomes darker with age; has an agreeable, sweetish, mild, spicy smell and taste; its specific gravity is 0.963 to 1.000; the latter when the oil is old. It congeals at —10° C. (14° F.), but loses this property after long keeping.

Gaultheria or *Winter-green Oil* is produced from *Gaultheria procumbens*, by distillation. All parts of the plant seem to contain this oil, though especially the blossoms. According to *Proctor*, the same oil is obtained by distilling *Bentula lenta*, a plant indigenous to North America. The oil in commerce is reddish; one distillation, however, suffices to discolor it completely; it has both a strong and a pleasant smell, and a warm aromatic taste. It is the heaviest of all known volatile oils; specific gravity at 10° C. (50° F.), about 1.18; it begins to boil at 211° C. (411.8° F.), whence the temperature gradually rises to 220° C. (428° F.) and then becomes constant. Winter-green oil consists in its main bulk of salicylate of methyl oxide, besides which it also contains a carburetted hydrogen gas, which is isomeric to the oil of turpentine. Its specific gravity is a means for testing its purity.

Geranium Oil.—This oil is obtained by distilling with water the leaves of the rose-geranium, *Geranium odoratissimum*, which is especially cultivated in Turkey and the south of France. Geranium oil smells very much like otto of roses, and is for this reason very frequently used for adulterating rose oil.

Caraway-seed Oil is produced from the seed of the common caraway plant, *Carum carvi*, by distillation with water. Caraway-seed grown in colder regions or in colder years furnishes more oil than that which has grown in warmer countries and warmer years. It is in its fresh state pale-yellow, turns in time dark-yellow or brownish, and is a very thin liquid. The statements as to its specific gravity vary between 0.8845 and 0.9745; the common specific gravity is 0.910 and 0.925. The smell and taste are purely like caraway. It begins to boil at 190° C. (374° F.). The ebullition at first is quiet, and about the third part of the oil distils over. From this point the temperature rises faster, while the liquid at the same time begins to turn yellow. Above 200° C. (392° F.) the oil decomposes, leaving a brownish resinous mass in the retort.

Oil of Jasmin.—This is obtained from *Jasminum officinale* and *Jasminum grandiflorum*. The fresh blossoms of these two jasmin species may, on account of their small yield of oil, most profitably be treated by enfleurage, or simplified thus: Cotton is saturated with ben oil, layers of fresh-cut jasmin flowers are spread upon it, and the whole exposed, in covered vessels, to the influence of the heat of the sun. After a while the blossoms are removed, the cotton is spread over with fresh flowers, and this is repeated until the oil has acquired a thorough jasmin smell, when it is separated from the cotton by pressing. The oil is of pale yellow, and possesses a pleasant jasmin smell. Good jasmin oil deposits, at 0° C. (32° F.), jasmin stereopts, which crystallize into lustrous scales, which melt at 12.5° C. (54.5° F.). It is lighter than water, and becomes easily soluble in alcohol, ether, and oils. This applies to the other perfume flowers, as tuberose, orange flowers, etc.

Limette Oil is produced from the fruit of *Citrus limetta vulgaris*, has a fine and aromatic smell, while its taste is burning, camphor-like. It reacts strongly acid, and has a specific gravity of 0.931.

Oil of Lavender.—Of this oil, which is yielded by the various species of an herb, the *Lavendula spica* especially of *L. agustifolia* and *L. vera*, there are many qualities in commerce, according to whether the flowers only are used, or the flowers with the leaves, or merely the leaves, or whether the entire plant is subjected to distillation in water. The finest grade is that which is made of the flowers only. The oil is colored greenish-yellow, but by rectifying, it becomes colorless, though by age it turns dark. It is a thin liquid, but becomes thicker with time or when exposed to the air. Its specific gravity fluctuates between 0.897 and 0.936. The best kind has a fine lavender smell, the inferior sorts have a smell like camphor or turpentine.

Oil of Cloves.—In the home of the cloves, on the Isles of the Moluccas, or Spice Islands, Cayenne, etc., there are known three varieties of the clove tree, viz.: *Cariophyllus aromaticus*, *i. e.*, with red, blood-red, and white fruits; the latter contain the most oil. The oil is obtained from the undeveloped blossoms, but frequently merely from the stems, the so-called clove-wood, by distillation.

In its fresh state this oil is light-yellow, afterwards yellow to light brownish-yellow. It is a thick liquid, and reddens litmus weakly, has a sharp burning taste, a specific gravity of 1.031 to 1.061; it is but little soluble in water, but dissolves in alcohol, ether, concentrated acetic acid, and in the fat oils; begins to boil at 100° C. (212° F.), and is at

—18° to —20° C. (—0.4° to —4° F.) still liquid. A common falsification is the mixture with oil of almonds, with castor oil and the alcoholic extraction of the cloves, or for producing the density of the fluid it is mixed with colophony. As soon as these admixtures exceed $\frac{1}{3}$, the oil no longer sinks in water. A genuine oil of cloves retains its entire clearness when dropped into water, unites easily at the bottom of the vessel, while an adulterated article discolors in its single drops, and these cover themselves with a whitish coating and do not reunite easily. The presence of alcohol is discernible by shaking the oil with water, when after clearing it proves a thicker liquid.

Neroli or Orange-Flower Oil.—This oil, obtained by distillation of the orange blossoms, *Citrus aurantium*, with water, is noted for its fine and fragrant smell, and is distinguished over all the other oils of the family *Aurantiaceæ* in such a manner that a falsification of it seems scarcely possible. It differs moreover in its action with nitric acid, by which it acquires a dark red-brown color, while the other oils of the same family of plants are much less colored, some only slightly shaded.

Oil of Patchouly.—This oil is prepared by distillation of the herb patchouly (*Pogostomen Patchouli*, Lindley, *Plectantrus crassifolius*, Burnett), a plant which grows in China and the East Indies. Its smell exceeds that of all other plants in intensity. It is a thick liquid of a brown color, and boils at 280° C. (536° F.). The adulterations are usually oils of cubebs and santal. The oil made in its native place is the best.

Oil of Portugal.—The oil of bitter orange peel, or Portugal oil, is prepared by pressing or distilling the outer skin of the bitter orange fruit. It is yellowish, its smell similar to that of bergamot oil; specific gravity = 0.819 to 0.9; it boils at 180° C. (356° F.). The adulterations are similar to those of the oils of lemon and bergamot.

Attar of Roses, Oil of Roses.—This precious oil is obtained from various species of roses, from *Rosa moschata*, *R. centifolia*, *Rosa sempervirens*, *R. damascena*, and others. In commerce two kinds of rose oils are known, the one is made in the East Indies from *Rosa moschata* (India rose-oil), the other in the Levant and Tunis (Levantic) of *Rosa sempervirens.* The method of producing rose oil is not everywhere the same. In the East Indies the plucked rose leaves are poured over with spring water and exposed to the sun; after the lapse of a few days yellow oily drops float on the surface, which are absorbed by a little cotton tied to a rod, and pressed out. In other places distillation is employed, the same water is distilled several times over, with a renewed supply of rose leaves. The oil of roses from Cashmere is acknowledged to be the most excellent. There they distil the same water over fresh roses, twice, permitting it to stand in open vessels, and at nights the latter are placed in cold water. The rose-oil thus separates in the water in small drops, which are carefully taken off. The pure oil when cold is in a semi-solid state, and does not entirely liquefy at 100° C. (212° F.). The genuine rose-oil is but little yellowish in color, that of Macedonia generally somewhat darker. It has a strong, penetrating smell of roses, which, however, is only agreeable as long as it is faint, otherwise it causes headache; its taste is mild, and a little sweetish. It congeals at a few degrees below 0° C. (32° F.) to an almost colorless translucent, lustrous leafy mass, which turns perfectly liquid only at 28° to 30° C. (82.4° to 86° F.). It does not redden litmus paper.

On account of its high price, rose-oil is exposed to many adulterations, especially to the mixing with other volatile oils, in which spermaceti is dissolved, in order to cause it to congeal like the genuine rose-oil. Such falsification is detected in this wise, because genuine rose-oil when melted and slowly cooled off crystallizes in thin translucent scales, which when held up against the light *iridesce* beautifully; while on the other hand an oil mixed with spermaceti, by congealing becomes almost dense, on account of the separation of the fine crystalline needles.

Most frequently rose-oil is now-a-days adulterated with the volatile oils of the various species of *Pelargonium odoratissimum*, *P. capitum*, and *P. roseum*, i. e., geranium oils; less often the falsification happens with rosewood oil, since it is almost as expensive as rose-oil itself. Whether we are handling a genuine rose-oil or a spurious article can be ascertained by mixing a few drops of concentrated sulphuric acid with the sample, when in the genuine article the fragrance remains unaltered, but in a mixture of Pelargonium-oil a very disagreeable strong smell develops.

Oil of Sassafras is the product of the distillation of the root of the sassafras tree, *Laurus sassafras*, a native of the United States. In its fresh state the oil is colorless or pale yellowish, in time it becomes dark reddish-brown. It has an agreeable fragrance and a sharp spicy taste. After keeping it for a longer period it separates a large quantity of stearopts, which crystallize in translucent, colorless, rhombic quadrilateral, or irregular hexagon prisms, with double planed points. The specific gravity varies between 1.07 and 1.09. It reddens litmus paper, and by shaking up with water may be separated into two oils, of which the one is lighter, the other heavier than water. The usual adulteration is with oil of turpentine.

Oil of Marjoram (Spanish hops).—The oil is obtained by distilling the flowering herb of *Origanum Majorana* of the family of labiate flowers. In its fresh state the oil is a light straw-color, but in time turns to a red-brown. It is a thin liquid of 0.946 specific gravity, and does not redden litmus paper, has a penetrating spicy smell, and a sharp burning taste.

Oil of Thyme.—To produce this oil from *Thymus vulgaris* by distillation with water, it is best to use the fresh herb. The oil is a thin liquid, which by age thickens, and when it is unadulterated it precipitates stearopts if kept for a longer period. In the rectified state it is colorless, turns gradually yellow and brownish-red. It has the strong and pleasant smell of the plant, and a camphor-like, cooling, biting taste. The fresh oil is neutral, the old brownish colored article very acid. Its specific gravity is 0.886 to 0.891.

Oil of Vitivert.—The oil of vitivert is obtained from the root of vitivert by distillation. This is the root of an Indian grass species of *Anatherum medicatum.* Vitivert oil smells very aromatic, boils at 286° C. (546.8° F.), and has much similarity with the santal wood oil.

Cassia Oil.—This oil is manufactured in its native country, by distilling the bark of *Cinnamomum aromaticum.* The fresh oil is light, turns with age to a darker yellow. Its fragrance is pleasant and cinnamon-like; but less refined than the genuine cinnamon oil; nor is its taste as sweet as that of the genuine article, but sharper. Specific gravity = 1.060; at 27.5° C. (81.5° F.), firm crystals separate, which, however, in the warmth again become liquid. The oil has an acid reaction.

Oil of Rosemary distilled from the fresh beans of the *Rosmarinus officinalis* is colorless, with an agreeable camphor-like smell. Its specific gravity is 0.911, it boils at 185° C. (365° F.), and its composition is $C_{45}H_{38}O_2$. If kept it deposits stearopts analogous to camphor. The adulterations are usually with oil of turpentine, which is not easily separated or detected.

Oil of Canada Snakeroot, from the root of the *Asarum Canadense*, is of a very agreeable spicy odor now much in vogue for essences, and blends so well with other oils that it might have a useful application for fine soaps.

Oil of Pimento is prepared from the berries of the allspice, but, as they do not yield much oil, 1 to 4 per cent., the cost is higher than the other useful spice oils, yet it can be often applied to shade mixtures of other oils.

Oil of Nutmegs.—Nutmegs yield two oils, a limpid oil by distillation with water, and a concrete oil by expression. The former is used in soap in combination with other essential oils. The concrete, or oil of mace, is also used in soap, but combined with the grease before saponification.

Oil of Cinnamon (Ceylon), obtained by distillation of the bark of *Cinnamomum verum*, with water, on the Island of Ceylon. In its chemical aspect, it is similar to the cassia. The fresh distilled oil, rectified by exclusion of air or oxygen, is a thin liquid, of a light yellow color, but it soon thickens and also acquires a darker color. Smell and taste are almost identical with that of the cassia oil, but finer. Its specific gravity ranges between 1.01 and 1.10; it remains liquid at —25° C. (—13° F.).

Ambergris is a product of the diseased liver of the *cachelot* or spermaceti whale. It floats upon the surface of the sea, and is gathered on the coasts of Coromandel, Japan, the Moluccas, and Madagascar. The color of ambergris is (grayish-white) black, and yellow marbled; of strong smell, but not unpleasant, its taste is mild and fatty, and melts at 60° C. (140° F.). It dissolves easily in absolute alcohol, ether, and also in fat and volatile oils, contains 85 per cent. amber fat, which cannot be saponified.

Musk or Bisam.—Musk originates from a roe-like animal, the Thibet musk, *Moschus moschifera.* The musk is found in a separate bag adjacent to the genital parts of the male, never in the female, and forms in its fresh state an ointment-like reddish-brown substance of a specific, penetrating, enduring odor, and has a bitter, offensive, spicy, salty taste. In commerce two kinds of musk are known, to wit, Inuginic and Carbadinic musk. The first, by far the better, possesses alone that fine odor, while the Carbadinic musk often has a sharp ammonia-like smell. In commerce musk appears in the form of the natural bags of the animal, and this is a special sign of genuineness and unadulterated state, when these bags are entirely intact, they are often cut open on the sides and filled with other substances and finely sewed up again. The contents of such a bag appear as a moist, grainy, mass of dark brown color, but little interspersed by small membranes. The Carbadine musk consists frequently almost entirely of skinny membranes with but little grainy musk, of a less dark color, even sometimes light brown. In purchasing a bag attention should also be paid, that through the natural opening of such a bag, no other substances, as shot, fine quartz grains, etc., have been inserted, in order to enhance its weight.

Peruvian Balsam.—According to the report made by Dr. Doret, who obtained his information at the native place, the Peruvian balsam originates solely from *Myrospermum pereira*. To obtain it, the bark of the tree is beaten in four different places, so that it peels off from the trunk of the tree. A few days after, these places are heated with burning torches, taking the bark away and placing cloths upon the stripped places, which absorb the oozed-out balsam. These cloths are boiled out in a vessel with water, until they appear entirely free from balsam. The water cooling off, the balsam settles upon the bottom. The balsam obtained thus, forms a dark brown, syrup-like, opaque liquid, of a very pleasant vanilla or benzoin-like fragrance, and aromatic, lasting taste. Sometimes it is adulterated by mixing castor oil with it. In order to detect this, distil 10 grammes (0.35 oz.), shaking the distillate, which consists of two layers, in baryta water, taking off the oil-layer floating upon it, by means of a pipette, and shaking it with a concentrated solution of bisulphide of soda. If the so-treated balsam contains some castor oil, the shaken balsam congeals forthwith into a crystalline mass.

Civet.—By this name we designate an animal secretion, which orignates from *Viverra zibetha*, the Asiatic, and *Viverra civetta*, the African civet. It separates in these animals from particular glands into a sort of pocket, which is situated between the anus and the genital organs, and opening outside. The wild animal squirts this mass from time to time spontaneously; from the captured animal it is taken with a spoon. Civet forms a smeary, soft, at first white, after a while brownish mass, becoming in time more consistent. It has a peculiar musk or amber-like fragrance, and a disagreeable, bitter, irritating taste. It melts when heated, puffs up, takes fire, and burns with a bright flame.

Tincture of Civet.

Civet	2 ounces.
Orris root (ground)	4 "
Alcohol	8 pints.

Triturate the civet with the orris in a mortar, adding the alcohol by degrees.

Tincture of Ambergris.

Ambergris (gray)	2 ounces.
Loaf sugar	4 "
Alcohol	8 pints.

Tincture of Musk.

Musk (the best)	2 ounces.
Sugar	4 "
Alcohol	8 pints.

These tinctures should be kept in a warm place, occasionally stirring for a month to properly extract the odors, which being of animal origin are difficult of solution.

These perfumes are those best known; there are, however, many other oils and substances used in perfuming soaps, but they are of minor importance.

PART II.

THE MANUFACTURE OF CANDLES.

SECTION I.

INTRODUCTION, INCLUDING THE THEORY OF FLAME.

Of all means of artificial illumination candles are perhaps the most convenient, and the bodies from which they can be made, though not very numerous, are such as are generally easily obtained and many of them cheap in cost. Thus tallow, lard, paraffine, spermaceti, wax, palm and cocoa-nut oil comprise nearly all the materials used for this purpose. A candle consists of one or more of these solid illuminating materials in the well-known cylindrical shape and provided in the direction of its longitudinal axis with a cotton wick, the thickness and plaiting of which are arranged in proper relation to the diameter of the candle.

It is difficult to trace from history the first introduction of the candle. Lamps are frequently spoken of in ancient history, and the Romans possessed other means of illumination supposed to be a kind of reed whose pith was saturated with grease or wax with a wick made of a film of flax similarly saturated. Wax was no doubt the first material used for this purpose, and Venice seems to have been the first to have made them in sufficient quantity to be called an art, though they had been made for church purposes a long while before.

In the 17th century the art was introduced into Paris, and as wax was not abundant they were very costly, and their use was confined to princely courts or wealthy churches.

Tallow candles were made at a very early date, though not as an established industry, for up to the 17th century oil was the principal means of light; candles were too scarce and high priced for use among the masses, and they do not seem to have been in general use until the middle of the last century, nor was there any important improvement in the art from the first crude methods of dipping except that they were about that period moulded in metal moulds. Indeed up to our own century very little improvement can be traced, nor did they receive their due importance or approach their present perfection until the discovery of the elements of the fatty bodies and their decomposition into the fatty acids, stearic and palmitic.

This we owe to the researches of Chevreul, Braconnet, Maujot, and others. Gay Lussac with Chevreul received a patent in 1825 for making stearic acid candles and converting the oleic acid produced in the manufacture into soap, nor was it until 1834 that they had succeeded in making candles that were considered faultless. Spermaceti candles had then been in use for about fifty years, but they were costly and were not in general use.

When in 1830 paraffine was discovered, candles were further improved by the addition of this valuable substance to the stearic acid to prevent their crystallization, or the stearic acid was combined with the paraffine to improve them and prevent their softening and bending in a warm atmosphere.

Candles of tallow or wax were first made by dipping; the latter were sometimes made by drawing and rolling, a mode still in vogue. The moulding of candles is of quite recent date, for, though they were moulded over a hundred years ago, they were not made systematically until 1820, and now owing to the many improvements in the materials and in the appliances for moulding with great facility and rapidity, in fact such has been the improvement in every branch of this art that it may be said to have reached perfection.

Beef and mutton tallow are the chief animal fats used for candles; they consist mostly of stearin, palmitin, and olein, stearin being the larger part, varying with the age and kind of food. Beef tallow has a yellowish color, is hard and brittle, melts at about 38° C. (100.4° F.), is insoluble in water, but dissolves in 40 parts of heated alcohol. Mutton tallow when fresh has but little color or odor, soon becoming rancid when exposed to the air, is less soluble in alcohol than beef tallow, and its melting point is about the same.

Hog's lard, much used in this country for making candles, having less stearin than olein, the latter has to be separated before it can be used for this purpose. Lard of good quality (and the quality varies very much) is a white oleagineous substance melting at about 27° C. (80.6° F.), and is very largely used for culinary purposes.

Stearin and stearic acid are the base of most of the candles now in use. The term stearin does not express the true character of this substance—it being stearic acid—but as it is the one accepted by commerce it may be proper to retain it. This valuable substance, the result of certain chemical processes, is now manufactured in nearly all parts of the world, and if properly made is a beautiful hard pearl-white solid which can be made from almost any description of fatty matter. Though known and used for a long while before, it was not till 1831 that De Milly overcame all previous difficulties and made stearin on a larger scale, establishing the industry upon principles which have been retained almost unaltered. Some of the processes have been materially changed and principally by the same chemist.

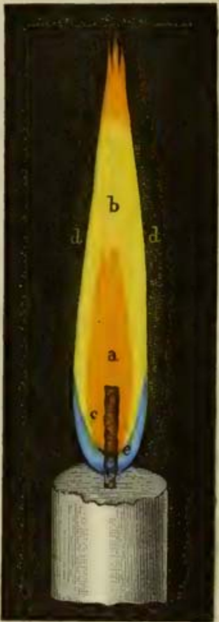
From palm oil and cocoa-nut oil and other vegetable oils and greases candles are now made, the solid portions of these oils being extracted in a similar manner to that in vogue for the other grease bodies already mentioned, with some modifications suitable to their nature. Thus it will be seen that the making of candles is now a scientific chemical industry of great importance, instead of the simple art it once was, when it was confined to the making of candles of tallow by dipping or moulding.

To illustrate the great importance of the stearic acid industry, it is interesting to know that France alone produces at least 60,000,000 pounds, the remainder of Europe 250,000,000 pounds; America about 30,000,000 pounds. The great candle factory of Price & Co., of London and Liverpool, with a capital of $5,000,000, makes many kinds of candles, principally those called composition candles, whose base is mostly extracted from palm oil and cocoa-nut oil. These candles are used by nearly all classes in England. France, however, may be considered the largest consumer of candles, and generally of the better kinds, the trade there demanding hard white candles which are consumed by all families and hotels; in fact that country may be said to excel in the art of manufacturing candles. France may also take a just pride in having given to the world such names as Chevreul and de Milly, who go side by side in the advancement of this industry, the first by his chemical researches, the latter by his ingenious devices in the accomplishment of great practical results, a pride equal to that of giving to the world Leblanc, who first made artificial soda from culinary salt, these arts having been of the greatest importance to civilized life in giving cheap light and cheap cleanliness.

The principles upon which artificial light is formed from the flame of a candle are simple, as it is only such solid or fluid bodies as become either volatilized or decomposed into gaseous matter at a temperature below that required for their combustion as can burn only in the shape of gas. The ensuing light is what we call flame. The well-known shape of flame is due to the pressure of the ambient air, because the latter becoming heated and rendered specifically lighter ascends. When the illuminating material, consisting either of tallow, stearin, paraffine oil, or petroleum, is sucked upwards in the interstices of the wick acting as capillary tubes, and in the immediate neighborhood of the flame, these substances are consumed into gases and vapors the nature of which agrees with that of purified illuminating gas.

In every candle flame four distinct parts can be distinguished: *a* (Fig. 73), a non-lighting dark nucleus; *b*, the mantle, which is the real lighting, yellowish-white cover, enveloping it towards the point above; *e*, the mantle which surrounds it towards the base, and is of a pretty azure blue; *d*, the so-called veil, which envelops the entire flame substance, and is of very weak lighting power, and hardly visible. The dark nucleus *a* consists of the gaseous and vapory products of decomposition, by the absorption of the lighting material of the wick *c*; *b* is the sphere of the partial combustion and decomposition of the carburetted hydrogen into bi-hydroguret of carbon, or hydrogen gas and carbon. Upon its inner side, where it borders on the dark nucleus, the lighting envelop is reducing; towards the outside, where it borders on the veil, it is oxidizing. At this place, the rejected carbon, which always burns sooner than the hydrogen, enters through the veil, and there combines with the oxygen, forming carbonic oxide. In the veil, *d*, which surrounds the body of the flame on all sides, the complete combustion takes place; that is, carbonic oxide and hydrogen burn to carbonic acid and water. Since in the veil only gases and no solid bodies are burning, its power of lighting is lessened; but in lieu thereof it is the hottest part of the flame, since in it alone the combustion of the hydrogen takes place. The veil envelops the entire surface of the flame body, but in various shades of color; because the carbonic oxide burns at a low degree of temperature with a blue flame, and when brought to a high temperature it burns with a yellowish-red flame. Hence the yellowish-red of the veil at the upper part, the azure blue at the base.

Fig. 73.



It has been customary to adduce that the luminosity of the flame is due to the eliminated particles of carbon; but how could a flame be so transparent as it really is, were it filled with solid particles of carbon? Yet it is possible that this elimination may take place in the decomposition of the hydro-carbons.

SECTION II.

THE MATERIALS FOR CANDLES, WITH THEIR PREPARATION.

The preparation of tallow to make it suitable for candles is a comparatively simple matter, and is done in various ways, but which mode is the most desirable depends upon the means at hand, the quantity worked, and other causes. In small factories rendering by the open fire is usually employed. In large establishments tallow is rendered by means of steam in covered vats or kettles, aided by sulphuric acid, caustic alkalies or currents of air in apparatus similar to that of Vohl, shown in Fig. 1, page 85, with suitable attachments for burning the offensive gases arising from the processes. By the first mode the greaves or cracklings can be saved and utilized in feeding swine, while the residuum from the acid or alkali process can only be used as a fertilizer.

At the present time tallow in a more or less pure state is an article of commerce, so that few soap or candle manufacturers now render their own, but there are perhaps many places in this country where the rough fat could be readily and cheaply purchased, when it would be advantageous for them to render it themselves. For those who may have these facilities it may be necessary to give some description of the usual method of rendering the fat used in the arts of making soap and candles.

The fresh fats are dried by exposing to the air or a warm room, care being taken that they do not become offensive; when they are reduced to small pieces by means of a chopping board, Fig. 74, which consists of a strong table having a long sharp knife B, under which is placed a hard wood board D, which can be replaced when worn. For larger operations a power machine for cutting tallow, Fig. 75, is a much more expeditious mode. In the hopper the rough fat is placed, when the knives upon the cylinder soon cut it into small pieces. A still better mode is to reduce it by means of a mill having polished iron rollers similar to the mill used for toilet soaps, Fig. 70, page 435; this mill breaks the membranes so thoroughly that the fats are rendered sooner and better. The kettles for rendering in small factories by an open fire are similar to Fig. 76. B is the caldron; C, steps to facilitate the stirring, filling, etc.; the caldron is egg-shaped, heated only at the base, and to prevent burning there should always be a portion of melted fat in the bottom, for if allowed to burn, the color is so injured that it cannot be bleached. When in operation the fat requires almost constant stirring, and the heat due regulation.

Fig. 74.

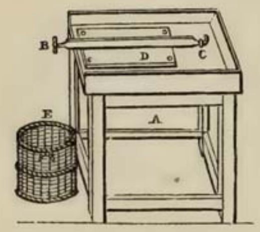
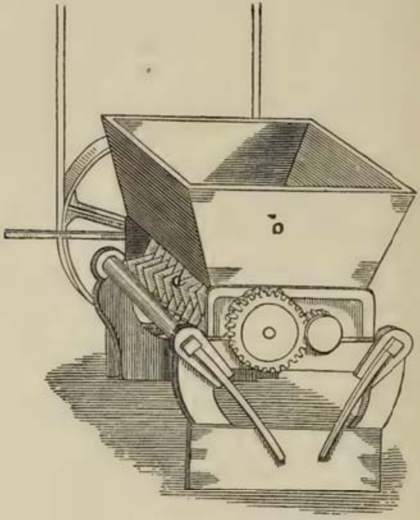
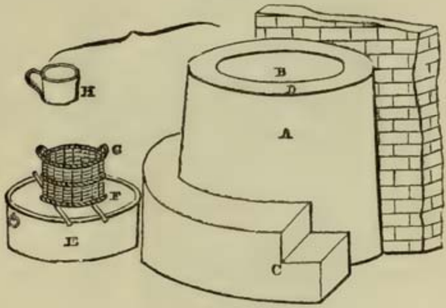


Fig. 75.



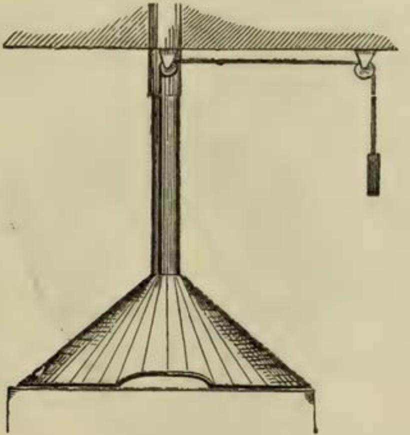
When the fat is melted it is strained with the sieve G, into the pan E, in which it is left to cool and harden. Steam is a great assistance in these operations, and the fats are rendered by its aid in kettles or jacket, such as are illustrated in Fig. 18, page 219.

Fig. 76.



In the rendering of tallows there is much offensive gas liberated, which is often a great annoyance to the neighborhood. This evil and the remedies are treated in our section on soap materials. For remedying this trouble in a great degree, it is customary to have a hood, Fig. 77, placed over

Fig. 77.



the kettle, and which is raised or lowered at pleasure, and conducts the disagreeable vapors into the chimney.

For extracting the fat from the greases it is necessary to have a press. These are of various kinds; Fig. 78 shows a very suitable one, and Fig. 79 an iron cullendered box with the pressed cake of cracklings.

Fig. 78.

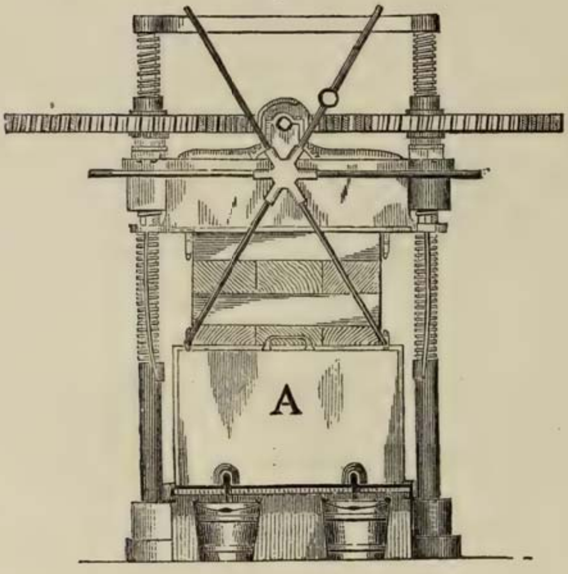
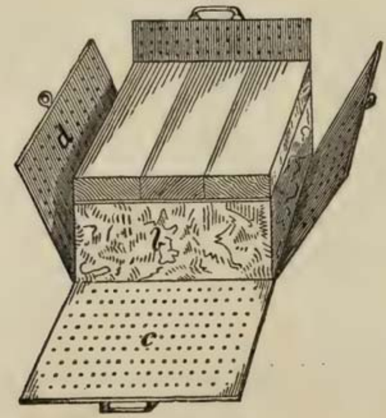


Fig. 79.



A newer invention, of greater power, is the elbow press of Messrs. Boomer & Boschert of Syracuse, N. Y. (Figs. 80 and 81). The cracklings are often heated the second time, and

Fig. 80.

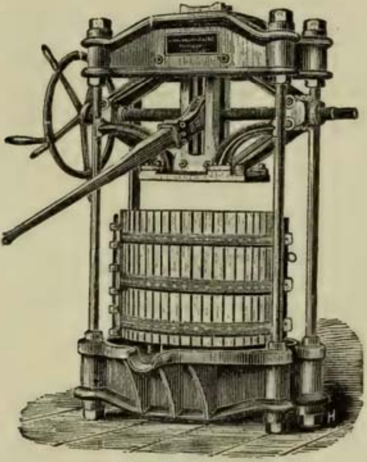
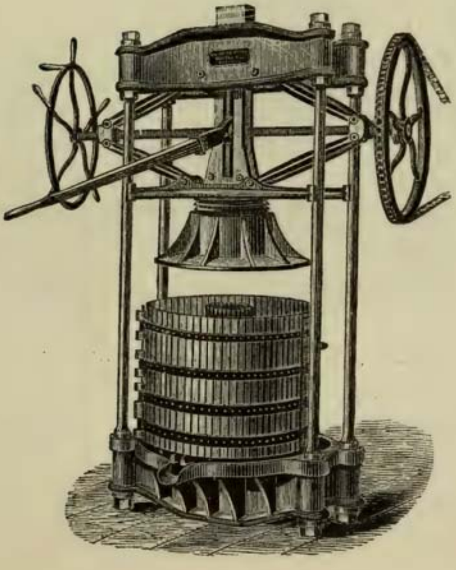


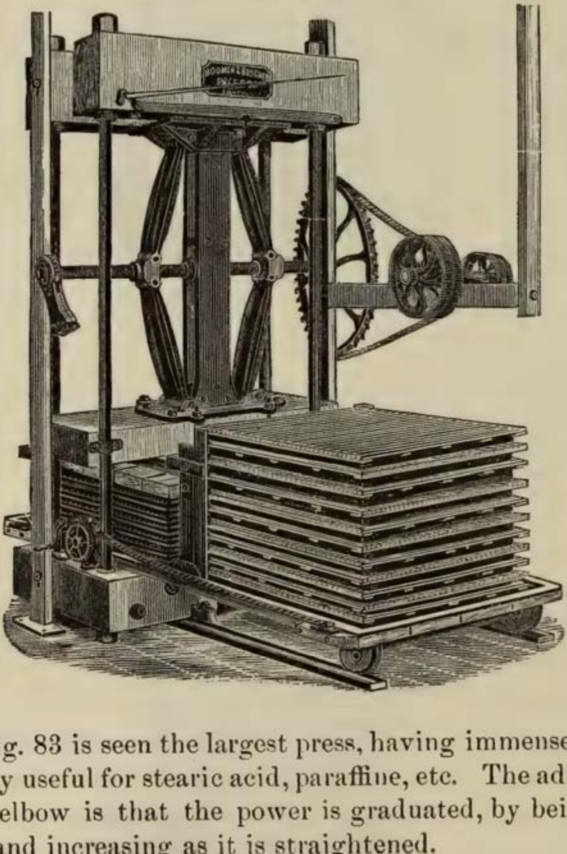
Fig. 81.



again subjected to pressure to obtain as much tallow as is possible by this process. For rendering fat on a larger scale, the steam digesters of Wilson are much used for all descriptions of fats. (See Fig. 2, on page 87.) By this means there is but a small percentage of greaves, the fat being almost entirely extracted.

For a large business we show two other presses (Figs. 82 and 83, also by Boomer & Boschert) very suitable for all the purposes described in this work where a press is used.

Fig. 82.



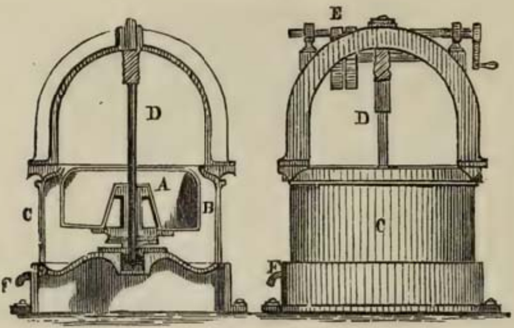
In Fig. 83 is seen the largest press, having immense power, and very useful for stearic acid, paraffine, etc. The advantage of the elbow is that the power is graduated, by being first gentle and increasing as it is straightened.

For candles the rendered tallow is usually purified, to accomplish which there are various means, and for the better qualities of candles the tallow should be white and hard; one of the simplest means to this end is to place the rendered fat

Fig. 83.

in a large vessel and permit it to cool very slowly, when the stearin and palmitin will grain or crystallize, and collect towards the edges, while the olein of the non-liquid part will be left free in the centre, when it can be ladled off, or, what is still better, it can be pressed out with the presses already mentioned. For this purpose the centrifugal mill has been constructed (Fig. 84). It consists of a drum A with a circumference of gauze wire B; and has an exterior jacket C, and the drum is attached to a shaft D drawn by the gearing E. The granulated fat, tallow or lard, being placed in the drum, it is driven at great speed; the centrifugal action throws the granulated fat against the wire gauze, which retains the solid particles, while the liquid escapes through the meshes into the outer jacket, and is drawn off by the cock F. This machine works with great rapidity; it is about four feet in diameter, and requires about one horse power to drive it. After the liquid part of the tallow is extracted, the remaining stearin will be whiter and harder, the olein having the greatest amount of color.

Fig. 84.



Other processes for whitening tallow, and which harden it at the same time, are by means of chemicals. Watts' method of bleaching tallow is with sulphuric and nitric acids, combined with bichromate of potash and oxalic acid. These substances cause the liberation of oxygen, which whitens the fats very satisfactorily. Watson's process for purifying and whitening is by means of permanganate of potash with dilute sulphuric acid. The permanganate is mixed with the melted fat, and free steam blown through it, or it is briskly stirred, when sufficient dilute sulphuric acid is poured in and the heat regulated not to exceed the boiling point of water, 100° C. (212° F.), after which it is allowed to rest, that the melted fat may rise to the top, and the acid solution subside to the bottom. The tallow is then placed in another vessel and washed with hot water. It is often tested to ascertain if sufficiently bleached, and if not, the first process is repeated to insure a perfect whiteness.

There are numerous formulas for bleaching the fat, as boiling with culinary salt and alum in a portion of water; or melting with about one per cent. of acetate of lead, keeping it at the melting point for some 15 or 20 hours, and turning off the heat and leaving to rest and harden. In the case of lard the pressed fat is melted, and one and a half per cent. of nitric acid is stirred with it for some hours. This forms the elaidic acid—a beautiful white solid grease, and this was, we believe, the first process in use for making candles from lard.

Candles made from these hardened and whitened fats obtain the name of stearin candles, though the term is now generally applied to the candles made of stearic acid.

Stearic acid, now generally used for the better class of candles, is seldom perfectly pure, nor is it necessary, except to have it as free as possible from oleic acid and glycerine, and to insure a high melting point. To obtain it pure the pressed tallow or stearin is saponified with potash, decomposing the soap with hydrochloric acid, collecting the flocculent stearic acid on a filter, washing with cold alcohol, and then dissolving in boiling alcohol. The solution is then gradually cooled, when the stearic acid will crystallize in beautiful nacreous leaflets. It is tasteless and odorless, dry to the touch, and can be powdered; its melting point is about 70° C. (158° F.), and it has a slight acid reaction with blue litmus paper.

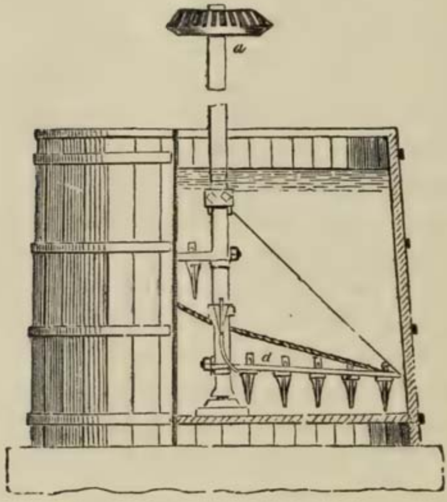
Stearic acid for candles is prepared in many ways, some of which have been abandoned in practice as too laborious or expensive. The whole object of these processes is to dissociate the fats from their glycerine and the greater portion of their oleic acid.

The processes still in use, each having its advocates, may be classed under the following heads:—

1. Saponification by lime.
2. Saponification with a little lime assisted with water and pressure.
3. Saponification by sulphuric acid and subsequent distillation.
4. Saponification by sulphuric acid.
5. Saponification by water combined with distillation.
6. Saponification by water under high pressure.

The Saponification by Lime.—The decomposition of the neutral fats by means of lime and the separation of the glycerine is conducted on a larger scale in a tun provided for the purpose having a stirring apparatus consisting of a central shaft with four brass arms studded with large teeth as shown in Fig. 85. Heat is communicated by the convoluted steam pipe placed in the bottom having perforations for the escape of the steam, which is regulated by an outside valve. In this tun hydrate of lime in the form of milk of lime is mixed with the fat in the proportion of 15 per cent.; the lime should be as pure as possible and caustic, or a larger amount of acid will be needed to neutralize it, and the im-

Fig. 85.



purities are difficult of removal from the fatty acid. The milk of lime having been thoroughly combined with the tallow, the cover is fastened down and the steam turned on while the stirrer revolves; after six hours, when the combination should be complete, the heat is turned off, and it is left to cool.

To test if the saponification is perfect, take out a small portion of the thick mass and allow it to deposit the lime soap; the supernatant water is poured off and the soap cooled. If it is smooth, homogeneous, and semi-transparent, it makes a sharp ring when broken, and can be powdered in a mortar, there is no decomposed fat. The steaming should be continued until the reactions are complete; the steam is then shut off and a quantity of cold water added, keeping up the agitation. This washing with cold water causes the insoluble lime soap to assume a granular appearance, and as soon as this is effected the agitation is discontinued.

When after a short time the whole has settled, the water with the glycerine in solution is drawn off by means of a cock in the bottom whose mouth is protected with a wire gauze so that no soap can pass through. When all the water is withdrawn, the outlet is stopped off, and more cold water poured in and again agitated; this is drawn off as before. By these repeated washings all the glycerine is removed, and nothing remains but the lime soap of stearic, palmitic, and oleic acids, and perhaps a little excess of lime.

The next step of the process is the decomposition of the soap and the removal of the lime. This is done with sulphuric acid in the proportion of 25 per cent. diluted with eight times its weight of water. The diluted acid is gradually added, the mixture heated to about 93° C (199.4° F), and no higher; it is gently agitated till the decomposition is complete, which is determined by the disappearance of the granular structure and the rising of the fatty bodies to the surface. Much care is necessary at this period in regulating the entrance of steam and the temperature, for if the heat is too great the color may be injured. The tun may be left uncovered during this decomposition without any disadvantage. When the separation of the lime is complete the contents of the tun are left to rest for some time, in order that the sulphate of lime may be entirely taken up by the water and removed from the fats that occupy the upper stratum. The cock at the bottom is then opened and all the liquid with the salts drawn off. Hot water is now let in and the agitator set in motion to wash out any lime or salts, and after a time the liquid is again left to rest as before till the water and impurities have settled to the bottom, when they are drawn off through the outlet. This washing is repeated till all traces of the mineral contents are separated, when the fatty acids are brought to the melting point and drawn off into trays to crystallize.

The trays, made of heavy tin plate, are about 18 inches long, 12 broad, and 3 deep. Figs. 86 and 87 represent a wooden framework A, bound by transverse bars of iron B, which support the trays C C at the same time. F F are leaden funnels for running the fatty acids, G a wooden plug for stopping them. The trays are kept in a convenient room

Fig. 86.

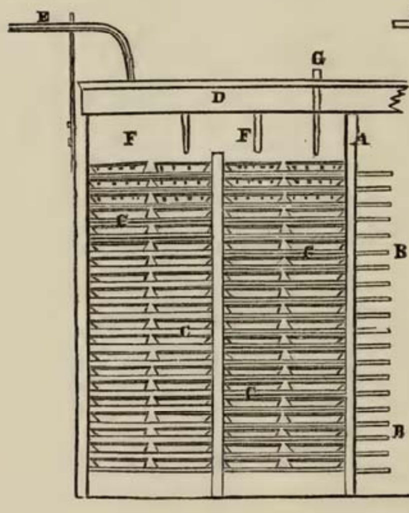
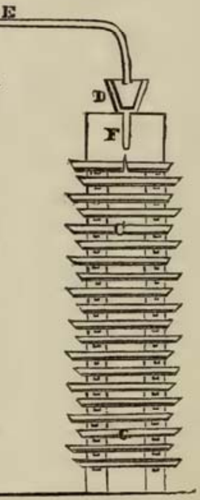


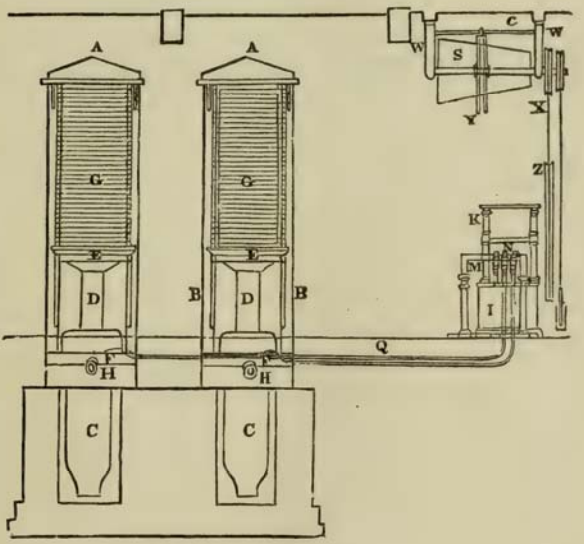
Fig. 87.



where the temperature stands at about 22° to 32° C. (71.6° to 89.6° F.), that they may cool slowly for several days—till the fatty acids assume a crystalline form, or granulate. At this temperature oleic acid does not solidify, and may be observed in drops exuding from the solid fats in the trays.

When the mass in the trays has granulated as far as possible, it is removed to a machine and cut in thin shreds with knives attached to a revolving wheel (similar to the soap stripper or the rasping machine for spermaceti, Fig. 94, page 484), the divided fat is then placed in canvas bags and pressed either in a hydraulic press or the elbow presses of Messrs. Boomer and Boschert, Syracuse, N. Y. (see Figs. 80, 81, 82, and 83), and the chief part of the oleic acid pressed out. In placing in the press every two bags are separated by a plate of sheet iron with turned-up rim; this prevents the mass from sticking together by the great pressure, and the canals of the plate collect the oleic acid. Fig. 88 is the usual form of hydraulic press.

Fig. 88.



When no more oil exudes, the press is loosened and the layers removed; by this pressure the fat cakes become so hard that the finger-nail can scarcely make any impression, but they still retain oleic and palmitic acid, to remove which it is necessary to submit them to a second pressure aided by heat, particularly if the fat is required for the best stearic acid candles. Fig. 89 is a drawing of the hydraulic press for hot pressing, and Figs. 90, 91, and 92 explain the working parts. Steam is conveyed by means of the movable

Fig. 89.

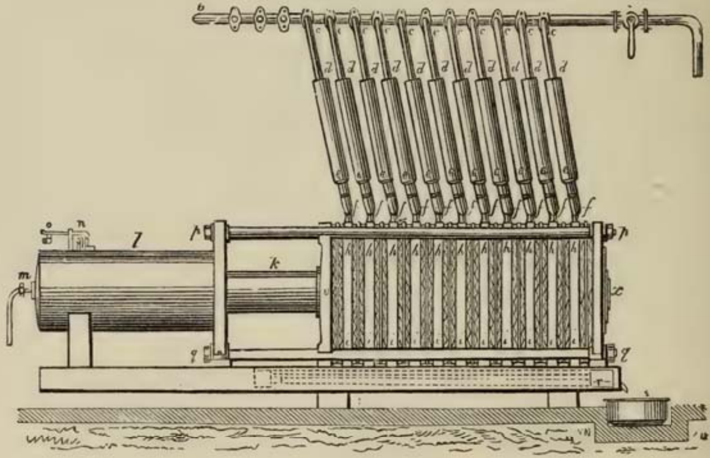
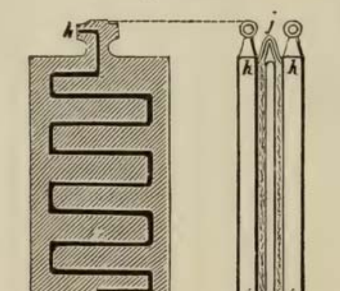


Fig. 90.



telescoping tubes into the press plates which are of iron having a winding channel for the entrance of the steam which furnishes the heat. The fat cakes are again reduced to shreds and placed in bags, and these enveloped in stronger ones of coarse jute-fibre or horsehair, and placed in the same manner in the horizontal press between the heated plates, and when sufficiently pressed taken out; when it can at once be used for moulding adamantine or stearic acid candles. If, however, a purer article is needed for the best stearic acid candles, a further saponification is necessary. The fatty acid is again melted and submitted to free steam for 5 to 8 hours, or until it is perfectly bleached.

Fig. 91.

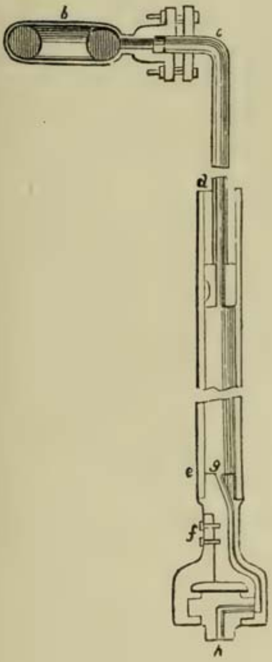
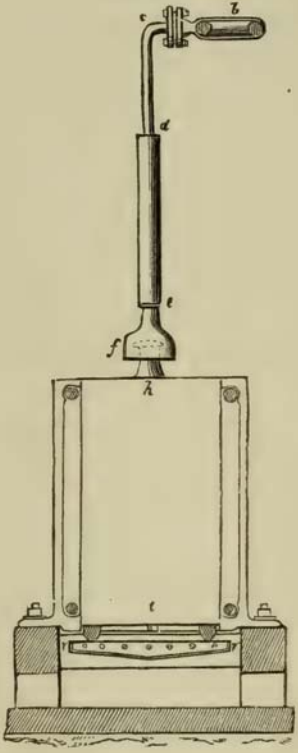


Fig. 92.



De Milly's Process.—De Milly has simplified this lime process by using only 2 to 4 per cent. of lime aided by a high steam pressure of 150 pounds at a temperature of 182° C. (359.6° F.).

Tallow treated in this way is saponified in about 6 hours. The style of boiler employed by him was a large upright cylinder of copper, provided with safety valve and gauge with pipes for the entrance of surcharged steam, and for filling and drawing off the contents; the ends both top and bottom were rounded, and the whole set in heavy masonry. In using this boiler the tallow is put in with an equal weight of water, less the quantity used in making the milk of lime, which is added by degrees so as not to arrest the ebullition, and continued until a complete emulsion is formed; when this occurs, the safety-valve is closed, allowing only a small escape of steam, causing a continued movement of the contents. The temperature is gradually elevated to a pressure of 8 atmospheres, about 175° C. (347° F.), when the flow of steam is arrested so as to maintain the temperature at this point for at least four hours. The saponification may then be considered finished, and the contents can be removed by the proper valves. The subsequent decomposing, washing, and pressing is similar to that already described. This process has many points of advantage and economy, saving lime, acid, and waste of fatty material.

The saponification by sulphuric acid has long been known, but has not until lately found a practical application. The process as now conducted may be described as follows:—

The fats are placed in large lead-lined vessels, with six to fifteen per cent. of concentrated sulphuric acid; the mixture is heated by a steam coil to nearly the temperature of boiling water for eighteen or twenty hours; some operate at a higher temperature and save time in the reaction, and also use a larger amount of acid. The fat is decomposed with an alteration of part of the glycerine, and part of the fat, sulphidic and carbonic acids being evolved. The black mass resulting from the action is now thoroughly washed with boiling water until all the fatty acids are freed from the sulphuric acid. The fatty acids are now put into a large still and heated from below to a temperature of 260° C.

(500° F.), when a jet of superheated steam of 350° to 380° C. (662° to 716° F.), is run through the charge; in about 12 hours the matter is distilled over, leaving behind a pitchy substance which can be used for many useful purposes in the arts. The fatty acids are cooled in the trays, and can be submitted to cold and hot presses as before described. When palm oil has been used, it is often made into candles without further manipulation. This process we think has no advantage over the lime process described, unless refuse or common fats are used.

Saponification by sulphuric acid without distillation may be described as conducted by De Milly. The fat is heated to 120° C. (248° F.), it is then caused to flow in a small stream and mix with a stream of strong sulphuric acid in the proportion of six per cent. of the latter; the mixture being briskly stirred, the action takes place at once and is arrested in two or three minutes by allowing the mixture to flow into boiling water, when the sulphuric acid and unaltered glycerine unite with the water, and the fatty acids float upon the surface and are of a dark color. But these acids are quite different from those in the method before described; here the coloring matter is soluble in the liquid fatty acid, so that by pressing both cold and hot the solid acids are obtained almost or quite white, ready to be moulded into candles. The entire operation can be conducted in about an hour's time; yet, if the cold pressure has not furnished the solid acid free from color, it is advisable to melt it again and granulate it in the trays and again press it; when a fatty acid fusible at about 56° C. (132 8° F.) is obtained admirably adapted for the best stearic acid candles.

Saponification of fats by water combined with distillation.—This process, though hinted at by Chevreul and Gay Lussac and practised by Dubrunfault, was not a complete success. But Mr. George Wilson, of the Price Candle-works near London, carried it to a practical success, at least when palm oil was the fat employed. In accomplishing this result, he heated the fat to a temperature of 290° to 315° C. (554° to 599° F.), and passed through the fat a current of surcharged steam of the same temperature. This great heat was necessary, otherwise the distillation was very slow, and acrolein was formed. The glycerine obtained by this process is of good quality, and when purified is the well-known Price's glycerine. It may be well to remark that this process, when other fats than palm oil were employed, did not give so satisfactory a result, so that it has but a limited application.

Saponification by water under high pressure.—When the true nature of the fats was discovered, it gave rise to many theories that eventually became of practical utility. Faraday pointed out this process as long ago as 1825, and Tilghman took out a patent in 1854, but has not yet we believe put it into practice. M. Melsens, of Belgium, has, however, succeeded, and works have been put up at Antwerp, where vessels holding a ton of tallow are used; fifty per cent. of water is added and heated to a temperature of 180° C. (356° F.)—ten or more atmospheres. In six hours the decomposition is complete, and the fatty acids produced are of a satisfactory quality, indeed, as good as result from more complicated processes. This process we think deserves much consideration from its simplicity and economy of time, and moreover, from the purity of the glycerine so obtained, this article having great commercial value.

The oleic acid recovered from various processes finds a ready application in the manufacture of soaps, some of the best domestic soaps being made of it, used alone or in combination with other fats or rosin. That furnished by the lime process claims a preference to that from the acid, the latter requiring more alkali and more time to make it into soap. The methods of its saponification have received full attention in another part of this work. Olein when purified is also used in fulling wool and dressing leather.[1]

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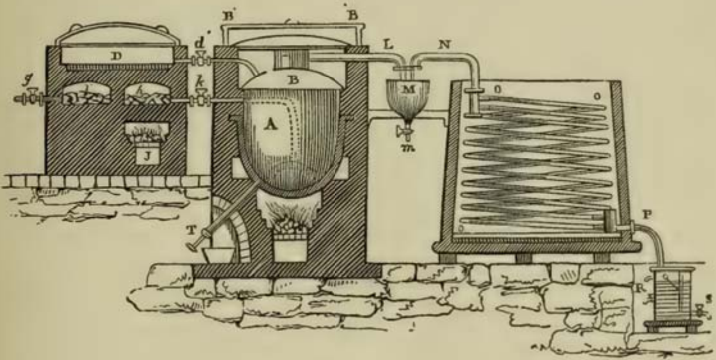
[1] Some of the latest information regarding the sebacic or fatty acids is given by Prof. T. Kraft, in his Reports to the German Chemical Society of October, 1879, as follows:—

"Palmitic acid obtained from palm oil melts at 62° C. (143.6° F.), and boils under a pressure of 100 millimetres at 268.5° C. (515.4° F.). Keton, A distilling apparatus in which the surcharged steam is brought to aid the processes here described, is here represented in Fig. 93. The flat metal boiler D with dome-shaped

Fig. 93.



cover is heated by the waste heat of the super-heater, the fluid fat is let into the copper boiler A, the cock d serves to regulate the flow. The dome cover B of the boiler has a cap of iron B B, which is heated with coals to prevent loss of heat by radiation. The steam, being heated from 248.8° to 304.4° C. (480° to 580° F.) and let into the boiler A, changes the fats into fatty acids and glycerine, and the vapors rising with the steam are carried into the pipes L and N and to the condenser O O. The steam excludes the air from the interior of the boiler, and thus promotes the saponification.

$C_{17}H_{34}O$, being obtained of equal weight parts of acetate of barium and palmitic acid barium, melts at 48° C. (118.4° F.), and boils under a pressure of 100 millimetres at 246° C. (474.8° F.), and under normal pressure at 319° C. (606.2° F.). By oxidation with bichromate of potassium and sulphuric acid, pentadecyl-acid is obtained $= C_{15}H_{38}O_2$, which melts at 55° C. (131° F.), and boils under 100 millimetres pressure at 266.5° C. (511.8° F.). By oxidation with bichromate of potassium and diluted sulphuric acid, we obtain the margarinic acid $C_{17}H_{34}O_2$, which Heintz had already prepared in a far more intricate way. The oxide of silver of this acid corresponds to the formula $AgC_{17}H_{33}O_2$. It melts at 59.8° C. (139.6° F.), 'and boils under 100 millimetres pressure at 277° C. (530.6° F.)."

SECTION III.

MATERIALS FOR CANDLES (CONTINUED).

Paraffine.—Perhaps the material next in importance to stearic acid for making candles is *paraffine*, called paraffine wax—a valuable hydrocarbon extracted from bituminous coal, shales, peat, lignite, petroleum, etc. The process for obtaining paraffine from all these different substances is generally the same. The materials are placed in retorts of a certain construction, and heated to a low red heat. The outlet of the retort communicates with a simple condenser cooled with water or a large surface of air. A current of steam passing through the retort greatly assists the distillation. Ammoniacal vapors first pass over, then brown vapors of the more volatile hydrocarbons, which continues with increased density until the materials are reduced to coke. The crude oil thus obtained is a kind of brown tar floating in a quantity of water which has absorbed the ammoniacal fumes. The crude oil is again distilled, and then agitated with strong sulphuric acid, and left to rest for a while, that the carbonaceous impurities may be taken up by the acid and subside and be removed. Any acid that may remain in the oil is neutralized with soda, and the oil is now distilled fractionally. The first and more volatile naphtha, termed "spirit," is run into one tank; next a heavier oil, called "paraffine oil," for burning; and thirdly, a heavy oil for lubricating, etc. This last running contains the paraffine or wax. To separate this wax the oil containing the crystalline scales is reduced to the freezing point, then bagged and pressed in presses such as we have before illustrated. The "paraffine scale" thus separated is of a brown or yellowish tinge, and requires further purification; this is effected by putting it into the trays, and cooling very slowly that it may crystallize. The cakes are then placed upon some porous substance, and exposed to a temperature just sufficient to melt the more fluid parts, which flow out from between the crystals; this is continued until the solid and liquid parts are separated as much as possible. The solid parts are again melted together, and again purified by melting by steam and adding 5 to 10 per cent. of strong sulphuric acid and agitating some hours. After allowing the whole to rest for some time to permit the mass to separate, the paraffine is drawn off and digested with animal charcoal, which is allowed to subside, and the liquid, if not yet clear, is filtered in a double filter kept warm by steam.

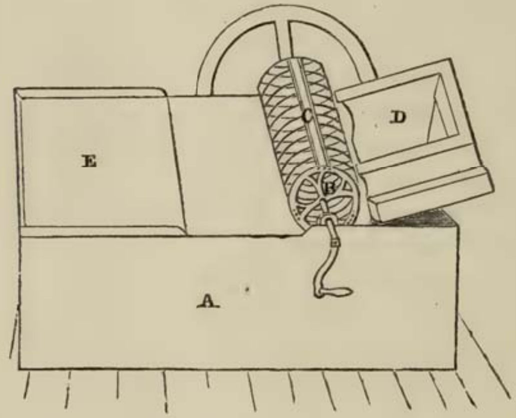
Later processes for bleaching paraffine are in vogue, using fuller's earth, silicate of magnesia, or lime, with marked success; in fact there are very many new processes for this manufacture, but we think we have given the simplest.

The value of paraffine for candles depends upon its melting point, which varies very much, depending upon the source of manufacture, and is from 35° to 65° C. (95° to 149° F.), and much care should be exercised in having that of the highest before making into candles. Paraffine from lignite or petroleum has a low melting point, that from ozokerite (a peculiar wax-like mineral) has a very high one, 65.5° C. (150° F.), and paraffine is of all the intermediate grades. Stearic acid and some of the vegetable waxes are added to paraffine to obviate its tendency to soften, which it often does, below its melting point, which causes the candles to bend and become misshapen.

From numerous sources are made similar substances to paraffine, and called by as many names, but they are analogous substances from a mineral source having nearly the same constituents and specific gravity, and there are many patented candles which have these matters for the base combined with wax, spermaceti, stearic acid, etc. Black paraffine candles are seen that are colored with anacardian shells.

Spermaceti must next claim our notice, for this substance is perhaps one of the best for the purpose of making a beautiful, transparent, pearl-like candle, giving a white light of high illuminating power, burning with great regularity, yet, owing to the cheapness of other materials for this purpose, these candles are too expensive for ordinary use, particularly as the material seems to become scarcer year by year. Spermaceti is the solid portions of the crude spermaceti, or "head matter" of the sperm whale, *Physter macrocephalus*, and some other of the *cetacea;* it is obtained by filtration from the oil, purified with steam and weak alkali, and hardened by pressure in the same manner as that given for stearic acid. The crystallized cakes are reduced to shreds by a machine represented by Fig. 94, the cakes being placed on D and cut by the knife C, the grains falling into the chest A, from which they are transferred to the bags and pressed in the press illustrated elsewhere, and purified as mentioned.

Fig. 94.



According to Heintz, spermaceti is a combination of cetyl with stearic, palmitic, myristic, cocinic, and cetinic acids. Owing to the tendency of spermaceti to crystallize in moulding, it is common to add a little white wax or some paraffine, which with proper manipulation gives the desired structure to the candles.

Wax of various origin, animal and vegetable, is used for making candles, the most useful being *beeswax*, which is now decided to be a secretion of the bee, and not from the plants they feed upon, as was at first supposed. Beeswax is obtained in commerce, of a more or less dirty color and very impure, and has to be bleached to render it fit for candles, the best process for this purpose being exposure to sun and air.

The first step in these operations is to boil the wax with water, with a small portion of alum and dilute sulphuric acid; boiling and stirring for some time, the impurities are allowed to subside, it is then dipped into a cullender attached to a machine where it falls upon a cylinder of polished hardwood kept wet by revolving in the water beneath, and is thus reduced to ribbons. It is then carried to a framework upon which is stretched a cotton cloth, and being placed on this cloth it is frequently stirred and sprinkled with water that the sun and air may act on all the surfaces. If the wax upon being remelted has not acquired sufficient whiteness, these operations will have to be repeated. Beeswax is often bleached with chemicals; the most efficient being bichromate of potash with a little sulphuric acid; the process seems, however, to alter the better properties of the wax, making it hard and brittle.

Other waxes.—Many other waxes are known in commerce: Chinese wax, from a kind of coccus insect, *Coccus cerifera*, feeding on the *Rhus succedanea;* Japan wax, though not a wax proper, containing palmitin and glycerine, is of a good white color, though apt to change on exposure; Pela wax, obtained from a species of palm called vegetable spermaceti, has a high fusion point, being 82° C. (179.6° F.); Myrtle wax, from the *Myrica cerifera*, found in our Southern States. Carnauba wax, received from South America, is a very hard and valuable wax, having a melting point as high as 84° C. (183.2° F.). Ocuba wax, also received from the Brazils, has rather a low fusion point, being 40° C. (104° F.). Many of these vegetable waxes and tallows could be used for candles if procured at low prices, as they might by their properties correct some of the objectionable ones of tallow, stearin, paraffine, etc.

Sebacylic acid should receive some notice, as it might perhaps serve to impart to paraffine and other kinds of candles a higher melting point. This acid is obtained by the dry distillation of oleic acid, or better, by treating castor oil with highly concentrated caustic soda solution; its high fusion point, 127° C. (260.6° F.), and its ready combustibility render it a fit material for melting with softer candle materials.

Elaidic acid, made by the action of nitric acid upon oleic acid, lard oil, and other oils, is also a material that might be advantageously used for candles. It can be made into a beautiful white solid. Its melting point, depending somewhat upon the source of its manufacture, ranges from 38° to 43° C. (100.4° to 109.4° F.), and, being an article that can be made at a small cost, it might be mixed with other substances for this purpose.

Glycerine, so often alluded to in our work, must not be passed without some notice, it being a by-product in many of the processes described for the saponification and preparation of the fatty acids for obtaining the solid sebacic acids for the manufacture of candles. This valuable substance is present in all the neutral fats to the amount of 8 to 9 per cent., and may be separated by treatment with the bases, with acids, steam, etc., so often described by us. It was first discovered by Scheele in preparing lead plaster. Glycerine is also formed by the alcoholic fermentation of glucose, etc.; the molasses from beet-root sugar and the residuum from the distillation of wine also furnish glycerine. In regard to the preparation and purification of glycerine, when its source is from the water after the separation of the lime soap in making stearic acid. The lime in the water is eliminated by sulphuric, or preferable, with oxalic acid, and the liquid evaporated to the consistency of a syrup, forming a glycerine pure enough for many technical purposes. When the decomposition of the neutral fat is effected with super-heated steam, the glycerine and fatty acids are both obtained comparatively pure, provided the heat has not been too great. The solution of glycerine and sulphuric acid in the process by that acid will yield the glycerine by evaporation, and the sub-lye from the soap boilers is a large source of crude glycerine. Glycerine is now largely employed in many industries, such as for keeping clay moist for modelling, preventing mustard from drying up, keeping snuff damp, preserving fruit, sweetening beer and liquors, also for lubricating fine machinery; in fact it would take a large space to enumerate its many uses.

SECTION IV.

THE MANUFACTURE OF CANDLES.

Wicks and their Preparation.

To form a correct estimate of the quality of candles various points have to be studied; we give the following:—

1st. The nature of the fatty matter used in their manufacture; 2d. Their whiteness; 3d. Their transparency; 4th. Their hardness; 5th. Their dryness to the touch; 6th. Their point of fusion; 7th. Their form and their moulding; 8th. The nature and kind of wick; 9th. The nature of the flame, if it be uniform, long or short, well supplied, illuminating, brilliant looking, with or without smoke; 10th. Does the capping at the top of the candle burn dry, or is it more or less filled with the melted fat? 11th. Is the fatty matter free from mineral substances?

This list we believe gives all the points worth noticing to furnish a correct idea of the quality of the candles of commerce. The point of fusion of the best quality of candles should not fall below 56° C. (132.8° F.). Candles made from the palm-oil acids, though giving a pure white light, seldom exceed 51° C. (123.8° F.). To obviate this, some manufacturers envelop them in a harder fat in the moulding; this is troublesome, and consumes much time. Candles made from the distilled acid give a good light, but generally discolor when exposed to the air; for this reason the stearic acid candles made by the lime saponification usually rank the highest in commerce. There are many other kinds of candles known by names peculiar to the manufacturers, as star, adamantine, palmitine, margarine, composition, etc., but they are all made from the materials already described, and may be a compound of the different ingredients which by mixing may be supposed to improve them or be combined for the sake of economy.

The wicks for candles require close attention, for much depends upon them, whether of the right size, of uniform thickness, free from loose threads, knots, etc. Cotton is now the material generally used for wicks for tallow candles; it is simply twisted; for stearin, paraffine, and sperm candles the wicks are plaited, so that when burning the threads twist out of the flame and are consumed, so that snuffing is not needed.

For tallow candles the following proportions are generally followed. "English style."

For an	8	candle to the	pound	38 to 42	threads of	No.	16.
"	7	"	"	42 to 45	"	"	16.
"	6	"	"	49 to 52	"	"	16.
"	5	"	"	52 to 55	"	"	16.
"	4	"	"	56 to 62	"	"	16.

The wicks for the stearic acid, paraffine, spermaceti, and many composite candles are of a much finer grade, and known as number 40; the following is usual:—

For an	8	candle to the	pound	60 to 64	threads of	No.	40
"	6	"	"	85 to 88	"	"	40
"	5	"	"	90 to 100	"	"	40
"	4	"	"	104 to 108	"	"	40

The wicks before using undergo certain preparations by steeping them in a solution of either boracic acid, nitrate of soda or potash, chloride of ammonia, etc., each having its advocates, but a solution of boracic acid with a few drops of sulphuric acid is now conceded to be the most effective. They are dried and soaked in the solution for 3 or 4 hours, when they are taken out and pressed and dried in a suitable oven. The purpose of this preparation is to cause the consumption of the ash of the cotton, and to retard their combustion.[1]

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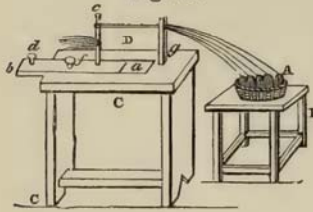
[1] In Germany, Belgium, Switzerland, America, as in most other countries, the English style of designating the degree of fineness of yarns is customary. In order to understand this, the following will be sufficient. Yarn, as is well known, comes into the market in hanks or skeins. The reel

For the cutting of the wicks there are many kinds of machines more or less convenient. The simplest form of wick cutter is here shown, Fig. 95, *C C* being the top, *d* a sliding top for graduating the length of the wick, *B* the stand for the balls of the wick *A;* the wick being cut of the proper length by the knife *g*. For a large business here is shown a very handy one in Fig. 96. It cuts, spreads, and twists the wicks in one operation and quite rapidly; its mode of working is very simple. *A* is the body of the machine, in the interior of which are the pulleys that regulate the movement of the carriage *B*, worked by the treadle *G*, a framework with a range of boxes for the balls of wick, one end of which runs through a notched reel below *H*, and comes forward upon the twisting board *E*, which has in its back edge a knife serving as the under blade of the movable clipper *D*. This, when drawn down vertically, severs the wicks evenly. The twisting box *E C* consists of two boards hinged, and moving on rollers. A turn of the crank near the end twists the wicks after they have been cut by the knife *E*, which having effected its purpose is drawn up again by a counterpoise *F*. At the front is a sliding board so fixed that it can regulate the length of the wicks.

Fig. 95.



Another wick cutter is well represented by Fig. 97. The wicks are rolled on spools which are placed in the drawer at

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upon which they are produced has a circumference of 1½ yards, or 54 inches English measure. 80 threads form a lea or wrap, seven of which go to one hank (number or skein), hence the hank has a thread length of 54 by 560 English inches, or 2520 English feet. The number of the yarn indicates the number of such hanks which make an English pound weight. No. 16 or 40 is therefore yarn whereof 16 or 40 hanks weigh 1 pound. In Austria and France other modes of numbering are in vogue; the numbers of an equal fineness according to the Austrian system are obtained by dividing the English number with 1.22, and that of the French mode of designating when the English number is divided by 1.18.—*Bolley on Illumination.*

Fig. 96.

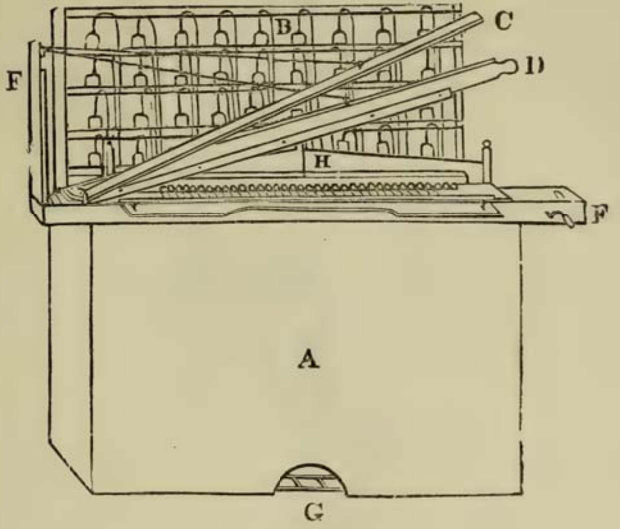
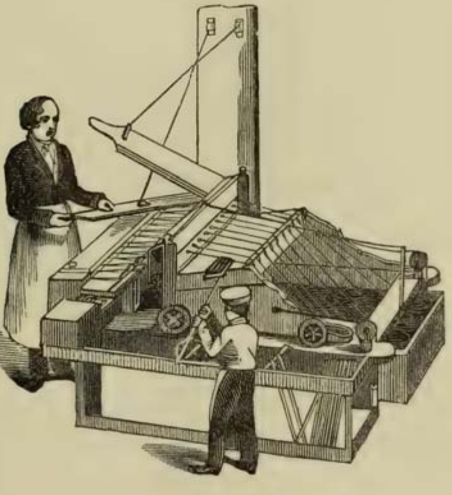


Fig. 97.



the rear. The ends are drawn over a rod and adjusted to the proper length; the knife is drawn down and cuts evenly a whole range of wicks, a motion of the machine giving at the same time a slight twist. The rod is then removed and replaced by an empty one to be in turn filled.

In order to combine the soaking of the wick end with the operations of cutting, an apparatus which we delineate in the Figs. 98, 99, and 100 is used. Fig. 98 is a vertical section, and Fig. 99 the ground plan of the apparatus; *c c* are spools upon which the wicks are rolled; *b* a roller into which circular gutters are cut, through which the wicks are introduced into the clamp *d*, and by which they are kept together. Fig. 100 represents the clamp on an enlarged scale in a side view; it consists of two side bands, *d* and *d*, which toward the centre are somewhat thicker. On each side a steel spring is affixed, which keeps the bands somewhat apart from each other, and a ring *e*, through which, when it is moved towards the centre, the bands can be brought near. If the

Fig. 98.

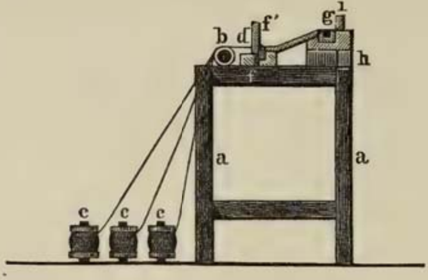
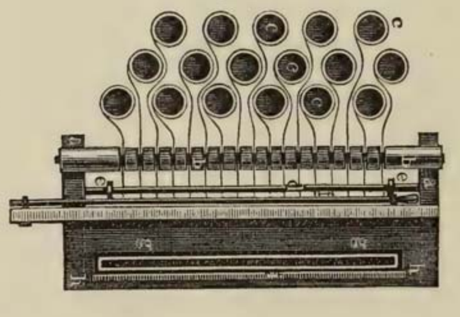


Fig. 99.



wick ends are to be kept together between the two bands, the rings must be pushed towards the centre. By taking the wicks out or placing them in, they are pressed towards the end. In the rear of this clamp is a cutting apparatus, consisting of a stationary blade *f*, and a knife *f* which has a handle moving on hinges; *g* is a small trough filled with liquid fat (which may be kept in a fluid state by steam), and finally *i* a band resting upon the table *h*.

Fig. 100.

The application of the apparatus is as follows: The wick ends wound off from the spools, are stuck into the clamp *d*, the rings upon them closed so that the wicks are all kept together. The movable blade *f* of the cutting apparatus is lifted up, and all of the wick ends which hang upon the clamp are moved backwards to the trough *g*, dipping the projecting ends of the same into the hot fat. This being done, the dipped ends are fastened by means of the band *i*, either by pressing upon the still soft fat, or by placing weights upon them and laying them upon the table. The opened clamp *d* is then carried back to its place, again closed and the blade *f* grasped by the handle, led down towards the sharp edge *f*, and thus all the wicks cut off to an equal length, whereupon the entire operation is commenced anew.

A great many devices in plaiting and gimping of wicks have been patented and used, but it has narrowed down to the simple plaiting for nearly all moulded candles and the coarse twisted for dipped candles. Of course the wicks are made of a size suitable to the diameter of the candle.

SECTION V.

THE MANUFACTURE OF CANDLES (Continued).

Dipped Candles.

Dipped candles, though rapidly dying out, are still made where tallow is abundant and large factories are remote, and in new countries, and they therefore should be properly described by us. They are always made of tallow more or less purified and hardened by processes we have already described, and assisted by apparatus that are here illustrated. Dipping by hand is accomplished without much help from machinery, which is of the simplest kind. The melted tallow is placed in a dipping trough; its length is about three feet, its height two feet, and its width twelve to eighteen inches; it should have handles or be on wheels, for convenience in moving; the edges incline slightly inward that the suet may run back into the melted fat.

On commencing operations the workman takes 10 or 12 rods strung with wicks as shown in Fig. 101, and dips each in the liquid fat to let them be thoroughly soaked; for this purpose the tallow is quite hot, that it may be completely absorbed by the wick; he then places them upon the frame Fig. 102, which is a strong framework of wood, the rods

Fig. 101.

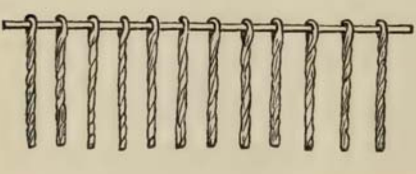
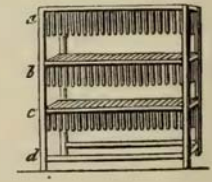


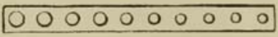
Fig. 102.



being passed upon the cross-pieces *a b c*. When the wicks have cooled sufficiently, they are again dipped into the tallow, which must now be much cooler, that it may adhere in sufficient quantity. They are again cooled and again dipped until sufficient tallow has adhered to form the desired size of the candle, which is regulated by a weight. The number of times necessary to dip a candle is governed by the fluidity of the fat. All the manipulations, though simple, require skill and practice.

Dipped candles are seldom symmetrical, but often quite unequal in appearance; to obviate this a drawing plate is often used. Fig. 103 is made of hard wood twelve inches long, two or three inches wide, and about three-quarters of an inch thick, in which are merely bored a number of holes of sizes required for the sizes of the candles. The holes are graded from large to small, the last being the size required for the finished candle. The holes have a slight bevel that the cutting edge may be the sharper, and that the candles may be the easier run through. The workmen draw the candles first through the larger hole which takes off a portion, then through a smaller one which removes more, and so on until the desired size is obtained for the finished candle. This operation improves the appearance as well as the burning of the candle.

Fig. 103.



To facilitate the dipping of candles many ingenious machines are in use. Figs. 104, 105, 106, 107, 108 show one much used. In this machine the rods loaded with wicks are arranged in a movable frame, suspended by cords over the vessels or baths, one inserted within the other. The larger or outer bath with its charge of tallow is kept warm by the furnace (Fig. 109), from 32.2° to 35° C. (90° to 95° F.), so that the inner bath heated by it may have a temperature of 12.7° to 15.5° C. (55° to 60° F.). A workman lowers and raises each frame alternately with the hand, thus dipping and re-dipping the candles until they attain their proper size.

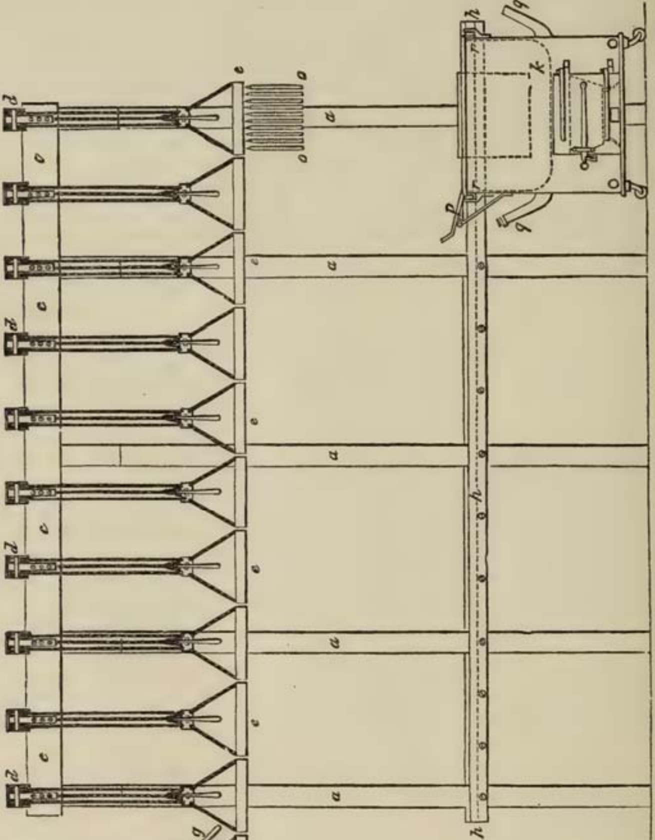


Fig. 105.

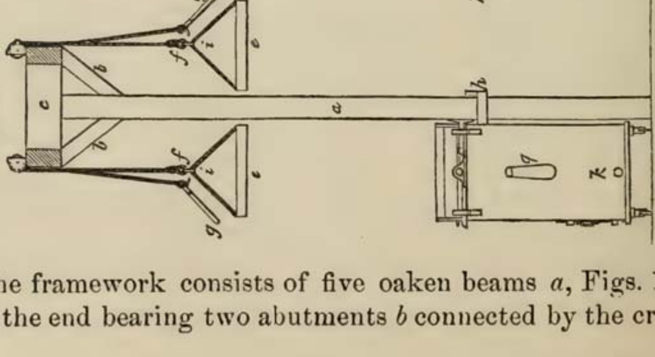


Fig. 104.

The framework consists of five oaken beams *a*, Figs. 104, 105, the end bearing two abutments *b* connected by the crosspiece *c*, throughout the length of which are five small trusses, into each of which is tennoned and mortised one of the beams *a*. The iron caps *d d* are fixed upon the sides of the long crosspiece of the frame *c*; each has two brass pulleys; the fastening of one of these caps is shown in front view and profile. Through each pulley runs a cord *f*, at the end of which is suspended a small wooden frame grooved for the reception of the rod *g* which carries the candle-wicks. The wooden handles *g g* have each a hook fastened in a hole in the centre of a small rectangular iron plate *i*, to which are attached the cords of the pulleys and the frame *e*.

Fig. 106.

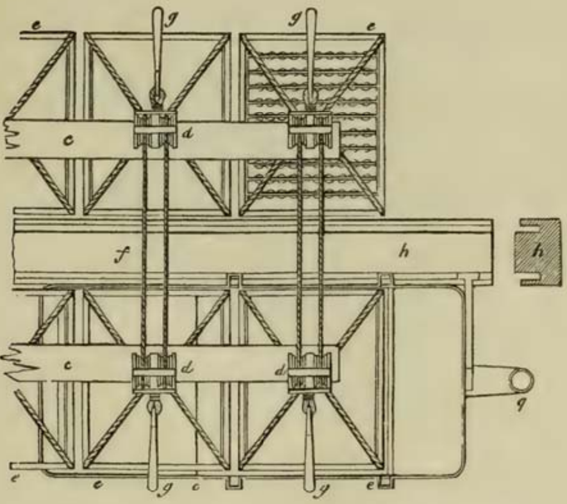


Fig. 107.

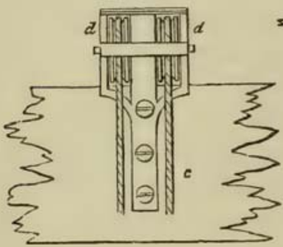
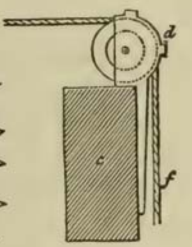
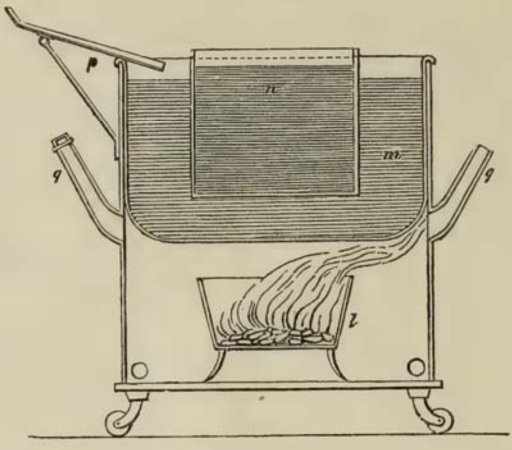


Fig. 108.



The long traverse *h* is grooved on each side to facilitate the movements of the furnace seen in the vertical cut (Fig. 105).

Fig. 109.

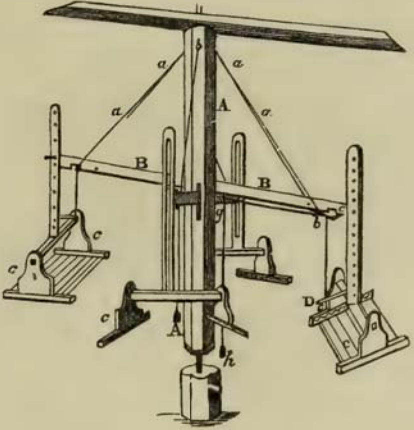


This furnace (Fig. 109) rests on four casters so that its position can be changed, and it has doorways for the small furnace *l* for maintaining the fusion of the tallow contained in the larger vessel. This tallow, kept at a temperature of 32.2° to 35° C. (90° to 95° F.), imparts sufficient heat to the contents of the smaller bath to insure the adherence of the tallow to the candles each time they are dipped. Upon the ledge of the larger basin is an iron drainer *p*, upon which the dripping from the candles is caught. The furnace is fed by currents of air admitted through the draughtway *q*; it has crockets *r* that work in the groove of the crosspiece *h* which serves to conduct the furnace from one frame of candles to another.

The mode of operating this machine is easily understood: when the candles have been dipped sufficiently, the frame is raised and left suspended by fastening the hook of the handle *g*, into the centre of the piece *i*, and while they are hardening the furnace is pushed to the succeeding frame. This machine works rapidly, and the work is uniform.

The Edinburgh wheel is an apparatus much used in this art, and is shown in Fig. 110. A A is the strong upright post, which turns upon pivots at its two ends. Near its middle six mortises are cut, into each of which a long bar of wood B B,

Fig. 110.



which moves vertically upon an iron pin, also passes through the middle of the shaft; the whole presenting the appearance of a long horizontal wheel with twelve arms. From the extremity of each arm is suspended a frame or "post" containing six or more rods or "baguettes" containing the wicks. The machine, though heavy, turns by the smallest effort, and each post as it comes in succession over the bath of tallow is gently pressed downwards, and the wicks immersed. In order to prevent oscillation, the levers are kept horizontal by small chains *aa*, the ends of which are fixed to the top of the upright shaft, and the other terminates in a small square piece of wood *b* which exactly fills the notch *c* in the lever. As a lever must be depressed at each dip, the square piece of wood is thrown out of the notch, and that it may recover its position on raising the post, a small cord is connected with a pulley, and the weight draws it back again to the notch. In this manner the dipping can be conducted with regularity and dispatch. The candles are assisted in cooling by being in constant motion in the air, thus completing from 9,000 to 15,000 per day.

Another very useful machine for dipping candles, which makes many thousand candles in an operation, is very well shown in Fig. 111. Forty frames each containing thirty loaded rods may be suspended on this machine. The frames are brought, one after the other, to the vessel of tallow and dipped. By means of a lever moved by the foot a wiping board is lowered after each dipping, which removes the excess of tallow from the ends of the candles. A kind of balance to which each frame is in turn attached, shows the weight of the candles. When by dipping they are of sufficient weight, they are set aside to harden and dry.

Fig. 111.

From these descriptions the manufacturer should receive sufficient instructions for the dipping of candles, though, from the great improvements in making moulded candles, which are much handsomer, dipped candles are not much used at the present time.

SECTION VI.

THE MANUFACTURE OF CANDLES (CONTINUED).

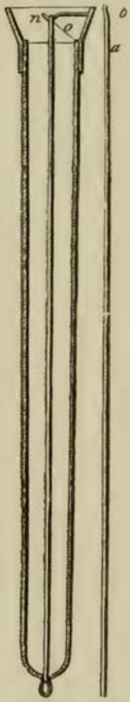
MOULDED CANDLES.

MOULDED candles are much more sightly, and are usually made of better materials than dipped candles; moreover, the operation of moulding is simpler and more expeditious, and moulding is the manner in which nearly all candles of the

Fig. 112.

Fig. 113.

Figs. 114, 115.



better class are made, and by numerous ingenious machines that greatly facilitate the process.

The moulds are usually made of pewter (lead and tin); those for stearic acid candles are made of tin and antimony, and are thinner. They vary somewhat in form; the French moulds are shown by Figs. 112, 113, 114, 115. Each mould consists of two parts, the body and the head piece, as shown by Fig. 112; the shaft *a a* is widened on top for the reception of the cap *m*, of the head piece *d*. Fig. 113 shows the two pieces united. Fig. 114 shows the position of the wick held by the small hook *n*, which is exactly in the centre of the mould. The moulds are bored out by machinery, so that the interior shall be perfectly true, and finely polished.

Fig. 116.

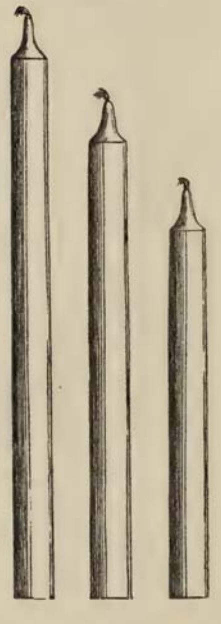


Fig. 117.

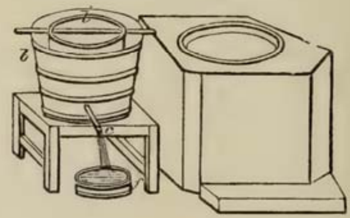
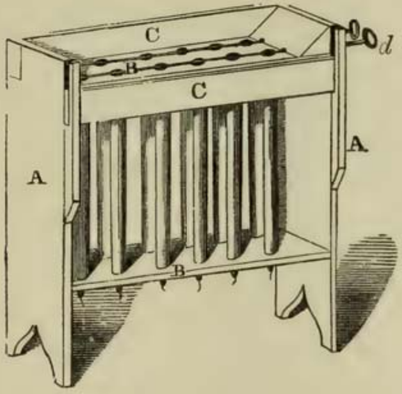


Fig. 118.

The moulds made in this country are of a better form, as seen in the Fig. 116, which represents the candles made in them. They are burnished by a vertical instead of a rotary motion, which makes the candles easier to remove. They consist of two pieces, the shaft and the tip, the latter being sometimes made of brass, or washed with brass, to resist the abrasive effects of the wick and pegs. The alloy for these moulds is tin and lead, with only sufficient of the latter to render them smoother and easier to work.

Moulding by hand is still conducted in small towns and factories, and is rather a simple process. Melting kettles for this purpose are the ordinary kettles set in brickwork as shown in Fig. 117, with tub, strainer and can, Fig. 118. Fig. 119 represents a convenient mould stand, now much in use. A A, two upright ends supporting the cross-beds B B, that hold the moulds; the upper bed is of metal. C C are broad side pans which form a receptacle for the tallow when the moulds are being filled, one side of which can be removed with convenience in working, and shows the wires that suspend the wicks.

Fig. 119.



The threading needle is shown by Fig. 115; it is of iron, and has a slight catch for holding the wick; it is used by holding it in the right hand, while in the left are held the wicks. The needle passing through the mould appears at the loop in the tip, when the wick is caught by the catch in the needle and pulled through, when the wire of the mould-stand passing through the loops holds the wicks in position. A small wooden peg is often put in the hole, which seems to hold the wick tight and prevent the melted tallow from leaking out.

The frames being in readiness and the tallow at the proper temperature, the moulds are filled with the same. To succeed well, care must be taken to have the tallow neither too hot nor too cold. If too hot, it hurts the mould and causes the candles to adhere and be full of cracks. If too cold, the candles have a granular structure and look uneven; in the first case, the candles are removed by dousing the moulds in warm water after they have cooled and the candles dexterously drawn out. The proper heat for the tallow is when on cooling a pellicle forms on the sides of the kettle, at a temperature of about 37.7° to 44.4° C. (100° to 112° F.). The mould while cooling should be left in quiet in an upright position, and the wick ends showing below the tip are straightened by pulling before the candle congeals, unless the pegs spoken of have held the wicks firmly in position. When the moulds have caps, the candles are easily drawn by raising the caps and cutting them at the junction, otherwise the workman presses his thumb against the bottom of each candle to loosen it, and draws it with a kind of bodkin.

When first made from ordinary materials, the candles are more or less yellowish, and it is customary to expose them to light and air, which bleaches them somewhat, but if packed away the color returns. The best remedy is to have the tallow whitened by some of the processes we have described in a previous section. It is true that they will become white with age, but it is by absorbing oxygen and becoming rancid unless kept from the air.

Moulding by machinery has nearly superseded the more tedious method by hand, and there are numerous mechanical appliances more or less perfect and rapid, for small as well as large manufactories. If the article to be moulded be tallow, it is preferable to have it hardened and bleached. The hardening is done by pressing out a portion of its oil, or by granulating and separating as previously described.

In the melting and refining of the tallows, steam is now generally employed, particularly when a large quantity is needed for moulding by machinery. We here illustrate a convenient form of apparatus for melting, Fig. 120. The steam generator A. The reservoir B contains the water for feeding the boiler by the cock N; the draft is regulated by the damper G. The boiling tubs C C C are heated by the pipe

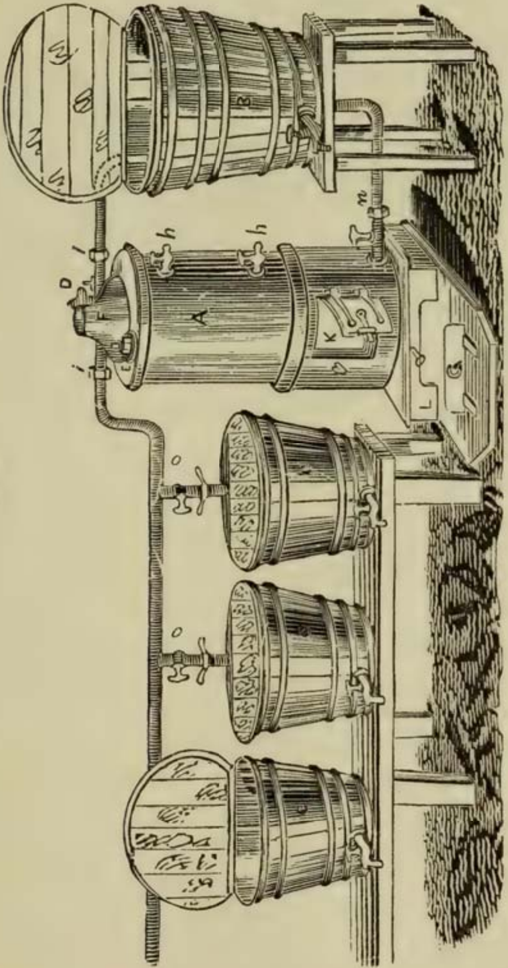
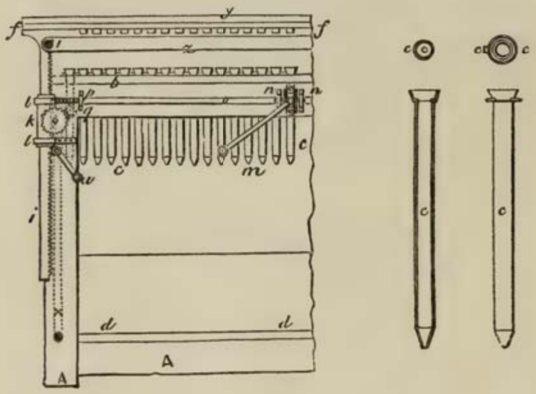


Fig. 120.

O O O. This range of melters is convenient, as a constant supply of melted fat can be kept up.

Leubel's moulding machine is arranged to make 396 candles at one operation. Fig. 121 shows a front elevation of one-half of the machine, also the moulds. The moulds are ranged in a stand somewhat like the ordinary one, on top ot which is a second stand but ledged and made of iron or other metal and pierced with holes corresponding with those in the wooden stand beneath. In each of these holes is lodged a kind of small funnel, to which is attached the wick which descends into the moulds. The metallic stand is so arranged that, by the aid of a winch moving a cogged rack, it can be raised or lowered at will. When the candles are about to be cast, the metal stand is lowered until the funnel caps touch in the top of the moulds, when the fluid tallow being poured upon this stand runs through the caps into the 396 moulds. After perfect congelation the metallic plate is raised by the winch and the candles severed with a long knife. In warm weather the moulds are cooled in a vessel of ice-water, elevated so that the filled moulds are dipped their whole length in it. A is the framework of oak wood; the platform *d* supports the vessel *e* of water for cooling the moulds. The metallic table *f* is pierced with holes cor-

Fig. 121.



responding in size and position with those in the wooden table *b*. Figs. 122 and 123 show other views of this machine; Fig. 124 the arrangement of the wick.

Fig. 122.

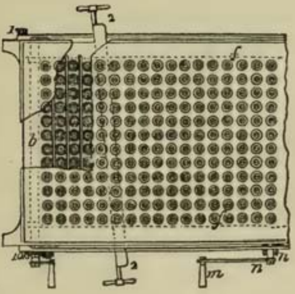


Fig. 123.

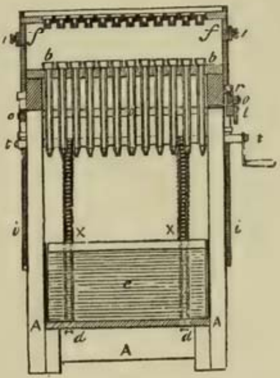


Fig. 124.

The manner of working this machine is to commence by placing the moulds in the holes of the wooden stand *t*, and the funnel caps in those of the metallic stand *f*, which being done, the upper stand is lowered by the winch *m*, until the caps get into the ends of the moulds. The wicks are arranged in the usual manner, and retained in position by hooks in the centre of each cap; when all is ready the melted tallow is poured in upon the table *f*, whence it runs into all the moulds.

When the candles have cooled and hardened in cold weather by the atmosphere or in warm weather by the bath of ice-water, the metal table to which the candles adhere is lifted up and the candles are detached with a knife. The operation being finished, the caps are removed and cleansed in hot water before using again. The moulding is facilitated by having the upper metallic frame warmed sufficiently to prevent the too rapid cooling of the fat; being larger than the lower frame, it can be heated with a tin box running along its edge filled with hot water or steam.

Morgan's moulding machine, used in England for tallow candles, is so constructed that, with a sufficient number of stands, the moulding can be continued for an indefinite period, and at a saving of labor and time. The wicks in this

Fig. 125.

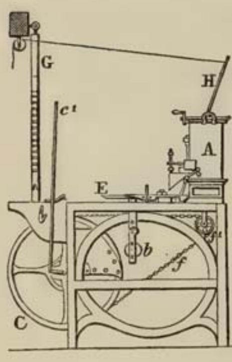


Fig. 126.

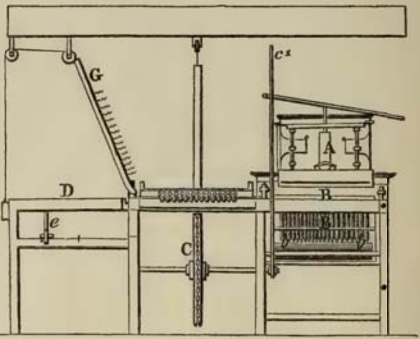


Fig. 127.

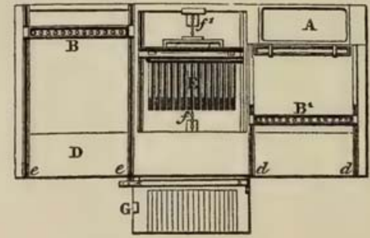


Fig. 128.

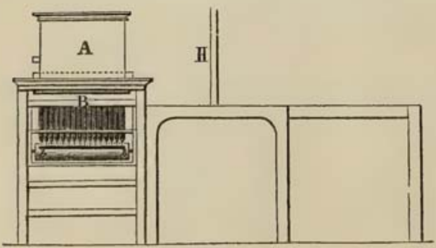
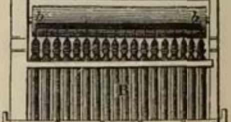
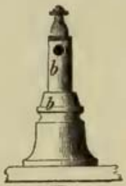


Fig. 129.



machine are threaded through the moulds at the same time and by the same action as that which expels the candles. Fig. 125 shows the end elevation, and Fig. 126 a front view; Fig. 127 the plan, and Fig. 128 the elevation of the back opposite Fig. 126. A represents the vessel or reservoir containing the fat; B, a series of moulds. Fig. 129, the range of moulds constructed in a peculiar manner. Fig. 130 shows the upper end of one of these moulds, and Fig. 131 a plan view of the same; it will be here seen that the top is in several pieces. *b* 1 is a portion of the cylindrical side of the mould; *b* 2, the movable portion. This latter *b* 2 is hollow for the passage of the wicks, and fits closely to *b* 1, when the tallow is poured in. But as soon as the candle is cold, and in a condition to be removed, instead of being drawn out in the usual way it is by this apparatus forced out by pressure applied to the extremity of the part *b* 2 following the course of the candle as it is forced from the mould, rewicking the mould for another candle. In Fig. 129 is shown a hollow cylinder of tin, *bb*, holding the bobbins of wick revolving on a shaft passing through its length. Fig. 132 exhibits a series of nippers opening and shutting by the action of the lever *e*, holding the wicks (at the end opposite to that of its entrance) in *b* 2 in a perpendicular position.

Fig. 130.



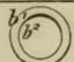
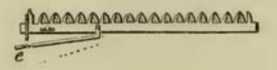


Fig. 131.

Fig. 132.

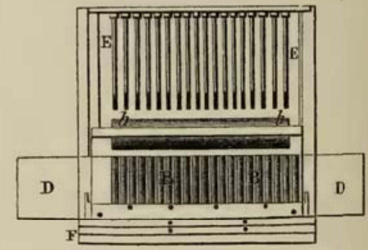


To work this apparatus we suppose a frame of moulds B regularly wicked and in the position shown at B^1, Figs. 126, 127, 128, where the case is supported perpendicularly on the small straight edges of a railway *dd*, Fig. 127. In this position they are run forward until they come under the reservoir A, when the tallow is applied in the usual manner. The moulds, being filled, are run along the railway *d d* to harden. When the candles have perfectly congealed, the moulds are brought to the position shown at B (Fig. 127), when they are placed on a railway similar to that shown at *d d* on the other side of the machine. Here they are pushed forward until they arrive at the hanging table D which vibrates on the joint *e e*, and is then let down, but immediately returned to the longitudinal position given at D, Fig. 127. The moulds B are moved until they arrive at the series of rammers E, as separately shown in Fig. 134, where the cylindrical case *b b* is removed by turning the jointed frame, as seen in Fig. 135, to be out of the way of the rammer E. This series of rammers E, moves freely in a horizontal direction supported on straight edges at each extremity, and is moved by the partial rotation of the wheel C, as shown in Fig. 125, where *f* shows a band or chain passing over its periphery, and round the guide pulley f^1. This chain or band *f* is attached to a series of rammers E, so that the pressing of the lever c^1 which is fixed on the axis of the wheel C imparts motion to the rammers E in a horizontal direction. The moulds being in the position shown at Fig. 135, the next thing to do is to bend down the lever c^1, thereby forcing the series of rammers E into contact with the sliding part, b^1, of each of the moulds, and thereby pushing out the candles which are received into the grooved table F, raised up in exact position to receive them

Fig. 133.

Fig. 135.

Fig. 134.

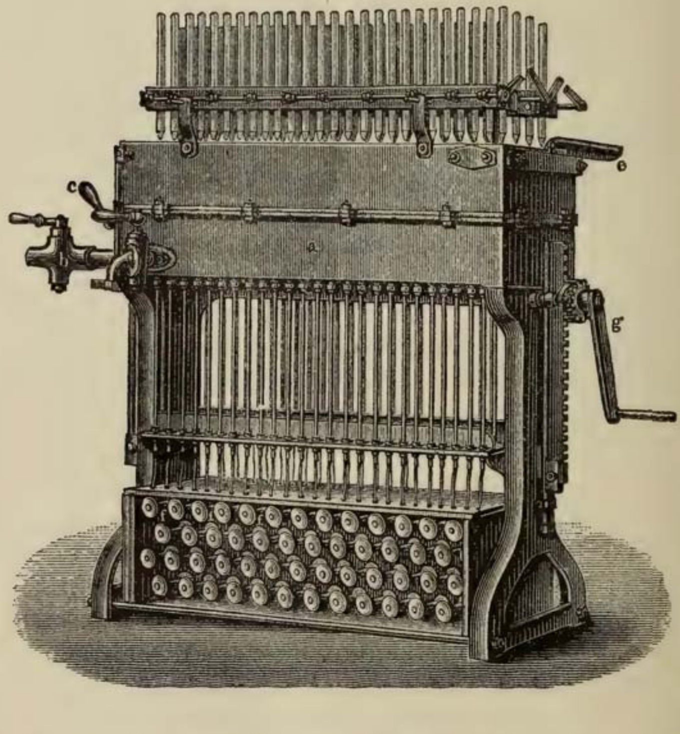


by the action of the scroll-piece c^2, attached to the wheel C, and on which the grooved table F is supported. The candles, being forced from the moulds by the rammers, are immediately secured and held stationary by depressing the lever G, which is provided with a series of like number of small convex pieces of pewter, formed of a section of the candle moulds, which are attached to slight springs, as seen in Fig. 126. The lever is held down by a small catch. From what has been said of the frame of moulds B, it is obvious that the same action of the rammers E, which displaces the candles, will carry down to the moulds a fresh supply of wicks for the succeeding candles, and, at this period, while the finished candles are secured on the table F, the nipper *f*, shown at Fig. 132, must be reapplied, after which the finished candles are cut off and disposed of.

The next duty of the operator is to replace the lever c^1, in the position shown at Fig. 125, which carries back the rammer E along with the sliding top of the moulds 2*b*, to their former position, and the moulds are wicked ready for a fresh supply of tallow. This series of rammers E, is formed of separate hollow tubes, supported in the cross-piece *gg*, each of which tubes is provided with a small spring having a slight projection on its inside by means of which when the rammers are pressed against the sliding part of the moulds, marked 2*b*, the spring gives way and catches firm hold of the notched part as shown at Fig. 130, and is thereby enabled to bring it back to its former position, where the candles are forced from the moulds as soon as the rammers are retired, and have brought back the sliding tops 2*b* of the respective moulds; the springs at their extremity, which had held the 2*b*, are relieved or lifted up by a second series of rammers or rods, which pass up the interior of the hollow rammers, as already described. This second series of rods is fixed in a similar cross-piece marked *hh*, in Fig. 127, which as soon as the rammers are retired from the moulds, is forced forwards by means of the lever H, and thereby the caps 2*b*, and the whole of the moulds marked B, freed from any connection with the rammers E. At this period the moulds are passed forward to the railroad *d d*, and replaced in the position shown at B^1; the tallow from the receiver A, again supplied to them, and the process already described, repeated any number of times. This description is elaborate, and judging by it the machine may seem complicated, but it is not so, the working is quite simple and rapid.

Improved Continuous Wick Machine.—The latest improvement in this useful machine is here shown, Fig. 136, applicable to tallow as well as to stearic acid or paraffin candles. The moulds, one hundred in number, are inclosed in the cast-iron box *a*; these moulds are tubes open at each end. The tip forming the top of the candle is fastened to a tube of iron through which the wick passes; these tubes are fastened to the platform which is connected by a rack and pinion

Fig. 136.



moved by the crank *g*. The wicks are reeled on bobbins inclosed in the lower case. Above the mould case is placed an apparatus called a nipper, which grasps the finished candles as they are raised out of the moulds by the piston tubes. The nipper is formed of hard wood lined with India-rubber and acted upon by means of hinges and cranks.

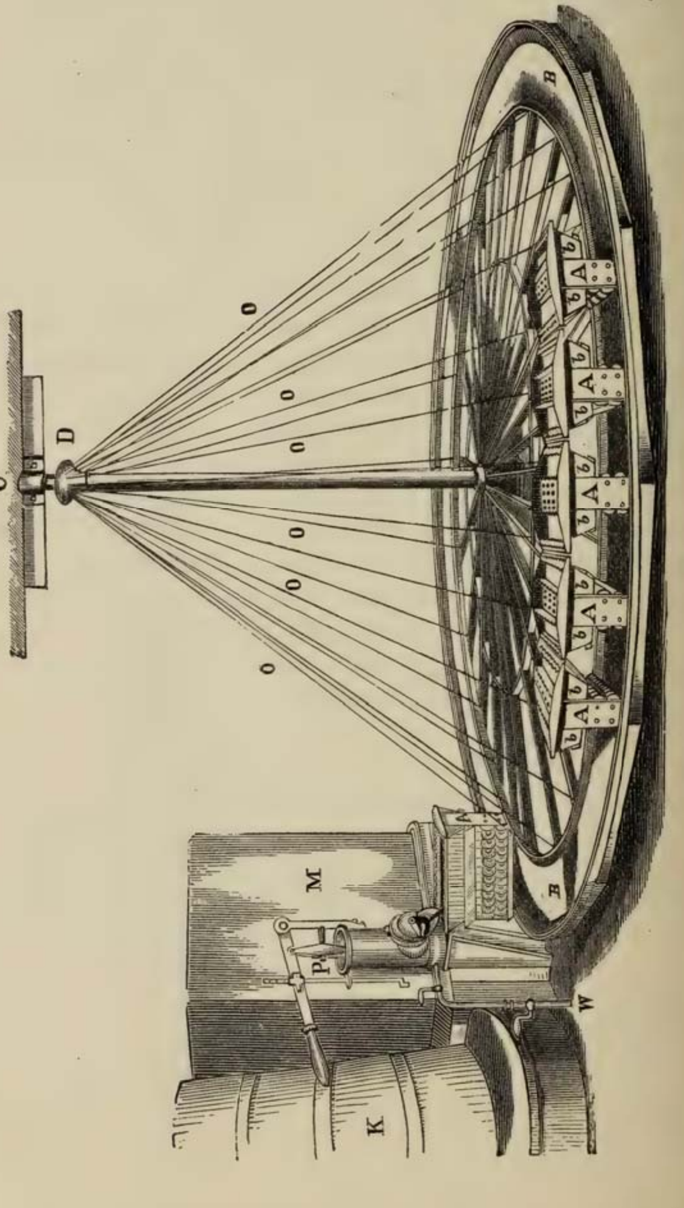
To the mould box are suitable valves for the admission of hot or cold water, either to warm the moulds or cool them and the candles. This machine for an ordinary business presents many advantages, as with proper management the moulding can be continued without much intermission.

Ashley's Moulding Machine has a device to impress the trade-mark or initials of the manufacturer upon the candles during the process of moulding, to accomplish which, the moulds are arranged in the stand at an angle of fifteen degrees, with their tips uppermost. Openings are made in the side near the tips for the passage of the melted tallow, which is supplied from a suitably arranged vessel. There is also an arrangement for making the wicks continuous, so that, as in the last machine described, the act of drawing one batch of candles simultaneously wicks the moulds for the next cutting. When the tallow is about to "set" in the moulds, stoppers are pressed into the mouths of the moulds, by which manipulation the candles acquire smoothness on the lower end, and at the same time receive the impress of the trade-mark.

Camp's Moulding Wheel.—This machine is an American invention, and is suitable for an extensive business, as with it a single workman can mould a thousand pounds of candles in a day. Its construction is very simple, and it is moreover easily managed, and its working has given general satisfaction throughout the United States.

It consists of a revolving platform or horizontal wheel *B*, Fig. 137, suspended by means of iron brace-rods *O*, which centre at *D*, in an upright shaft turning upon its pivoted ends in sockets affixed to the floor and ceiling *C*. The platform serves as a table for the support of the mould-slabs *A*, which are made with lateral recesses *b*, for the reception of ice when the warm weather renders its use necessary for cooling the candles. In the lower part of the stands, and just below the tips of the moulds are the spools of wick cor-

Fig. 137.



responding in number with those of the moulds in the stand. At the outset the wicks are drawn from the spools through the moulds and adjusted in the usual manner, by hand. This being done and the platform being filled with stands in regular order, the moulding is commenced by opening the mouth valve of the feeding tube *M*, immediately adjoining the melting tub *R*, from which it is supplied with the fluid tallow. The first stand being filled, the wheel is then pushed around till the next stand succeeds to its place under the valve of the feeder and is filled in its turn, and so on, the operation proceeding until all the stands are filled. Before, however, the last stands are filled, those first filled will have cooled, enabling the operator to be kept constantly at work filling or drawing from the stands the solidified candles, or preparing the mould stands to maintain their order during the revolution of the wheel, thus making the process rapid and continuous. The whole row of candles is drawn simultaneously, and the candles are laid over in grooved ruts, cut in the ledges of the stand for their support. As the wicks are also drawn at the same time, it follows that the moulds are threaded for the succeeding candles, the first candle is allowed to rest in the groove until the succeeding candles have cooled when it is cut off and removed, this also seems to keep the wick in the centre of the moulds.

Upon this very useful apparatus there have been several minor improvements, as an attachment of an iron cylinder to the feeder, with valves to admit only the requisite amount of tallow for each frame, also a brake on each frame to steady it when reaching its place under the valve, and also a steam pipe for warming the moulds in very cold weather, preventing a too rapid cooling which causes irregularity in the appearance of the candle, etc. etc.

Stearine Candles.—Stearine is the name given to such candles as are made from the more solid parts of the neutral fats. We have described the partial separation of the olein in our section on dipped candles, yet there are other and more elaborate processes for making them. Lard is the most desirable base, as it makes with suitable care a beautiful white candle. We have made these candles many years ago (1843), in the west where lard was very abundant and other means of lighting scarcer and high priced. The process was comparatively simple, and consisted of separating the oil by pressure through deer skin, protected with canvas, and melting and refining the stearine or harder parts, using a portion of nitric acid, which had the property of whitening and hardening the fatty body. This simple process conducted with care gave at that time a satisfactory candle.

Braconnot, a French chemist, as long ago as 1821 pointed out the affinity of some of the hydrocarbons for the olein in the fats, and his hints have been utilized in forming a good stearine by using a rectified oil of turpentine as a solvent of the more fluid parts. The process as followed out is described thus: Lard or tallow is melted by steam, and permitted to cool slowly and granulate, and it is then pressed to expel the oil and again steamed and cooled as before, and pressed in a hydraulic press.

After sufficient pressing the cakes of fat are taken out and melted in a jacketed kettle at a temperature of about the boiling point of water, when after a few hours heating, the fat is allowed to rest and cool to about 48.9° C. (120° F.), when to every 100 pounds of the fat are added while constantly stirring eight pints of rectified spirits of turpentine of recent distillation. The fat thus prepared is drawn off into tubs and allowed to rest for several days at a temperature of about 10° C. (50° F.), when it will have hardened into a granular mass, which is again pressed in a hydraulic press, using a gentle pressure at first, gradually increasing it until the utmost is used. The oil that exudes is used for the cheaper kinds of soap. When thoroughly pressed the fat is removed and immediately steamed until all trace of the turpentine is dispelled, the water is drawn off and a weak solution of an alkali used to refine it. When the scum arises and is removed and the liquid assumes a clear aspect, it is finished, and is now strained off into clean tins, and when cool should have a beautiful wax-like appearance, especially if lard has been the body operated upon. It can now be melted and moulded in the manner described for the best tallow or stearic acid candles. The improved continuous wick machine (Fig. 136, page 512) is the most efficient, as by that machine the moulds can be warmed or cooled for moulding at any time in the year.

Moulding Stearic Acid Candles.—Stearine candles, as they are called, though improperly, as the term stearine seems to apply to any candle harder than tallow; stearic acid being quite a different substance. Some attention has to be given in the preparation of the wicks for stearic acid candles, as the pure cotton would absorb too much fat and burn too rapidly, also to keep the proportion of burning wick to the melted matter constant, as well as to adopt those wicks which in burning turn their tops out of the flame so that coming in contact with the air outside of the enveloping curtain of the flame they are reduced to ashes. This is managed by so plaiting the wick that a twist is given to it which causes it to become unplaited in burning and twist itself out of the flame. The wick is composed of three threads (each thread having a suitable number of fine ones), one thread being shorter and thus having a greater strain upon it than the others, gives a curvature to the whole point as soon as the melting of the candle allows it to have fair play. To prevent the wicks burning too rapidly, several chemical substances are used, as muriate of ammonia, phosphate of ammonia, etc., but we have found a solution of boracic acid, one ounce to one gallon of water, adding a few (say twenty) drops of sulphuric acid, to be the most simple and efficient.

Stearic acid crystallizes very rapidly in certain temperatures, and care must be taken to prevent it, as the candles would have an uneven appearance and be brittle. To remedy this the melted acid is kept agitated while cooling and put into the moulds in a creamy state; this is very much assisted by mixing with the stearic acid about 10 to 20 per cent. of paraffine, but even with this addition the mixture must not be moulded until it looks milky, and is constantly stirred. Wax is also used for this purpose, but it is more expensive, while the paraffine tends to make the candles more transparent.

The moulds for stearic acid candles are made of an alloy of one part tin and two parts lead, and in some instances antimony is added, and it is advisable to have thinner moulds than those used for tallow candles; this is necessary as the moulds are warmed and cooled rapidly when being used. Moulds of glass have been recommended, but they have not as yet found much favor, though it would seem to be a very suitable material for them.

Bleaching the Stearic Acid.—This process may be necessary, as it is seldom sufficiently white for moulding when first prepared. If the stearic acid has been properly washed there is but little to do in further preparation for moulding, but to melt it with a current of steam, continuing the stirring gently for some hours, letting it rest and pouring off the clear acid into pans, taking due care to have everything free from dirt of all kinds. Another method is to add to the melted acid five per cent. of sulphuric acid diluted with ten per cent. of water, and stirring as before. Again, the further bleaching is promoted by taking off the above acidulated water, adding fresh water and the whites of twenty-five eggs to each one hundred pounds of fat, the steam is again turned on, and the scum of albumen that rises skimmed off.

For a very white stearic acid we have found that nitric acid is a very efficient agent; five per cent. of this acid is added to the fat previously melted by steaming. After the acid has been gradually added the steam is shut off, but the agitation is continued with a twirl or by constant stirring for upwards of an hour, when being left to repose, the acidulated water is drawn off and the stearic acid washed several times with warm water, draining off the water of each washing. The last washing is accomplished by the addition of steaming, and when finished, the clear stratum of fat is ladled off into the pans to cool.

Moulding stearic acid candles by hand is but seldom adopted except in very small factories, yet it may be well to give some details. The first step is to melt the stearic acid in a steam jacket similar to the one here shown (Fig. 138), from whence it is ladled into a convenient vessel to be stirred till it assumes a milky appearance, which destroys the tendency to crystallize, and assists the moulding. In the mean time the moulder is gotten ready, the moulds wicked and arranged. Figs. 139 and 140 show an iron casing where the moulds are made warm by a water bath and the steam is introduced by a perforated pipe running on the bottom and which heats the water. When by this steaming the moulds are warmed to the proper degree, say 46° to 49° C. (114.8° to

Fig. 138.

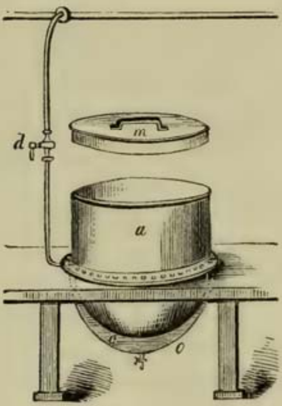
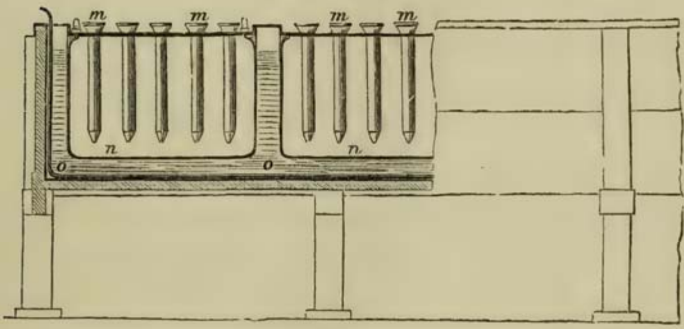
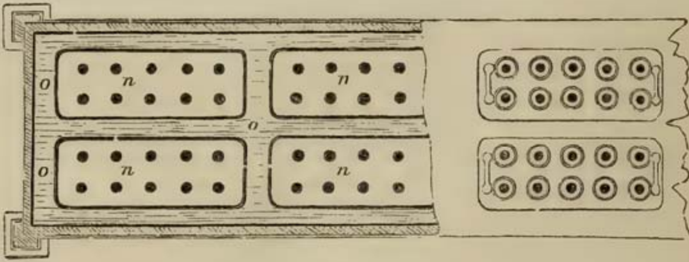


Fig. 139.



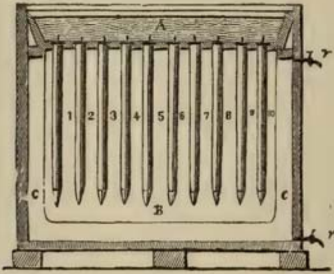
120.2° F.), the stands of moulds are taken out and immediately filled with the milky stearic acid, and placed where

Fig 140.



they can cool. With the proper precautions, the candles will be of uniform appearance, and easily drawn from the moulds. Fig. 141 is a jacketed mould stand, useful for a small business, and in which hot and cold water can be used.

Fig. 141.



Moulding by steam has so many advantages that the method is indispensable to large operations. For this purpose some of the machines already described may be employed, yet there are several in use by the French manufacturers that are more efficient. We illustrate one of the best. Fig. 142 represents an elevation, *A A* being the case for the bobbins of wicks in number corresponding with the number of moulds. *B B* is another case of plate iron called the heating box, into which the steam enters by the valve *C*, or the cold air by the flue *D*, having a suitable register *E*. *F* is a movable carriage running on four wheels upon the railway *G*. *H H* are vertical racks operated by the toothed wheels *I*, turned by the crank *J*. *K* is the wick holder serving to keep the wick in position.

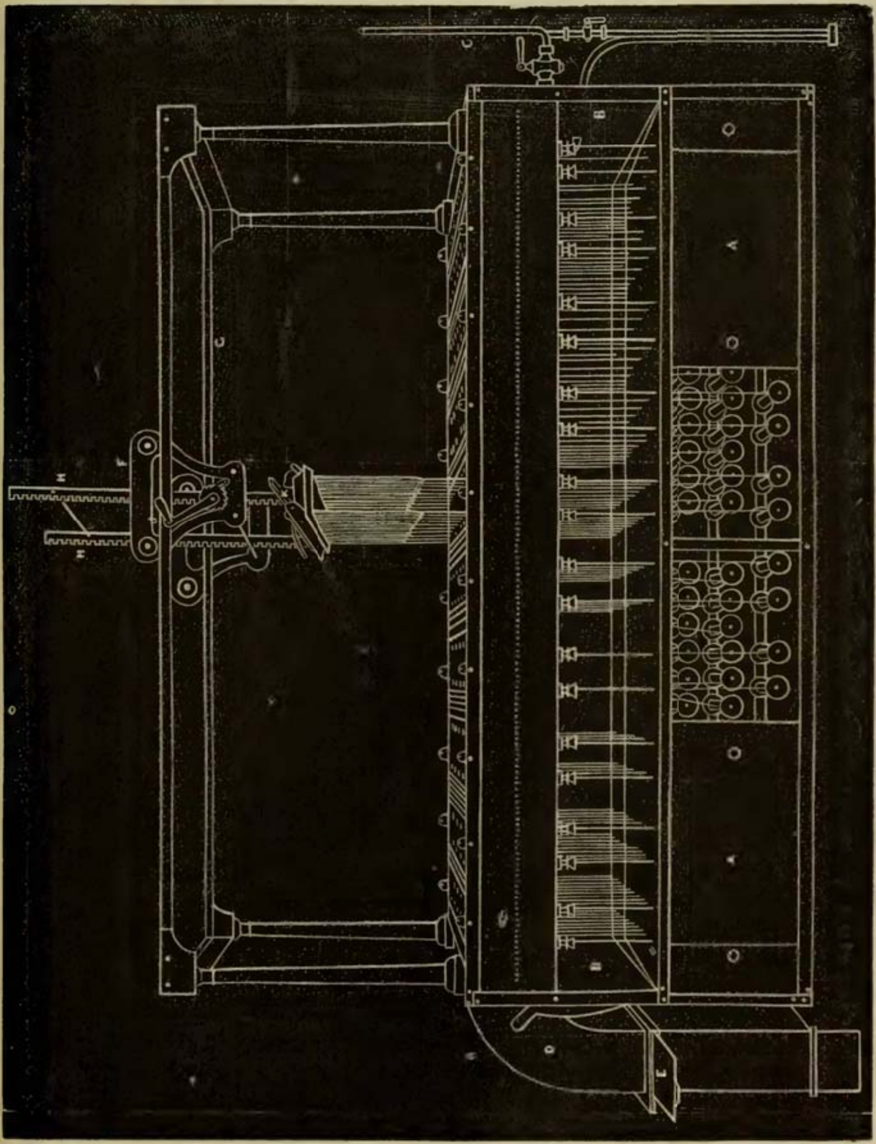


Fig. 142.

To operate this machine, the wicks being in their proper places, the steam is admitted by the valve *C*, until the moulds are sufficiently heated, when it is turned off. Each of the ten mould stands containing eighty moulds fits closely into its appropriate place, that there may be little or no escape of steam or air. The moulds are then all filled, when the register *E* of the ventilator *D* is opened and cold air forced in by means of a blower, and when the candles are solid, each mould stand is emptied by means of the hooks grasping the wick holder which has an appliance for grasping the ends, and is raised and lowered with the crank. The wicks are cut with a suitable knife, and the carriage brought to another stand and so on until finished; the moulds being all emptied, the operation can be resumed. This apparatus is designed for a large business, and is applicable to the moulding of paraffine, spermaceti, and nearly all composite candles.

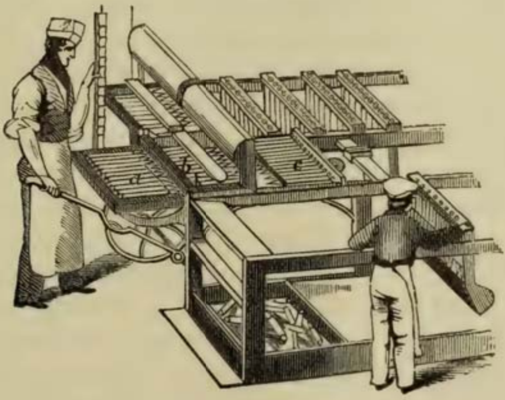
Paraffine candles may be considered next in importance to the stearic acid. This substance is found in nearly all mineral oils and as a by-product in the preparation of coal gas, the refining of petroleum, etc. Paraffine when pure is a white, wax-like, tasteless, and odorless substance, having a fatty appearance. It is harder than tallow, but softer than wax; it has various melting points, ranging from 43° C. (109.4° F.) to 65.5° C. (150° F.), and is a beautiful material for candles, being almost transparent, giving a clear white light.

Moulding Paraffine Candles.—This industry has but few points of difference from the moulding of other candles, the moulds being the same as for stearic acid and spermaceti, and the same kind of plaited wicks are also used. The principal difference is in the regulation of the heat in moulding, the moulds being heated to about 66° C. (150.8° F.), or a little above the melting point of the paraffine, and when well filled they are left to rest a few moments and then suddenly cooled by immersion into cold water. This method prevents their crystallization and their becoming opaque, instead of the natural transparency so much desired. As paraffine candles are apt to become misshapen and bend owing to their softening below their melting point, it is customary to add from 5 to 15 per cent. of stearic acid to them; and, again, paraffine to the amount of 15 to 20 per cent. is added to the stearic acid candles to promote their good appearance.

Spermaceti candles are, next to wax, the best and handsomest in use, giving a beautiful white light. Spermaceti before being made into candles has to be very pure, and the process for its purification has been elsewhere described more in detail than we can do here. In commerce it is found in a sufficiently pure state for this manufacture, though it is customary for the refiners of the sperm oil to also purify and mould into candles the spermaceti so extracted.

Moulding spermaceti candles can be done in almost any of the moulding machines heretofore described. There is however some difference in the manipulation, as it is customary to mould them in cold weather, heating the spermaceti to about the boiling point of water, running it into the moulds and cooling rapidly, thus keeping them transparent. The apparatus here given (Fig. 143) is one made especially for sperm candles. Each frame contains a row of eighteen moulds, and in a receptacle at the bottom, there is a corresponding number of rolls of wicks (the plaited or braided wicks before mentioned) connected with the moulds. In threading the moulds, the wick is left to protrude at the

Fig. 143.



top; and when the sperm has been poured in and the candles have set or cooled, the frame is drawn forward by means of a lever, directly in front of a series of horizontal rammers, which are made to press against the conical tips of the moulds. The candles, in passing from the moulds, draw after them sufficient wick to re-thread the mould for the next casting.

The candles are drawn as shown at *a*; and in that position they are firmly held by a hinged board, suitably indented and covered with flannel; while a circular knife moving between *a* and *b* cuts the wicks and frees the candles. The ends of the wicks are then caught by clasps arranged on a rod and tightened by drawing back the plungers, which bring with them at the same time the conical tips of the moulds. The whole frame is then placed on a pair of rails at the side. The frames are brought under a reservoir of sperm, placed above the rails, the contents of which are kept in a state of fusion by steam pipes. Being filled, they are pushed to the end of the railway to cool. When the candles have set, the excess of sperm and the clasps are removed from the top; and the frames are removed on a suitable truck to a parallel railway opposite, and are then moved up to the rammers and drawn as before mentioned. Care must be taken to keep the clasps in their proper positions, so as to maintain the wicks in the centre of the candles.

Composition candles in which spermaceti or paraffine enters largely are used for decorations, being colored and painted in ornamental designs. This branch of the art will be treated of in a subsequent section.

Wax candles, though expensive, are much used in many countries in the homes of the wealthy, on festive occasions, and in the churches of several religious denominations. We have outlined the process for refining and bleaching the wax for this purpose. The wax bleached by the action of light is much the best for nearly all purposes, while that bleached by the aid of chemicals, though equally white, loses much of its toughness and adhesive property. Wax, and especially beeswax, added to other materials for candles generally improves their quality and appearance. It has been customary to add a certain quantity to spermaceti and stearic acid candles to obviate the liability of these candles to crystallize when moulded, causing a brittleness and a cloudy appearance.

Moulding Wax Candles.—It would be a somewhat difficult process to mould wax candles in any of the many moulding machines we have described and illustrated in this work, though it is possible to do so if great care be taken in regulating the heat of the wax, the moulds, etc. For moulding wax candles glass moulds have been found the most desirable and to make them less liable to fracture; they are coated externally with gutta percha, and when the candles are to be drawn the moulds are dextrously dipped into warm water, and the candies withdrawn while the mould has been expanded by the heat. Wax has also the property of greatly contracting while cooling, causing the candles when moulded to crack.

Wax candles are most frequently made by basting. For this purpose the wicks (either twisted or plaited) are covered at the ends with small tin tubes, to protect them from the moulten wax; they are then suspended upon a hoop hanging over a furnace having a large round copper kettle *c*, Fig. 144, containing the melted wax; this kettle has a rim *d* so bent at the front as to catch the dripping wax and return it to the kettle. The workman standing by this vessel and having the hoop with the wick in the proper position, pours with the ladle *i* a portion of wax on each wick in succession, turning the hoop at the same time, also giving a twist to the candles to insure a uniform coating. By the time the first basted wick has returned to him it may be sufficiently cool and hard to receive another coating of wax, and so on until sufficient has adhered to form the required size, which is regulated by a balance or by the practised eye of the operator.

When the candles have acquired the requisite size, they are finished to their proper length, and polished by rolling on a marble slab or hard-wood table with a suitable roller like Fig. 145, the slab or table being dampened with water to prevent adhesion: the tops are formed with a suitable tool and the lower ends cut off smoothly.

For the large *bougies* or *cierges* used in the ceremonies of the churches, many of which weigh twenty to forty pounds, there are several processes of making besides the one just described. The large size altar candles are usually made by first soaking the wick (which is part cotton and part linen) in the melted wax, then forming the wax, kept soft by warm water, into long strips or ribbons and covering the wicks, continuing until they acquire the proper thickness, rolling and polishing as described. Or, again, the candles are made of the requisite size, and the wicks inserted into a channel

Fig. 144.

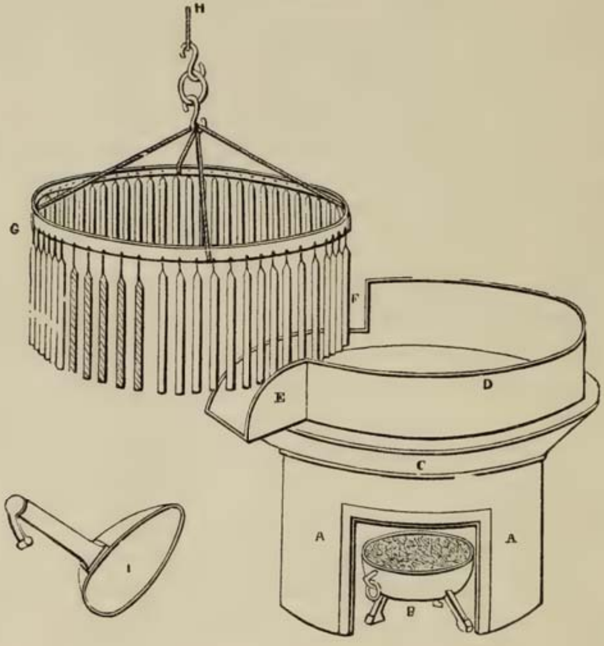
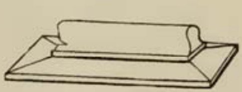


Fig. 145.



bored through the centre, filling up the channel with melted wax.

There have been made several machines for moulding wax candles in a continuous length, usually in the shape of a press, heated by steam to the proper temperature necessary to keep the wax soft. The wick is inserted in such a manner that it is concentrically surrounded with wax when ejected from the spout of the cylinder of the press, thus forming a continuous candle which is cut into the required length and finished as described.

Wax has so many uses that it is kept at a price too high for use in ordinary candles; it is therefore not much used for candles in this country. But it is a material that might enter into many of the better class of composite candles, which see.

SECTION VII.

THE MANUFACTURE OF CANDLES (CONTINUED).

POLISHING AND FINISHING.

FOR the common candles of tallow there is not much attention given to the finish or the bleaching. They are cut at the ends with a large knife attached to an open tray, having a gauge board to regulate the length, and are submitted to the action of air and light, by being placed in a wire grating of lead upon a proper table or framework, as

Fig. 146.

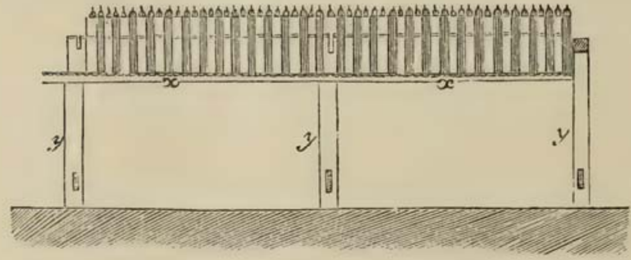
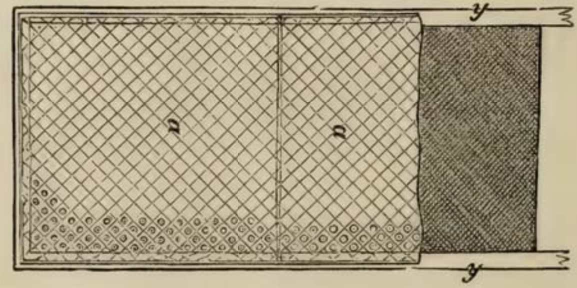


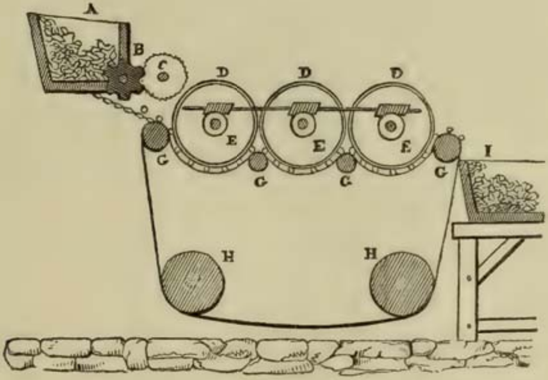
Fig. 147.



shown by Figs. 146 and 147. This frame and wire are applied for bleaching stearic acid and other fine candles.

The better class of candles are polished by hand by being rubbed with a soft woollen cloth moistened with ammoniated alcohol, or are polished by a machine made for the purpose. Fig. 148 is a drawing of a simple machine in general use in

Fig. 148.



France; A, being the hopper in which the candles are arranged, and from which they are taken singly by the fluted cylinder B. This latter, in revolving gives them to the circular saw which cuts the ends, when they drop upon the endless belt of woollen cloth, running on the rollers G G G and passing around the drums H H. Three other rollers D D D covered with cloth, run by aid of pinions E E E, are run in an opposite direction. By these alternate motions the candles are made smooth and glossy, and delivered into the receptacle I.

A more complete polishing machine is shown by Figs. 149 and 150; A A being the framework strengthened by the beam B, the belt C driving the pulley D or the loose one E, the moving axle carries the two fly-wheels H H, moving the shafts I I, and giving motion to the rubber J and the rubbing sheave M. The belt N connects M and M′. The latter sheave is fixed in a horizontal shaft O with a pinion wheel P at the end, working into a large toothed wheel Q. The shaft O also carries two small wheels with square teeth II, which

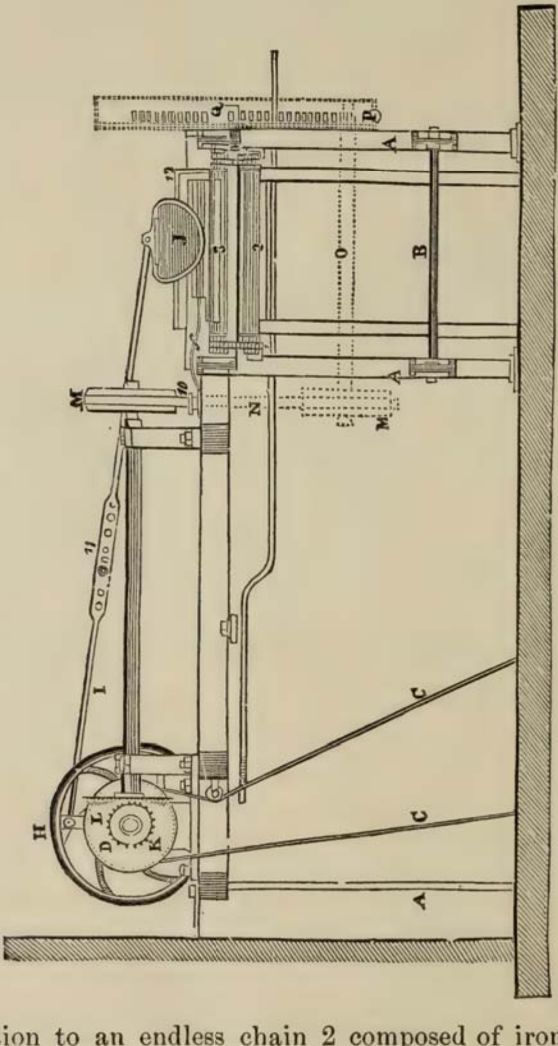


Fig. 149.

give motion to an endless chain 2 composed of iron rods, and between which the candles 3 are placed. A small table covered with woollen cloth is fixed under the endless chain on which the candles roll as they are drawn forward from an incline, ranging parallel with each other. The candles are retained in their position under the rubber, by means of

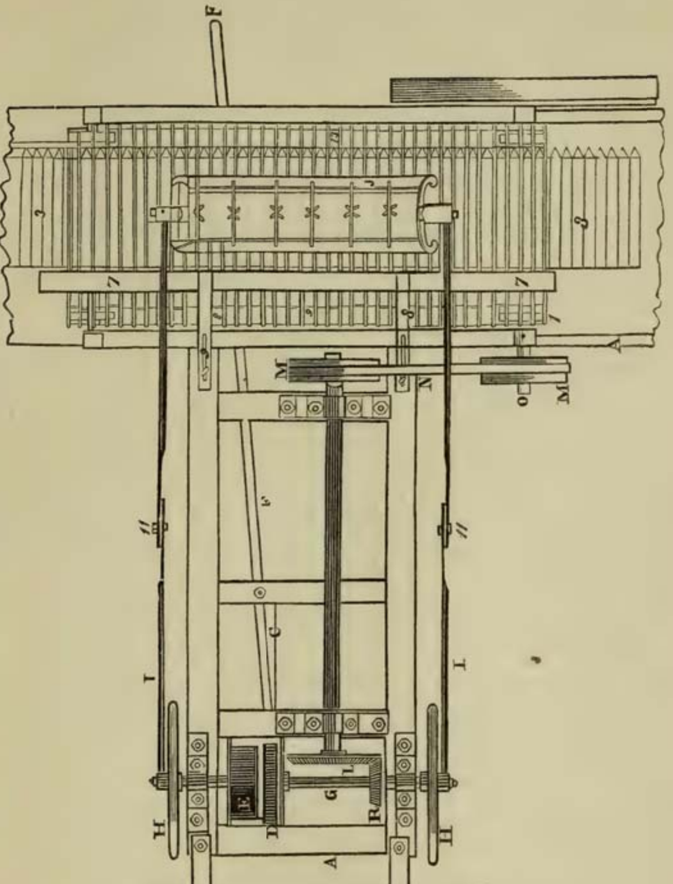


Fig. 150.

the guide 7 regulated by springs 8 8, and when sufficiently rubbed and polished are deposited on the table at the other end of the machine.

Almost all stearic acid, paraffine, and spermaceti candles and many of the composite candles are now made so perfectly by finely finished moulds, that they require but little polishing and finishing; yet, some machinery for this purpose, however simple it may be, is indispensable to give a smooth and glossy appearance to the finished candles.

SECTION VIII.

THE MANUFACTURE OF CANDLES (CONTINUED).

COMPOSITE AND PATENT CANDLES.

FROM the number of materials heretofore mentioned, there are a great variety of candles made with as many different names, yet they have much sameness in their characteristics as their composition is usually of two or more ingredients, thus we see stearo-palmitic, margaro-elaidic, stearo-cocinic, etc. etc., but with fancy names. The value of these candles depends upon their clean burning and light-giving properties as much as their handsome appearance, which in all cases should be as white and transparent as possible. Sometimes candles are made having a part neutral fat with the stearic, palmitic, or cocinic acids, but as a rule they have not the illuminating power of the fatty acids; then again their melting point is generally too low.

Belmont sperm candles are made from a mixed body of stearic and cocinic acids combined with a portion of paraffine.

Belmont wax candles are we believe stearic acid and a portion of wax tinted a creamy white with gamboge.

Star candles have usually a base of stearic acid prepared from tallow and lard.

Cérophane bougies, a French invention, are we think a composition of very white stearic acid, with ten to twelve per cent. of bleached beeswax, made transparent by careful moulding.

Adamantine candles, named thus from their hardness, are made from a stearic acid produced from tallow which has the highest melting point, about 68.3° C. (155° F.). Though not so white or transparent, they give a good white light.

Artificial wax candles are made in varying proportions of stearic acid and wax, principally beeswax, though there are several vegetables waxes used which have to be previously bleached. Wax candles have a creamy white color which is usually imparted to the artificial wax by means of yellow pigment. There is also a certain art in the moulding of these candles necessary to give a waxy appearance and to deserve their name. This consists principally in so melting the material and keeping it quiet for about half an hour, while the temperature has reached the proper point, when it is carefully run into the previously warmed moulds which are gradually cooled.

Diaphanous candles are also a French invention, and are we believe made of a superior stearic acid, from lard and some of the vegetable waxes (say Japan wax), which latter has been purified by chemicals. Care also is necessary in moulding to give a great transparency by a due regulation of the heat both of the moulds and the fatty bodies.

Composition candles.—By this name so many different candles have been made that it would be almost impossible to give formulas. The term is applied to candles that have in their composition certain neutral fats or sebacic acids in certain proportions, one giving to the other a quality to improve either their consistency or lighting power.

From these formulas the intelligent manufacturer should receive such hints as by experiment would enable him to make any candle he might desire.

Various patent candles.—From the many candles that have at times been patented, and which have been more ingenious than useful, we must select a few, for they may serve as hints to other inventions. In England candles have been moulded with a perforation through the centre (Fig. 153), the diameter regulated to the size of the candle; the wick is drawn through or a small wick having a weight attached (Fig. 154), which carries down the wick as the candle is consumed, and requires no snuffing. Figs. 151 and 152 show candles moulded in solid form, the wicks being but two or three inches long, and attached to a tube (Fig. 158) of a shape to fit the candle, and which descends as the fat is melted and consumed. Fig. 155

is a candle moulded in oval form in which is to be placed a flat wick for the purpose of giving a larger flame and increased light. Figs. 156 and 157 are devices for making candles in two parts, a hollow exterior cylinder *b*, and an interior one *a*, the latter being one-eighth of an inch less in diameter than the hole in *b*; this space between the two being filled with the wick, and if the interior cylinder has a perforation as seen in Fig. 157 the wick will be supplied with air similar to an argand lamp.

Fig. 151.

Fig. 152.

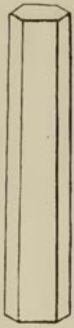


Fig. 153.

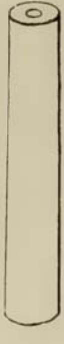


Fig. 154.

Fig. 155.

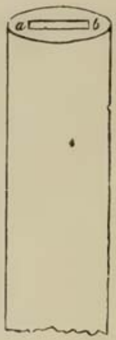


Fig. 156.

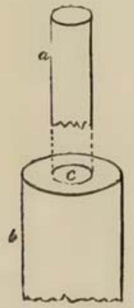


Fig. 157.

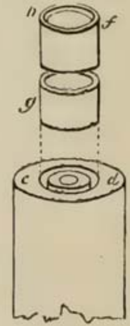


Fig. 158.

Similar devices for supplying air to the flame of the candle have been patented, and also to prevent the candle guttering when carried, the melted fats running into perforations beside the wick. For these candles it is usual to mould them in solid form and perforate them through their length with a suitably shaped tool. Fig. 159 shows one that makes a triangular perforation, through the centre of which a coated wick is drawn, leaving three channels for the access of air or for permitting the overflow of fat to run into when melted faster than it can be consumed, or dropping when the candle is carried about.

Fig. 159.

Fig. 160.

Many improvements in the moulds for candles might be mentioned. Fig. 160 represents one that possesses much merit; *a a* is the shaft of the mould, *b* the box or trough. The lower portion of the mould is compressed at *c c*, to form a resting place for the tip *d*, which tip is widened at the outer end that it may be forced up to loosen the candle before being drawn when it again falls into its place. These moulds are made of a hard material and of less weight and thinner sides that they may be the sooner cooled or heated ; moreover, they are susceptible of a finer polish to their interior surface, thereby moulding a better finished candle.

To prevent the guttering of candles metallic cups have been devised as seen in Figs. 161 and 162, a simple cup of thin metal to be placed upon the top of a candle ; the wick coming through the hole is lighted, and, as the material is melted and consumed, the cup descends, preventing any overflow. The inventor proposes to place on top of this cup another holding a circular tube of glass or mica to act as a chimney, as shown in the cut, Fig. 163.

Another ingenious invention of a candle or bougie to burn on water is represented by Fig. 164, very useful for a night light. They are made of stearic acid or wax. A plate of metal A covering the vessel of water has attached a tube in which the candle floats, and which acts as a guide for it while it is consuming and burns at the surface. There can also be placed upon the tube graduated marks showing the time of night by the length of candle consumed (Fig. 165).

Fig. 161.

Fig. 163.

Fig. 164.

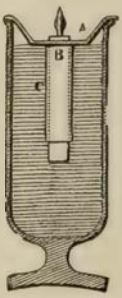


Fig. 165.

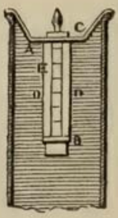


Fig. 162.

It would be impossible in our limited space to give all the ingenious devices and patents that pertain to these useful articles. What we have given may serve to stimulate the inventive powers of our readers who may make something much better.

SECTION IX.

THE MANUFACTURE OF CANDLES (CONCLUDED).

DECORATED AND COLORED CANDLES, TAPERS, NIGHT LIGHTS, ETC.

WITH the advanced taste for house decorations, illuminated, decorated, and colored candles find a conspicuous place, and there has been a rapid advancement towards perfection in them, for they are seen in very handsome colors, with decorations that may be considered quite artistic, these being upon tints that form a suitable ground for their proper display.

Colored Candles.—The usual base for these candles is stearic acid or spermaceti, though they are found of wax and of paraffine, but as paraffine will not hold color, there has to be some other substance combined with it that can be colored. Thus we find nearly all the colored candles are a combination of several ingredients, but generally of fine materials, as the base should be as white and transparent as possible. Colored candles are sometimes made that are colored only on the outer surface. This is done by moulding them in very thin moulds, so that when the colored material is placed in them, it cools rapidly, when they are emptied of the internal liquid part, while the solidified part has adhered to the inner surface of the moulds. They are then filled with the material for the body of the candle, taking care to have it of as low a temperature as possible, so that it will not melt the colored surface. When cold they are drawn as usual, and if they adhere too strongly, the moulds are dextrously dipped in warm water, which expands them so that the candle is loosened. This process is seldom followed, as it entails too much labor for a large business, and is not rapid enough.

The colors for candles have heretofore been of mineral origin with but few exceptions, for there are few vegetable colors which will color fat that are permanent. And there are well-grounded objections to the use of many of the mineral colors in vogue, that, when combined with the fatty body and burnt, give off the oxides of the minerals to contaminate the air of the apartments with poisonous vapors. Thus arsenic, lead, copper, mercury, and zinc, the base of most of these colors, are volatilized and become deleterious to health, so that such colors must be avoided if possible. The vegetable colors of alkanet for red, and gamboge or roucou for yellow, are quite fugitive and soon fade on exposure to light, so that the use of minerals is to some extent necessary.

Aniline colors have also had the same objections, and have not been permanent, but although they have in many instances a base of metallic oxide, yet at this time they are made so durable that they must serve to give nearly all the colors needed, and whatever metallic substances they may contain are in such minute quantity when burnt as to be almost imperceptible.

For yellow there are used gamboge, roucou, chromate of lead, and naphthaline yellow.

For red, alkanet root, minium, vermilion, and several permanent aniline reds.

For blue, ultramarine, sulphate of copper, and aniline blue.

For green, distilled verdigris, Schweinfurt green, or a mixture of yellow with blue.

For purple or violet, a mixture of blue with red: and for the neutral tints, some of the brown oxides of iron, yellow ochres, and Frankfort black. With the articles here mentioned, nearly any shade can be obtained.

It has been quite customary for manufacturers to use a little ultramarine to give a bluish-white shade to the white candles, or to disguise the yellowish shade of their fats.

Toy candles are the colored candles above mentioned, made of small size, and usually of a mixture of stearic acid and paraffine. They are made 20, 40, 60, and 80 to the pound.

Decorated candles have become much in vogue, as are the better class of candles generally, for lighting the drawing-rooms of society, and in fact are becoming more in use from the objection to gas as made in our larger cities being usually quite impure, and when burning, throwing off sulphuretted hydrogen to the injury of the colors of fine fabrics used, as well as of valuable paintings. Thus we see the old-fashioned candelabra again in use, and candles more in vogue.

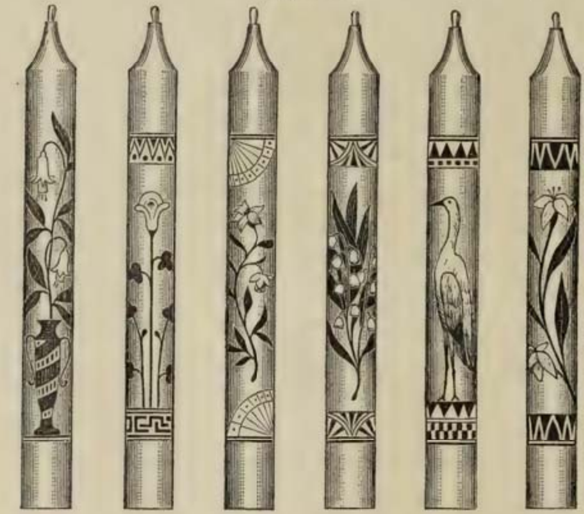
From this circumstance we have given this subject some attention, for there is no good reason why, with our cultivated taste, we should be dependent upon France and England for these useful articles.

The base of almost all the decorated candles we have seen is a compound of stearic acid and wax or paraffine, and many that are called wax have really but little wax in their composition, nor can it be considered much to their disadvantage for these composite candles, while costing one-half the price of pure wax, have nearly as good an appearance, and give as white and good a light. With the materials named, and in the proportions given in our last chapter, with suitable colors as we have just named, with care in the manipulations when moulding, there cannot be much difficulty in making very satisfactory candles. For this purpose, above all, care must be taken that the material has a high melting-point to insure their retaining their form in the warmest weather, and that they may not bend when placed in the candelabra.

We here illustrate a few styles of decoration, but they are given merely as hints, for the colors and designs are innumerable. Fig. 166 will serve to show how effective they can be made for the purpose of decoration.

As a ground for these decorations, whether done by hand or transferred by the process of decalcomanie, a suitable varnish is put on the candle. This varnish is made by dissolving gum damar in rectified oil of turpentine or absolute alcohol, and should be quite thick that it will not require renewing, or that one coating may be sufficient. These designs for decalcomanie are found in commerce for the purpose of the decoration of various articles, and are in nearly every conceivable design, and many are made for this purpose especially, and it is usual for the dealers in them to give instruction for their proper application. They are printed upon a porous paper: and when the design is pressed upon the warmed varnished surface, and has hardened, the paper is wet with water and afterwards gently rubbed off, leaving the design adhering to the candle. When the candles are decorated by hand, it is customary to have them of the best quality, and they are prepared with a coating of the damar varnish spoken of, or a still better varnish is now made with gum mastic. It is not our province to give further details for this art, as it pertains to another.

Fig. 166.



Wax Tapers.—These useful articles have much importance as they are employed for many purposes: for lighting the gas, for melting the wax for sealing letters (the twisted taper), for night lights, etc. The twisted tapers are in a great variety of forms and sizes, and usually in bright colors; a hollow coil is the commonest form. They are made of wax as a base with a small percentage of either stearic acid, paraffine, or fine resin. We illustrate a machine used for this purpose (Figs. 167–170), where it will be seen that the wick, usually several fine yarns of cotton twisted to suit the thickness of the taper (generally about a quarter of an inch thick, often thinner), is wound from one wooden drum to the other,

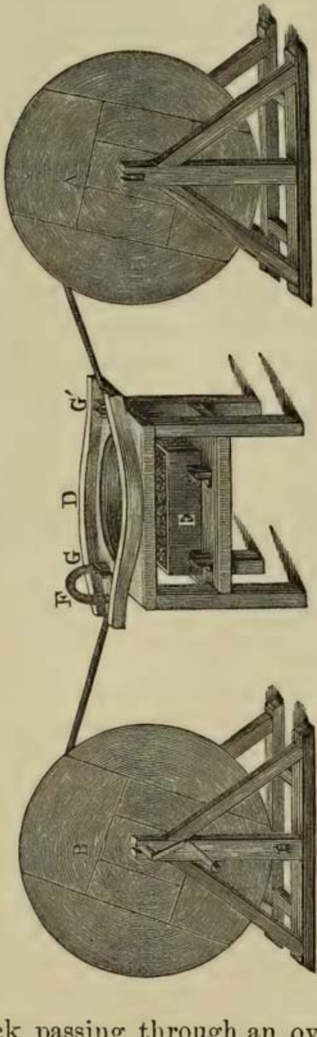


Fig. 167.

Fig. 168.

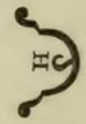


Fig. 169.

Fig. 170.

the wick passing through an oval copper pan, D, having a raised rim, G G′. This pan contains the melted wax kept fluid by the brazier E, and passing through the hook H, placed in the bottom of the pan. F is a metallic bevelled ring through which the dipped wick passes, and which serves to regulate the size of the taper. It can be made in any form to give other shaped tapers. In working this machine, it is only necessary to have the drums and copper in the position shown, and wind the taper from A to B, having B at such a distance that the wax may cool before reaching it. As the wick requires more than one dipping, the taper is next wound from B to A, changing the gauge F to the other end of the copper. Figs. 168–170 show the detached parts. If the tapers are to be gas-lighters, they are cut into lengths of about twenty inches; if the twisted tapers, they are cut into suitable lengths, slightly warmed, and wound on suitable forms to give them the desired shape.

Night Lights or Tapers.—The most common form for these is a cylinder of wax, stearic acid, or a combination of other solid sebacic acids, in size about one and a quarter inches in diameter, by one and a half in length. They are moulded in tin tubes, generally six dozen in one frame, and made solid, the wick being placed in afterwards. This wick is usually quite small, that the taper may be consumed very slowly.

APPENDIX.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES.

THE United States being the first to introduce the decimal system into the coinage of the country, and to demonstrate its superior utility, it is remarkable that we have hesitated so long in regard to the substitution of the same simple and rational system of weights and measures for the complicated and confused standards in general use.

In May, 1866, the Committee on Coinage, Weights, and Measures presented to the House of Representatives an exhaustive report, accompanied by bills authorizing the introduction of the *metric system* into the various departments of trade, and making all contracts, based on this system of weights and measures, valid before any court in the United States. They said:—

"THE METRIC SYSTEM.

"It is orderly, simple, and perfectly harmonious, having useful relations between all its parts. It is based on the METER, which is the principal and only arbitrary unit. The meter is a measure of length, and was intended to be, and is, very nearly one ten-millionth of the distance on the earth's surface from the equator to the pole. It is 39.37 inches, very nearly.

'The *are* is a surface equal to a square whose side is 10 meters. It is nearly four square rods.

"The *liter* is the unit for measuring capacity, and is equal to the contents of a cube whose edge is a tenth part of the meter. It is a little more than a wine quart.

"The *gramme* is the unit of weight, and is the weight of a cube of water, each edge of the cube being one one-hundredth of the meter. It is equal to 15.432 grains.

"The *stere* is the cubic meter.

"Each of these units is divided decimally, and larger units are formed by multiples of 10, 100, &c. The successive multiples are designated by the prefixes, *deka*, *hecto*, *kilo*, and *myria*; the subordinate parts by *deci*, *centi*, and *milli*, each having its own numerical significance.

"The nomenclature, simple as it is in theory, and designed from its origin to be universal, can only become familiar by use. Like all strange words, these will become familiar by custom, and obtain popular abbreviations. A system which has incorporated with itself so many different series of weights, and such a nomenclature as 'scruples,' 'pennyweights,' 'avoirdupois,' and with no invariable component word, can hardly protest against a nomenclature whose leading characteristic is a short component word with a prefix signifying number. We are all familiar with *thermometer*, *barometer*, *diameter*, *gasometer*, &c., with *telegram*, *monogram*, &c., words formed in the same manner.

"After considering every argument for a change of nomenclature, your committee have come to the conclusion that any attempt to conform it to that in present use would lead to confusion of weights and measures, would violate the early learned order and simplicity of metric denomination, and would seriously interfere with that universality of system so essential to international and commercial convenience.

"When it is remembered that of the value of our exports and imports, in the year ending June 30, 1860, in all $762,000,000, the amount of near $700,000,000 was with nations and their dependencies that have now authorized, or taken the preliminary steps to authorize, the metric system, even denominational uniformity for the use of accountants in such vast transactions assumes an important significance. In words of such universal employment, each word should represent the identical thing intended, and no other, and the law of association familiarizes it.

"Your committee unanimously recommend the passage of the bills and joint resolutions appended to this report. . . . . . The metric system is already used in some arts and trades in this country, and is especially adapted to the wants of others. Some of its measures are already manufactured at Bangor, in Maine, to meet an existing demand at home and abroad. The manufacturers of the well-known Fairbanks' scales state: 'For many years we have had a large export demand for our scales with French weights, and the demand and sale are constantly increasing.' Its minute and exact divisions specially adapt it to the use of chemists, apothecaries, the finer operations of the artisan and to all scientific objects. It has always been and is now used in the United States coast survey. Yet in some of the States, owing to the phraseology of their laws, it would be a direct violation of them to use it in the business transactions of the community. It is, therefore, very important to legalize its use, and to give to the people, or that portion of them desiring it, the opportunity for its legal employment, while the knowledge of its characteristics will be thus diffused among men."

WEIGHTS AND MEASURES.

APOTHECARIES' WEIGHT, U. S.

Pound.		Ounces.		Drachms.		Scruples.		Grains.
℔ 1	=	12	=	96	=	288	=	5760
		℥ 1	=	8	=	24	=	480
				ʒ 1	=	3	=	60
						℈ 1	=	gr. 20

The imperial standard Troy weight, at present recognized by the British laws, corresponds with the apothecaries' weight in pounds, ounces, and grains. but differs from it in the division of the ounce, which, according to the former scale, contains twenty pennyweights, each weighing twenty-four grains.

AVOIRDUPOIS WEIGHT.

Pound.		Ounces.		Drachms.		Troy grains.
℔ 1	=	16	=	256	=	7000.
		oz. 1	=	16	=	437.5
				dr. 1	=	27.34375

Relative Value of Troy and Avoirdupois Weights.

Pound.		Pounds.		Pound.	Oz.	Grains.
1 Troy	=	0.822857 Avoirdupois	=	0	13	72.5
1 Avoirdupois	=	1.215277 Troy	=	1	2	280.

WINE MEASURE, U. S.

Gallon.		Pints.		Fluidounces.		Fluidrachms.		Minims.		Cubic inches.
Cong. 1	=	8	=	128	=	1024	=	61440	=	231.
		O 1	=	16	=	128	=	7680	=	28.875
				f℥ 1	=	8	=	480	=	1.8047
						fʒ 1	=	♏ 60	=	0.2256

IMPERIAL MEASURE.

Adopted by all the British College.

Gallon.		Pints.		Fluidounces.		Fluidrachms.		Minims.
1	=	8	=	160	=	1280	=	76800
		1	=	20	=	160	=	9600
				1	=	8	=	480
						1	=	60

Relative Value of Apothecaries' and Imperial Measures.

APOTHECARIES' MEASURE.		IMPERIAL MEASURE.			
		Pints.	Fluidozs.	Fluidrms.	Minims.
1 gallon	=	6	13	2	23
1 pint	=		16	5	18
1 fluidounce	=		1	0	20
1 fluidrachm	=			1	2.5
1 minim	=				1.04

IMPERIAL MEASURE.		APOTHECARIES' MEASURE.				
		Gallon.	Pints.	Fluidoz.	Fluidrms.	Minims
1 gallon	=	1	1	9	5	8
1 pint	=		1	3	1	38
1 fluidounce	=				7	41
1 fluidrachm	=					58
1 minim	=					0.96

Relative Value of Weights and Measures in Distilled Water at 60° Fahr.

1. Value of Apothecaries' Weight in Apothecaries' Measure.

		Pints.	Fluidoz.	Fluidr.	Minims.
1 pound =	0.7900031 pints =	0	12	5	7.2238
1 ounce =	1.0533376 fluidounces =	0	1	0	25.6020
1 drachm =	1.0533376 fluidrachms =	0	0	1	3.2002
1 scruple =		0	0	0	21.0667
1 grain =		0	0	0	1.0533

2. Value of Apothecaries' Measure in Apothecaries' Weight.

		Pounds.	Oz.	Dr.	Sc.	Gr.	Grains.
1 gallon =	10.12654270 pounds =	10	1	4	0	8.88 =	58328.886
1 pint =	1.26581783 pounds =	1	3	1	1	11.11 =	7291.1107
1 fluidounce =	0.94936332 ounces =	0	0	7	1	15.69 =	455.6944
1 fluidrachm =	0.94936332 drms. =	0	0	0	2	16.96 =	56.9618
1 minim =	0.94936332 grains =						1.9493

3. Value of Avoirdupois Weight in Apothecaries' Measure.

		Pints.	Fluidozs.	Fluidrms.	Minims.
1 pound =	0.9600732 pints =	0	15	2	53.3622
1 ounce =	0.9600732 fluidounces =	0	0	7	40.8351

4. Value of Apothecaries' Measure in Avoirdupois Weight.

1 gallon = 8.33269800 pounds.
1 pint = 1.04158725 pounds.
1 fluidounce = 1.04158725 ounces.

5. Value of Imperial Measure in Apothecaries' and Avoirdupois Weights.

Imperial Measure.	Apothecaries' Weight.					Avoirdupois Weight.		Grains.	Cubic inches.
1 gallon =	12 ℔	1 ℥	6 ʒ	2 ℈	0 gr. =	10 ℔	0 ℥ =	70,000	=277.27384
1 pint =	1	6	1	2	10 =	1	4 =	8,750	= 34.65923
1 fluidounce =			7	0	17.5 =		1 =	437.5 =	1.73296
1 fluidrachm =				2	14.69 =			54.69 =	0.21662
1 minim =								0.91 =	0.00361

In converting the weights of liquids heavier or lighter than water into measures, or conversely, a correction must be made for specific gravity. In converting weights into measures, the calculator may proceed as if the liquid was water, and the obtained measure will be the true measure *inversely* as the specific gravity. In the converse operation, of turning measures into weights, the same assumption may be made, and the obtained weight will be the true weight *directly* as the specific gravity.

TABLES

SHOWING THE

RELATIVE VALUES OF FRENCH AND ENGLISH WEIGHTS AND MEASURES, &c.

Measures of Length.

Millimetre	=	0.03937	inch.
Centimetre	=	0.393708	"
Decimetre	=	3.937079	inches.
Metre	=	39.37079	"
"	=	3.2808992	feet.
"	=	1.093633	yard.
Decametre	=	32.808992	feet.
Hectometre	=	328.08992	"
Kilometre	=	3280.8992	"
"	=	1093.633	yards.
Myriametre	=	10936.33	"
"	=	6.2138	miles.
Inch ($\frac{1}{36}$ yard)	=	2.539954	centimetres.
Foot ($\frac{1}{3}$ yard)	=	3.0479449	decimetres.
Yard	=	0.91438348	metre.
Fathom (2 yards)	=	1.82876696	"
Pole or perch (5½ yards)	=	5.029109	metres.
Furlong (220 yards)	=	201.16437	"
Mile (1760 yards)	=	1609.3149	"
Nautical mile	=	1852	"

Superficial Measures.

Square millimetre = $\frac{1}{645}$ square inch.
" " = 0.00155 " "
" centimetre = 0.155006 " "
" decimetre = 15.50059 " inches.
" " = 0.107643 " foot.
" metre or centiare = 1550.05989 " inches.
" " " = 10.764299 " feet.
" " " = 1.196033 " yard
Are = 1076.4299 " feet.
" = 119.6033 " yards.
" = 0.098845 rood.
Hectare = 11960.3326 square yards.
" = 2.471143 acres.
Square inch = 645.109201 square millimetres.
" " = 6.451367 " centimetres
" foot = 9.289968 " decimetres.
" yard = 0.836097 " metre.
" rod or perch = 25.291939 " metres.
Rood (1210 sq. yards) = 10.116775 ares.
Acre (4840 sq. yards) = 0.404671 hectare.

Measures of Capacity.

Cubic millimetre = 0.000061027 cubic inch.
" centimetre or millilitre = 0.061027 " "
10 " centimetres or centilitre = 0.61027 " "
100 " " " decilitre = 6.102705 " inches.
1000 " " " litre = 61.0270515 " "
" " " " " = 1.760773 imp'l pint.
" " " " " = 0.2200967 " gal'n.
Decalitre = 610.270515 cubic inches.
" = 2.2009668 imp. gal'ns.
Hectolitre = 3.531658 cubic feet.
" = 22.009668 imp. gal'ns.
Cubic metre or stere or kilolitre = 1.30802 cubic yard.
" " " = 35.3165807 " feet.
Myrialitre = 353.165807 " "

Cubic inch = 16.386176 cubic centimetres.
" foot = 28.315312 " decimetres.
" yard = 0.764513422 " metre.

American Measures.

Winchester or U.S. gallon (231 cub. in.) = 3.785209 litres.
" " bushel (2150.42 cub. in.) = 35.23719 "
Chaldron (57.25 cubic feet) = 1621.085 "

British Imperial Measures.

Gill = 0.141983 litre.
Pint ($\frac{1}{8}$ gallon) = 0.567932 "
Quart ($\frac{1}{4}$ gallon) = 1.135864 "
Imperial gallon (277.2738 cub. in.) = 4.54345797 litres.
Peck (2 gallons) = 9.0869159 "
Bushel (8 gallons) = 36.347664 "
Sack (3 bushels) = 1.09043 hectolitre.
Quarter (8 bushels) = 2.907813 hectolitres.
Chaldron (12 sacks) = 13.08516 "

Weights.

Milligramme = 0.015438395 troy grain.
Centigramme = 0.15438395 " "
Decigramme = 1.5438395 " "
Gramme = 15.438395 " grains.
" = 0.643 pennyweight.
" = 0.0321633 oz. troy.
" = 0.0352889 oz. avoirdupois.
Decagramme = 154.38395 troy grains.
" = 5.64 drachms avoirdupois.
Hectogramme = 3.21633 oz. troy.
" = 3.52889 oz. avoirdupois.
Kilogramme = 2.6803 lbs. troy.
" = 2.205486 lbs. avoirdupois.
Myriagramme = 26.803 lbs. troy.
" = 22.05486 lbs. avoirdupois.
Quintal metrique = 100 kilog. = 220.5486 lbs. avoirdupois.
Tonne = 1000 kilog. = 2205.486 " "

Different authors give the following values for the gramme :—

Gramme = 15.44402 troy grains.
“ = 15.44242 “
“ = 15.4402 “
“ = 15.433159 “
“ = 15.43234874 “

AVOIRDUPOIS.

Long ton = 20 cwt. = 2240 lbs. = 1015.649 kilogrammes.
Short ton (2000 lbs.) = 906.8296 “
Hundred weight (112 lbs.) = 50.78245 “
Quarter (28 lbs.) = 12.6956144 “
Pound = 16 oz. = 7000 grs. = 453.4148 grammes.
Ounce = 16 dr'ms. = 437.5 grs. = 28.3375 “
Drachm = 27.344 grains = 1.77108 gramme.

TROY (PRECIOUS METALS).

Pound = 12 oz. = 5760 grs. = 373.096 grammes.
Ounce = 20 dwt. = 480 grs. = 31.0913 “
Pennyweight = 24 grs. = 1.55457 gramme.
Grain = 0.064773 “

APOTHECARIES' (PHARMACY).

Ounce = 8 drachms = 480 grs. = 31.0913 gramme.
Drachm = 3 scruples = 60 grs. = 3.8869 “
Scruple = 20 grs. = 1.29546 gramme.

CARAT WEIGHT FOR DIAMONDS.

1 carat = 4 carat grains = 64 carat parts.
“ = 3.2 troy grains.
“ = 3.273 “ “
“ = 0.207264 gramme
“ = 0.212 “
“ = 0.205 “

Great diversity in value.

Proposed Symbols for Abbreviations.

M—myria — 10000	Mm	Mg	Ml	
K—kilo — 1000	Km	Kg	Kl	
H—hecto — 100	Hm	Hg	Hl	Ha
D—deca — 10	Dm	Dg	Dl	Da
Unit — 1	metre—m	gramme—g	litre—l	are—a
d—deci — 0.1	dm	dg	dl	da
c—centi — 0.01	cm	cg	cl	ca
m—milli — 0.001	mm	mg	ml	

Km = Kilometre. Hl = Hectolitre. cg = centigramme. c. cm = $\overline{\text{cm}}^3$ = cubic centimetre. $\overline{\text{dm}}^2$ = sq. dm = square decimetre. Kgm = Kilogrammetre. Kg° = Kilogramme degree.

Celsius or Centigrade.	Fahrenheit.	Réaumur.
— 15°	+ 5°	— 12°
— 10	+ 14	— 8
— 5	+ 23	— 4
0 melting	+ 32	ice 0
+ 5	+ 41	+ 4
+ 10	+ 50	+ 8
+ 15	+ 59	+ 12
+ 20	+ 68	+ 16
+ 25	+ 77	+ 20
+ 30	+ 86	+ 24
+ 35	+ 95	+ 28
+ 40	+104	+ 32
+ 45	+113	+ 36
+ 50	+122	+ 40
+ 55	+131	+ 44
+ 60	+140	+ 48
+ 65	+149	+ 52
+ 70	+158	+ 56
+ 75	+167	+ 60
+ 80	+176	+ 64
+ 85	+185	+ 68
+ 90	+194	+ 72
+ 95	+203	+ 76
+100 boiling	+212	water + 80
+200	+392	+160
+300	+572	+240
+400	+752	+320
+500	+932	+400

1° C. = $1^\circ.8$ Ft. = $\frac{9}{5}^\circ$ Ft. = $0^\circ.8$ R. = $\frac{4}{5}^\circ$ R.

1° C. × $\frac{9}{5}$ = 1° Ft. 1° Ft. × $\frac{5}{9}$ = 1° C. 1° R. × $\frac{9}{4}$ = 1° Ft.
1° C. × $\frac{4}{5}$ = 1° R. 1° Ft. × $\frac{4}{9}$ = 1° R. 1° R. × $\frac{5}{4}$ = 1° C.

Calorie (French) = unit of heat
= kilogramme degree } English.

It is the quantity of heat necessary to raise 1° C. the temperature of 1 kilogramme of distilled water.

Kilogrammetre = Kgm = the power necessary to raise 1 kilogramme, 1 metre high, in one second. It is equal to $\frac{1}{75}$ of a French horse power. An English horse power = 550 foot pounds, while a French horse power = 542.7 foot pounds.

Ready-made Calculations.

No. of units.	Inches to centimetres.	Feet to metres.	Yards to metres.	Miles to Kilometres.	Millimetres to inches.
1	2.53995	0.3047945	0.91438348	1.6093	0.03937079
2	5.0799	0.6095890	1.82876696	3.2186	0.07874158
3	7.6199	0.9143835	2.74315044	4.8279	0.11811237
4	10.1598	1.2197680	3.65753392	6.4373	0.15748316
5	12.6998	1.5239724	4.57191740	8.0466	0.19685395
6	15.2397	1.8287669	5.48630088	9.6559	0.23622474
7	17.7797	2.1335614	6.40068436	11.2652	0.27559553
8	20.3196	2.4383559	7.31506784	12.8745	0.31496632
9	22.8596	2.7431504	8.22945132	14.4838	0.35433711
10	25.3995	3.0479450	9.14383480	16.0930	0.39370790

No. of units.	Centimetres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.	Square inches to square centimetres
1	0.3937079	3.2808992	1.093633	0.6213824	6.45136
2	0.7874158	6.5617984	2.187266	1.2427648	12.90272
3	1.1811237	9.8426976	3.280899	1.8641472	19.35408
4	1.5748316	13 1235968	4.374532	2.4855296	25.80544
5	1.9685395	16.4044960	5.468165	3.1069120	32.25680
6	2.3622474	19.6853952	6.561798	3.7282944	38.70816
7	2.7559553	22.9662944	7.655431	4.3496768	45.15952
8	3.1496632	26.2471936	8.749064	4.9710592	51.61088
9	3.5433711	29.5280928	9.842697	5.5924416	58.06224
10	3.9370790	32.8089920	10.936330	6.2138240	64.51360

No. of units.	Square feet to sq. metres.	Sq. yards to sq. metres.	Acres to hectares.	Square centimetres to sq. inches.	Sq. metres to sq. feet.
1	0.0929	0.836097	0.404671	0.155	10.7643
2	0.1858	1.672194	0.809342	0.310	21.5286
3	0.2787	2.508291	1.204013	0.465	32.2929
4	0.3716	3.344388	1.618684	0.620	43.0572
5	0.4645	4.180485	2.023355	0.775	53.8215
6	0.5574	5.016582	2.428026	0.930	64.5858
7	0.6503	5.852679	2.832697	1.085	75.3501
8	0.7432	6.688776	3.237368	1.240	86.1144
9	0.8361	7.524873	3.642039	1.395	96.8787
10	0.9290	8.360970	4.046710	1.550	107.6430

No. of units.	Square metres to sq. yards.	Hectares to acres.	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.
1	1.196033	2.471143	16.3855	0.02831	0.76451
2	2.392066	4.942286	32.7710	0.05662	1.52902
3	3.588099	7.413429	49.1565	0.08494	2.29354
4	4.784132	9.884572	65.5420	0.11325	3.05805
5	5.980165	12.355715	81.9275	0.14157	3.82257
6	7.176198	14.826858	98.3130	0.16988	4.58708
7	8.372231	17.298001	114.6985	0.19819	5.35159
8	9.568264	19.769144	131.0840	0.22651	6.11611
9	10.764297	22.240287	147.4695	0.25482	6.88062
10	11.960330	24.711430	163.8550	0.28315	7.64513

No. of units.	Cubic centimetres to cubic inches.	Litres to cubic inches.	Hectolitres to cubic feet.	Cubic metres to cubic feet.	Cubic metres to cubic yards.
1	0.06102	61.02705	3.5317	35.31659	1.30802
2	0.12205	122.05410	7.0634	70.63318	2.61604
3	0.18308	183.08115	10.5951	105.94977	3.92406
4	0.24411	244.10820	14.1268	141.26636	5.23208
5	0.30514	305.13525	17.6585	176.58295	6.54010
6	0.36617	366.16230	21.1902	211.89954	7.84812
7	0.42720	427.18935	24.7219	247.21613	9.15614
8	0.48823	488.21640	28.2536	282.53272	10.46416
9	0.54926	549.24345	31.7853	317.84931	11.77218
10	0.61027	610.27050	35.3166	353.16590	13.08020

No. of units.	Grains to grammes.	Ounces avoir. to grammes.	Ounces troy to grammes.	Pounds avoir. to kilogrammes.	Pounds troy to kilogrammes.
1	0.064773	28.3375	31.0913	0.4534148	0.373096
2	0.129546	56.6750	62.1826	0.9068296	0.746192
3	0.194319	85.0125	93.2739	1.3602444	1.119288
4	0.259092	113.3500	124.3652	1.8136592	1.492384
5	0.323865	141.6871	155.4565	2.2670740	1.865480
6	0.388638	170.0250	186.5478	2.7204888	2.238576
7	0.453411	198.3625	217.6391	3.1739036	2.611672
8	0.518184	226.7000	248.7304	3.6273184	2.984768
9	0.582957	255.0375	279.8217	4.0807332	3.357864
10	0.647730	283.3750	310.9130	4.5341480	3.730960

No. of units.	Long tons to tonnes of 1000 kilog.	Pounds per square inch to kilogrammes per square centimetre.	Grammes to grains.	Grammes to ounces avoir.	Grammes to ounces troy.
1	1.015649	0.0702774	15.438395	0.0352889	0.0321633
2	2.031298	0.1405548	30.876790	0.0705778	0.0643266
3	3.046947	0.2108322	46.315185	0.1058667	0.0964899
4	4.062596	0.2811096	61.753580	0.1411556	0.1286532
5	5.078245	0.3513870	77.191975	0.1764445	0.1608165
6	6.093894	0.4216644	92.630370	0.2117334	0.1929798
7	7.109543	0.4919418	108.068765	0.2470223	0.2251431
8	8.125192	0.5622192	123.507160	0.2823112	0.2573064
9	9.140841	0.6324966	138.945555	0.3176001	0.2894697
10	10.156490	0.7027740	154.383950	0.3528890	0.3216330

No. of units.	Kilogrammes to pounds avoirdupois.	Kilogrammes to pounds troy.	Metric tonnes of 1000 kilog. to long tons of 2240 pounds.	Kilog. per square millimetre to pounds per square inch.	Kilog. per square centimetre to pounds per square inch.
1	2.205486	2.6803	0.9845919	1422.52	14.22526
2	4.410972	5.3606	1.9691838	2845.05	28.45052
3	6.616458	8.0409	2.9537757	4267.57	42.67578
4	8.821944	10.7212	3.9383676	5690.10	56.90104
5	11.027430	13.4015	4.9229595	7112.63	71.12630
6	13.232916	16.0818	5.9075514	8535.15	85.35156
7	15.438402	18.7621	6.8921433	9957.68	99.57682
8	17.643888	21.4424	7.8767352	11380.20	113.80208
9	19.849374	24.1227	8.8613271	12802.73	128.02734
10	22.054860	26.8030	9.8459190	14225.26	142.25260

HYDROMETERS AND THERMOMETERS.

An areometer is a convenient glass instrument for measuring the density or specific gravity of fluids. Areometer and hydrometer are synonymous terms, the first being derived from the Greek words αραίος, *rare*, and μετρον, *measure;* and the latter from ὑδωρ, *water*, and μετρον, *measure;* hence the same instrument is frequently denominated both hydrometer and areometer. This apparatus is often referred to throughout this work; for instance, in speaking of alcohol, or lye, their strength is stated as being of so many degrees (17° or 36°) Baumé, that is, its force or value is of that specific gravity, corresponding with the degree to which the hydrometer sinks in either the alcohol or alkaline solution. But, for those liquids lighter or rarer than water, viz., alcohol, ethers, etc., the scale is graduated differently than for the heavier or more dense, examples of which are the acids, saline solutions, syrups, and the like. There are several kinds of hydrometers; but that called Baumé's is the most used, and to this our remarks are applied.

They are blown out of a piece of slender glass tubing, and of the form shown by Figs. 171 and 172; A being the stem containing the graduated paper scale, B the bulb portion, and D the small globes containing mercury or shot, serving as ballast to maintain the instrument in an upright position, when it is placed in a liquid.

Fig. 171.

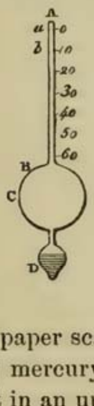
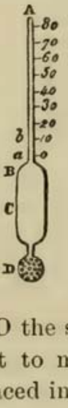


Fig. 172.



The graduation is accomplished by plunging it into distilled water of 58° F., and weighting the globe with shot or mercury, until the instrument sinks to the line *a*, which is its zero point. This zero point thus determined is to be marked accurately upon the glass or its accompanying paper scale, and the instrument again plunged into ninety parts of distilled water, holding in solution ten parts of previously dried chloride of sodium or common salt. The point to which it sinks in this liquid, say *b*, for instance, is then also marked carefully upon the scale, and rated as ten compared with its zero point. The interval between these two points is then spaced off into ten equal divisions, according to which the remainder of the tube is graduated so that each degree is intended to represent a density corresponding to one per cent. of the salt.

The above mode of graduating refers to the hydrometer for liquids denser than water, but that for the liquids rarer than water is a little different from the preceding in form, and necessarily has a modified scale, which is graduated as is shown by Fig. 172. The instrument should be sufficiently heavy in ballast to sink in a saline solution of ten parts of dried chloride of sodium in ninety parts distilled water to the bottom of its stem *a*, to be marked as the zero of the scale.

Now, when it is again placed in distilled water alone, it floats or sinks to a point somewhere about *b*, which is to be the ten degree mark. The rest of the stem is then to be accurately divided into as many ten degree intervals as its length will permit, and each subdivision into ten uniform smaller degrees or intervals.

As it would be troublesome, and with many impracticable, to estimate the specific gravities of their liquids in a scientific way, these little instruments are a great convenience, for by taking out a portion of the fluid to be tested, and placing it in a glass cylinder, Fig. 173, its degree Baumé may be ascertained by noting the point to which a hydrometer sinks therein, and afterwards its specific gravity, by comparing that with its corresponding degree in the table. For instance, suppose the hydrometer sinks in alcohol to 35°, then its specific gravity is 0.8538, and this again can be translated into its absolute spirit strength by comparison with any accurately calculated alcohol tables. So, also, if a hydrometer for liquids denser than water sinks in lye to 26°, it denotes that the lye, as will be seen by reference to Tünnermann's tables (pages 259 and 261), has a specific gravity of 1.2268. The presence of foreign

Fig. 173.

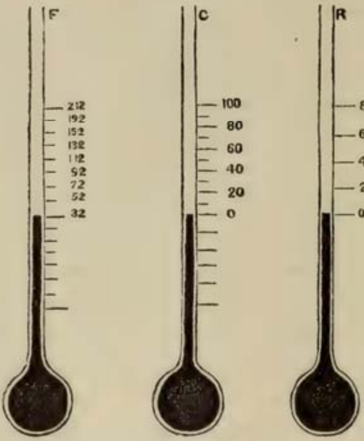
matters will cause the hydrometer to give a false indication, and it is, therefore, necessary, when lyes contain impurities, to follow the directions given under ALKALIMETRY, to ascertain their amount of caustic alkali. When the lye is nearly pure, they answer satisfactorily; and, indeed, under all circumstances, they serve very well for noting a progressive increase or diminution in the strength of lyes or other liquids. The temperature of the liquid should be 58° to 60° F., at the moment of testing it.

Thermometers.—The thermometer is an instrument made of glass exclusively, when intended for practical purposes. Fig. 174 shows one with the scale of Fahrenheit, graduated on the glass, so that, when having been dipped in liquids, it may be easily cleansed. It derives its name from two Greek words, θερμος, *warm*, and μετρον, *measure*, and is, as its title indicates, a measurer of the variation of temperature in bodies. The principle upon which it is constructed, "is the change of volume which takes place in bodies, when their temperature undergoes an alteration, or, in other words, upon their expansion." As it is necessary, in the construction of thermometers, that the material used to measure the change of temperature shall be of uniform expansion, and with a very distant interval between its freezing and boiling point, as fulfilling these requisites better than any other body, metallic mercury is generally used. There are several different thermometrical scales, all constructed upon the same principle, but varying in their graduation; the boiling and freezing points of each, though corresponding in fact, being represented by different numbers. The Fahrenheit scale is most used in this country; that of Celsius, called the Centigrade, in France and the Continent generally, except Spain and Germany, where Reaumur's scale is preferred. The relation between the three scales is shown by Fig. 175. The Fahrenheit scale is most convenient, because of the lesser value of its divisions.

Fig. 174.

In the graduation of the scale, it is only necessary to have two fixed determinate temperatures, and for these the boiling and freezing points of water are universally chosen. The scales can be extended beyond either of these points, by continuing the graduation. Those degrees below zero or 0° have the minus (—) prefixed, to distinguish them from those above; thus, 55° F. means fifty-five degrees above zero, Fahrenheit's scale, and —9° C., nine degrees below zero, Centigrade scale. The thermometers for general use very seldom, however, extend either way beyond the boiling and freezing points of water, but for manufacturers' use they are graduated sometimes to 400° or 600°.

Fig. 175.



Centigrade and Fahrenheit.—In the Fahrenheit thermometer the number 0° on the scale corresponds to the temperature of a mixture of salt and ice—the greatest degree of cold that could be artificially produced when the thermometer was originally introduced; 32° (freezing point) corresponds to the temperature of melting ice; and 212° to the temperature of pure boiling water—in both cases, under the ordinary atmospheric pressure of 14.7 pounds per square inch. Each division of the (this) thermometer represents 1° Fah., and between 32° and 212° there are 180°. In the Cent. thermometer, used universally in scientific investigations, 1° corresponds to melting ice, and 100° to boiling water. From the freezing to the boiling point there are 100°.

The accompanying table shows the relation of the Centigrade and Fahrenheit thermometer scales, 5° C. being equal to 9° F., because the interval between the freezing and boiling points of water is divided into 100 and 180 equal parts, and these numbers are respectively multiples of, or 20 times 5 and 9. If the superfluous 32° on the F. side were disposed of, the mutual translation of the scales would be simple, since the two units are to each other inversely as the number of them in any given range.

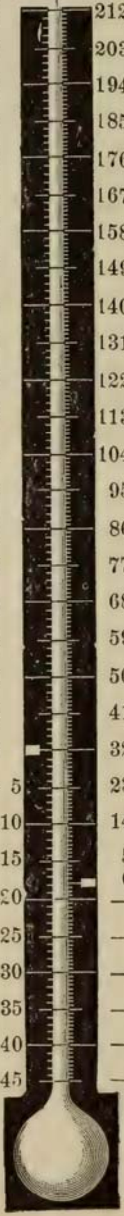
To reduce F. above melting ice to terms of C., 32° must first be subtracted from the given F. temperature, then multiply the remainder by $\frac{5}{9}$; the product will be the C. term for the given temperature; and conversely divide C. by $\frac{5}{9}$ and add 32 to translate C. into F.; to prove the work, read the terms across the diagram in the table. Below melting ice, the same rules as given above apply, except that where 32 is added above, it should be subtracted here, and *vice versa*.

In the columns at the right hand of each diagram in this table, are found the approximate steam pressures per square inch, due to the adjoining indications of temperature. The pressure is expressed in pounds and in atmospheres.

The high pressures are obtained from the several authors who have deduced and tabulated them from experiments and formulas of Regnault and others; and being hypothetical, accuracy is not claimed for them.

COMPARISON OF CENTIGRADE AND FAHRENHEIT SCALES, AND APPROXIMATE STEAM PRESSURE IN POUNDS AND ATMOSPHERES PER SQUARE INCH DUE TO THE TEMPERATURE.

Thermometer.		Steam. Non-condensing Engine.		
Centi.	Fahr.	Pres. per gauge. lbs.	Total Press. Lbs.	Total Press. Atmos.
260	500	665	680	46.
255	491	610	625	42.
250	482	560	575	39.
245	473	515	530	36.
240	464	472	487	33.
235	455	430	445	30.
230	446	390	405	27.5
225	437	354	369	25.
220	428	321	336	23.
215	419	290	305	20.7
210	410	262	277	18.8
205	401	235	250	17.
200	392	211	226	15.3
195	383	188	203	13.8
190	374	167	182	12.4
185	365.	148	163	11.1
180	356	131	146	9.9
175	347	115	130	8.8
170	338	100	115	7.8
165	329	85	100	6.8
160	320	73	88	6.
155	311	63	78	5.3
150	302	55	70	4.7
145	293	45	60	4.1
140	284	37	52	3.5
135	275	30	45	3.
130	266	25	40	2.7
125	257	19	34	2.3
120	248	14	29	1.9
115	239	10	25	1.6
110	230	6	21	1.4
105	221	3	18	1.2



Thermometer.			Steam. Condensing Engine.				
Centi.	Fahr.		Press. per gauge.		Back Press. Lbs.	Back Press. Atmos.	
100	212	Temp. of Condenser.	0		14.7	1.	
			Vacuum, effective.		Lbs.	Atmos.	
95	203		Gauge.	Lbs.*	12.	0.85	
90	194		9½	4.7	10.	0.7	
85	185		12½	6.2	8.5	0.6	
80	176		15½	7.7	7.	0.5	
75	167		18¼	9.1	5.6	0.4	
70	158		20½	10.2	4.5	0.3	
65	149		22	11.	3.7		
60	140		24	11.9	2.8	0.2	
55	131		25	12.4	2.3		
50	122		26	12.9	1.8	0.2	
45	113		26½	13.3	1.4		
40	104		27¾	13.6	1.1	0.1	
35	95		28½	13.8	.9		
30	86		29	13.9	.8		
25	77						
20	68						
15	59						M. T. Mines of Brittany, 500 ft., . . . 59 F.
10	50						Hydr'chloric Ether boils, 52 F.
5	41						Max. density of water, {39.2 F. =4 C.
0	32						Melting Ice, . 32 F. =0 C.
— 5	23						Blood freezes, . . 25 F. Castor Oil freezes, . 21 F.
—10	14						Spirits of turpentine freezes, . . 14 F.
—15	5						
	0						
—20	— 4						Brandy freezes, . —7 F.
—25	—13						
—30	—22						
—35	—31						
—40	—40						Mercury freezes, . —40 F.
—45	—49						Sulphuric Acid (1.641) freezes, . . —45 F.
							Greatest artificial cold, . —166 to —220 F.
							Absolute cold, . {—459.4 F. —273. C.

* To be added to the pressure indicated by steam gauge to get total pressure on piston,

NOTE.—*Soda Ash by the Ammoniacal Soda Process.* Much attention has been attracted to a very pure soda obtained by this process, which was really not perfected in a practical way until 1878. This process is the only one that has successfully competed with that of Leblanc, and consists of the conversion of ammonium carbonate and sodium chloride (common salt) into sodium bicarbonate and ammonium chloride. The equation is—

$$NaCl + (NH_4) HCO_3 = NH_4Cl + NaHCO_3.$$

The latter two salts are easily separated, as sodium bicarbonate is very slightly soluble in a solution of sal ammoniac and separates in the form of crystals. Of course the ammonium carbonate must always be regenerated.

Mr. Hemming obtained a patent in England in 1838 for this process, and it attracted much attention in France, Germany, and Austria, and was tried in numerous places, and became the subject of many patents in each country, but it seems that it is due to the untiring perseverance of Mr. Ernest Solvay, of Belgium, that the process has been practically carried out to a paying enterprise. He has several patents in both England and Germany, and the last is as late as 1877, and since then several other chemists have made some slight improvements upon his methods.

Soda, made by this process, is now an article of commerce, and is much used by the soap manufacturers of Europe, and by a few in this country, and seems to have given entire satisfaction, as it should, as it is much more free from admixture of other salts, and consequently must produce a better soap with less labor than the sodas by the old processes. In appearance it differs very much from the ordinary crystallized carbonate of soda, being in the state of amorphous lumps of various sizes combined with some powder. We add this note to call the attention of the alkali as well as the soap manufacturer to this valuable soda.

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