A TREATISE

ON

CHEMISTRY APPLIED

TO THE MANUFACTURE OF

SOAP AND CANDLES;

BEING A

THOROUGH EXPOSITION, IN ALL THEIR MINUTIÆ, OF THE PRINCIPLES AND
PRACTICE OF THE TRADE, BASED UPON THE MOST RECENT
DISCOVERIES IN SCIENCE AND ART.

BY

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A New and Improved Edition,

ILLUSTRATED WITH TWO HUNDRED AND SIXTY ENGRAVINGS ON WOOD.

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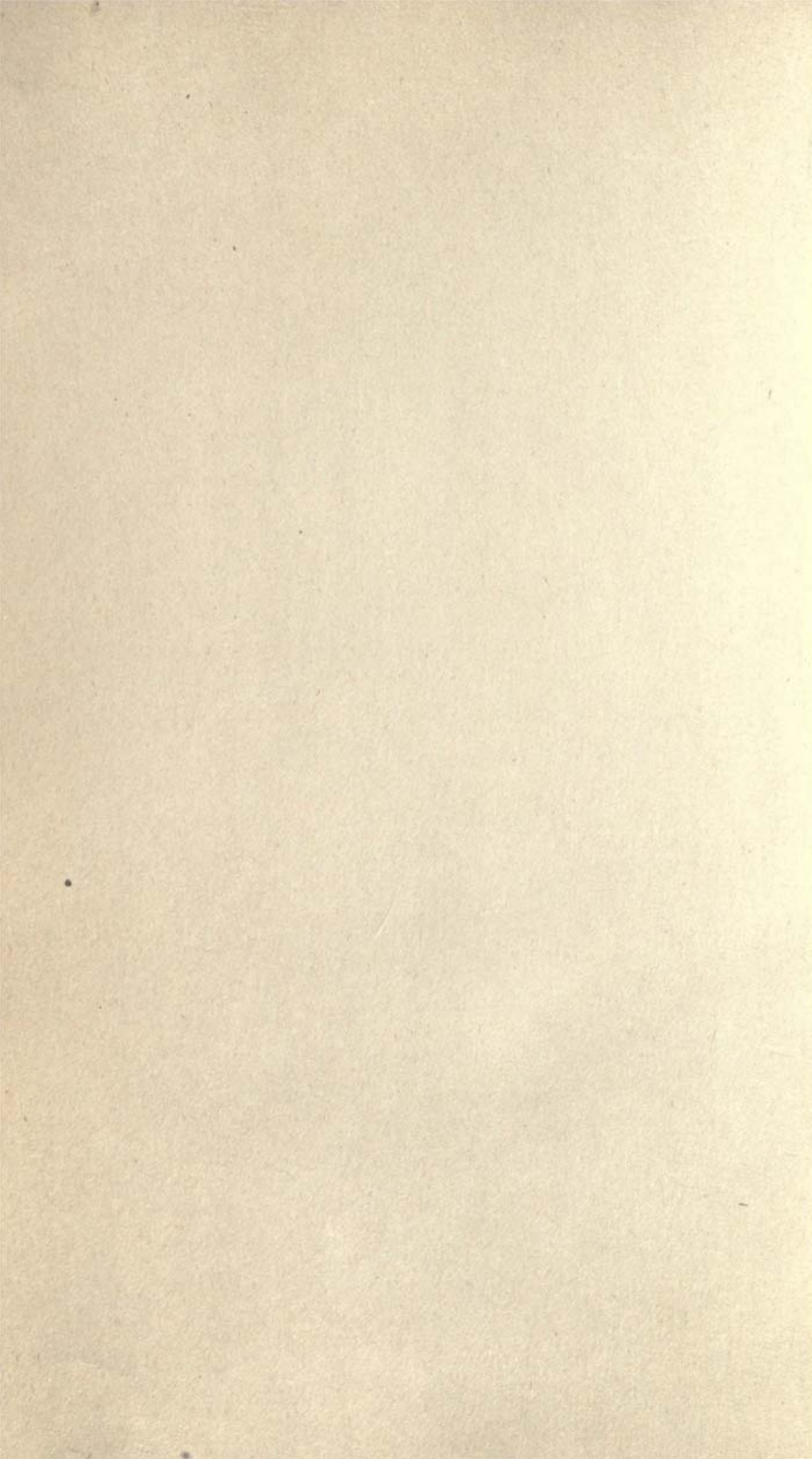
TO

Prof. JAMES C. BOOTH,

OF PHILADELPHIA.

DEAR SIR:

I dedicate this Book to you, with the grateful remembrances of a Pupil and Friend, because I have so often experienced the happy influences of your teaching, example, and association.

Affectionately,

CAMPBELL MORFIT.

UNIVERSITY OF MARYLAND,
Baltimore, March 18, 1856.

PREFACE.

THE present work comprises, in an emended form, all that is valuable in the first edition, together with a larger amount of fresh matter suggested by recent discoveries in Science and Art, and the subsequent experience of the Author. The effort has been to treat the subject progressively, from the very rudiments up to its highest refinements; and, to give greater intelligibility to its technical features, numerous explanatory drawings have been introduced. The Author therefore hopes that, in its fulness and comprehensiveness, it may prove a prompt and reliable instructor as well in the theory as in the practice of the arts to which it relates.

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is the stimulus to merit and industry to accomplish still more. The trades no longer now, as in former times, are viewed merely as mechanical operations, but labor and learning unite to work out subjects of beauty as well as utility. Science and art are, in fact, co-dependents—the one dealing in the mental and the other in the physical realities of life. It would be difficult to say which is most entitled to the common thanks of mankind, for if one begins the race, the other as surely carries it to its destined end. Scarcely an improvement in any of the great exhibitions of human ingenuity but can be traced to the operations of science; nor can a spark be struck from the mind of science to which the skilful hand of the artisan may not impart an additional lustre. Prometheus, who in fable made the mechanism of a human being, is the true figure of art; while the fire which he stole from heaven to animate its being may be said to represent the vitality of science.

The sciences would appear to be precursors of the arts, at least of those in the highest state of improvement, from the fact that it is their province to suggest or mark out those principles which it is the business of art to illustrate. Speculative discoveries may sometimes arise by chance, as the searcher in the quarry may light by surprise upon a vein of gold; but though the workman, whose right hand knoweth its cunning, may effect good results without his understanding the reason, yet they are invariably the consequence of fixed rules, which it would have greatly facilitated his progress to have known. The caprices and uncertainties in processes, so often complained of in manufactories, owe their origin to this very ignorance in regard to the theory or principles of the art.

There is no incongruity between occupations, however manual, and a knowledge of the principles which are interwoven with the work or its products. Artisans are like

travellers, though on different roads; but in every route of life, whether operative or scientific, the course is the more facile as the instructed mind is enabled to shed its light upon the pathway. It is by continuing in the steady tracks of their calling that good men, aided by many helps from science and from study, have advanced themselves to high places among their fellow-men, and are enabled thus practically to illustrate the dignity of labor and the value of education.

The theory which accounts for the union of oils and alkalies in the formation of soaps, or the decomposition of fats into their crystalline acids, is as abstruse as that which expounds some of the most refined instances of affinities. The manufacture of soaps and candles is, therefore, strictly scientific, and they who desire to advance in that art must not merely make, but make understandingly; so that each result may be an advancing lesson for their own profit, while it enables them to repay the benefits they have derived from chemistry, by furnishing new lights to others who may be followers in the same path.

True, soap is a definite chemical compound of one or more of the fat acids, with an alkaline base, soda being the basis element of *hard*, and potassa of *soft* soaps; and both kinds were known to the ancients. Soap owes its cleansing property to what is called *detergency*, or, in other words, a power of aiding water to dissolve and remove the greasy dirt of the clothes and skin, for washing which it is almost exclusively used.

The term soap has its derivation from the Latin word *sapo*, which is corrupted from the German *sepe*, now written *seife*. The Germans derived their knowledge of the art from the Gauls, to whom Pliny ascribes its origin; for though, in periods anterior to the birth of Christ, the Hebrews, Egyptians, and Greeks washed their clothes, it was with free alkali, and by rubbing and stamping. From the

Germans it passed probably to the Romans; and Miss
Stark, in her letters from Italy, speaks of a complete soap-
maker's shop being found in the ruins of Pompeii, de-
stroyed by an eruption from Mount Vesuvius in the first
Christian century.

The art, in more modern times, dates back, in England,
to an unknown epoch prior to 1500. During Queen Anne's
reign, about 1710, soap was made in London, it is said,
very much after the method at present followed by some
old-fashioned soap-makers—that is, with potash and salt;
for barilla and kelp, two species of crude soda made by
incinerating sea-shore plants, and much used previous to
the introduction of soda ash, were not then known, for
that purpose at least. At what time it was brought to
this country is not stated; but certain it is that the great
impulse which the art received originated in 1804, from
the discovery of Leblanc, by which artificial soda, com-
mercially known as soda ash, was economically supplied
and introduced to the trade from the extensive chemical
works of Mr. James Muspratt, England. This grand dis-
covery, and the equally important investigations of Chev-
reul in 1811, by which the proximate constituents of the
fats were exactly demonstrated, and their practical appli-
cations designated, gave to the soap and candle manufac-
ture that consistence and method by which its present
improved condition has been attained, and which elevates
it to the distinction of a scientific art.

Much in the success of the chandler, as in other ope-
rative trades, depends upon his method and the economy
of his processes. To the former he will be indebted for
whatever approach he may make to perfection in his art,
and to the latter for that saving in detail which, after all,
is the element in the sum total of fortune. Saving is
accomplished not merely by the careful use of the ingre-
dients in a trade, because if it is not upon a good basis, a

proper or scientific plan, no caution can realize a gain. It is by the completeness of the system, and the agencies of an instructed experience, and an intimate knowledge of what, as to time, labor, and materials, will produce the best results, that saving is reached. A mill per pound, in any article, is seemingly a small item when confined to a mere unit, but, when extended, it adds ten per centum in the general profit.

The advantages of the special mode by which a manufacturer advances the quality of his articles is perhaps of greater benefit, because reputation follows in proportion to that advance; and when to a high reputation is superadded the economy of a scientific system of working, the enterprising man has two prizes within his own command —good name and fortune.

It is for these reasons that the workman must seek all information he can conveniently find; he must study the reasonings and listen to the suggestions of others; and when he ascertains that the practice of his business may be improved from such sources, he must seize the lights held out to him by those workers, and apply and extend them, with the promulgation of his own improvements, to the rest of his fellow-laborers.

In this way a perpetual fund of benefits will be spread about, and, like a spirit of true humanity teaching by good example, it will descend in the form of a progressive benefit to distant generations.

CHAPTER II.

CHEMICAL COMBINATION.

ALL bodies in nature are either *simple* or *compound*. The simple bodies usually styled *elements* are so designated, because they are not reducible, by any known chemical means, to constituent principles. When, in the progress of chemical knowledge, it may be proved that any of them consist of two or several elements, they will then have to be classified among compound bodies; and the terms *simple* and *compound* have, therefore, in the chemical sense, an opposite signification. Thus, in time, there may be transfers from the two classes, mutually; and the list of elementary principles will, accordingly, be enlarged or diminished by new discoveries; but the accredited number, at present, is sixty-five. The following table exhibits them in alphabetical order; those which exist naturally in the state of gas being printed in *Italics*, while the liquids are in SMALL CAPS, and the solids in Roman letters.

Names of elements.	Sym-bol.	EQUIVALENTS.		Names of elements.	Sym-bol.	EQUIVALENTS.	
		Oxygen = 100.	Hydro-gen = 1.			Oxygen = 100.	Hydro-gen = 1.
Aluminum	Al	171.2	13.7	MERCURY			
Antimony (Stibium)	Sb	1612.9	129.0	(Hydrargyrum)	Hg	1250.0	100.0
Arsenic	As	937.5	75.0	Molybdenum	Mo	596.1	47.7
Barium	Ba	858.0	68.6	Nickel	Nk	369.0	29.5
Bismuth	Bi	2660.8	212.9	Niobium	Ni	?	?
Boron	B	136.2	10.9	Nitrogen	N	175.0	14.0
BROMINE	Br	1000.0	80.0	Norium	No	?	?
Cadmium	Cd	696.7	55.7	Osmium	Os	1245.6	99.4
Calcium	Ca	250.0	20.0	Oxygen	O	100.0	8.0
Carbon	C	75.0	6.0	Palladium	Pd	663.4	53.3
Cerium	Ce	574.7	46.0	Pelopium	Pl	?	?
Chlorine	Cl	443.5	35.5	Phosphorus	P	400.0	32.0
Chromium	Cr	328.9	26.2	Platinum	Pt	1232.0	98.6
Cobalt	Co	369.0	29.5	Potassium (Kalium)	K	488.9	39.1
Tantalium	Ta	1148.4	91.9	Rhodium	R	652.0	52.2
Columbium				Ruthenium	Rt	?	?
Copper (Cuprum)	Cu	396.6	31.7	Selenium	Se	495.3	39.6
Didymium	D	?	?	Silicon	Si	177.9	14.2
Donarium	Do	997.4	79.7	Silver (Argentum)	Ag	1350.0	108.0
Erbium	E	?	?	Sodium (Natrium)	Na	287.2	23.0
Fluorine	F	235.4	18.8	Strontium	Sr	549.0	43.9
Glucinum	G	87.3	7.0	Sulphur	S	200.0	16.0
Gold (Aurum)	Au	2458.4	196.7	Tellurium	Te	801.0	64.1
Hydrogen	H	12.5	1.0	Terbium	Tb	?	?
Ilmenium	Il	?	?	Thorium	Th	7439	59.5
Iodine	I	1586.0	126.5	Tin (Stannum)	Sn	735.3	58.8
Iridium	Ir	1232.0	98.5	Titanium	Ti	3147	25.1
Iron (Ferrum)	Fe	350.0	28.0	Tungsten or Wolfram	W	1188.4	95.0
Lantanum	La	?	?	Vanadium	V	8569	68.6
Lead (Plumbum)	Pb	1294.6	103.6	Uranium	U	7500	60.0
Lithium	Li	81.7	6.5	Yttrium	Y	4025	32.2
Magnesium	Mg	150.0	12.0	Zinc	Zn	4066	32.5
Manganese	Mn	344.7	27.6	Zirconium	Zi	4202	33.7

For convenience of expression, each of these elements is briefly represented by *symbols* which are generally the initial letters of its Latin name, for example *Pb* for lead; *Cu* for copper, &c. As will be seen hereafter, in the construction of formulæ, this mode of abbreviation is indispensable. The *equivalents* are the representative numbers of the relative values of the elements. In other words, they express the quantities, by weight, in which one element may replace another in chemical combinations, as will be more fully explained in the progress of this chapter. The elements of water are each taken as the standard of comparison, and hence two scales of equivalents are in use. That preferred in this country, is the hydrogen scale, hydrogen = 1, being taken as unity; whilst in Europe, oxygen = 100, is most used. It is evident, however, that as the equivalent of hydrogen is 12.50 on the oxygen scale, that number divided into 100 will reduce

the equivalents of the latter to those of the former standard.

It has already been said, that all bodies are either elementary or compound. Now, irrespective of this difference, every substance is made up of innumerable particles, each of which, however infinitesimal, possesses the properties of the original mass. Thus, for example, in dividing a grain of lead into a million of parts, we do not change the nature of those parts. Each one is still unaltered lead. So, likewise, if a grain of oxide of lead were similarly reduced, each particle would have the same equivalent ratio of oxygen and lead as the entire and original grain. The term *atom* has therefore been applied to these molecules of matter, and the force holding them together in mass is called *cohesion*. This force is physical in its character, and varies with the nature of the body, being greatest in solids, and very feeble in gases, while in liquids its power is intermediate. It is, moreover, confined to particles of a similar nature, and differs wholly from *chemical affinity*, which exerts attraction between bodies entirely dissimilar, disposing them to a closer connection, so that, by their union, the formation of new products endowed with new properties may result. In these reactions, the imponderable bodies—heat, light, and electricity—have also an important incidental agency; and the resulting products are termed *chemical* compounds, in contradistinction to a *mechanical* compound, which is nothing more than an admixture of any several substances—the union being, as it were, a mere physical effect. Thus, for example, tallow is a chemical compound, because it consists of fatty acids and a base, united together in definite proportions to form salts; whereas, by melting this same body with wax, the production of a mechanical compound is illustrated. Only a mixture ensues, and there is no chemical change. But if potassa is substituted for the wax, being a

strong base, it exerts a chemical action upon the tallow, draws off the fatty acids from their natural base glycerin, and unites with them to form salts, thus effectually decomposing the tallow into its constituent parts. On the other hand, by applying a knife instead of potassa to the tallow, there is only a mechanical division of it into smaller particles, each of which retains unaltered its original character, and the same ratio of fat acids and glycerin as existed in the entire mass.

Affinity does not exert its force alike between all bodies, but is elective in its character, and prefers one body to another.

Thus, for instance, in making stearic acid block, when, in the first step, lime is added to the melted suet, the fatty acids which the latter contains by reason of a greater affinity or preference for the lime, leave their natural base and combine therewith; and thus the original suet consisting of an oleo-stearate of glycerin is transformed into an oleo-stearate of lime, the natural base glycerin, at the moment of its elimination, becoming dissolved in the water which is added to facilitate the action. This is an instance of what is termed *simple elective affinity,* by the influence of which an original combination is broken up and a new one formed; it is, however, applicable but to those circumstances where a third body, in its action upon a compound, has a stronger affinity for one of its ingredients than they have for each other; for example, the process of rendering soda ash caustic, or, in other words, depriving it of carbonic acid, is due to this power, for, as will be learned hereafter, soda ash consists chiefly of carbonic acid, and soda united as carbonate of soda. Now when lime is added, that being a stronger base, breaks up the original union, and by reason of its greater affinity, abstracts the carbonic acid from the ash, becomes itself carbonated, and in that state is insoluble,

whilst the free soda entirely devoid of acid is obtained in solution. The following diagram will illustrate the changes; the water added in the process serving as the solvent of the soda:—

I.	II.	III.
Carbonate of soda . =53.	{ Carbonic acid =22. { Soda . . . . =31.	Caustic soda in solution . =31.*
Lime . . =28.	{ Oxygen . . = 8. { Calcium . . =20.	Carbonate of lime = { 22 28 } =50.
81.		81.

When there are two compounds brought into contact, the number of affinities is increased; thus, for instance, let us take common soft soap, which is an oleo-stearate of potassa, and add to it a solution of acetate of lead;—here then are four affinities in action, exhibiting an instance of what is called *double elective affinity*, or double decomposition, as it is sometimes styled, and explicable as follows:—

I.	II.	III.
Oleo-stearate of potassa	{ Oleo-stearic acid { Potassa	Acetate of potassa.
Acetate of lead	{ Acetic acid . . . { Oxide of lead . .	Oleo-stearate of lead.

The first column designates the substances in their original state; the second, their composition or constituency; and the third, the results and the title of the compound newly formed. To explain further, the oleo-stearic acid of the soap having a preference for the base of the acetate of lead, leaves its own and goes over, and forms with it an oleo-stearate of lead, whilst that base which it abandoned takes up with the acetic acid, similarly situated, and forms acetate of soda, which, unlike the other new compound, remains dissolved in the menstruum. This kind of affinity is of the utmost importance, for it is solely by its action that many compounds are formed.

There are certain conditions and circumstances involved in combination by affinity; it must be sufficiently powerful to overcome the opposing forces of gravity, cohesion, and elasticity. Its action must be promoted by such mechanical or other means as will tend to a close approximation of the ultimate particles of bodies, and bring them into immediate contact; such as pulverization and trituration in the case of solids, admixture in that of liquids, and inter-diffusion in that of gases. Heat also is a predisposing influence applicable in the large majority of instances.

The changes resulting from the play of affinities are manifold and various, both as regards density, form, color, and chemical properties. The original bodies undergo an entire transmutation into new products, frequently of opposite characters. In the combination of solids or liquids there is generally a condensation of volume, as well as a change of state. As familiar illustrations, when carbonic *acid* gas is brought into contact with ammoniacal vapor, which is *alkaline,* a solid salt, carbonate of ammonia, is formed. This same carbonic acid, passed into lime-water, precipitates *solid* carbonate of lime. An intermixture of two gases, oxygen and hydrogen, produces *liquid* water; and caustic lime, heated with sulphate of ammonia, generates gaseous ammonia. The evolution of heat and light is a phenomenon incidental, generally, to chemical combination.

But be the change what it may in physical and chemical properties, the chemical combination of bodies always takes place in obedience to certain fixed and invariable laws. Chemical compounds contain their elements under all circumstances in definite and constant proportion. These proportional numbers have been determined for each simple body by exact analysis, and are recorded in the preceding table. They are synonymously termed

equivalent numbers, atomic weights, combining proportions, and combining weights of bodies. Taking the scale in which hydrogen is assumed as unity, it will be found then by reference to the table, that oxygen has a combining weight of 8; copper 31.7; zinc 32.5; lead 103.6; and silver 108.

It therefore follows that 8 parts (pounds) of oxygen

Combine with	1 part (pound) of hydrogen, to form water.		
	31.7 parts (pounds) of copper to form oxide of copper.		
	32.5	"	zinc, to form oxide of zinc.
	103.6	"	lead, to form oxide of lead.
	108.0	"	silver, to form oxide of silver.

The numerical value of one equivalent of oxygen is therefore 8, that of hydrogen 1, and that of silver 108. Every equivalent of water consequently, regardless of its source, contains eight parts by weight of oxygen, and one part by weight of hydrogen, making a totality of 9, which is the combining weight of the water. So also one equivalent of oxide of silver = 116, will be found to consist invariably of 108 parts by weight of silver, and eight parts by weight of oxygen. If, in practically preparing either of these compounds, any excess of their respective elements should be used, there will be a waste in the ratio of that excess beyond the combining proportion; unless, perchance, there is more than one compound of the two elements. Then they will unite in a simple multiple of the lowest proportion, but never in any intermediate proportion; as in the case of carbon and oxygen, thus 1 equivalent of carbon = 6, and 1 equivalent of oxygen = 8, combined form 1 equivalent of carbonic oxide = 14; by adding another equivalent of oxygen, the one equivalent of carbonic *oxide* becomes 1 equivalent of carbonic *acid* = 22.

There is another law of chemical combination, according to which, when one element replaces another in a compound, it is always *in reciprocal proportion;* that is,

they enter uniformly into all combinations in the ratio indicated by their equivalent numbers. For example: lime is composed of calcium and oxygen, in the proportion of 20 of the former and 8 of the latter; when, therefore, chlorine, for example, is made to displace the oxygen to form chloride of calcium, it will be found that the calcium has entered into combination with it in the same proportion (20) as it held to the oxygen. So also the oxygen, when uniting with another element, always observes its equivalent proportion of 8—as, for instance, in water which is composed of hydrogen 1 and oxygen $8 = 9$; and in oxide of copper, consisting of copper 31.7 and oxygen $8 = 39.7$.

Nor is the combining proportion of *compound* bodies less regulated by these laws than that of the simple bodies. The former, like the latter, have also their equivalent numbers; and the equivalent number of a compound body is always *the sum of its combining weights, or equivalent numbers of its constituents*. For example, carbonic acid being composed of carbon 6 and oxygen 16, its combining weight is therefore 22; and lime, being composed of calcium 20 and oxygen 8, its combining weight is therefore 28. Now, when these two opposite substances are brought together, they always unite in these proportions of 22 and 28, forming carbonate of lime $= 50$, which is its equivalent. Furthermore, when another acid is substituted for the carbonic, the lime, in combining with it, always observes this proportion of 28, as shown by the diagram on page 26.

In the first part of this chapter, when citing the decomposition of tallow by lime as an instance of simple elective affinity, we stated that stearic and oleic acids, united with glycerin, made up its composition. These three ingredients are termed its *proximate constituents*, in contradistinction to its *ultimate* components, of which the

former are made up. Thus, carbon, oxygen, and hydrogen are the ultimate components of suet and of each of its fatty acids and base; and sulphuric acid and soda, the proximate constituents of Glauber's salt, as the diagram will show.

	Proximate constituents.	Ultimate components.
Sulphate of soda	{ Sulphuric acid	{ Sulphur. { Oxygen.
	{ Soda	{ Sodium. { Oxygen.

We have heretofore said, that bodies combine in certain definite ratios and proportions; now, in order to a convenience of expression in an abbreviated form, chemical bodies and compounds are represented by certain symbols and groups of symbols, so placed together as to furnish at a glance the actual composition of the substance, that is, its atomic composition, " which means the relative proportions of the equivalents of its constituents as well as the ultimate or percentage composition." In this way a full knowledge is conveyed to the reader, at sight, of the constitution of a body; a very important consideration and a great improvement upon the old-fashioned mode of using the unmeaning term of " copperas," for instance, instead of the more appropriate title of sulphate of iron, which, when written symbolically $Fe.O.SO_3+7HO$, conveys the knowledge, that it is composed of one equivalent of oxide of iron, one equivalent of sulphuric acid, and seven equivalents of water; a fact that could not be communicated by the old method of expression.

So also crystallized sulphate of magnesia (Epsom salts) may be expeditiously and accurately written MgO, SO_3, $7HO$; whereas, if expressed by its numerical composition, a much greater time and space would be required, as is shown by the annexed diagram :—

	Equivalent or atom.	Atomic weight.	Percentage composition.
Magnesia . .	. 1	21	16.8
Sulphuric acid .	. 1	40	32.3
Water . .	. 7	63	50.9
Sulphate of magnesia	. 1	124	100.0

To continue the illustration : Sulphate of lead, consisting of an equivalent of oxide of lead combined with one equivalent of sulphuric acid, may, by grouping the distinctive symbols of its elements, be intelligibly expressed by five letters, PbO, SO_3; and this formula gives alike its composition and combining number.

By reference to the preceding table, it will be seen that the combining equivalent of lead is 103.7 and that of oxygen 8; therefore, as oxide of lead consists of one atom of each, by adding the two together we get its atomic weight $= 111.7$; now this equivalent of oxide of lead, when converted into a sulphate, unites with one equivalent of sulphuric acid, the equivalent of which is 40, because it is composed of 1 equivalent or 16 parts of sulphur, and 3 equivalents or 24 parts of oxygen. The sum of the atomic weights of its two constituents, oxide of lead and sulphuric acid, viz: $111.7 + 40 = 151.7$, is the atomic weight of the compound or sulphate of lead. The symbols, in short, represent the chemical equivalents of the elements of a body; for example, stearic acid read from a formula, as $C_{68}H_{66}O_5$, $2HO = \overline{St_2}HO$, is directly known to be composed of 68 atoms of carbon, 66 of hydrogen, 5 of oxygen, and 2 of water. By a repetition of the symbol, or by the prefix of a corresponding figure to it, any number of equivalents can be indicated, thus, chromic acid, which consists of 1 equivalent of chrome and 3 equivalents of oxygen, is expressed by Cr 3O or Cr, OOO, or, still more preferably, by the annexation of a smaller figure, Cr, O_3.

"The association of symbols, as before said, expresses combination : thus, FeO represents a compound of an

equivalent, or one proportion of iron and one of oxygen, or the protoxide of iron : SO_3, a compound of one equivalent of sulphuric acid and three of oxygen; that is, one equivalent of sulphuric acid and sulphate of iron itself, consisting of one equivalent of each of the preceding compounds, may be represented as follows :—

$$FeOSO_3, \text{ or}$$
$$FeO + SO_3, \text{ or}$$
$$FeO, SO_3.$$
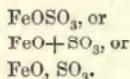
The algebraic sign $+$, for which the comma is frequently substituted, indicates in the above formulæ the distribution of the elements of the salts into its two proximate constituents, oxide of iron and sulphuric acid, in order that it may be more distinct. The propriety occurs frequently of using both the *comma* and $+$ in the same formula, as in writing out the composition of the double sulphate of iron and potassa, $= FeO, SO_3 + KO, SO_3$, in which case the comma is employed to indicate combination more intimate in degree, or of a higher order than the $+$; viz: of the oxide with the acid of each salt, while the combination of the two salts themselves is expressed by the sign $+$.

The small figures in the preceding formulæ on the right hand of a symbol do not apply to any other than that to which it is immediately attached, but the larger figures placed antecedent, and on the same line with the symbols, relate to the whole compound expressed; as in the formula of stearic acid before given, there is so much carbon, oxygen, and hydrogen, and $2HO$, that is, two equivalents of water. And to further exemplify: $3NO_5$, $5SO_3$, $7CrO_3$, signify respectively three equivalents of nitric acid, five of sulphuric acid, and seven of chromic acid, and $2PbO$, two equivalents of oxide of lead. The interposition, however, of a comma (,) or ($+$) prevents the influence of the figure extending further. Thus—

$$2PbO, CrO_3, \text{ or}$$
$$2PbO + CrO_3$$
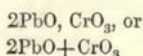
is two proportions of oxide of lead, and one of chromic acid or the subchromate of lead. To make the figure apply to symbols separated by the comma (,) or plus (+) sign, it is necessary to inclose all that is to be affected within parentheses, and place the figure before them: Thus,

$$2(PbO, CrO_3)$$
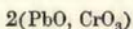
signifies two proportions of the chromate of lead."

The mode adopted in the expression of vegetable and animal acids, so as to distinguish them from those of mineral origin, is by surmounting the first, and in some instances the first two initials of their title with a dash: for example, we write Acetic acid $\overline{A}$ and Citric acid $\overline{C}$. In scientific treatises, however, the symbol is frequently accompanied with a formula in parenthesis expressive of its composition, as instanced in the case of the former acid: thus, $\overline{A} = (HO + C_4H_3O_3)$; and in that of stearic acid as follows: $\overline{St+} = (2HO + C_{68}H_{66}O_5)$.

The laws regulating chemical nomenclature so simplify the system that it becomes an easy matter to memorize every compound without any great exercise of the memory.

" The names of compound bodies are contrived to express their composition and the class to which they belong, and are founded on a distribution of compounds into three orders, namely, compounds of one element with another; as, for instance, oxygen with sulphur in sulphuric acid, or oxygen with sodium in soda, which are called *binary* compounds. Secondly, combinations of binary compounds with each other, as of sulphuric with soda in sulphate of soda, and the salts generally, which are termed *ternary* compounds. And thirdly, combinations of salts with one another, or double salts, such as sulphate of alumina and potassa (alum), which are *quaternary* compounds."

" (1.) Of the compounds of the first order, the greater number known to the original framers of the chemical

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nomenclature contained oxygen as one of their two constituents; and hence an exclusive importance was attached to that element. Its compounds with the other elementary bodies may be divided by their properties into (*a*) the class of neutral bodies and bases, and (*b*) the class of acids.

"(*a*.) To members of the first class the generic term *oxide* was applied, the first syllable of oxygen, with a termination (*ide*) indicative of combination; to which the name of the other element was joined to express the specific compound. Thus a compound of oxygen and hydrogen is *oxide of hydrogen;* of oxygen and potassium, *oxide of potassium;* of which compounds the first, or water, is an instance of a neutral oxide; the second, or potash, of a base or alkaline oxide. But the same elementary body often combines with oxygen in more than one proportion, forming two or more oxides; to distinguish which, the Greek prefix *proto* (πρῶτος, first) is applied to the oxide containing the least proportion of oxygen, *deuto* (δεύτερος, second) to the oxide containing more oxygen than the protoxide, and *trito* (τρίτος, third) to the oxide containing still more oxygen than the deutoxide; which last oxide, if it contains the largest proportion of oxygen with which the element can unite to form an oxide, is more commonly named the *peroxide*, from *per*, the Latin particle of intensity. Thus the three compounds of the metal manganese and oxygen are distinguished as follows:—

	COMPOSITION.	
Names.	Manganese.	Oxygen.
Protoxide of manganese	100	28.91
Deutoxide of manganese	100	43.36
Peroxide of manganese	100	57.82

"As the prefix *per* implies simply the highest degree of oxidation, it may be applied to the second oxide when there are only two, as in the oxides of iron, the second oxide of which is called indifferently the deutoxide or peroxide of iron. M. Thénard, in his *Traité de Chimie*, avoids the use of the term deutoxide, and confines the application of peroxide to such of these oxides as, like the peroxide of manganese, do not combine with acids. He applies the names *sesquioxide* and *binoxide* to oxides which are capable of combining with acids, and contain respectively once and

a half and twice as much oxygen as the protoxides of the same metals. He has thus the protoxide, sesquioxide, and peroxide of manganese, the protoxide and sesquioxide of iron, the protoxide and binoxide of tin, &c. Certain inferior oxides, which do not combine with acids, are called *suboxides;* such as the suboxide of lead, which contains less oxygen than the oxide distinguished as the protoxide of the same metal.

"The compounds of chlorine and several other elements are distinguished in the same manner as the oxides. Such elements resemble oxygen in several respects, particularly in the manner in which their compounds are decomposed by electricity. Chlorine, for example, like oxygen, proceeds to the positive pole, and is therefore classed with oxygen as an electro-negative substance, in a division of elements grounded on their electrical relations. Thus, with the other elementary bodies,

Oxygen	forms	.	.	.	Oxides.
Chlorine	"	.	.	.	Chlorides.
Bromine	"	.	.	.	Bromides.
Iodine	"	.	.	.	Iodides.
Fluorine	"	.	.	.	Fluorides.
Sulphur	"	.	.	.	Sulphides (or sulphurets).
Phosphorus	"	.	.	.	Phosphides (or phosphurets).
Carbon	"	.	.	.	Carbides (or carburets).
Nitrogen	"	.	.	.	Nitrides.
Hydrogen	"	.	.	.	Hydrides.

"When several chlorides of the same metal exist, they are distinguished by the same numerical prefixes as the oxides. Thus we have the protochloride of tin and the bichloride of tin, the protochloride and the sesquichloride of iron. The compounds of sulphur greatly resemble the oxides, but they have been generally named sulphurets, and not sulphides or sulphurides. Berzelius, indeed, applies the term sulphuret to such binary compounds of sulphur only as are basic and correspond with basic oxides, while sulphide is applied by him to such as are acid or correspond with acid oxides. Hence he has the *sulphuret of potassium,* and the *sulphide of arsenic* and *sulphide of carbon.* Compounds of chlorine are distinguished by him into chlorurets and chlorides on the same principle; thus he speaks of the *chloruret of potassium* and of the *chloride of phosphorus.* But these distinctions have not served any

important purpose, while, besides conducing to perspicuity, it is an object of some consequence, in a systematic point of view, to allow the termination *ide*, already restricted to electro-negative substances, to apply to them all, without exception.

" The combination of metallic elements among themselves are distinguished by the general term *alloys*, and those of mercury as *amalgams*.

" (b.) The binary compounds of oxygen which possess acid properties, are named on a different principle. Thus, the acid compound of titanium and oxygen, is called *titanic acid ;* of chromium and oxygen, *chromic acid ;* or the name of the acid is derived from that of the substance in combination with oxygen, with the termination *ic.* Where the same element was known to form two acid compounds with oxygen, the termination *ous* was applied to that which contained the least proportion of oxygen, as in *sulphurous* and sulphuric acids. On the discovery of an acid compound of sulphur which contained less oxygen than that already named sulphurous acid, it was called *hyposulphurous acid* (from the Greek ὑπο, under) ; and another new compound intermediate between the sulphurous and sulphuric acids, was named *hyposulphuric acid.* On the same principle, an acid containing a greater proportion of oxygen than that already named chloric acid, was named *hyperchloric acid* (from the Greek ὑπερ, over), but now more generally *perchloric acid.* The names of the different acid compounds of oxygen which have been referred to for illustration, with the relative proportions of oxygen which they contain, are as follows :—

			COMPOSITION.	
Names.			Sulphur.	Oxygen.
Hyposulphurous acid	.	.	. 100	50
Sulphurous acid	.	.	. 100	100
Hyposulphuric acid	.	.	. 100	125
Sulphuric acid	.	.	. 100	150

" The same system is adopted for all analogous acids. An acid of chlorine, containing more oxygen than chloric acid, is named perchloric acid, and other similar compounds, which all contain an unusually large proportion of oxygen, are distinguished in the same manner: as peri-

odic acid, and permanganic acid. The perchloric acid is sometimes also called *oxichloric ;* but this last term does not seem so suitable as the first.

"Another class of acids exists, in which sulphur is united with the other element in the place of oxygen. The acids thus formed are called *sulphur acids.* The names of the corresponding oxygen acids are sometimes applied to these, with the prefix *sulph*, as *sulpharsenious acid*, and sulpharsenic acid, which resemble arsenious and arsenic acids, respectively, in composition, but contain sulphur instead of oxygen.

"Lastly, certain substances, such as chlorine, sulphur, and cyanogen, form acids with hydrogen, which are called hydrogen acids, or *hydracids.* In these acid compounds the names of both constituents appear, as in the terms *hydrochloric acid, hydrosulphuric acid,* and *hydrocyanic acid.* Thénard has proposed to alter these names to *chlorhydric, sulphohydric,* and *cyanhydric acids,* which, in some respects, are preferable terms.

"(2.) Compounds of the second order, or salts, are named according to the acid they contain, the termination *ic* of the acid being changed into *ate,* and *ous* into *ite.* Thus, a salt of sulphuric acid is a *sulphate ;* of sulphurous acid a *sulphite ;* of hyposulphurous acid a *hyposulphite ;* of hyposulphuric acid a *hyposulphate ;* and of perchloric acid a *perchlorate ;* and the name of the oxide indicates the species : as sulphate of oxide of silver, or sulphate of silver ; for the oxide of the metal being always understood, it is unnecessary to express it, unless when more than one oxide of the same metal combines with acids, as sulphate of the protoxide of iron, and sulphate of sesquioxide of iron. These salts are often called protosulphate and persulphate of iron, where the prefixes proto and per refer to the degree of oxidation of the iron. The two oxides of iron are named *ferrous oxide* and *ferric oxide* by Berzelius, and the salts referred to, the ferrous sulphate, and the ferric sulphate. The names stannous sulphate and stannic sulphate, express in the same way the sulphate of the protoxide of tin, and the sulphate of the peroxide of tin. But such names, although truly systematic, and replacing very cumbrous expressions, involve too great a change in chemical nomenclature to be

speedily adopted. Having found its way into common language, chemical nomenclature can no longer be altered materially without great inconvenience. It must be learned as a language, and not be viewed and treated as the expression of a system. A *super*-sulphate contains a greater proportion of acid than the sulphate or neutral sulphate; a *bi*-sulphate twice as much; and a *sesqui*-sulphate one and a half as much as the neutral sulphate; while a *sub*-sulphate contains a less proportion than the neutral salt; the prefixes referring in all cases to the proportion of acid in the salt, or to the electro-negative ingredient, as with oxides. The excess of base in sub-salts is sometimes indicated by Greek prefixes, expressive of quantity, as *di*-chromate of lead, *tris*-acetate of lead; but this deviation is apt to lead to confusion. If a precise expression for such subsalts were required, it would be better to say, the bibasic subchromate of lead, the tribasic subacetate of lead. But the names of both acid and basic salts are less in accordance with correct views of their constitution, than the names of any other class of compounds.

"Combinations of water with other oxides are called *hydrates;* as hydrate of potassa, hydrate of boracic acid.

"(3.) In the names of quaternary compounds, or of double salts, the names of the constituent salts are expressed. Thus: *sulphate of alumina and potash* is the compound of sulphate of alumina and sulphate of potash; the name of the acid being expressed only once, as it is the same in both of the constituent salts. The name alum, which has been assigned, by common usage, to the same double salt, is likewise received in scientific language. The *chloride of platinum and potassium* expresses, in the same way, a compound of chloride of platinum and chloride of potassium. An oxichloride, such as the *oxichloride of mercury* is a compound of the oxide with the chloride of the same metal."

The explanations in this chapter, when well studied, will insure a complete understanding of the general principles of chemical combination, and afford that facility in comprehending its results, without which it will be impossible to make progress in any scientific art.

CHAPTER III.

ALKALIES AND ALKALINE EARTHS.

THE general characteristics of alkalies are their ready solubility in water, power of neutralizing the strongest acids (this also being a test of their purity and strength), and capability of changing many vegetable blue colors into green, and some yellows to brown, or of restoring the colors of those which have been changed by acids. Among these, the yellow of turmeric, and litmus reddened by an acid, are exceedingly delicate tests of the presence of an alkali. The term was formerly applied to the ashes of plants, but is now generally used to designate potassa, soda, and ammonia, called respectively, also, vegetable, mineral and volatile alkali. Even when combined with carbonic acid, for which they have a great affinity and attract it from the atmosphere, the above three exercise the discoloring power before mentioned; a property not possessed by the alkaline earths, lime and barytes, when in a similar state of combination. These three alkalies have also an acrid and somewhat urinous taste. Ammonia and potash are energetic solvents of animal matter, and the three combine with oils so as to form soaps. They unite with water in every proportion, and also with alcohol.

Potassa, soda, and lithia, are formed by the union of oxygen with their respective metallic radicals. The affinity of these metallic radicals for oxygen is so powerful as to enable them to decompose the coldest water, and even ice instantaneously, with the disengagement of

hydrogen. To the above might be added baryta, stontia, lime, and magnesia, which have certain properties in common with the alkalies proper, and on this account are sometimes classed with them. These are called alkaline earths, a term originating from the fact, that whilst in many respects they are possessed of alkaline properties, they otherwise resemble the earths. The property before spoken of as that possessed by the carbonated alkalies, viz: solubility in water, and power of changing blue and yellow colors, is the chief mode of distinguishing between the alkalies and the alkaline earths—a power not belonging to the carbonates of the latter.

We have rated ammonia among the alkalies, because, though differing from them in its organic constitution, it yet has similar properties. We shall make no further mention of any, except those used in the manufacture of soap.

Lime, or Hydrated Oxide of Calcium, CaO.—Lime has been known from remote antiquity, and is found in nature under different forms. Combined with sulphuric acid it is called sulphate of lime, gypsum and plaster of Paris, and when in a crystalline form, selenite or alabaster. Combined with carbonic acid it constitutes chalk and limestone, which, when it assumes a crystalline structure, is marble. In these forms, lime is more or less scattered in different localities throughout every part of the terrestrial globe, and composes a goodly portion of it. Lime is obtained by exposing oyster shells or any of the carbonates of lime to a red heat in kilns specially constructed for the purpose; in this way all the carbonic acid is driven off and lime remains, more or less pure, according to the quality of the limestone used. The product, thus obtained, is called *quicklime*. When sprinkled with water, it becomes very hot, and crumbles down into a dry powder termed *slaked lime*, or hydrate of lime. The heat

evolved in this instance is that which served to keep the water in a state of liquidity, and now given up because no further needed, the water having, as an acid, combined with the lime to form a salt, viz: the above hydrate of lime. This process takes place also upon exposure for some weeks to air, the lime then falling into powder by the absorption of moisture and a portion of carbonic acid gas, so that in such case a part of the lime having gradually returned to its original state of carbonate, has lost its causticity. To explain more fully the phenomena produced by the contact of water with lime, let us suppose that some water be added to recently burned lime; it is immediately absorbed with the disengagement of heat, a great quantity of aqueous vapor is evolved, the lime crackles, then swells, and eventually falls to powder. If a fresh quantity of water is thrown upon the remaining unaffected fragments, it is absorbed with an accompanying hissing sound. Five hundred and seventy degrees, Fahrenheit thermometer, is the temperature estimated as produced by this reaction, and in working upon larger masses of material, the heat is sufficiently intense to ignite powder. This evolution of great heat by the slaking of lime has been applied to the warming of apartments, and to that end several patents have been obtained for proper and convenient apparatus, but without any permanently satisfactory results. Instances have been known of the destruction of lime-houses by fire, by reason of water dripping upon the lime contained in them. Lime, in a state of purity, is white, easily pulverizable, and has a warm caustic taste. It exerts a powerful action upon the cuticle, hair, and nails, but does not extend its destructive influence to other animal textures. Its specific gravity is about 2.3. It becomes highly luminous when heated to a full redness, and the injection of the inflamed oxygen and hydrogen gases com-

bined, against a lump of it, is what makes the well-known "Drummond Light." Hydrate of lime is very sparingly soluble in water, and what is remarkable, cold water solves it more readily, as well as in greater quantity, than hot water. Thus, according to Dalton, one grain of lime requires for solution 1270 grains of water at 212° F.; 972 grains of water at 130° F.; and 778 grains of water at 60° F.; consequently, on heating lime water, which has been prepared in the cold, deposition of lime ensues. Philips likewise observed that water at 32° is capable of dissolving twice as much lime as at 212°. One of its peculiar properties is its tendency to absorb carbonic acid and thus become a carbonate, in which state it is insoluble in water, and hence are owing the deposit and incrustation which form in and upon lime waters or solutions and milks of lime. Upon this property depends the preparation of the caustic lyes, of which we will speak hereafter. Lime, as was demonstrated by Davy, is a metallic oxide, and consists per cent. of

| Calcium (its metallic base) | . | . | 71.43 |
| Oxygen . | . | . | . | . | . | 28.57 |

Lime, that is, the oxide of calcium, combines with the acids and forms salts, but as they are inappropriate to this work, we shall make no note of them. We will merely say, however, in passing, that the aqueous solutions of the salts of lime have the property of decomposing the ordinary soaps, and thus forming a lime base soap, which is insoluble; hence the impropriety of using hard, or water containing lime, for washing clothes, or for other detergent operations.

A delicate test of the presence of lime is oxalate of ammonia, a solution of which, when added to water supposed to contain lime, will, if that body is present, throw down a white almost insoluble precipitate of oxalate of lime. This reagent serves sufficiently well for all tech-

nical purposes, though a chemist, in making a professional analysis, would have to carry his examination further, in order to distinguish whether the precipitate may not be oxalate of baryta or strontia, both of which are likewise sparingly soluble.

POTASSA, OR PROTOXIDE OF POTASSIUM, KO.—This alkali is indiscriminately called, in commerce, vegetable alkali, sal tartar, pearlash, potash, hydrated protoxide of potassium, &c. It exists in the ashes of vegetables, combined with carbonic, sulphuric, nitric, hydrochloric, oxalic, and tartaric acids, but each and every kind of vegetable ashes are not equally rich in potassa, for some are very meagre in that constituent. The following tables will show the comparative value of the different sources, according to several authorities:—

TABLE I.

Names of the plants.	Quantity of ashes.	Proportion of alkali.	Names of the plants.	Quantity of ashes.	Proportion of alkali.
100 PARTS.			100 PARTS.		
Willow	2.8	0.285	Fumitory	21.9	7.9
Elm	2.36727	0.39	Hop stems	10.000	3.015
Oak	1.35185	0.15343	Windsor Bean Stalks	10.000	4.129
Poplar	1.23476	0.07481	Common Nettle	10.67186	2.5033
Yoke-elm . . .	1.1283	0.1254	Common Thistle	4.04264	0.53734
Beech	0.58432	0.14572	Fern	5.00781	0.6259
Fir	0.31740	0.7318	Large Rush	3.85394	0.72234
Vine-shoots. . .	3.379	0.55	Heath	2.9019	0.84
Corn-stalks . . .	8.86	1.75	Horsechestnut		
Absinthe, or Worm-			(bark)	18.460	4.840
wood	9.744	7.3	Centaury	8.44	2.008

TABLE II.

Species of wood.	Amount of ash in air-dried wood.	In young wood.	In old wood.	Authority.
Silver Fir (*Pinus Picea*)	0.83	—	—	Berthier.
Do.	—	0.15	0.15	Karsten.
Scotch Fir (*Pinus Sylvestris*)	1.24	—	—	Berthier.
Do.	—	0.12	0.15	Karsten.
Birch . . . . _	1.00	—	—	Berthier.
Do.	—	0.25	0.30	Karsten.
Oak	2.50	—	—	Berthier.
Do.	—	0.15	0.11	Karsten.
Lime	5.00	—	—	Berthier.
Do.	—	0.40	—	Karsten.
Fir (*Pinus Abies*) . . .	—	0.23	0.25	"
White Beech	—	0.32	0.35	"
Alder	—	0.35	0.40	"
Red Beech	—	0.38	0.40	"

TABLE III.

Varieties of wood.	Amo'nt of ash in air-dried solid stem-wood.	Wood of branches.	Brush-wood.	Authority.
Beech	0.73	1.54	0.72	Chevandier.
Oak	1.94	1.49	1.32	"
Birch	0.57	1.00	0.48	"
Aspen	1.49	2.38	—	"
Willow	2.94	3.66	—	"
Pine*	1.04	—	—	"
Fir	1.02	—	—	"
Alder	1.38	—	—	"

The knowledge of this alkali dates from time immemorial, and though we offer no proof of its antecedence to soda, it may be as well to remark that ashes were calcined by the Egyptians, and used as caustics. It is called potash from having been prepared for commercial purposes, by the evaporation, in iron pots, of the lixivium of the ashes of wood fuel. Of all the Greek philosophers, Aristotle is the first who announced that the ashes of the rush and reed give an abundant lye. Pliny speaks of alkaline lyes, but we find the first data upon alkali in the writings

* According to Saco, the ashes of pine wood contain 2.3 per cent. of potassa, and 14 per cent. of soda.

of the Arabs; for it was under this name of alkali that both potash and soda were confounded until 1745, when the works of Pott, Duhamel, and Margraaf announced the difference as determined by evident proofs. These two alkalies took their names respectively: the potash, of *vegetable* alkali; the soda, of *mineral* alkali.

The word alkali is compounded of the Arabic name *kali*, which is that of the plant from which it is extracted, and of *al*, which indicates the superiority, or greater strength of the salt over the plant whence it is obtained. The title of mineral alkali, however, is as well applicable to potash as to soda, since the former has been found in feldspar, augite, obsidian, and in the green sand of New Jersey and Delaware, from which latter Wurtz (Silliman, x. 326) has proposed to extract it on a large scale.

It was for a long time doubted, whether the alkalies exist already formed in the plants, or are the product of their combustion, a question now settled ; for the ashes of those woods which have been soaked for a long time in water, do not yield alkali. We will add, however, that combustion seems to augment the quantity. Fontenelle has also announced, that those plants which have undergone an incipient state of putrefaction furnish a greater product. But this increase of quantity doubtless must arise from the absorption of a certain quantity of carbonic acid gas by the alkali.

In the crude state called potashes, it is composed of such constituents of burned vegetables as are very soluble in water and fixed in the fire, and hence contains, besides potassa, other salts and impurities. When this crude potash is calcined, it is partially purified by the action of the fire upon some of its foreign salts and admixtures, and becomes an impure carbonate of potassa, called in commerce *pearlash*.

The process for the extraction of potash from the ashes

of plants, varies according to the substances from which it is to be drawn. It is better to gather the ripe, yet not perfectly dry plants, for Chaptal and Lavoisier both say that, though combustion augments the quantity of alkaline product, it must not be too rapid, else the yield is much lessened. The manufacture of potash is largely carried on in many of the States of the Union, and the process followed is partially that used by the soap boiler for leeching ashes, and is as follows, recollecting, however, that in the latter instance the ashes are already at hand, whereas, in the manufacture of alkali from the plants, the latter must first be reduced to ashes before they can be lixiviated.

This is done by a rough incineration in dry pits, sunk into the ground to a depth of three to four feet. The plants are thrown in portion-wise, and burned until the pit is nearly full of ashes; a method preferable to that of burning them in pyramids, because the combustion is slower, and there is greater protection from the wind. The ashes are then mixed with about five per cent. of lime, and leeched with successive portions of fresh water, in vats similar to those hereafter described for the preparation of soap-lyes. The first liquor running through, being saturated, is passed directly into the evaporating pan; while the second or third runnings, being weaker, are reserved and poured upon fresh ash to bring them up to the required strength. This succession of liquors requires a series of vats; but the system is economical as well as convenient, for one of the cisterns can be kept always ready charged with fresh ash, for bringing up the weak liquors from a nearly exhausted ash to the required degree of saturation. The evaporating pans are broad and shallow, and made of iron, with corrugated bottoms, to produce greater extent of heating surface, and as evaporation progresses, new supplies of strong liquor are poured

in, and the heat continued until a syrupy consistence is attained, when the fire is slackened, and the contents of the pan, gradually brought to a solid state, are dug out and placed away as *crude potash*. By subjecting the crude potash to the heat of a reverberatory furnace, most of the sulphur, and all excessive water and empyreumatic matters, are expelled, causing a loss of ten to fifteen per cent. The product thus modified by the heat, is white, with a bluish tinge, contains more carbonic acid than the original crude product, and takes the name of *pearlash*.

By a second solution of the pearlash, and evaporation of the liquor to a dense volume, and allowing it to repose for several days, the greater portion of .the least soluble impurities will crystallize out and subside to the bottom, leaving a clear, supernatant liquor. This latter, drawn off through a siphon, and evaporated to dryness in clean flat iron pans, during constant stirring towards the end, forms white lumpy granulations, and, as thus treated, it is called *salt of tartar*. This purification of pearlash is founded upon its greater solubility in water than are the neutral salts which debase it.

The ashes of plants are composed of a number of saline constituents, metallic oxides, &c. Of this number are, among the oxides, those of alumina, iron, manganese, and silica; among the salts, the carbonates and hydrochlorates of lime, magnesia, potassa, and soda; the hydriodate of potassa (that is, supposing, with Claubry, that the iodine exists in *varech* under this form), the nitrates of lime, magnesia and potassa; the phosphates of lime, magnesia, and potassa; the sulphates of potassa and soda; and sulphur and bromine.

All these saline constituents do not exist simultaneously in the same plant; those most frequently met with are the subcarbonates and phosphates, the hydrochlorates and sulphates of potassa, also the subcarbonates and phos-

phates of lime, the phosphate of magnesia, the chloride of sodium (hydrochlorate or muriate of soda), the silicate and oxides of iron and manganese.

The marine plants, such as the salsola, the fucus, &c., in place of the subcarbonate and sulphate of potassa, &c., give carbonate and sulphate of soda. Chaptal and Fontenelle have announced that certain plants, such as the *tamarix gallica, &c.*, cultivated upon the coast, or a short distance from the sea, yield salts having soda as their base, whilst those reared ten leagues distant produce potash salts. After what has been said of the constituent principles of ashes, it is easily seen that the potash of commerce must and does contain always more or less of foreign matter, and that such impurities render it unfit, in that state, to be used in the facture of soaps.

We give below Vauquelin's accurate estimate of the amount of alkali in 1,152 parts of each of the following commercial potashes:—

In 1152 parts of	American potash	he found		857	of potassa.
"	"	Russian	"	"	772	"
"	"	Dantzig pearlash		"	683	"
"	"	Vosges	"	"	444	"
"	"	Triers	"	"	251	"

Bley has recently analyzed the potash of Illyria, and found it to contain from 79 to 83 per cent. of carbonate of soda and 12 per cent. of carbonate and sulphate of soda.

To obtain the potassa pure, take equal weights of pearlash and quicklime slaked into powder, dissolve the former in from six to ten times its weight of water, and boil both together for thirty minutes in a clean iron pan. The lime abstracts the carbonic acid from the salt of potash and becomes carbonate of lime, which, being insoluble, precipitates. When the potash salt has been entirely deprived of carbonic acid, a little of the clear liquid taken from the pan will fail to effervesce when acid is added to it. It is a remarkable fact that the decomposition is never com-

plete if the carbonate of potassa or pearlash has been dissolved in less than the prescribed quantity of water. Liebig says that a concentrated solution of potash decomposes carbonate of lime, and consequently hydrate of lime could not, under similar circumstances, decompose carbonate of potassa. The pan, being covered by a lid, may be allowed to cool and settle, after which the supernatant clear solution is drawn off through a lead siphon into a clean iron basin, and rapidly evaporated until an oily liquid remains. This liquid, poured into moulds, forms the stick potassa of the shops. To obtain a purer article requires the use of platinum vessels, more care, and a further extension of the process.

This fused potash is a solid, white, crystalline mass of sp. grav. 1.706, fusible at a heat under redness, and, like the commercial potash, very deliquescent.

Davy, in 1807, discovered potassa to be an oxide of a metal to which he gave the name of potassium, and its percentage composition is—

| Potassium | . | . | . | . | . | 82.98 |
| Oxygen | . | . | . | . | . | 17.02 |

The solution of potash (potash lye) has a slight but peculiar characteristic odor, an acrid taste, and is highly caustic. It absorbs carbonic acid with great avidity from the air, on which account it should be kept in closed vessels. To prepare lye, strong potash should be dissolved in water until the liquid has a strength of 12° Baumé. After having heated this solution to 120° F., add, in five or six separate portions, one pound of quicklime to every two pounds of potash, taking care, however, that one parcel is extinct before another is added, in order that you may evade the heat which would result from a too rapid application of the lime, and which might cause a spattering of the contents of the vessel. When all the lime has been put in, the mixture is run up to and then kept at boiling

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heat for an hour and a half, after which it is allowed to repose, and the supernatant liquor drawn off and preserved in closed vessels. With the above indicated proportions, a solution of potash should be obtained, marking ten to eleven degrees. If for certain operations a greater strength is required, this may be attained by evaporating the solution to the degree requisite. The rationale of the above process is as follows: Commercial potash consists of potassa or oxide of potassium, carbonic acid, and the sulphates and hydrochlorates of potassa. The lime (which is the oxide of calcium), by reason of its greater affinity, abstracts the carbonic acid from the potash and falls down as an insoluble precipitate of carbonate of lime, with any excess of lime that may have been added, whilst the decarbonated potassa remains in solution. The other two salts, being less soluble, crystallize out on cooling.

The following table exhibits the quantity of *fused potassa* in 100 parts of *caustic lye*, at their respective densities:—

Specific grav.	Potassa in 100.	Specific grav.	Potassa in 100.	Specific grav.	Potassa in 100.	Specific grav.	Potassa in 100.	Specific grav.	Potassa in 100.
1.58	53.06	1.46	42.31	1.34	32.14	1.22	23.14	1.10	11.28
1.56	51.58	1.44	40.17	1.32	30.74	1.20	21.25	1.08	9.20
1.54	50.09	1.42	37.97	1.30	29.34	1.18	19.34	1.06	7.02
1.52	48.46	1.40	35.99	1.28	27.86	1.16	17.40	1.04	4.77
1.50	46.45	1.38	34.74	1.26	26.34	1.14	15.38	1.02	2.44
1.48	44.40	1.36	33.46	1.24	24.77	1.12	13.30	1.00	0.00

Soda (NaO).—The earliest knowledge of this alkali is of very remote date. The Arab Geber spoke of it in the 9th century, as a substance kindred to potassa; but the distinction between the two was not definitely established until the time of Bergmann.

The commercial demand for soda is chiefly supplied from two sources—the combustion of marine plants, which furnishes the impure alkalies called *kelp, barilla, salicor, blanquette,* and *varec;* and the decomposition of common salt,

or rather of sulphate of soda, obtained by the decomposition of salt by sulphuric acid.

Native soda.—Soda is found occasionally native in the form of incrustations upon "soda-lakes," having been left there by solar evaporation of the waters. They consist of bicarbonate of soda, with a large portion of sulphate and chloride. The Egyptian article is mineralogically known as *trona*, that from South America and Mexico has the name of *urao*, and that from Hungary is termed *széksó*. Soda is also a constituent of many minerals.

Soda from the combustion of marine plants.—There are a large number of marine plants which yield soda, it being one of the attributes of their nature to assimilate that mineral component of sea water.

The incinerated ashes of the *salsola soda*, fused into gray masses, form the impure carbonate of soda, known in commerce as *barilla*, and imported generally, by way of England, from Spain and the Levant. The ripened plant is cut down and dried, and burned in pits or rude furnaces at a temperature just sufficient to cause the ashes to enter into a state of semi-fusion, so as to concrete on cooling into moderately compact cellular masses. The most valuable variety of this article has a grayish-blue color, and, when exposed to the air for some time, effloresces at the surface. It is hard and difficult to break, and, when applied to the tongue, gives a pungent alkaline taste. Its average proportion of free or alkalimetrical soda, according to Ure, is about 17 per cent., though several varieties contain but 14, whilst a few even reach as high as 20 per cent. This soda is chiefly a carbonate, with a little sulphuret and sulphite, and is mixed with sulphate and muriate of soda, carbonate of lime, carbon, &c.

The *salicornia annua*, cultivated on the French coasts of the Mediterranean, yields an ash containing 14 to 15

per cent. of carbonate of soda, commercially known as *salicor*.

Blanquette is the ash of the coast plants of southern France, and contains from 3 to 8 per cent. of soda. *Varec* or *kelp* is the incinerated product of the sea weeds of the shores of the North Sea. Formerly, "very large revenues were derived, by the proprietors of the shores of the Scottish islands and the Highlands, from the incineration of sea weed by their tenants, who usually paid their rents in *kelp ;*" but since the manufacture of soda from salt has been generally established, the article is not much used. The proportion of alkaline constituent varies with the source whence the kelp is obtained.

Ure analyzed two specimens, the result of which is as follows, as regards their soluble portion :—

Sulphate of soda	8.0	19.0
Soda, as carbonate and sulphuret	8.5	5.5
Muriates of soda and potassa	36.5	37.5
	53.0	62.0

The insoluble matter consisted of

Carbonate of lime	24.0	10.0
Silica	8.0	0.0
Alumina tinged with iron oxide	9.0	10.0
Sulphate of lime	0.0	9.5
Sulphur and loss	6.0	8.5
	100.0	100.0

Kelp also contains metallic iodides. The first of these specimens was from Heisker, the second from Rona, both in the Isle of Skye. From other analyses besides these, the composition of kelp is proven to be too variable and meagre in soda power, to be used as the alkaline material in soap making; and the very low price that *soda ash*, which is nothing more than dry crude carbonate of soda, from the decomposition of sea salt, is now sold for, renders it a most acceptable substitute.

A solution of caustic soda, or soda lye, is obtained by decomposing the *soda ash* (dissolved in four or five times its weight of water) by means of half its weight of hydrate of lime; the same points being attended to, as in the preparation of potash lye. The solution thus obtained contains foreign salts, as the chloride of sodium and sulphate of soda, &c.; but Mr. W. Blyth says, that by concentrating it considerably, these salts become insoluble and precipitate. We give below Richter's table of the quantity of *caustic soda* contained in *lyes* of different densities.

Sp. grav.	Soda per cent.	Sp. grav.	Soda per cent.	Sp. grav.	Soda per cent.	Sp. grav.	Soda per cent.
1.00	0.00	1.12	11.10	1.22	20.66	1.34	31.67
1.02	2.07	1.14	12.81	1.24	22.58	1.35	32.40
1.04	4.02	1.16	14.73	1.26	24.47	1.36	33.08
1.06	5.89	1.18	16.73	1.28	26.33	1.38	34.41
1.08	7.69	1.20	18.71	1.30	28.16		
1.10	9.43			1.32	29.96		

* Soda is soluble in all proportions of water and alcohol, and the *solid fused soda* is obtained by evaporation precisely in the same manner as the corresponding preparation of potash. Soda is distinguished from potassa and other bases by several properties: 1st. All its salts are soluble in water, and it is therefore not precipitated by tartaric acid, chloride of platinum, or any reagent except the antimoniate of potassa which throws down white antimoniate of soda, provided the solution is neutral or slightly alkaline and free from carbonate. 2d. With sulphuric acid it gives a salt which crystallizes in large efflorescent prisms, easily recognized as Glauber's salt. 3d. Its salts communicate a rich yellow tint to flame.

Until 1817, soda was considered a mineral alkali, but at that time Davy discovered that it is an oxide of a

metal to which he gave the name of sodium. Its composition is:—

Sodium	74.20
Oxygen	25.80
	100.00

This combination forms the protoxide of sodium. It is white, very caustic, and, when exposed to air at the ordinary temperature, attracts moisture and deliquesces; if the contact is prolonged, it absorbs carbonic acid, becomes efflorescent, and passes into the state of a subcarbonate. The oxide of sodium combining with water, forms a hydrate.

Artificial sodas.—This is the title given to the sodas extracted from common sea salt by a process of Leblanc, a French chemist, made known towards the close of the last century. The supply of Spanish barilla being cut off from France during the cessation of the commercial intercourse between France and Spain at the time of the French Revolution, the National Convention made an appeal to the chemists of France, to devise a process in which common salt might be made available as a source of soda. The result was Leblanc's discovery, whose method is that still practised most generally both in Europe and in this country. The inventor, it is said, neglected by the government of his native country, after having spent all his own means in perfecting his plan, at last died in a hospital. The British government, however, gave him a handsome reward, and at Greece and Rome, statues of the inventor have been erected.

The process consists in decomposing with sulphuric acid common sea salt, improperly called muriate of soda, it being a combination of two elementary substances, chlorine and sodium, in the proportion of one equivalent (35.5 parts by weight) of the former, and one equivalent

(23 parts) of the latter. Its proper designation, therefore, is the chloride of sodium. It contains no water of crystallization. The salt being converted by the sulphuric acid into a sulphate of soda by proper manipulation and arrangements, a reaction takes place during the operation, and may be easily understood by the assistance of the following diagram.

Reaction of strong oil of vitriol (sulphuric acid, containing only one equivalent of water) on common salt (chloride of sodium).

Before decomposition.

After decomposition.

58.5 Chloride of sodium .. { 35.5 Chlorine . . — 36 Hydrochloric acid.
23 Sodium . . . .

49 Oil of vitriol { 1 Hydrogen . . .
8 Oxygen . . . .
40 Sulphuric acid . . — 71 Sulphate of soda.
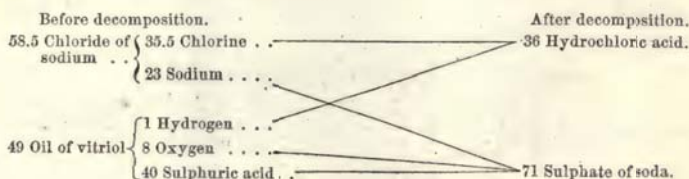
From which it appears that 58.0 parts of common salt should afford, when sufficient sulphuric acid is added, 71.0 parts of dry sulphate of soda.

The sulphate of soda being obtained, the next step in the process consists in calcining it with chalk or broken limestone, and coal dust, in certain proportions, in a reverberatory furnace called the *fluxing* or *black ash* furnace.

The product of this operation, which is known as black ash, black ball, and British barilla, should contain from 30 to 35 per cent. of available alkali. Its composition varies considerably and with the skill of the furnacer; the principal insoluble constituents are carbonaceous matters, sulphate and carbonate of lime and a compound of lime and sulphuret of calcium; the soluble ingredients are, carbonate of soda, undecomposed sulphate of soda and common salt, caustic soda, and generally some sulphuret or bisulphuret of sodium.

The operation of calcining is the most important part

of the soda process. By the fusion of sulphate of soda
with coal, the former parts with either the whole or a
portion of its oxygen, and is thereby reduced either to the
state of sulphuret of sodium only, or else to a mixture of
sulphuret of sodium and carbonate of soda.

In effecting this abstraction of oxygen, the hydrogen
of the coal plays as important and active a part as the
carbon; but in the following diagram, illustrative of this
decomposition, the carbon of the coal may be supposed,
for the sake of simplicity, to be the only reducing agent
concerned.

Reduction of Sulphate of Soda by Carbon.
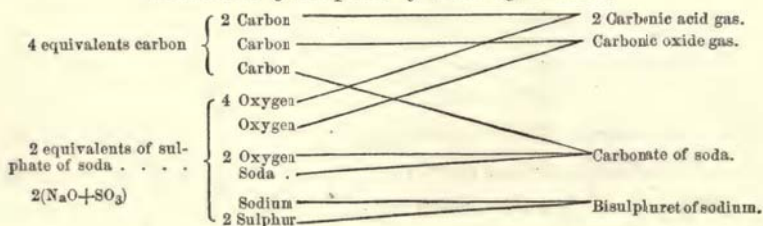
The above is Liebig's explanation. If carbon is pre-
sent in a greater proportion, it is taken up by the carbonic
acid gas, which thereby is reduced to a state of carbonic
oxide. By the fusion of sulphate of soda with carbonate
of lime, as well as with coal, the sulphuret of sodium pro-
duced through the latter is converted into carbonate of
soda. The calcium of the carbonate of lime and the sodium
of the sulphuret exchange places, and the resulting sub-
stances are sulphuret of calcium and carbonate of soda.
The calcination of sulphate of soda with both coal and
carbonate of lime, is by no means essential to the process.

Three hundred weight of material constitute a charge,
and the product of this charge, the black ash, or "*black
ball*," before spoken of, is now subjected to another opera-
tion, by which is effected the separation of all the soluble
constituents from the carbonaceous and other insoluble

matters. This process consists in lixiviation, evaporation, and calcination, and the residue, when ground under edge stones, or in one of Bogardus's eccentric mills (Fig. 1), is

Fig. 1.
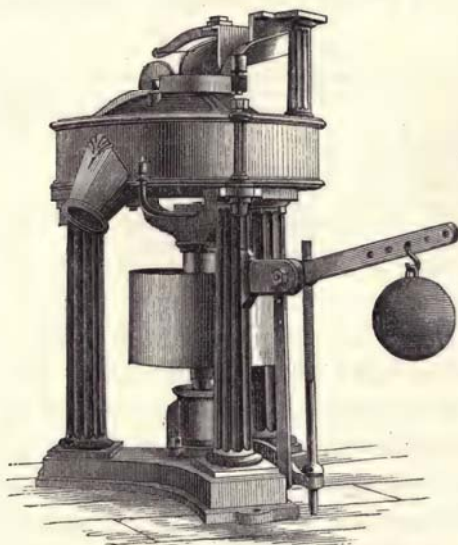
the *white ash* or *soda ash* of commerce. The article thus prepared is sufficiently pure for ordinary manufacturing purposes, but Descroizilles says, that some artificial sodas bear the just reproach of being too highly charged with hydrosulphurets, which render the ash unfit for making white soap; and of also possessing, at the moment of their fabrication, a degree of alkalimetrical strength, which they very soon lose. Some sodas are so highly charged, that they deliquesce and emit a characteristic odor of rotten eggs. Now-a-days, however, the processes are so perfect that both the French and English sodas are uniformly of a beautiful gray ash color, without odor or much varia-tion in specific gravity, and mostly of uniform properties. Soda, nearly caustic, is now largely manufactured at Pitts-

burg. The sulphuretted sodas, nevertheless, are more suitable than the purer, for making marbled soaps.

The following table, from *Brown*, shows the composition of the different products of the soda manufacture:—

	1	2	3	4	5	6	7
Carbonate of soda . . .	68.91	71.61	79.64	84.00	84.31	96.47	98.12
Hydrate of soda	14.43	11.23	2.71	1.06	trace	90.94	1.08
Sulphate of soda . . .	7.02	10.20	8.64	8.76	10.26	...	...
Sulphite of soda . . .	2.23	1.11	1.24	trace	trace	...	...
Sulphide of sodium . .	1.31	...	trace	...	...	...	...
Chloride of sodium . .	3.97	3.05	4.13	3.22	3.48	0.42	0.74
Soda alumina	1.02	0.92	1.17	1.01	0.63	...	...
Silicate of soda	1.03	1.04	1.23	0.98	0.41	...	...
Insoluble matter and sand	0.81	0.31	0.97	0.71	0.25	...	...
Water	...	...	...	...	...	02.15	...

Analysis No. 1 is the salt obtained by evaporating the extract of the crude soda to dryness at 212°, and then heating in a calciner, which makes No. 2 soda ash ; or, the extract is evaporated nearly dry, the mother liquor drained off from the crystals; the dried residue, 3, is heated in a furnace, 4. By repeated solution, evaporation and calcination of the crystals, a better kind, 5, is produced, and by crystallizing the purer kind, *soda*, 6, results; and when this is calcined, the best product, 7, is obtained.

There are many modifications of the preceding method of making soda ash, but they do not (with one exception) materially differ from the latter, in general principles. That exception is Tilghman's process, by which, with the aid of high steam, alumina, and carbonic acid, common salt is reduced to soda and converted into carbonate in quickly succeeding steps of the same process. This mode, so well grounded in theory, promises, when practically developed in detail, to produce an important change in the manufacture of caustic and carbonated soda, as it will, by its great economy of time and money, reduce their

price to the minimum. Experiments are now being made with it, in this country, upon a very extensive scale.

To obtain the crystallized carbonate of soda, a further purification and solution of the ash and crystallization must be resorted to. Crystallized carbonate of soda consists of

Carbonic acid	15.37
Soda	21.83
Water	62.80
	100.00

Its crystals are colorless, transparent rhomboids, which readily effloresce in the air and melt in their own water of crystallization.

AMMONIA, NH_3.—This substance has a very unimportant relation to our subject, and is only treated of here, because of its being the basis of ammoniacal soap, and having properties analogous to those of potassa and soda. In its pure state, it is a gas at all temperatures, and hence its name *volatile* alkali, in contradistinction to the remaining three (potassa, soda, and lithia), which are called *fixed* alkalies, they not being at all volatile at red heat.

Ammonia is a gas of which the *aqua ammoniæ* is a solution, and, in its caustic state, is thus met with in commerce. It has a strong, pungent odor, and is recognized by this and its transient alkaline effect upon vegetable colors, and the production of white fumes when it is approached by hydrochloric acid. Ammonia, as a gas, is a compound of nitrogen and hydrogen, and consists as follows :—

Nitrogen	.	.	1 atom $=$ 14		82.35
Hydrogen	.	.	3 atoms $=$ 3		17.65
				17	100.00

Pure ammonia is obtained in the form of gas, by heating a mixture of quicklime and muriate of ammonia. Water absorbs 780 times its volume of this gas, and by

this absorption, the volume of the water is increased in the ratio of six to ten. Its specific gravity in the gaseous state is 0.590. The specific gravity of water saturated with ammoniacal gas is 0.900, and contains, in weight, water 74.63, ammonia 25.37 = 100.00.

The title of ammonia originated from the fact of the camel's dung, its original source, collected for the purpose in Egypt, having been burned about the temple of Jupiter Ammon. Davy and Ure have prepared tables which exhibit the percentage of ammoniacal gas contained in ammoniacal solutions of different specific gravities. We compile therefrom as follows :—

Table of the Strength of Caustic Ammonia.

DAVY.		URE.	
Specific gravity.	Per cent. of Ammonia.	Specific gravity.	Per cent. of Ammonia.
0.8750	32.30	0.8914	27.940
.8857	29.25	.8937	29.633
		.8969	29.038
		.8983	26.751
.9000	26.00	.9000	26.500
.9054	25.37	.9045	25.175
		.9090	23.850
.9166	22.07	.9133	22.525
		.9177	21.200
.9255	19.54	.9227	19.875
		.9275	18.550
.9326	17.52	.9320	17.225
.9385	15.88	.9363	15.900
.9435	14.53	.9410	14.575
.9476	13.46	.9455	13.250
.9513	12.40	.9510	11.925
.9545	11.56		
.9573	10.82	.9564	10.600
.9597	10.17		
.9616	9.60	..9614	9.275
.9692	9.50	.9662	7.950
		.9716	6.625
		.9828	5.500
		.9887	3.975
			2.650

CHAPTER IV.

ALKALIMETRY.

ALKALIMETRY is that branch of chemical art by which the practical value of commercial potash, soda ash, and alkaline matters generally, may be estimated. This practical value is in proportion to the amount of caustic and carbonated alkali which they contain, for there is always more or less accompaniment of foreign matters and salts, wholly unavailable, for the purposes of the soap and candle manufacturer.

The necessary appliances are an alkalimeter, a glass-graduate (Fig. 2), a small balance with weights from one-tenth of a grain upwards to 100 grains, a glass mortar,

Fig. 2.

Fig. 3.

one 8 oz. beaker glass (Fig. 3), one 8 oz. jar with lip (Fig. 5), a glass funnel, two glass rods, and filtering paper.

The "*alkalimeter*" is a tall glass cylinder, of 12 inches height, and three-fifths of an inch internal diameter, closed at the bottom, and graduated uniformly downwards into 100 divisions. Its form is shown by Fig. 4; and it may be obtained, with all the necessary apparatus, from

Bullock & Crenshaw, Philadelphia; and J. J. Griffin, London.

Fig. 4.
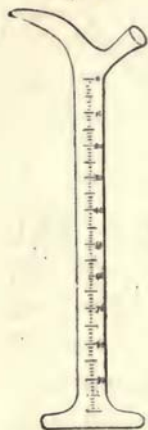
The process consists in determining the quantity of an acid required to neutralize the alkaline reaction of a known weight of the sample of potash, or soda ash, &c., to be tested, which must, of course, be equivalent to the amount of alkalies present in a free state, or as carbonate. Sulphuric acid being the best for the purpose, is the one generally employed; for, while it wholly expels the carbonic acid, and takes up all the soda or potassa existing free or as a carbonate, it does not extend its decomposing influence to the foreign salts, in any important degree, and therefore affords sufficiently accurate results for practical purposes.

The decomposition is regulated strictly by the laws of definite proportions; and the test acid is adjusted to such a strength that the one hundred alkalimetrical divisions of it will be exactly equal to one equivalent of potassa, or of soda, as the case may be. In other words, the above volume of test liquid should precisely neutralize 53 grains of pure anhydrous carbonate of soda (one equivalent) containing 31 grains (one equivalent) of pure or caustic soda. The equivalent of potassa being 47, and higher than that of soda, of course, the 100 volumes of test acid will represent 69 grains (one equivalent) of anhydrous carbonate of potassa, containing 47 grains (one equivalent) of caustic potassa. So in like manner will the same volume neutralize one equivalent, or 17 grains, of caustic ammonia, and 28 grains, or one equivalent, of caustic lime.

The mode of adjusting the strength of the acid is to pour into a beaker glass ten fluidounces of distilled water,

and add to it, *dropwise, during constant stirring with a glass rod*, one fluidounce of commercial sulphuric acid of 66° Baumé. When the mixture is complete and cool, the alkalimeter is filled with it through the opening *b*, exactly to the level of the mark *O*. This being done, a solution of 53 grains of pure and dry neutral carbonate of soda, in one or two fluidounces of water, is prepared. The carbonate of soda, for this purpose, may be made by heating to dull redness, in a platinum crucible, a quantity of pure bicarbonate of soda until all the water and bi-equivalent of carbonic acid is driven off. All being ready, a slip of litmus paper is placed in the soda solution, and the test acid allowed to flow in it, dropwise, through the capillary opening, *a*, during constant stirring, until the test paper begins to assume a red tint, when the whole is left for a few minutes, or until all effervescence has ceased. The liquid is then tested with a fresh slip of litmus paper, and if the blue is barely reddened, and this reddening is not restored to blue by gently warming the test paper, the neutralization is exact; and the level of the test acid remaining in the alkalimeter must be noted, to learn the number of divisions that have been poured out for the purpose of neutralizing to 53 grains, or one equivalent, of carbonate of soda. Let us suppose, for the sake of explanation, that fifty divisions of acid have been consumed; then these fifty divisions contain one equivalent of acid, equal in neutralizing power to one equivalent of soda or potassa, and therefore the whole of the acid liquor must be accurately measured off, and thoroughly mixed with distilled water in the exact proportion of fifty to fifty equal volumes. In this way the acid liquor is adjusted to such a strength that 100 of the divisions of the alkalimeter will just neutralize 53 grains of carbonate, or 31 grains of caustic soda, and must be immediately put into

glass stoppered bottles, to be preserved for use as it may be wanted.

The manipulations to be observed, in testing a sample of soda ash, or potash, are as follows:—

Fifty grains of an average sample are carefully weighed and rubbed up in the mortar with fresh portions of dis-

Fig. 5.

tilled water, until all soluble matter is extracted. As each portion of the water becomes charged, it is filtered through paper, as shown by Fig. 5, in order to separate insoluble foreign matters which might interfere with the accuracy of the test. The liquor which passes will be clear, and must be set aside for a few minutes, during which the alkalimeter is to be filled with the test acid exactly to the line *O*, and a dozen slips of blue and red litmus paper prepared. The alkalimeter is then taken with the right hand in manner as shown by Fig. 6, and inclined upon the ledge of the glass containing the filtered solution of the material

Fig. 6.
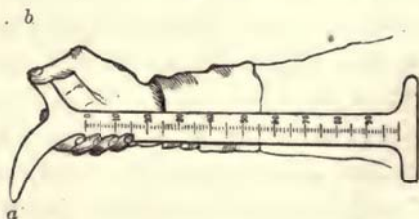
to be tested, so that the acid may run out in a thin stream or dropwise, through the capillary opening *a*. The flow of the liquid can be easily adjusted by regulating the admission of air with the thumb at *b*, as may be necessary. The liquid is to be continually stirred with a glass rod, during the addition of the acid, so as to facilitate the

escape of the carbonic acid which is set free and produces effervescence. When about sixty divisions of the alkalimeter have been emptied, it is prudent to note how near the alkaline solution approaches to saturation; and this is done by letting a drop of the mixture fall upon a slip of blue litmus paper. As the characteristic property of acids is to redden blue litmus, it consequently follows, if there is no change of the color of the paper, that sufficient acid has not been added, and therefore a few more hundredths, or divisions, must be poured in, and the mixture again examined with litmus paper. These cautious additions and testings are alternately continued until the paper begins to take a feeble red tint, which is indicative of saturation. Care must be taken to observe the distinction between the purplish red tint, which carbonic acid produces towards the end of the operation, and the distinct reddening caused by the sulphuric acid just beyond the point of neutralization. As long as any caustic or carbonated alkali remains in the mixture, a drop of it will restore the blue color of reddened litmus paper, and as soon as every atom is neutralized, the blue litmus paper assumes a red color.

When the point of saturation is attained, the level of the test acid remaining in the alkalimeter must be carefully read off and a note made of the number of divisions consumed. Suppose, for explanation, that 80 have been required, then as the whole hundred are only equal to 1 equivalent of soda = 31; or 1 equivalent of potassa = 47, the 50 grains of material under examination contain only 80 parts of one equivalent of either; or, in other words, 24.80 grains of caustic soda, or 37.60 grains of caustic potassa, accordingly as the material may have been soda ash or potash. As fifty grains were taken for this assay, it is only necessary to double the number to get the percentage composition.

5

CHAPTER V.

ACIDS.

THESE, composing a large class of bodies in the organic and mineral kingdoms, are found sometimes free, but usually combined with bases. In the earlier days of the modern science of chemistry, it was usual to apply this term to such oxidized bodies as possessed a sour taste, reddened certain vegetable blue colors, and neutralized alkalies. It soon became evident that the definition of the term acid should be extended; for some acids, such as the hydrochloric, hydriodic, &c., contain no oxygen (formerly considered the sole acidifying principle), excepting when in an aqueous solution; and some bodies analogous to acids, and possessing many of their properties, are insoluble in water, and therefore can neither redden litmus nor taste sour: such is the silicic acid. Lastly, some acids have not the power of masking the alkaline nature of potassa or soda, excepting when in excess: thus the carbonate of potassa and soda, and the sulphate of soda, exhibit alkaline reaction. The subsequent development of sulphur salts by Berzelius led to the further extension of the term acid to certain sulphurets, such as sulphuretted hydrogen, &c. It is difficult to give a definition of acids which may at the same time be technically precise and chemically correct.

The acids, a knowledge of some of which is important to the soap-boiler, are arranged into two classes, inorganic and organic. The latter will be studied when we speak of fats and oily matters; those of the former division,

connected with our art, will be mentioned directly. Practically speaking, the general properties of acids are a sour taste, and the power of changing certain vegetable blue colors, such as litmus, to red. Their capability of forming salts by saturating or neutralizing earthy or metallic oxides, is a more general characteristic than any other. The insoluble silicic acid, and such like, do not, as before mentioned, of course, taste sour; and the boracic, although soluble in water, has scarcely an acid taste; but both neutralize bases—the former by fusion, and the latter either in that way or in solution.

Acids are classified into *oxacids* and *hydracids.* The first are those in which a simple body, called the *radical* of the acid, is united with oxygen; as the sulphuric from sulphur and oxygen, the carbonic from carbon and oxygen.

The hydracids are produced by the combination of hydrogen with a non-metallic simple substance, in the proportion of one equivalent of each; as the hydrochloric, from hydrogen and chlorine; as the hydriodic, from hydrogen and iodine, &c.

CARBONIC ACID (CO_2).—This acid, also sometimes called fixed air and mephitic air, was first found by Dr. Black to exist in limestone and the mild alkalies, and to be expelled from them by heat and the action of acids. It occurs also in the atmosphere, forming about 0.05 of one per cent. in volume; is ejected from volcanoes, caves, and cellars; exists in mineral springs, and is thrown off from the lungs in respiration. It is also a product of the vinous fermentation; and the staleness of beer, ale, and other fermented liquors, upon exposure to air, is occasioned by the loss of this acid, to which is due their agreeable pungency. It is also largely produced by the combustion of carbonaceous fuel, of the diamond, and organic substances, in air or oxygen.

Carbonic acid, at ordinary pressures, is a transparent,

colorless gas, of a slightly piquant odor and sourish taste. It feebly reddens the vegetable blues, extinguishes flame, and, when inspired, produces asphyxia. Water, under the pressure of the atmosphere, and at 68° F., can dissolve its volume.

The specific gravity of the gas is 1.5291, the air being reckoned as unity. This acid combines with most of the salifiable bases, and forms carbonates decomposable by all the mineral acids, save the hydrosulphuric and hydro-selenic acids, which, upon some carbonates, are without action. The same decomposing power is possessed by many of the mineral acids also; and the effervescence following the application of an acid to a carbonate is due to the escape of the gaseous acid, which is set free by the union of the base, to which it was connected, with the acid added, and for which latter the affinity is much stronger.

When carbonic acid has accumulated in wells, cellars, &c., its presence can be ascertained by letting down a lighted taper, which, if it be not extinguished, indicates that the air may be safely breathed for a short time. Carbonic acid, being so much denser than common air, may be drawn out of cellars or fermenting tubs by a pump, furnished with a leather hose, which reaches to the bottom. Quicklime, mixed with water, on account of its affinity for and power of absorbing it, can be used to purify the air of this aerial acid. In the arts, it is used in the preparation of aerated waters; and the "mineral water" of our day, and much of the so-called champagne wine, is nothing more than—the first, an aqueous solution of carbonic acid; the latter, purified cider, surcharged with carbonic acid gas, pumped in by means of forcing pistons. Liquefied by pressure, carbonic acid has an elastic force of 38.5, atmosphere at 32° F.; and, when allowed to escape through a small jet, it partially solidifies by its own eva-poration, and forms a white, soft mass like snow, which

may be handled, and does not evaporate very rapidly, owing to its low conducting power, although its temperature cannot be more than 148° F. Dr. J. K. Mitchell exhibited and explained these phenomena with improved apparatus, some ten years since, at the Franklin Institute of Philadelphia.

SULPHURIC ACID (SO_3).—The extensive application of oil of vitriol has rendered it by far the most important of all acids used in the arts. It is less expensive, and in energy surpasses all other acids, possessing, by its superior affinity for bases, a power liberative of most of them from their combinations.

Sulphuric acid, and oil of vitriol, which is a hydrate (SO_3+HO), is a combination of sulphur with oxygen, in the proportion of three equivalents of the latter to one equivalent of the former.

The earliest mention of sulphuric acid is by Basil Valentine, a celebrated alchemist, who wrote in the early part of the fifteenth century. The original process by which it was prepared consisted in the distillation of dried copperas, which is the sulphate of the protoxide of iron. The highly concentrated liquor which passed over into the receiver, having an oily appearance and consistence, gave rise to the name of oil of vitriol; green vitriol being the title then applied to the copperas or protosulphate of iron which furnished it. This process is still adhered to at Nordhausen, in Saxony, but in most countries has been abandoned for a much better method. The acid of commerce is a transparent colorless liquid, and should mark 66° Baumé. It freezes at 29° below zero, and boils at 620° F. Submitted to distillation, it volatilizes and passes over without being decomposed, and it is upon this property that its purification is founded; a process necessary to be resorted to when it is to be used for analytical pur-

poses, as the commercial acid contains more or less foreign matters.

Sulphuric acid has a great affinity for water, and much heat is evolved when the two are brought together. It is necessary to be careful when mixing them to use a thin beaker glass as the containing vessel, and to pour the acid portion-wise into the water during constant stirring of the latter, so as to prevent breakage and ejection of particles.

The following table by Ure, shows the quantity of concentrated and dry sulphuric acid in 100 parts of dilute at different densities:—

Liquid.	Specific gravity.	Dry.	Liquid.	Specific gravity.	Dry.	Liquid.	Specific gravity.	Dry.
100	1.8460	81.54	66	1.5503	53.82	32	1.2334	26.09
99	1.8438	80.72	65	1.5390	53.00	31	1.2260	25.28
98	1.8415	79.90	64	1.5280	52.18	30	1.2184	24.46
97	1.8391	79.09	63	1.5170	51.37	29	1.2108	23.65
96	1.8366	78.28	62	1.5066	50.55	28	1.2032	22.83
95	1.8340	77.46	61	1.4960	49.74	27	1.1956	22.01
94.	1.8288	76.65	60	1.4860	48.92	26	1.1876	21.20
93	1.8235	75.83	59	1.4760	48.11	25	1.1792	20.38
92	1.8181	75.02	58	1.4660	47.29	24	1.1796	19.57
91	1.8026	74.20	57	1.4560	46.48	23	1.1626	18.75
90	1.8070	73.39	56	1.4460	45.66	22	1.1549	17.94
89	1.7986	72.57	55	1.4360,	44.85	21	1.1480	17.12
88	1.7901	71.75	54	1.4265	44.03	20	1.1410	16.31
87	1.7815	70.94	53	1.4170	43.22	19	1.1330	15.49
86	1.7728	70.12	52	1.4073	42.40	18	1.1246	14.68
85	1.7640	69.31	51	1.3977	41.58	17	1.1165	13.86
84	1.7540	68.49	50	1.3884	40.77	16	1.1090	13.05
83	1.7425	67.68	49	1.3788	39.95	15	1.1019	12.23
82	1.7315	66.86	48	1.3697	39.14	14	1.0953	11.41
81	1.7200	66.05	47	1.3612	38.32	13	1.0887	10.60
80	1.7080	65.23	46	1.3530	37.51	12	1.0809	9.78
79	1.6972	64.42	45	1.3440	36.69	11	1.0743	8.97
78	1.6860	63.60	44	1.3345	35.88	10	1.0682	8.15
77	1.6744	62.78	43	1.3255	35.06	9	1.0614	7.34
76	1.6624	61.97	42	1.3165	34.25	8	1.0544	6.52
75	1.6500	61.15	41	1.3080	33.43	7	1.0477	5.71
74	1.6415	60.34	40	1.2999	32.61	6	1.0405	4.89
73	1.6321	59.52	39	1.2913	31.80	5	1.0336	4.08
72	1.6204	58.71	38	1.2826	30.98	4	1.0268	3.26
71	1.6090	57.89	37	1.2740	30.17	3	1.0206	2.44
70	1.5975	57.08	36	1.2654	29.35	2	1.0140	1.63
69	1.5868	56.26	35	1.2572	28.54	1	1.0074	0.81
68	1.5760	55.45	34	1.2490	27.72			
67	1.5648	54.63	33	1.2409	26.91			

HYDROCHLORIC ACID, HCl.—Muriatic acid, known com-

monly as marine acid, and spirits of salt, is gaseous at the ordinary temperature, but is readily condensed by water. It is in aqueous solution that we meet with it in commerce, and as such usually with a yellow tinge; but the chemically pure acid is perfectly colorless. The yellow tinge is owing to the presence of iron, which initiates itself during the course of preparation; the process being conducted in iron retorts, and by the action of sulphuric acid upon common salt, with the assistance of heat. Under the pressure of 40 atmospheres at 50° F. the gas is condensed into a liquid of specific gravity, 1.27; and, according to Dr. Thomson, one cubic inch of water absorbs 418 cubic inches of gas at 69° F., and becomes 1.34 cubic inch. Its composition is one equivalent of chlorine, and one equivalent of hydrogen. The following table of his construction gives the specific gravity of hydrochloric acid of determinate strengths, adjoining which we also affix the useful table of Mr. Davy:—

HYDROCHLORIC ACID.						HYDROCHLORIC ACID.			
Atoms of water to one of acid.	Real acid in 100 of the liquid.	Specific gravity.	Atoms of water to one of acid.	Real acid in 100 of the liquid.	Specific gravity.	Specific gravity.	Quantity of acid per cent.	Specific gravity.	Quantity of acid per cent.
6	40.66	1.203	14	22.70	1.1060	1.21	42.43	1.10	20.20
7	37.00	1.179	15	21.512	1.1008	1.20	40.80	1.09	18.18
8	33.95	1.162	16	20.442	1.0960	1.19	38.38	1.08	16.16
9	31.35	1.149	17	19.474	1.0902	1.18	36.36	1.07	14.14
10	29.13	1.139	18	18.590	1.0860	1.17	34.34	1.06	12.12
11	27.21	1.1285	19	17.790	1.0820	1.16	32.32	1.05	10.10
12	25.52	1.1197	20	17.051	1.0780	1.15	30.30	1.04	8.08
13	24.03	1.1127				1.14	28.28	1.03	6.00
						1.13	26.26	1.02	4.04
						1.12	24.24	1.01	2.02
						1.11	22.22		

The liquid muriatic acid has a very sour taste, a pungent suffocating smell, and acts very powerfully upon a very large number of mineral, vegetable, and animal substances. Its specific gravity is 1.2474. A mixture of two measures of muriatic, and one of nitric acid, forms the *aqua regia*, so called from its property of dissolving

gold and the less oxidable metals, platinum, &c. The power of nitric acid to decompose hydrochloric acid (an evolution of chlorine taking place by the oxidation of the hydrogen of the acid) imparts to it this property. For analytic purposes, the commercial acid should be purified of the foreign matters which are always present in the commercial article.

NITRIC ACID, NO_5.—This acid, called also *aquafortis*, is never found isolated. It was known as far back as the thirteenth century, and is now obtained by distillation of a mixture of cubic nitre (nitrate of soda) and sulphuric acid. The soda having a stronger affinity for the sulphuric acid, unites with it to form sulphate of soda, which remains in the retort, while the nitric acid set free passes over and is condensed in receivers.

Commercial aquafortis is generally contaminated with foreign salts, which may be gotten rid of by a re-distillation at a gentle heat. For analytic purposes, it must be further purified. In its dry state, this acid consists of one equivalent of oxygen, and five equivalents of nitrogen.

The pure liquid acid is colorless, odorant, and corrosive; that of commerce has a slight straw-color tint. Nitric acid has a great affinity for water, which is necessary to its existence, and at its maximum of strength (specific gravity 1.522) contains one equivalent.

As, in a number of operations, it is requisite to know the quantity of real acid contained in 100 parts of a mixture of known density, we here add the following table by Ure :—

Specific gravity.	Liquid acid in 100.	Dry acid in 100.	Specific gravity.	Liquid acid in 100.	Dry acid in 100.	Specific gravity.	Liquid acid in 100.	Dry acid in 100.
1.5000	100	79.700	1.3783	66	52.602	1.1895	33	26.301
1.4980	99	78.903	1.3732	65	51.805	1.1833	32	25.504
1.4960	98	78.106	1.3681	64	51.068	1.1770	31	24.707
1.4940	97	77.309	1.3630	63	50.211	1.1709	30	23.900
1.4910	96	76.512	1.3579	62	49.414	1.1648	29	23.113
1.4880	95	75.715	1.3529	61	48.617	1.1587	28	22.316
1.4850	94	74.918	1.3477	60	47.820	1.1526	27	21.519
1.4820	93	74.121	1.3427	59	47.023	1.1465	26	20.722
1.4790	92	73.324	1.3376	58	46.226	1.1403	25	19.925
1.4760	91	72.527	1.3323	57	45.429	1.1345	24	19.128
1.4730	90	71.730	1.3270	56	44.632	1.1286	23	18.331
1.4700	89	70.933	1.3216	55	43.835	1.1227	22	17.534
1.4670	88	70.136	1.3163	54	43.038	1.1168	21	16.737
1.4640	87	69.339	1.3110	53	42.241	1.1109	20	15.940
1.4600	86	68.542	1.3056	52	41.444	1.1051	19	15.143
1.4570	85	67.745	1.3001	51	40.647	1.0993	18	14.346
1.4530	84	66.948	1.2947	50.	39.850	1.0935	17	13.549
1.4500	83	66.155	1.2887	49	39.053	1.0878	16	12.752
1.4460	82	65.354	1.2826	48	38.256	1.0821	15	11.955
1.4424	81	64.557	1.2765	47	37.459	1.0764	14	11.158
1.4385	80	63.760	1.2705	46	36.662	1.0708	13	10.361
1.4346	79	62.963	1.2644	45	35.865	1.0651	12	9.564
1.4306	78	62.166	1.2583	44	35.068	1.0595	11	8.767
1.4269	77	61.369	1.2523	43	34.271	1.0540	10	7.970
1.4228	76	60.572	1.2462	42	33.474	1.0485	9	7.173
1.4189	75	59.775	1.2402	41	32.677	1.0430	8	6.376
1.4147	74	58.978	1.2341	40	31.880	1.0375	7	5.579
1.4107	73	58.181	1.2277	39	31.083	1.0320	6	4.782
1.4065	72	57.384	1.2212	38	30.286	1.0267	5	3.985
1.4023	71	56.587	1.2148	37	29.489	1.0212	4	3.188
1.3978	70	55.790	1.2084	36	28.692	1.0159	3	2.391
1.3945	69	54.993	1.2019	35	27.895	1.0106	2	1.594
1.3882	68	54.196	1.1958	34	27.098	1.0053	1	0.797
1.3833	67	53.399						

Aquafortis, strictly speaking, is a weaker nitric acid; whilst *nitrous* or hyponitric acid, a title which is sometimes improperly given thereto, is a separate and distinct definite compound of oxygen and nitrogen (NO_4). In acting upon the less oxidable metals, such as copper and mercury, nitric acid is itself decomposed, and nitric oxide gas (NO_2) is evolved with effervescence and in red fumes.

BORACIC ACID, BO_3.—This acid is a compound of oxygen with an elementary substance, *Boron*. It is prepared by adding one part of oil of vitriol to a boiling and saturated solution of four parts of borax in water, and filtering while hot. On cooling, the acid crystallizes out in thin

plates. Its application in candle-making will be spoken of hereafter.

Boracic acid is inodorous, and has a weak scarcely acid taste, and affects blue litmus paper like carbonic acid, imparting to it only a light red tint, and not that deep red which the stronger acids produce. At 60° F. it requires 25.66 times of its weight of water for solution; but only 2.97 times at 212° F. It is soluble in alcohol, and the solution burns with a green flame.

For practical purposes, the strength of acids may be determined by the HYDROMETER.

CHAPTER VI.

ORIGIN AND COMPOSITION OF FATTY MATTERS.

FATS, or fatty matters, as generally considered, are those bodies greasy to the touch, inflammable, and capable of being converted into candle or soap material. They are natural products, having their source at present solely in the organized structures of plants and animals; though it is possible that in the progress of chemical discovery some method will be discovered for their artificial creation, as an initiative step has already been accomplished by Pelouze in that direction. In consequence of the different consistence of fats, they have been classified under several distinct heads, viz: as *oils*, *butters*, and *suets;* the former are the most fluid, the latter the most solid of the three, whilst the second class holds a medium position. All fats were originally, and for some time considered as simple products, but the researches of Chevreul, and Braconnot, have corrected this erroneous idea by developing experimentally but accurately, the actual constitution of most fats, showing them to be compound bodies formed partially of liquid, and partially of solid ingredients. The melting point of the fat is higher in proportion as the solid ingredient predominates. It is to be noted, however, that the melting point is not uniformly the same, for solid fats have different phases of physical condition which often modify it in a degree.

100 parts yield	Fluid.	Solid.
Fresh butter in summer	60	40
" " " winter	37	63
Hog's lard	62	38
Ox marrow	24	76

100 parts yield									Fluid.	Solid.
Goose fat	.	.	.	.	.	.	.	.	68	32
Duck fat	.	.	.	.	.	.	.	.	72	28
Ox tallow	.	.	.	.	.	.	.	.	25	75
Mutton suet	.	.	.	.	.	.	.	.	26	74
Olive oil	.	.	.	.	.	.	.	.	72	28
Oil of sweet almonds		.	.	.	.	.	.	.	76	24
Palm oil	.	.	.	.	.	.	.	.	69	31

The food and age of animals are the influences affecting the physical properties of their fat. Those which feed upon flesh give a rancid fat and much less firm than the solid, inodorous suet of herbivorous animals. The quality is best at middle age when the animals have attained their full growth, for at an earlier or later epoch the consistence is variable and flabby.

The fluid constituent here expressed, is olein, an unerring verification of the presence of which, in fats, is the formation of sebacic acid by their distillation; but the solid portion of the animal greases generally consists of two distinct principles, palmitin and stearin, though in some instances one or the other is wanting. But olein, palmitin, and stearin, are only the *proximate* constituents of fats, for their *ultimate* components, scarcely varying in any of them, are carbon, hydrogen, and oxygen, which, being solidified, as it were, and confined by certain chemical forces, are united in the proper ratio in the form of fat, and so remain until the influence of some stronger power effects its decomposition.

The following diagram will intelligibly show the distinction between the proximate and ultimate components of stearin, for example:—

Proximate.							Ultimate.
Glycerin	.	.	.	.	.	.	$C_6H_8O_6$
Stearic acid	.	.	.	.	.	.	$C_{136}H_{132}O_{10}$
Stearine	.	.	.	.	.	.	$C_{142}H_{140}O_{16}$

The proximate components above named, and which possess all the interest for the soap and candle-maker,

are not universally the same in all fats, for among these latter there are a few of peculiar physical and chemical properties, the solid principle of which slightly differs from that of others; thus, for instance, in palm oil, crystalline palmitin occupies the place of stearin in tallow; so also cetine in spermaceti. All these components, are themselves compound bodies, being positive salts and definite chemical unions of their several natural fatty acids with a natural base. This base, in most cases, is glycerin, though in some instances, spermaceti for one, ethal takes its place, and the presence of the former is always proved when the tested fat on being boiled yields *acroleine*, a pungent gaseous body.

The fatty acids, by changing the termination of its title into *ic*, take the name of the compound which yields them; thus the acid united with glycerin in olein, is called oleic acid. They differ in their properties, and are distinguishable by certain characteristics peculiar to each. None of these acids, when absolutely pure, is alterable in the air, nor indeed are any of the natural fats which yield them; the rancidity, therefore, assumed by fats on exposure is owing to absorption of oxygen from the atmosphere, which, promoting a species of fermentation in the impurity of the fat, develops an acrid odor; or, it may be, that albuminoid matters of the fat acting upon a portion of the fat itself, decompose it into its base acids, and one or more of which latter in a free state may possess sufficient volatility to produce a disagreeable odor. In some fats, however, for example, that of the goat, volatile acids exist already formed; and it is to these that the peculiar natural scent of such greases is owing, the ordinary temperature of the atmosphere rendering them so diffusive as to be readily perceptible. Pure olein, palmitin, and the like, are perfectly inodorous and unalterable in the air, because all their volatile and other

taint has been dissipated and removed during their puri-
fication.

Vegetable fats exist mostly in the pulpy envelop of the
seeds, whilst the animal fats are found secreted in the *fat
cells* in the cavities of the cellular tissue. Intervening
the muscular fibres, between the skin and the flesh,
around the kidneys and within the abdominal cavity of
the omentum, it is most abundant. In the species of
whale, the bony cavity of the head is the receptacle of
the secreted spermaceti, and in the case of butter, it is
mixed in a liquid state in milk. The molecular forma-
tion of fat was first announced by Braconnot and Raspail,
who have proved that animal fats consist of small micro-
scopic particles inclosed in sacs, a number of which
conglomerated together form a mass. Crumbling the
whole in cold water between the fingers, separates these
granules, which are readily removable, free of membran-
ous matter and water, by means of a sieve. Having ex-
plained what fats are, and their composition, the next
step is to speak of their origin and of the means by which
they are stored in those natural receptacles from which
we extract them. In the first place, then, the living
plant is as much indebted to food for the support of life
as is the living animal, and the presence of fat is an evi-
dence of the conversion or assimilation of a part of the
elements of their nourishment into those constituents of
which it is naturally formed. Assimilation, or the pro-
cess of growth, says Liebig, goes on in the same way both
in animals and vegetables, and the formation of fat in
either is owing to the same cause, and that is, the sepa-
ration of the oxygen from the elements of the food.
Plants feed mainly upon the atmosphere from which they
absorb their carbon in the form of carbonic acid, the oxy-
gen of which latter is returned by respiration so soon as
the organism of the plant has assimilated the carbon and

formed it into fat, and those parts of the structure in which it is an ingredient; the other constituents of the fat being similarly procured from the same source. This transmutation of the atmospheric nourishment is effected by the vital force of the vegetable under the influence of light; the digestion of the food being performed by the leaves of the plant, which act the part of the stomach in animals, in absorbing carbonic acid (CO_2), ammonia (NH_3), and water (HO), the food requisite for their sustenance, from the surrounding media, whence are derived not only the elements of fat, but of all the various secretions upon which the support of life is dependent; for it is now known that plants breathe, feed and digest, and these functions with them are explicable upon as reasonable bases as those which elucidate similar phenomena in animals. There is, however, this difference, that "animal life depends upon the absorption of oxygen, which is evacuated again under the form of carbonic acid and water, whilst the plants fix both the carbonic acid and water, and eliminate the oxygen." To sum up, therefore, the formation of vegetable fat, differing nothing in its ultimate constitution from animal fat, and, as before said, composed of carbon, hydrogen and oxygen, is then owing to absorption and transformation of food, containing these gaseous elements, which, by the vital force and the peculiar organic structure of the plant, is secreted and arranged into entirely new products—one of which is fat.

There are two views respecting the formation of animal fat: one, that it is assimilated exclusively from the vegetable food, wherein it exists already formed; the other, and that which is the theory most accepted (Liebig's), assumes its production, by the living organism of the animal, from the non-nitrogenous parts of food, such as starch and the like.

It is true that fat taken into the body contributes to the formation of fat, but it has other sources, also, for the carnivorous animals, which, as their name designates, are flesh eating, have more muscle but less fat than the herbivorous; and for the reason that the organic principles of the food of these animals are assimilated by their digestive and other apparatus without being organized. The herbivorous animals, on the contrary, obtain the constituents of their bodies from plants, the comparatively limited nitrogenous portion of which goes to form muscle and the other nitrogenized parts of the structure; and the non-azotized, or sugar and starchy components, to the production of fat, &c. The absence of these latter ingredients from the food of animals creates a leanness of flesh.

The "first and main conditions of animal life are nutritious matter and oxygen," the supply of which comes from the surrounding atmosphere, and is inhaled at every inspiration, the constant sensation of warmth in the body, known as "animal heat, having its source in the mutual action between the elements of the food and the oxygen, conveyed by the circulation of the blood to every part of the body."

The non-azotized constituents of the body are water and common fat; and hence the latter can be increased by augmenting the quantity of non-nitrogenous food, as is evidenced in the case of a stall-fed pig or cow, but with those animals which naturally require flesh diet there is no more fat produced than exists in the meat which it consumes; for the composition of the food in nowise differing from that of the body, serves entirely for its reproduction, or rather the reproduction of those parts wasted or destroyed by the process of respiration.

When the analyses of fats are compared with those of the different starchy matters of such plants, grains, &c., as serve as food for certain animals, it will be seen that their

composition in carbon and hydrogen is very analogous, the proportion of one to the other being nearly the same; the only difference is in the oxygen ratio; hence it follows that starch and the like, by the mere separation of a part of their oxygen in the process of assimilation, may pass into fat, and that the *solidification*, as it were, of these gases eliminates or is the cause of the animal heat before mentioned. Fat, therefore, is a product consequent upon a deficient supply of oxygen to the body, and is derived from the non-nitrogenous elements of their food, when these are in excess and oxygen is deficient, this latter being absolutely indispensable to the dissipation of the former; otherwise it becomes assimilated into fat, "the deficit of oxygen being supplied at the expense of the starch, sugar, and the like, which, by losing oxygen, gives rise to fat; for the proportions of carbon and hydrogen in sugar, &c., and in fat, are exactly the same, that of oxygen alone being different." From this it therefore follows that farinaceous food and abstinence from exercise are promotive of the increase of fat, rest being a requisite condition, for by locomotion sufficient oxygen is taken into the body to consume all its starch and non-nitrogenous food, and hence there is no fat produced, a muscular leanness ensuing, as in the case of the fleet bounding stag which roves at liberty, yet is nourished by food of the same nature as that consumed by cattle. The penned pig (want of exercise being equivalent to a deficiency of oxygen), on the contrary, which eats and reposes merely for digestion, consumes more non-nitrogenous food than is needed for the support of respiration and maintenance of animal heat, and the excess going to the production of fat is deposited in the cellular tissue as oil and suet.

It is an established rule that an animal fed exclusively on nitrogenous food becomes lean and muscular, whereas

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those that subsist upon potatoes, grain, and vegetable diet generally, gain of fat. The excess of carbon taken into their bodies, as a component of their food, when eliminated during the process of digestion, being unable to form any part of an organ, is transformed into fat; and here is the reason for the practice of stalling animals in order to fatten them before killing time, though the rationale of the process is scarcely known to any one of the whole fraternity of victuallers who practise it.

From this exposition it is readily seen that there is a mutual dependence between the animal and vegetable kingdoms, the practical effect of which admirably illustrates a very important instance of the economy of nature. The plants deriving their food from the earth and surrounding media, in their turn serve for the nutrition of animals, and these, after the process of decay has extinguished their vital force, again serve in an elementary form to reproduce themselves through the aid of that vegetable matter which is generated from their remains. The plant feeds upon the atmosphere, and, having nourished itself, becomes animal food; the animal perishing, restores to the vegetable creation that which, while living, it took from it for the support of life; and thus is the process of reproduction constantly maintained, the animal and vegetable food, consisting of certain fixed salts, and of carbon, hydrogen, oxygen, and nitrogen, being assimilated by appropriate organism, and assorted out, as it were, in mixtures of proper ratio for the production of that part of the structure for which its constituents are adapted; and hence are produced simultaneously all the wasted portions of the body, both nitrogenous and non-azotized.

In this most beautiful arrangement there is evidenced a wonderful realization of the truth of that figurative expression which declares that our bodies are of dust and

to dust must return, for the same earth which yields the plant thereby sustains animal existence, and hence both man and worm alike are recipients of, and contributors to, its productive power; generated from its elements—dying, they are again resolved into the same, and become a source of nutriment for new creations of life.

CHAPTER VII.

SAPONIFIABLE FATS.

THE saponifiable fatty matters are of both vegetable and animal origin, and they may be considered in five classes. 1. Those which are liquid at 50° to 60° F., and called *Oils*. 2. The fats of soft consistence at 65° F., and styled *Butters*. 3. The *Suets*, the fusing point of which is about 100° F. 4. The *Waxes* which melt at 115° to 150° F. Finally, the 5th class consists of the *Resins*, the characteristics of which are their solidity, high point of fusion, affinity for greasy bodies, friability, and odor.

It is readily perceived that there is much difficulty in determining an exact classification of the fatty bodies. For the sake of convenience, we will limit our remarks here to the truly saponifiable fats of both vegetable and animal origin, including wax, and leave the essential oils and resins to be treated of in a subsequent chapter.

VEGETABLE FATS.—The knowledge of oil dates back to a remote period, for Abraham (*Gen.* xv. 17) served it in the lamps; and from his history we read that the Cecrops brought olive oil from Sais, in lower Egypt, there acquired the art of extracting the oil, and imparted it to the Athenians. The use of oil was thus carried into Europe (*Herod.*, book ii. 59). It seems certain, nevertheless, that though the Greeks at the time of the siege of Troy, knew of oils, they were ignorant of their mode of application to illumination, for no note to that effect is made by Homer; but, on the contrary, the heroes used torches of wood for this purpose.

Under the name of oil are designated those unctuous liquids which retain their fluidity at a low temperature. They are generally lighter than water, and produce a semi-transparent spot on paper. They are more or less viscid, and of a feeble, but sometimes disagreeable taste. If oil is added to, and stirred with water, by reason of its lesser specific gravity, and immiscibility, it rises, after repose, to the surface of the water, and forms a separate and distinct layer. The water beneath, and forming the lower stratum, having dissolved out retains a portion of the foreign matters originally contained with the oil.

The same kind of oils frequently possess variable qualities dependent upon the locality where the original plant was cultivated, and the mode of extracting it. The specific gravity of oil increases with its age, but we will here remark, in passing, that the degree of purity of an oil cannot be accurately deduced from its specific gravity, for this itself varies with the same kind of oil, but is, however, a pretty fair criterion.

List of the Ordinary Oils of Commerce.

Plants.	Oils.	Sp. gravity.
Linum usitatissimum	Linseed oil	0.9347
Corylus avellana ⎫ Juglans regia ⎭	Nut oil	0.9260
Papaver somniferum	Poppy oil	0.9243
Cannabis sativa	Hemp oil	0.9276
Olea Europæa	Olive oil	0.9176
Amygdalus communis	Almond oil	0.9180
Guilandina moringa	Oil of ben	
Fagus sylvatica	Beech oil	0.9225
Sinapis nigra	Oil of mustard	0.9160
Helianthus annuus	Oil of sunflower	0.9262
Brassica napus	Rapeseed oil	0.9128
Ricinus communis	Castor oil	0.9611
Prunus domestica	Plum kernel oil	0.9127
Theobroma cacao	Oil of cacao	0.8920
Cocos nucifera	Cocoa nut butter	
Avoira elaïs	Palm oil	0.9680
Gossypium barbadense	Cotton seed oil	
Brassica campestris	Colza oil	0.9136

Plants.	Oils.	Sp. gravity.
Prunus cerasus	Cherry-stone oil	0.9239
Madia sativa	Madia oil	0.9350
Arachis hypogæa	Ground-nut oil	
Æsculus hippocastanum	Horse-chestnut oil	0.9270
	Codfish oil	0.9230
	Train oil	0.9270
	Tallow oil	0.9003
	Lard oil (winter)	0.9154
	Sperm oil "	0.8797
	Whale oil	0.9200
	Seal oil	

Among the different species of oil, there are those which can be raised to a high temperature without volatilizing, but which, when brought near the point of ebullition, begin to be decomposed, blacken, and emit thick, whitish fumes.

Below is Planche's table of the solubility of certain oils in 1000 drops of alcohol, at 40° Baume. The solubility is said to increase with the proportion of oxygen they may contain.

Oil of ricini (castor oil)	all proportions.
" poppy (year old)	8 drops.
" linseed	6 "
" poppy (fresh)	4 "
Nut oil (juglans)	6 "
Beech oil	4 "
Olive oil	3 "
Oil of sweet almonds	3 "
Nut oil (corylus avellana)	3 "

The saponifiable fats are *fixed* oils; that is, they do not evaporate or volatilize at ordinary temperatures. Moreover, they are, excepting castor oil, nearly insoluble in alcohol; but ether, chlorine, and benzole dissolve them readily.

The fixed oils exist in the seeds of plants, and sometimes, but rarely, in the fleshy pulp of fruits. The oleaginous grains contain at the same time fecula, and a kind of mucilage, which renders them miscible with water, giving with this liquid a white liquor, known by the name

of *emulsion ;* and it is by reason of this property that some seeds are called emulsive. The fat oils are contained in that part of the seed which gives birth to the cotyledons, but not in the plumula and radicle. Of all the families of plants the cruciform is the richest in oleiferous seeds. One root, alone, contains a fat oil, viz : the *cyperus esculenta.* The fixed oils are, at the atmospheric temperature, nearly all liquid ; some, however, as the palm, butters of galam and cocoa, &c., are more or less consistent; they are greasy, occasionally colorless, but generally of an amber shade, and rarely greenish, the color probably being due to a peculiar principle held in solution.

Several fat oils, mixed with one or two per cent. of sulphuric acid, instantly assume a dark green, or brown hue, and when allowed to stand quietly, after some time, deposit a coloring matter. It consists in a chemical combination of the sulphuric acid with a body, thus separated from the oil, which becomes in consequence more limpid, and burns with a brighter flame, especially after it has been washed with steam and clarified by repose or filtration. Any remaining moisture may be expelled by the heat of a water bath.

In close vessels, oils may be preserved fresh for a long time; but when exposed to air or oxygen gas, they undergo a gradual alteration, and become rank, thick, and viscid. The albuminous matters contained in the vegetable oils render them especially liable to decomposition. Acting as a ferment, they transform them into glycerin and fat acids.

Some oils even harden, when exposed in thin strata to the atmosphere. These last take the name of drying or siccative oils, a property which makes them available for varnishes and mixed paints. Of this number are the oils of linseed, nuts, poppy, grapeseed, &c. Others, again, do not dry up, yet thicken, become less combustible, and

contract a disagreeable smell. They are then called rancid and *non-siccative* oils, in contradistinction to the first mentioned drying oils. Among them are the oils of olive, colza, and sweet almonds.

Saussure has explained the phenomena occurring during exposure, as follows : A layer of nut oil, one-quarter of an inch thick, and three inches diameter, inclosed with oxygen gas over quicksilver, in the shade, absorbed only three times its bulk of gas during eight months, between December and August, but in the ten days following the first of the latter month, it had absorbed 60 times its volume. At the end of October, the time at which the diminution of the volume of the gas became nearly insensible, this oil had taken up 145 times its volume of oxygen gas, and given out 21 times its volume of carbonic acid gas, and without any production of water. The oil thus treated, formed a kind of transparent jelly, which no longer spotted paper. To a similar absorption may be attributed the elevation of temperature which happens when wool or hemp, besmeared with olive or rapeseed oil, is left in a heap, circumstances under which it has frequently taken fire, and caused the destruction of cloth mills and storehouses. For instance, by way of illustration, if paper, linen, wool, tow, cotton, mats, straw, moss or soot, be slightly imbued with linseed or hempseed oil, and placed in contact with the sun and air, especially when in heaps or piles, they become very soon spontaneously hot, emit smoke, and finally burst into flames. If linseed oil and ground manganese be triturated together, the soft lump so formed will speedily become firm, and in a short time take fire. This spontaneous combustion is owing to a rapid abstraction of oxygen from the atmosphere ; the hydrogen of the oils being inflamed by the caloric eliminated from the gas at the moment of its

absorption by the oil, and until then, existing as latent heat, and serving to retain the oxygen in an aëriform state.

Oils possess the same ultimate constituents, carbon, hydrogen, and generally oxygen, and sometimes a little nitrogen. The fat oils exposed in a retort to a temperature sufficiently high to effect distillation, are in part decomposed; derivative fatty acids, and other fatty and inflammable substances, pass over into the receiver, and a carbonaceous residue remains. When allowed to trickle down in a thin stream upon incandescent coke, they are carbonized and converted into gas. It is upon this property that is founded their conversion into illuminating gas, a simple apparatus for which purpose was invented by Messrs. J. & P. Taylor, England, as far back as 1815. The oils dissolve both sulphur and phosphorus by the aid of heat; but if the temperature is too high, a violent reaction ensues with sulphur. Their action upon oxides, or that of the oxides upon them, will be explained further on, when speaking of the theory of saponification. Chlorine and iodine act upon oils even in the cold, and from the decomposition of the latter, result the hydrochloric and hydriodic acids and other combinations, which have not as yet been examined. Strong mineral acids decompose the oils.

Olive oil.—The *olea europea*, a tree regarded by the Greeks as the emblem of peace, is one of the prettiest in nature, and occupies so distinguished a place in agriculture, that Varron called it the "first of all trees." Its origin it is supposed was in Greece or Asia Minor. It is impossible to say exactly when the discovery was made of the oil, and its application to the wants of man. It seems to have been known from antiquity, for its mode of facture is mentioned in Holy Writ, and what is remarkable, it has but little varied ever since. In the different countries of Spain, as Catalonia, Valencia, &c., whence

comes the most delicious oil, ignorance and prejudice, favorable to the old routine, have prevented all improvement. The olive oil, well prepared, is of a bright yellow color, sometimes inclined to greenish, unctuous to the touch, transparent when very pure, with a mild, agreeable taste; and insoluble in water, but slightly soluble in alcohol and ether; heated up to 315° F., it leaves a spot upon paper not removable by heat, a property distinguishing it from the volatile oils. Exposed to high heat it is partially decomposed, one portion volatilizing and running over in an altered state;—more colored, of a strong odor, lighter, and of greater fluidity. There are three kinds of olive oil in the market. The best, called virgin salad oil, is obtained by gentle pressure of the freshly gathered fruit, in the cold; the common sort is procured by stronger pressure, aided by partial fermentation of the olives and the heat of boiling water; and thirdly, an inferior kind, by boiling the residuum or *marc* of the olives (after these two pressures) with water, whereby a good deal of mucilaginous oil rises to and floats on the surface. The latter serves chiefly for making soaps. A few degrees above 32° F. it begins to deposit some white granules, especially if the oil has been originally expressed with heat. At 22° it deposits twenty-eight per cent. of its weight of solid constituent, which is fusible again at 68°, and affords seventy-two per cent. of olein. All the varieties of olive oil are left to repose for a month after being made, in order that the impurities may subside. This latter, after the clear oil is racked off, serves as an excellent soap material.

The pure salad oil is used for table and domestic purposes; the inferior kinds in the manufacture of soaps. Its superiority over other sorts of oil, and higher price, render it liable to adulteration, more especially with lard oil, which sometimes forms as high as sixty or seventy

per cent. of "*surfin Lucca huile*." The composition of olive oil is oleic and margaric acids in union with glycerin; the more solid constituent, or margarate of glycerin, being in the proportion of about twenty to twenty-eight per cent.

Oil of sweet almonds.—This oil is obtained by pressing the bruised fruit of the *amygdalus communis* (previously cleansed of the adherent furz and dust, by being well shaken and sieved) in strong bags, between iron plates, slightly and uniformly heated by hot water or steam. The oil thus obtained is filtered and kept in carefully stoppered bottles, as it is prone to become rancid. It is of a bright color, with a feeble taste of almonds, and, after a time, deposits a mucilaginous substance which must be immediately separated by filtration, as it promotes rancidity. The tree which furnishes the nut is native to Africa, but cultivated in Spain, Italy, and France. There are several varieties, and their fruits are usually distinguished as sweet and bitter almonds. Sweet almonds were analyzed by Boullay and others; the bitter by Vogel.

Sweet Almonds by Boullay.		*Bitter Almonds by Vogel.*	
Fixed oil	54.0	Fixed oil by pressure	28.0
Emulsin	24.0	Emulsin	30.0
Uncrystallized sugar	6.0	Uncrystallized sugar	6.5
Gum	3.0	Gum	3.0
Woody fibre	4.0	Woody fibre	5.0
Seed pellicles	5.0	Seed pellicles	8.5
Acetic acid	0.5	Loss in water	19.0
Water	3.5	Fixed and volatile oil, &c.	
	100.0		100.0

The important constituents are fixed oil, and emulsin in both varieties, and amygdalin and volatile oil in bitter almond. The fixed oil, as above said, is obtained by expressing both sweet and bitter almonds, but usually the former. It generally congeals at a lower temperature

than olive oil. It is soluble in ether, and in six parts of boiling and twenty-five of cold alcohol.

Emulsin is an albuminous substance.

Amygdalin is a crystallizable constituent of the bitter almond, and its source is the almond cake, or *marc*, which remains after the expulsion of the fat oil by pressure between hot iron plates. It is very soluble in water, soluble in boiling alcohol of ninety-four per cent., but scarcely so in cold anhydrous alcohol. It was discovered, subsequent to the foregoing analyses, by Roubiquet, and Boutron-Charlard. The volatile oil of bitter almonds, it is now conceded, does not exist ready formed in the fruit, but, according to Liebig and Wohler, is produced from amygdalin by the presence of emulsin and water. Amygdalin and emulsin being in distinct cells in the cotyledon of the bitter almond, together with the fixed oil, cannot act on each other, and are still further prevented when the water is expelled, by drying. The fixed oil is separated by pressure, and upon boiling the residual cake with alcohol, the emulsin is coagulated, and amygdalin extracted. When the cake is moistened with cold or lukewarm water, the odor and taste of prussic acid (which, together with formic acid, sugar, &c., are also contemporaneous products), and of the volatile oil, are at once perceived, but if the quantity of water be too small, a portion of amygdalin is undecomposed. The decomposition commences instantly, but requires some time for a complete transformation, so that but little oil would be obtained by hastily distilling the mixture, as the emulsin would be coagulated and further action cease. The same result takes place when the pressed cake is thrown into boiling water, the emulsin being instantly coagulated and rendered inert. To obtain the volatile oil, the almond cake, after the removal of the fixed oil, is made into a thin paste with lukewarm water, left for twenty-four

hours in a closed carboy, and distilled in a water or chloride of calcium bath. One hundred parts of amygdalin yield forty-seven parts of crude oil; these forty-seven parts contain 5.9 parts of free prussic acid. This oil is highly poisonous; has a golden yellow color, an agreeable odor, an acrid bitter taste, burns with a white flame, is soluble in ether and alcohol, and has a specific gravity of 1.0436. Sulphuric acid forms with it a thick crimson red liquor, which, by dilution with water, gives a yellow emulsion. The volatile oil is used for flavoring soaps, &c.

The fixed oils of almonds mostly used in our art, are not very frequently met with in commerce pure and unadulterated, their greater portion being either olive or lard oil. Indeed, I know of instances of pure olive oil merely flavored with that of almonds, being sold as the genuine article, having been present in a large drug house when the oil was being "made up."

The composition of fixed almond oil is oleic, margaric, and perhaps a little stearic acid in combination with glycerin; and it belongs to the non-drying class of oils.

Beech oil.—This name is applied to the fruit of the *fagus sylvatica.* The oil is prepared by pressure in the cold, in a manner similar to that by which the preceding oils are made. It has an amber color, a mild savor, and is inodorous. Although inferior to olive oil, it is sometimes substituted therefor as an aliment, and frequently forms a part, as an adulteration, of that which is sold for the pure article.

Rapeseed oil.—This oil is prepared from the seeds of the navette, or *napus brassica,* by heating them with hot water and pressing them. The oil is yellow, has a peculiar smell, and contains a large quantity of mucus, albumen, and other foreign matters which render it viscid. This viscidity and the coloring matter retained by the oil, lessen its combustibility and occasion much smoke

during its burning. It may be purified by adding to it two-hundredths of its weight of sulphuric acid, and agitating well the mixture with double its volume of water. After eight or ten days, the oil which swims to the surface of the water and forms the upper stratum, must be filtered through a displacing funnel, the holes in the diaphragm of which are furnished with cotton wicks of four or five inches in length.

In this operation, the sulphuric acid precipitates the coloring matter under the form of greenish flocculæ, the latter becoming insoluble as soon as the water is abstracted from it by the acid. The clear oil is racked off after sufficient repose. A mild heat assists the operation, which is equally applicable to the purification of other vegetable oils. At 32° it congeals, and reaches 43° F. again before it melts. Its peculiar odor is stronger when the oil is heated, and the latter at 398° F. becomes greenish yellow. It yielded to Webesly, by saponification, white solid *Brassic acid*, fusible at 90° F. and soluble in absolute alcohol; and a fluid acid differing from the oleic.

Oil of mustard.—This oil is obtained by pressing the bruised seeds of the *sinapis alba* and *nigra*. Thus is procured from twenty to twenty-five per cent. of a very mild yellow oil, which concretes when cooled a little below 32° F. It is a remarkable fact, says Fontenelle, that the mustard seed, after the expression of the mild oil therefrom, becomes more medicinally active by reason of the volatile oil which is then in a nascent state. This volatile oil is not contained in the seed, but results from the reciprocal action of water and an albuminous substance called *myrozine*, by Bussy, upon another crystallizable principle, *myronic acid*, which is soluble in water, and apparently is an acid, though this is not positive, as but little is yet definitely known respecting it. This oil is the cause of the acidity of black mustard, a property

worthy the consideration of manufacturers of mustard. As in the case of volatile oil of almonds, the application of boiling water (to the mustard), of alcohol, of acids, or of alkalies, which coagulate the albuminous body, prevents the formation of the volatile oil. This volatile oil is not used by the soap factor, therefore we shall make no further note of it.

Oil of grape seeds.—This is an oil which deserves some attention. It is prepared from the seeds of the *vitis vinifera* by pressure. It is yellow, slightly odorous, and of a mild taste when it is very pure and fresh. By age it becomes viscous, thick, and rancid. It should be purified as is directed for the oil of navette.

Oil of poppy.—This name is given to that oil yielded on pressure of the bruised seeds of the *papaver somniferum*. It is whitish yellow, inodorous, of an almond taste, and when pure is less viscous than most oils, and remains liquid even to 0°. It has none of the narcotic properties of poppy juice. It is soluble in ether in every proportion, and is used as a means of detecting the presence of spirits of turpentine in essential oil. This oil is purified as those of the other oleaginous grains. It belongs to the class of drying oils.

Nut oil.—This is a drying oil derived from the seeds of the *juglans regia* by either cold or hot pressure. That prepared by hot pressure has a peculiar taste and odor, the latter being recognizable during combustion, a general attendant of which is much smoke. The nuts which yield it must be freed of their ligneous envelop before being expressed. The cold-pressed oil is almost colorless, of an agreeable odor and taste, and syrupy consistence. Exposed to the air, it rapidly rancidifies, and becomes transparent, particularly when it is put into large shallow vessels with water at the bottom. This oil, thus altered, is used for fine colors in painting; it having a more drying

quality than linseed oil, and, like it, congealing into a white mass at the same temperature. The hot-pressed oil is very much colored, of a strong odor, and full of mucilage.

The oil of noisette, or *fructus avellanæ*, also sometimes called nut oil, is similarly obtained. This also is a drying oil, and in its properties not unlike the above oil. The composition of both this and the preceding oil is in all probability olein and margarin, or, properly speaking, oleate and margarate of glycerin.

Linseed oil.—This oil is obtained in its greatest purity by cold pressure, but by a steam heat of about 200° F. a very good oil may be extracted. The usual method is to torrefy the seeds (*linum usitatissimum*), in order to destroy the mucilage, bruise, and then submit them to pressure. The oil is of an amber color, and has an odor peculiar to itself. It is siccative, especially when boiled with litharge, becoming then reddish and clear after repose. It dissolves in five parts of boiling, and forty of cold alcohol, and in 1.6 parts of ether. When kept for some time in a partially open cask, and in a cool place, it darkens, and deposits a portion of its solid constituent along with a brown powder. This solid deposit is difficultly saponifiable. Linseed oil solidifies at about 20° F. below freezing point.

The composition of linseed oil is oleic and margaric acid in union with oxide of glyceryl, or, in other words, olein and margarin.

Castor oil.—This oil is drawn from the seeds of the *palma christi*, or *ricinus communis*, which, after being peeled, bruised, and boiled in five times their weight of water, are then pressed. When very pure, this oil is bright yellow, inodorous, insipid, thick, liquid many degrees below zero, siccative, and inspissates on exposure to air without losing its transparency. The oil of commerce has generally, however, an unpleasant smell and nauseous taste. It is heavier than most other fixed oils, and is

soluble in all proportions in cold absolute alcohol. Weaker alcohol, of specific gravity 0.8425, takes up about three-fifths of its weight, and adulterations with other fixed oils may thus be detected, as the latter are but slightly soluble in this fluid. It is used in medicine as a cathartic and vermifuge, and in the arts for making a very beautiful, but rather expensive, soap.

According to Bussy and Lecanu, a soap made from castor oil, when decomposed by a mineral acid, yields glycerin and three fatty acids, one solid (*margaritic*) and two fluid (*ricic* and *elaioidic*). The two latter are also obtained by dry distillation of the oil. Saalmuller found but one liquid acid of the composition $C_{38}H_{36}O_6$, and called it *ricinoleic* acid. Scharling's *ricinostearic* acid is the solid fat of castor oil, and corresponds with the margaritic acid of Bussy and Lecanu.

Castor oil gives, by distillation, volatile oil, acetic acid, empyreumatic matter, ricic and elaioidic acids, acrolein, and œnanthole; leaving, according to Stanek, a yellow, caoutchouc-like residue, insoluble in water, alcohol, ether, or the oils, and but slightly acted on by sulphuric, nitric, or hydrochloric acid. Its formula is $C_{42}H_{34}O_5$.

Castor oil, solidified with nitrate of suboxide of mercury, or with nitrous acid, forms a yellow waxy transparent mass, which, washed with water and dissolved in boiling alcohol, furnishes *palmine* in confused crystalline grains. This new fat, soluble in alcohol and ether, is easily saponified, like elaidine, by alkalies, glycerin being disengaged and palmate of soda or potassa being formed. When the soap thus produced is solved in water, and hydrochloric acid added to the solution, it is decomposed, and the *palmic* acid separates, on cooling, in a crystalline mass. When pure, this acid strongly reddens litmus paper, decomposes the carbonates, fuses at 122° F., and crystallizes in white silky needles. Alcohol and ether

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solve it in all proportions. According to Playfair, palmic acid is represented by $C_{34}H_{32}O_5$; but when obtained by saponification with potassa, has an additional equivalent of water, making it $C_{34}H_{33}O_6$. The rancidity is owing to the presence of a peculiar volatile acid called the œnanthylic acid.

Behen or ben oil.—This oil is obtained by expression from the seeds of the *moringa aptera* and *oleifera*, indigenous to Arabia and Syria, but growing also in the West Indies. It is a colorless, inodorous fat, which, by repose, separates into two portions, one thick and the other fluid even at very low temperatures. The obstinacy with which ben oil resists the rancidifying action of the atmosphere, renders it a most valuable vehicle for the extraction of the delicate perfume of certain flowers, by the process of *enfleurage*.

The oil consists, according to Walter and Volcker, of margaric, stearic, behenic, and moringic acids.

Palm oil.—This fat, which, owing to its consistence, should more properly be called palm butter, is one of the natural products of the western coast of Africa, whence it is imported into this country in such quantities as to make it an important article of commerce. It is obtained by boiling with water the pulpy portion of the fruit of several varieties of palm—*avoira elais*, &c.—the oil being collected as it rises to the surface. The discrepancy in the melting point of different samples is owing to the variableness of its origin. It ranges from 76° to 95° F., and increases with age, oil of three years' standing requiring as high as 105° F. for fusion.

By pressing the boiled nut, which the pulpy part of the fruit envelops, an inferior butter is obtained, called *quio-quio*, or *thio-thio*.

Palm oil has a buttery consistence, and, when fresh, is of a violet odor, a mild taste, and an orange color, which

bleaches by age. These characteristics distinguish it from the factitious article, which is nothing more than tallow and lard melted together, colored with turmeric, and aromatized with powdered orris root. Palm oil is lighter than water, becomes rancid and pale by exposure to air, and dissolves in boiling alcohol, but separates on cooling. Ether dissolves it in all proportions.

Palm oil is chiefly used for admixture with fats to form yellow soaps; and its agreeable odor renders it, when bleached, a serviceable material also for toilet soaps.

The composition of palm oil is, according to Fremy, free oleic acid, free palmitic acid, free glycerin, and palmitin, the solid fats amounting to 30 per cent. As the oil becomes old and rancid, the proportion of glycerin decreases. The characteristic orange color is owing to the spontaneous decomposition of a peculiar principle of the palm, always associated with the oil, and must be decomposed in order to make the oil available for the purposes of the soap-maker, for it is not removed or destroyed during saponication.

Chlorine has been tried for bleaching palm oil, but with only partial success; for, while destroying the color, it acts injuriously at the same time upon the oil itself.

Sulphuric acid added to the melting oil, in the proportion of 4 per cent., is sometimes employed.

Mr. Watt, not long since, secured a patent in England, by which he proposed to use the nascent oxygen produced by the decomposition of chromic acid, which consists of one equivalent of chromium, and three equivalents of oxygen $= CrO_3$. This method, though very successful, is not economical, and, therefore, unavailable for practical purposes. The old plan, too, of employing nitric acid, though not objectionable on the score of cost, has yet the disadvantage of partly impairing the peculiar violet odor of the oil, in which consists much of its value, whilst

at the same time it only destroys the coloring matter without perfectly bleaching the oil—the soap into which it is made being of a grayish-yellow hue. Two gallons of acid, sp. gr. 1.40, are required for every five tons of oil. The oil operated upon by the chromic acid process, produces a soap of most beautiful whiteness, and rich with the characteristic odor of the oil—facts which I have verified by my own experiments. The expense attendant upon this process per ton of oil, labor included, reaches ten dollars, and I strongly recommend it, regardless of its cost, where a soap is desired of excellent whiteness and flavor.

First heat the oil by steam in a common boiler for thirty minutes or more, then allow it to repose until having cooled to 130° F., when it must be drawn off from the sediment and water, formed by the condensation of the steam, into wooden vessels, each capable of containing about half a ton. To each vessel containing the half ton of oil, so far deprived of foreign matter, make the following addition : Twelve and one-half pounds of bichromate of potassa dissolved in water so as to make a saturated solution, four pounds of concentrated sulphuric acid and about twenty-five pounds of strong hydrochloric acid, well mixed together. These are Mr. Watts' proportions; some bleachers take ten pounds of bichromate of potassa, and forty pounds of commercial hydrochloric acid. After thoroughly agitating this mixture with the oil for a few minutes, the oil changes in color, becoming first black, then dark green, and soon afterwards light green, when a thick froth appears on the surface. This appearance of a light green color and a froth, is an indication of the completion of the process. If a sample of the oil, when taken out and allowed to settle, does not appear sufficiently decolorized, an additional portion of the bleaching mixture may be added. The process is complete in from ten to

fifteen minutes. The whole is now allowed a repose for a half hour or more, so that the aqueous solution of chloride of chromium, sulphate of potassa, and other foreign matters may subside; after which, the oil is drawn off clear, from this sediment, into a wooden cask, mixed with a little water, and heated for a short time by the introduction of steam. After one more settling, it is ready to be racked off for use.

The rationale of this process is as follows: The coloring matters of the oil are oxidized and thus rendered soluble, by the oxygen of the chromic acid of the bichromate of potassa, decomposed by the muriatic and sulphuric acids. The chromic acid having yielded its oxygen to the coloring matter, becomes reduced to the state of a green oxide of chromium, which, by the action of hydrochloric (muriatic) acid, is converted into chloride of chrome, and the sulphuric acid takes up with the liberated potassa. This, and the coloring matters, when the oil has settled, are found in solution with the water at the bottom of the cask.

One of the simplest methods of bleaching palm oil is that proposed by Pohl. Twelve hundred pounds of the oil are placed in a cast-iron boiler, of capacity sufficient for double that quantity, to prevent any overrunning, as the oil expands considerably during the heating. The pan is then covered, and its contents rapidly raised to 464° F., and kept at that temperature for ten minutes, when the operation is completed. Access of light and air is unnecessary; but the oil must be first freed from foreign matters, to which end it should be melted, and after repose drawn off from the subsident impurities.

The oil acquires an empyreumatic odor in the bleaching, but loses it by exposure, and also during saponification. The soap which it makes is hard, and of an agreeable violet scent.

The difficulty in keeping the whole mass of oil at the same temperature, and preventing carbonization of the lower stratum nearest the fire, has caused some objections to this method ; and these are sought to be removed by the following modification, known as Zier's process :—

It consists in heating the oil to 230° F., over the open fire, and then maintaining the temperature by blowing in a current of high steam for ten or twelve hours. The steam must be of 15 pounds pressure to the square inch, and the mixture kept constantly agitated with a twirling shaft. Four tons of oil is the proper quantity for one operation. An apparatus specially adapted for this process is described by Knapp, as follows :—

"The apparatus, which must be constructed of copper,

Fig. 7.
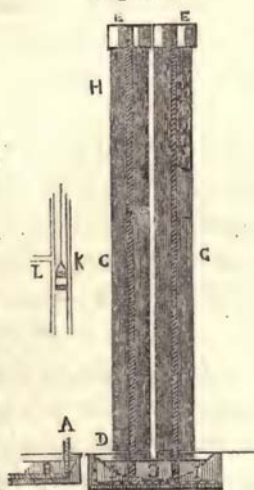
consists of a large steam pipe, A, Fig. 7, over which the bunghole of the cask is inverted; and as the oil melts, it runs into the cistern, B, where any sediment is allowed to deposit. It is then siphoned off into another cistern, C, where it is kept in a liquid state by the steam pipe D. The melted oil is pumped into the cisterns, E E, by the pumps, F F. The bottoms of these cisterns are pierced with a number of small holes, through which the oil flows down the shafts, G G, in a shower of small streams, as shown at H, into the cistern, C, at L L. The oil is pumped up again, and heated in the manner described, until perfectly free from color."

"The pumps are inclosed in a copper pipe, as shown at

K, between which and the shaft of the pump, a jet of steam is admitted at L."

"The cost of this method is very small, being only the wear and tear, and the expense of the fuel for raising steam."

Mr. Cameron's process for bleaching palm oil differs from the preceding in some points, but is equally practicable. Not having tried it, we are unable to speak of its efficiency. "The oil is introduced into a cast-iron kettle, of three or four tons' capacity, and fixed over a small furnace, and furnished with two or more pipes, for the circulation of steam, and a horizontal revolving fan of sheet iron for the purpose of agitating the oil. By means of a fire in the furnace underneath, the oil is heated to the temperature of 230° F.; the fire is then withdrawn, but the temperature of the oil is maintained at that point by introducing high pressure steam from a boiler loaded with fifteen pounds on the square inch of the valve, until the oil is sufficiently deprived of its color. During the whole process, the oil requires to be agitated for the purpose of bringing it into more complete contact with the air, the oxygen of which is the principal agent concerned in the decoloration. The agitating fan may be revolved at the speed of about six revolutions per minute. Four tons of oil may be thus bleached in ten hours, at one operation, and at an expense of half a ton of small coal. All that is essential in this mode of bleaching, is obviously the exposure of the oil to the combined influence of air and heat, many modes of accomplishing which might be devised. In a process for bleaching oil and fatty matters of this nature, patented by Mr. Arthur Dunn, in 1843, the air is forced below the surface of the oil through pipes, by means of a blowing apparatus, and then allowed to rise through the liquid in numerous small streams; the oil being maintained at a temperature between 170° and

230° F., by steam pipes or other means. A hood communicating with a chimney is placed over the vessel containing the oil, for the purpose of conducting away the unpleasant vapors which are disengaged.

"The oxidizing action of the air on the impurities in palm oil, seems to be accelerated by combining the influence of light with that of heat. With the view of accomplishing this, the oil is sometimes placed in thin strata, in a large shallow uncovered vat. Several vats, each about one foot in depth, may be heated by means of steam passed through serpentine leaden pipes proceeding from a common boiler: one extremity of each tube may terminate in a receiver for the condensed water which may be returned to the boiler. Each vat is first two-thirds filled with water; when this is become hot, a sufficient quantity of palm oil is introduced, to form, when fluid, a stratum of about two inches in depth, which should be maintained during the whole process at a temperature as near 212° F. as possible. To preserve an equal temperature at different parts of the vat, the steam may be admitted at opposite ends and circulated in opposite directions by two distinct serpentine tubes. Both air and light having access, the time required for the decoloration of the oil at a temperature near 212°, is from ten to fifteen hours; the thinner the stratum of oil the more rapid is the process. M. Payen has ascertained, in operating on the small scale, that the rapidity of the bleaching action is not sensibly lessened by loosely covering the contained vessel with a plate of glass, provided the renewal of the air over the surface of the oil is not much interfered with; because if exposed to a temperature of 212° in a *closed* glass vessel, so that light and heat have access but not air, the oil does not become blanched. Hence, Payen suggests to manufacturers the propriety of adopting such an expedient on the large scale as will, while not exclud-

ing the air, partially prevent the great loss of heat which occurs from the extensive surface of oil presented to the air in the open vessels commonly used in this mode of bleaching the oil. While fluid, the blanched oil retains a fawn-colored tint, but when cold and solid is grayish-white."

In conclusion, it must be remarked that in the process of bleaching the palm oil by heat, the temperature should not exceed the given point, else the result will be a decomposition of the oil, and its resolution into entirely new bodies. The operation of bleaching in this way is founded upon the destructibility of the coloring matter at a lower temperature than that at which the oil becomes altered.

Nutmeg butter.—This concrete oil, sometimes and improperly called "oil of mace," is the product of the fruit of the *myristica moschata*. It is extracted by bruising the nutmegs, steaming them in a bag, and then pressing. The yield is about twelve per cent. of a yellowish, solid fat, of an agreeable aromatic odor. It is imported from the East Indies, and consists, according to Schrader, of fifty-two per cent. of a liquid fat, forty-four per cent. of pulverulent *myristicin* or *sericin*, and four per cent. of volatile oil. The myristicin has a silky lustre, fuses at 88° F., and is saponifiable by the alkalies, the resulting soap, when decomposed by a strong acid, yielding sericic acid and glycerin. The *sericic* or *myristicic* acid is soluble in alcohol, and drops from its solution in white brilliant scales, which melt at 120° F., and congeal into a distinctly crystalline mass. The liquid oil is yellowish or brownish, and, unlike the myristicin, dissolves in cold alcohol and ether.

Bay-laurel butter.—This is the expressed oil of the fresh berries of the bay-laurel (*laurus nobilis*). It is concrete and greenish, and consists, according to Mawson,

of *lauro-stearin* and olein. By saponification it yields *lauro-stearic* acid.

Otoba.—This is a butyraceous substance, extracted by pressure from the fruit of the *myristica otoba* of New Granada. According to Uricocchea, it melts at 100° F., and emits, in fusing, a disagreeable odor. He found it to be composed of an oily acid, myristicin, and a peculiar principle called *otobite.* The latter is insoluble in water, but soluble in boiling alcohol and ether, from which it drops in white crystals. It fuses at 271° F., and becomes crystalline on cooling, and has the formula $C_{24}H_{13}O_5$.

Oil of cacao.—This is the fat expressed from the fruit of the *theobroma cacao* of Mexico, Guatemala, Nicaragua, and various parts of South America. It is solid at 75° F., has a pale yellow color, an agreeable odor, and mild taste. According to Pelouze and Boudet, it consists of olein and stearin.

Cocoa butter.—A white fat, extracted from the kernel of the cocoa palm (*cocos nucifera* and *butyracea*) growing in Malabar, Bengal, Ceylon, and Brazil. The "*copperah,*" as the kernels are commercially termed when ground, steamed in bags and pressed, yields nearly sixty per cent. As this fat seems to exist naturally as a mixture of two portions, one of which is much more solid than the other, the oil differs in consistence with the temperature at which it is pressed. This fat is fluid at tropical temperatures, but solidifies at 60° to 65° F., and fuses again at 85° F. It is of the consistence of lard, has a disagreeable odor, which it imparts to the soap that is made from it, and is saponifiable, on a large scale, with some difficulty, much salt being required for separating it from the alkaline lyes. According to the recent investigations of Specht and Gössmann, it consists of olein, palmitin, and stearin, the latter being in largest proportion. Georgy contends that its chief principle is the *pichuric* or *lauro-stearic*

acid of Marrson. He found it also to contain capric, myristic, and palmitic acids, with some caproic and capryllic acids.

Galam butter (ghee or *shea butter*), the product of the Phulwana tree (*Bassia butyracea*), growing in Africa. It is a dirty white, sometimes reddish fat, solid at 85° F., nearly insoluble in alcohol, and but partially soluble in cold ether. It is of a mild odor and taste, soon becomes rancid, and saponifies readily. Its composition has not been definitely established, but it is known to contain free acid and free oxide of glyceryl, and probably stearin.

Ilpa or Epei oil.—A butter-fat extracted from the seeds of the *Mahwah* or *Mawy* tree (*Bassia longifolia*), growing on the coasts of Coromandel and Bengal. It is greenish white, solid at 70° to 73° F., and fuses at 78° to 82° F. into a yellow oil. Its smell is aromatic, and its taste mild, until after exposure to air, by which it becomes rancid. Is slightly soluble in boiling alcohol, and consists, according to Pelouze and Boudet, of olein and stearin.

Kokum butter.—The concrete oil of mangosteen (*garcinia purpurea*), growing in Bombay and its vicinity; and extracted by boiling the seeds, which yield ten per cent.

It is firm and solid, very friable, of a pale yellow color and mild odor, and gives a peculiar cool after-taste when melted in the mouth. Ether dissolves it readily, and alcohol only sparingly. Heated with oil of vitriol, it forms a crimson red solution.

According to Redwood, it melts at 98°, begins to congeal at 72°, from which epoch the temperature begins to rise until it reaches 92° F., when the fat has become solid. The composition of this fat has not yet been determined.

Stillingia butter.—The so-called Chinese vegetable butter obtained by pressure from the bean-like fruit of the Kan-shu (*stillingia sebifera*), a tree growing in the low lands of China. It is white, dry, inodorous and tasteless,

and very light, its specific gravity at 54° F. being .818. It fuses at 99° F., and is very soluble in ether. Alcohol dissolves it sparingly in the cold, but takes up a portion at boiling heat, and drops most of it in granules on cooling. The portion which it retains is *stillistearin* with a little olein. Von Borck has examined the butter, and finds that it yields by saponification, oxide of lipyl and *stillistearic acid* ($C_{30}H_{30}O_4$). This acid melts at 142°—144° F.; dissolves readily in hot alcohol, and crystallizes in pearly laminæ.

The butter remains fixed to 572° F., but beyond that point distils over unaltered.

Mafurra tallow. — This is a newly-discovered fatty matter extracted by hot water from the Mafurra seeds, which abound in Mozambique, Madagascar, and the Isle of Bourbon (*Ch. Gaz.*, 1855, 471). It has a yellowish color, and an odor similar to that of cacao-butter. Is less fusible than tallow; sparingly soluble in boiling alcohol, and very soluble in hot ether, which, however, drops it on cooling in small stellate crystals. With the alkalies, it forms a brown soap. According to Pimentel and Bouis, it is composed of a highly colored liquid acid, and a solid acid, the *palmitic*, which constitutes 0.55 of its weight. The liquid acid gives elaidic acid with hyponitrous acid, and sebacic acid by distillation. Mafurra tallow may be easily distilled with sulphuric acid.

The readiness with which this material may be abundantly harvested, and its very large percentage of solid fat, are great advantages in its favor, and will render it a profitable soap and candle stock.

ANIMAL FATS.—The fat of animals is secreted near the kidney, in the folds of the omentum, under the skin in the cellular membrane, at the base of the heart, among many of the muscles, and also upon the surface of the intestines. The variations in consistence, color, and odor

of the different fats, depend mostly upon the kind of animal whence obtained, its climate and its food; but the male animals generally yield a firmer fat than the females. A good quality of fat can come only from a healthy animal, and winter fat is better than that taken in summer. Those which are fed upon dry roots and allowed free air and exercise produce the best article. Oil cake diet lessens the consistence of animal fat; and distillery slop renders it soft. According to Watt, the fat of an animal is more solid the further it exists from the surface of the body; and the delicacy of the cellular tissue enveloping the fat is in proportion to the consistence of the latter. Hence, he says, that the fat of animals in temperate and tropical climes is much firmer than that from those of cold regions. Royer, an experienced tallow-chandler in Cuba, confirms the statement, but additional facts and observations are required to establish it as a law of the animal economy.

The greater the amount of solid constituents, the more valuable is the fat for soap and candle purposes. Those of firmer consistence are reserved for candles, while the softer kinds are used for soap.

The fats always melt at lower temperatures than the solid acids which they yield by saponification; but the fusing point varies with the part of the animal whence extracted.

Fats are generally tasteless and neutral to test paper when fresh, but become altered and rancid by exposure to air. Their density is less than that of water, and they are all more or less fusible. Alcohol partially dissolves them, but they are wholly insoluble in water.

"In the *cetaceii*, the fats are generally fluid; in the carnivorous animals soft and rank flavored, and nearly scentless in the ruminants; usually white and copious in well-fed young animals; yellowish and more scanty in the

old. As taken out by the butcher, fat is not pure, for being of a vesicular structure, it is always inclosed in membranes, mixed with blood, bloodvessels, lymphatics, &c." The modes of separating these impurities and rectifying the fats, are given in the chapter on RAW MATERIAL FOR CANDLES. Fat unites with the alkalies and forms soaps; the phenomena occurring during the combination are fully explained in the chapter on the THEORY OF SAPONIFICATION. Fats are frequently adulterated with foreign matters and inferior fats. The former settle at the bottom when the fat is melted and left to repose. The latter are so various and often so well concealed that they escape the observation of experience. In those cases, the aid of an analytic chemist must be invoked, as it would be impossible to give, within the limits of the present work, the requisite information to meet all or many of the cases that might arise. The characteristic properties of each fat are given under its appropriate head, and will in a great degree serve in most instances as guides to the intelligent operative; though in complex substances they would hardly suffice without a chemical training.

We proceed to describe, separately, each of the fats having connection with our art.

Lard.—This is generally prepared from the adipose matter of the omentum and mesentery of the hog by freeing it with the hand from the membranous matter connected with it, washing with water until colorless, and melting, with moderate heat, until the dissipation of all moisture, which is known by the absence of crepitation when small portions are thrown on burning coals, and by the transparency of the melted substance. The western lard is rendered differently and by steam. The whole hogs, excepting the hams and shoulders, after being scraped and cleansed, are steamed in a properly con-

structed cistern, which, when full, is allowed to settle, and the melted lard is then run off into barrels, clear and free from the lower stratum of water and sediment. Of all arrangements for rendering lard by steam, none is more advantageous, I think, than that of Wilson's, of Ohio. A description of this patent, accompanied by drawings, is given in another part of this work. Western lard has a granular appearance, owing to the manner in which it is prepared, and it is this characteristic that renders it so eligible for the purpose of making lard oil, as it can be pressed for oil without further granulation. Corn fed lard has the most consistency; mast fed is next in quality, whilst that obtained of hogs fed on distillery refuse, is thin, flabby, and deficient in body. Pure, properly prepared lard is white, rather soft at the ordinary temperatures, inodorous, fusible at 81° F., and has a specific gravity of 0.938 at 50° F. Treated with 100 parts anhydrous boiling alcohol, 2.80 parts of olein are taken up. Exposed for some time to air, it becomes yellow and rancid for the same reasons that other fats are similarly affected, and which have been before mentioned. When saponified with an alkaline solution, glycerin is eliminated; and when the resulting soap is decomposed by an acid, it is converted into the oleic, margaric and stearic acids; 100 parts by saponification yielding 9.0 of glycerin and 94.65 of oleic, margaric, and stearic acids; the two latter, or solid portion, constituting 38 per cent. of the lard. Lard, then, consists of olein, margarin, and stearin, or, to speak more correctly, of the oleate, margarate, and stearate of the oxide of glyceryl.

Lard, when granulated and pressed at a low temperature, gives off its fluid constituent, *olein*, as LARD OIL. The pressed cake, or stearin, and "*solar stearin*," as it is commercially termed, amounting to 30 or 38 per cent. of the lard, and of which large quantities are sent to market,

is a most excellent soap material. For very hard soaps, lard alone will not answer, it being necessary to add to it a portion of tallow or mutton suet. According to Olmstead, an addition of 33 per cent. of common rosin softens the lard, and renders it limpid at 90° and semi-fluid at 76° F. It moreover prevents decomposition and acidity of the lard.

Mutton suet.—When carefully prepared, this fat is of a beautiful white color and peculiar odor. It is very firm and brittle, completely insoluble in water, and but partially so in alcohol, 100 parts boiling alcohol at 0.821, dissolving but 2.272 parts. This fat, which is taken from the sheep, is richer in stearin than the others, and contains 74 per cent. of solid ingredients. It is saponifiable with the alkalies. The melting point of mutton suet is 98° to 104° F.; and that of its solid portion is 144° F. According to Heintz, the fluid part of mutton suet consists of olein and another oil of lower atomic weight; the solid portion, of stearin, margarin, and palmitin. There is probably some hircin also present.

Beef tallow, or suet of the ox.—Tallow and mutton suet are similarly constituted, except that the latter contains no hircin, and that its proportion of stearin is somewhat less. Its general characters are well known; it is firm, brittle, not so white as mutton suet, has a yellowish tint, and is fusible between 98° and 104° F., insoluble in water, and soluble in 40 parts boiling alcohol. There are many varieties in commerce, but American tallow holds the first rank. Russia tallow is also highly esteemed, and, like the American, always contains more or less of mutton suet, but the quality varies with the province from which it comes. South American tallow is used for common candles and soap.

Beef marrow.—This fat is of a bluish-white color, of a weak taste and odor, and is fusible at 113° F. It is com-

posed of 24 parts of olein, and 76 parts of solid fats (stearin and margarin).

Bone fat, soap grease, and oil lees are, each, an inferior kind of fat, available for making common yellow soap. The first is procured by boiling bones in water; the second, by the expression of heated pork or beef cracklings. The last is the odds and ends, saved in the different processes for making and purifying fish oils. The two former serve for hard soaps—the latter is used for a semi-concreted soft soap known as "oil soap."

Kitchen stuff.—This is the refuse of kitchens, and known as "*soap-fat.*" After being melted by steam and drawn off clear from subsident matter, it furnishes a fat sufficiently good for yellow soap. Being a compound of many kinds of fat, it is difficult to determine, quantitatively, its proportion of olein, stearin, &c.

Elephant fat.—This is a rare article. When fresh, it is of the consistence of lard, yellowish or white, inodorous and neutral to test paper. It melts at 82° F. According to Filhol and Joly, it is composed of 79 parts of olein and 21 of margarin. The olein is yellow, and has the property of not being changed into elaidic acid by the action of hyponitrous acid.

Human fat.—This fat is more or less fluid, according to the proportion of its solid constituent, yellowish, of a feeble taste and smell, and forms about the twentieth part of the human body. One hundred parts of cold alcohol dissolve 2.48 of the fat. With the alkalies it gives a firm soap, and Chevreul says, that a soap, made with fat taken from the breast of a woman, when dissolved in water, emitted a cheese-like odor, whilst this characteristic was not incident to the soap prepared with fat from the leg.

This fat varies with the part of the body whence it is taken; it is most firm near the kidneys and under the skin, whilst between the muscular fibres, it is only of the

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consistence of a semi-congealed oil, and near the movable viscera it is of a granular texture. Age also has much influence upon the grease, for in the fœtus it is a kind of granulated gelatin, becoming gradually more solid till the springtime of life; and at the age of forty the fat attains its maximum, and after that gradually diminishes in consistence, as shown by the wrinkling of the skin, which it serves to distend. It is much softer in males than in females, and in old age the fat lessens in quantity.

According to Heintz, human fat is composed of olein, a second fluid fat, the properties of which have not yet been defined, stearin, and palmitin.

Adipocire, according to Wetherill's recent investigations, consists chiefly of free fatty acids. Organic tissue, water, coloring matter, traces of lime, phosphate of lime, and other matters are also often present.

It is generally found in graveyards, and moist situations where ammonia has been generated by the decomposition of animal matter. It is a peculiar fatty matter, resembling in some of its properties a mixture of fat and wax, and hence its name from two Latin words, *adeps*, fat, and *cera*, wax. Its fusing point is 125° F.

Cow butter.—This fat exists in the milk of mammiferous animals, from which it separates, spontaneously, after a sufficient repose. The cream, rising to the surface and holding the butter in a chemico-mechanical state of intimate suspension, being skimmed off and churned at 55° F., yields about 4.5 of butter in every 100 parts. It is white or yellow, of consistence more or less firm, and of agreeable smell and taste. Milk is composed of butter, casein, sugar of milk, several salts and water, but in variable proportions. The butter exists in the form of very small transparent globules of nearly uniform size. The comparison between human milk and cows' milk, is shown by the following analyses, by Henry and Chevalier.

	Human milk.	Cows' milk.	Asses' milk.
Butter	3.55	3.13	0.11
Salts or mucous matter	0.45	0.60	0.34
Sugar of milk	6.50	4.77	6.08
Cheese	1.52	4.48	1.82
Water	87.98	87.02	91.65
	100.00	100.00	100.00

Braconnot contends that there is a difference between butter prepared in summer and that made in winter, as regards consistence. The following analyses exhibit its composition in each season.

	Butter of summer.	Butter of winter.
Oily or fluid constituent	60	35
Firm or solid "	40	65

Butter is insoluble in water, and becomes rancid by exposure. By steaming butter for five or six hours, or melting it by fire, and keeping it at a temperature of 70° F. for one or two days, the solid portion crystallizes or granulates, and can be separated by filtration. According to Heintz's recent investigations, butter is composed of butyrin, caproin, caprylin, caprine, olein, myristin, butin, stearin, and palmitin. The latter four constitute nearly all of the solid portion; the four first yield acids which are volatile, and to them is due the pleasant and peculiar odor of fresh butter. As different conditions of life cause slight variations in the nature of an animal secretion, butters of some seasons and localities contain, in place of the butyric and caproic acids, vacinnic acid.

With respect to making butter, the scientific explanation of the theory of churning is as follows: By agitation the globules of butter are broken, and made to unite together in a mass. The introduction of air during churning, aided by the heat of the cream or milk, occasions the formation of lactic or acetic acid, and this coagulates the casein, and thus assists the separation of the butter. In summer, when the heat prevents the ready coherence of

the butter, a quantity of cold spring water, thrown in after the buttermilk has formed, often effects the desired end. The temperature is thus depressed, and the butter rendered solid, while the air contained in the water aids in the formation of acid and in coagulating the casein. The only thing, in a scientific point of view, necessary to be attended to after the separation of the butter, is to free it from buttermilk or casein. If the casein be suffered to remain, putrefaction ensues, and the butter acquires a rank putrid taste. Its separation, therefore, is of the first moment.

The superiority of certain brands of butter, noted for the excellent flavor and taste which they retain for a considerable time, is more due to their freedom from casein than to any mystery in the mode of preparing them.

Sperm oil.—Certain fish, particularly the *cetaceii*, yield a greasy fluid or oil, called or named according to that of the fish whence it is extracted. The greater number of the oils under this head are liquid at ordinary temperatures, and consequently are excessively rich in olein. Spermaceti oil is obtained by melting and pressing the adipose panicle of the *physeter macrocephalus*, and of all that species of fish. It is found in commerce, bleached and unbleached, the latter having a brownish appearance and disagreeable odor. Cooled to zero, it drops a solid constituent (spermaceti), somewhat varying in the different oils, and bearing the same relation to fish oil that stearin and margarin bear to lard and the so-called fixed oils. Sperm oil, for instance, yields spermaceti, and, when separated from it, is clear and limpid. It saponifies with facility, requiring but 0.6 of its weight of potassa, and five parts of water; and the soap obtained is brown, rather soft, and completely soluble in water. Hofstædter, who has recently examined the oil from the head matter, found it to contain spermaceti, oleic, valerianic, and *physetoleic*

acids. The solid acids are not given by him, because their amount was too small to be estimated. The physetoleic acid ($C_{32}H_{29}O_3 + HO$) is colorless, inodorous, melts at 86° and solidifies at 82° F. It does not yield sebacic acid by distillation, nor elaidic acid by the action of nitrous acid.

Neat's-foot oil.—This is the oil of cattle feet, extracted by the following process: The feet, as collected from the slaughter-houses, are soaked in cold water to remove the blood, and, after the cutting off of the sinews, which make valuable glue pieces, placed perpendicularly in a depth of scalding water sufficient to cover the hoofs. In fifteen or twenty minutes they are to be taken out, and each one dexterously handled, under a shear-like lever machine, for the separation of the hoof. The next step is to joint them with a knife, to sever the toes from the large bone. The latter, being intended eventually for button material, are boiled carefully with water by steam, while the former, which are more obstinate in yielding their fat, are boiled in the open pan with the water previously used for the large bones. After the boiling, the liquid is left to repose, so that the oil may rise to the surface and be drawn off. The collected oil deposits in time a thick stratum of dirty semifluid fat, from which the clear supernatant portion must be decanted.

This oil consists of olein, margarin, and stearin, the solid constituents being in considerable proportion. It is white and fluid at moderate temperatures, but congeals in the winter.

The commercial article, unless obtained direct from a reliable manufacturer, is rarely pure, being adulterated generally with horse oil, common lard oil, bone fat, and even fish oil.

FISH OILS.—The leading fish oil of commerce is whale oil, which is the product of different species of whale

from the polar seas. Dolphin oil, seal oil, shark oil, porpoise oil, cod oil, and the like, are of inferior quality, and comprised under the general title of train oil.

All fish oils contain certain peculiar animal matters, which impair their illuminating power, but do not injure them for the purposes of the soap-maker. They are obtained by melting the blubbers, and usually contain foreign matters, which, when the oil is steamed and left to repose, form a substratum, and may thus be separated.

For the clarification of oils by means of the filter, Tard, of Paris, recommends a medium of paper pulp mixed with one-third to one-half its weight of beech sawdust, washed for several days, and then moulded into cakes. One of these cakes, 10 inches in diameter and 32 inches in thickness, the inventor says, is capable, with a pressure of 13 feet of oil, of filtering 315 gallons in twenty-four hours.

Oil of the beak-nose whale.—This is the doegling train oil from the *balœna rostrata* of the Faroe Islands. It becomes semifluid at a few degrees above 32° F., burns with a bright flame, and has an illuminating power fifty per cent. greater than common whale oil. Its specific gravity is 0.868. According to Scharling, it consists of spermaceti, doeglic acid, and doeglic oxide.

Shark oil.—The oil of the liver of the basking shark (*squalus maximus*) of the bay of Galway, or sunfish, as it is commonly called. The quantity of oil obtained from a single fish frequently amounts to 120 gallons. It is light yellow, of specific gravity .870 to .876, and retains its fluidity several degrees below freezing point. The disagreeable fishy odor of the fresh oil passes off by exposure to air. It is said to give a brilliant flame, and without clogging the wick.

Ronalds, who made a partial examination of it, reports that it consists of glycerin, a peculiar oleic acid very rich in carbon, and another undefined liquid oil.

Cod-liver oil.—The product of the *gadus morrhua*, or common cod of the banks of Newfoundland. Its specific gravity, at 72° F., is .917. The commercial article is frequently a mixture of oils from the several species of gadus of the seas of Northern Europe and America, viz: the hake, haddock, pollock, and coal-fish. The density of this inferior oil ranges from .915 to .919.

Either kind is obtained by steaming the livers with water, straining the pultaceous mass, and collecting the oil as it rises to the surface of the strained liquor. According to De Jongh's analysis, cod-liver oil consists of olein, margarin, butyrin, several of the components of the bile, and iodine, bromine, and chlorine; but the more recent investigations of Winkler prove the entire absence of glycerin, and that *oxide of propyl* replaces it.

Spermaceti.—The beautiful white crystalline fat found in the bony receptacles of the head of the white whale of the South Sea (*physeter macrocephalus*), and allied species. In the living animal it is fluid, but congeals immediately after death, forming a crude mixture which, by hydraulic pressure, yields nearly all its oily portion, and becomes dry and hard. When further purified, it is a brilliant pearly white solid, of a lamellated structure. It melts at 122° F., and has a specific gravity of .943 at 60° F. Hot ether dissolves it in large quantities, and alcohol of .821 takes up 3½ per cent., but, on cooling, deposits 0.9 per cent. in crystalline plates.

The spermaceti of commerce always is contaminated with more or less of a yellowish oil, which it retains with great tenacity, and by which its melting point is greatly lowered. The best means of purifying spermaceti is to treat it two or three times with boiling alcohol, and then to subject it to one or more solutions and crystallizations in ether, until the temperature at which the spermaceti solidifies reaches 120° or 121° F., when it may be regarded

as perfectly pure. In this state, the name of *cetine* has been assigned to it by Playfair. The so-called "*solar sper-maceti*" is stearic acid black of superior quality, with which there is mixed, occasionally, a portion of true spermaceti.

The composition of spermaceti was formerly thought to be analogous to that of the neutral fats, except as to the basic constituent. Chevreul considered it a mixture of oleic and margaric acids combined with ethal instead of glycerin; and at a much later day, Lawrence Smith gave cetylic acid and ethal as its sole constituents.

The recent investigations of Heintz, however, seem to establish that it yields, by saponification, some little olein and a whole series of acids which exist naturally in combination with ethal, or oxide of cetyl. They may be tabulated as follows :—

1. Stearophethal (Stearophanate of oxide of Cetyl) $= C_{36}H_{35}O_3 + C_{32}H_{33}O.$
2. Margethal (Margarate " ") $= C_{34}H_{33}O_3 + C_{32}H_{33}O.$
3. Palmethal (Palmitate " ") $= C_{32}H_{31}O_3 + C_{32}H_{33}O.$
4. Cetethal (Cetate " ") $= C_{30}H_{29}O_3 + C_{32}H_{33}O.$
5. Myristethal (Myristate " ") $= C_{28}H_{27}O_3 + C_{32}H_{33}O.$
6. Cocethal (Cocate " ") $= C_{26}H_{25}O_3 + C_{32}H_{35}O.$

The myristic acid melts at 112° F.; the cocinic, at 94° F.; and the cetic at 135° F.

WAXES.—The term wax belongs strictly to the solid portion of the honey-comb produced by the *apis mellifica* or hive-bee; but it is usually extended to certain sebaceous secretions of plants, which have similar external characters.

Beeswax.—It has been a mooted point, whether the bee collects its wax ready formed from plants, or fabricates it by the aid of the vital mechanism of the body, from the honey and sugar portion of its food. The latter is the accepted theory; and Huber, its author, thus describes the complex and singular operation of making wax.

"The wax-makers having taken a due portion of honey and sugar, from either of which wax can be elaborated,

suspend themselves to each other, the claws of the forelegs of the lowermost being attached to those of the hind pair of the uppermost, and form themselves into a cluster, the exterior layer of which looks like a kind of curtain. This cluster consists of a series of festoons or garlands which cross each other in all directions, and in which most of the bees turn their back upon the observer. The curtain has no other motion than what it receives from the interior layers, the fluctuations of which are communicated to it. All this time the nurse bees preserve their wonted activity, and pursue their usual employments. The wax-makers remain immovable for about 24 hours, during which period the formation of wax takes place, and thin laminæ of this material may be generally perceived under their abdomen. One of these bees is now seen to detach itself from one of the central garlands of the cluster, to make way amongst its companions to the middle of the vault cr top of the hive, and by turning itself round to form a kind of void in which it can move itself freely. It then suspends itself to the centre of the space which it has cleared, the diameter of which is about an inch. It next seizes one of the laminæ of wax with a pincer, formed by the posterior metatarsus and tibia, and drawing it from beneath the abdominal segment, one of the anterior legs takes it with its claws and carries it to the mouth. How the bees mould the scales into the walls of the cells, is not yet exactly understood."

Beeswax is prepared for market, by pressing out the honey from the comb, melting the residual wax cake in boiling water, and allowing the whole to cool gradually. The deposition of suspended foreign matters is thus prevented, and as they collect at the bottom of the cooled wax, may be easily removed by the knife.

Wax has usually a brownish yellow color, but is occasionally of lighter shades, approaching in some instances to gray. It may, however, be bleached to perfect white-

ness by the method given in the chapter on wax candles; though it must be stated that its quality for candle material is impaired when bleached by other (chemical) means than by exposure in thin ribbons to moisture and light.

Wax is very hard and brittle at 32°, and breaks with a dry, granular, splintering fracture; at 90° it may be kneaded and moulded; and at 149° it melts. Its specific gravity in a solid state is .960 to .966; and in a fluid state .8247 at 200° F.

Wax is tasteless, but has an agreeable odor; is insoluble in ether and cold alcohol, but partially soluble in boiling alcohol. At high temperatures it volatilizes, and burns with a brilliant white flame. By distillation, it yields oily products and combustible gases. In the cold, acids are without action upon it.

It is often adulterated with earthy matters, stearic acid and rosin. The former may be detected by melting the wax, when they will subside to the bottom in insoluble form. Stearic acid is known to be present, when, on boiling the subjected sample in distilled water containing one-fiftieth of its weight of carbonate of soda, an effervescence and gelatinization of the solution take place. The admixture of rosin causes the wax to give a smoky flame in burning, and moreover reveals itself by its peculiar odor.

When wax is boiled repeatedly with fresh portions of strong alcohol, it is separated into soluble *cerin* and insoluble *myricin*. According to the recent and conclusive investigations of Brodie, cerin is not converted by oxidation into stearic acid, as has been represented by Lewy and Gerhardt, but is a compound body yielding by saponification *cerotic acid* ($C_{54}H_{54}O_4$) and cerotin, existing as such in beeswax to the amount of 22 per cent. It is a white, brittle, crystalline, volatile body, melting at 175° F. This acid was found in all the European waxes, but not in the beeswax of Ceylon; and hence it is evident that

different conditions of climate and vegetation cause a variation in the nature of an animal secretion.

The myricin or matter insoluble in boiling alcohol is saponifiable with difficulty, and yields palmitic acid ($C_{32}H_{32}O_4$) and a new wax alcohol, *melissin* ($C_{60}H_{62}O_2$). Palmitic acid, together with a solid hydrocarbon, was also obtained by distillation of the myricin.

Pela, or Chinese wax.—This concrete substance imported from China, and the secretion of an insect (*coccus pela* or *sinensis*), is sometimes confounded with *stillingia, butter* already described. In general appearance it resembles spermaceti, being in large brilliant white crystalline lumps, but is harder, more fragile and fibrous, and does not cake under the pestle. According to Martius, its fusing point is 181° F., whereas spermaceti melts at 122° F. By prolonged exposure to air its surface becomes yellow, but is restored to whiteness by ether. It is very slightly soluble in alcohol.

Brodie succeeded in partly saponifying this wax by fusing it with potassa, and obtained from it *cerotic acid* ($C_{54}H_{54}O_4$) and *cerotin*, or oxide of *cerotyl* ($C_{54}H_{56}O$). It contains also a little glycerin. By distillation, it is decomposed into cerotic acid and a solid paraffin-like hydrocarbon.

Cerotin or oxide of cerotyl dissolves in ether, and, when crystallized from the solution, fuses at 175° F.

Vegetable wax, though allied to beeswax in external characters, differs slightly in elementary composition and certain chemical properties. It forms a part of the pollen of wax-bearing plants, and constitutes the glazed coating or bloom of their leaves and fruits. It is also a component of several species of wax or berry. The vegetable waxes are not as readily whitened as beeswax, but are still capable of being bleached by economical means. The wax being melted, is then diluted with a mixture of oil of

vitriol with one-half of its weight of water, and while still hot is treated during constant stirring with gradual additions of nitrate of soda. The nitric acid evolved, under the circumstances, from this salt, oxidizes and destroys the coloring matter.

The kinds usually found in commerce are as follows:—

Myrtle wax.—The product of the pulpy portion of the fruit of the *myrica cerifera,* or candleberry myrtle of Cape Colony, Louisiana, and different parts of North America. According to Simmons, it is extracted by boiling the ripe berries with water and skimming off the molten wax as it rises to the surface, and straining through flannel bags.

It is yellowish-green, hard and brittle, and emits a fragrant balsamic odor. Its specific gravity is a little greater than that of water, and its melting point is 109° F. Cold alcohol does not dissolve an appreciable quantity of it, but at boiling temperature takes up about 87 per cent., most of which is deposited on cooling. Ether and spirits of turpentine dissolve it largely.

Japan wax is said to be the product of the *rhus succedania* of Japan, is white, crystalline, and fuses at 105° to 108° F. Differs from beeswax in being softer, more brittle, and feebler in illuminating power; is soluble in naphtha, but almost insoluble in alcohol. Forms a soluble soap with potassa, and yields palmitic acid and glycerin.

Palm wax.—This wax, which is known also by the name of *carnauba,* is a secretion of the leaves and stems of the *corypha cerifera,* of Brazil. It is white or yellowish-white, hard, dry, and brittle, with a smooth and shining fracture. According to Brandes, it is analogous to beeswax, though presenting different physical properties.

CHAPTER VIII.

THE neutral fats and their fat acids are closely allied in chemical behavior to heat and the mineral acids, and so we shall confine our remarks, in this chapter, to a general exposition of the influence of those agents, and leave the more special account of the reactions of the fats to be given under the head of their respective components, olein, stearin, palmitin, &c.

There is seldom any change produced by heating a fat until its fusing point is exceeded. At points beyond this, varying with different fats, peculiar and characteristic decomposition commences, and at boiling temperature they blacken, acquire consistence, and disengage pungent acrid fumes very annoying and injurious. If allowed to fall in a fluid state upon incandescent coke, or to pass through a red-hot iron tube, entire decomposition is effected. Carbonic oxide, nitrogen, hydrogen, and gaseous inflammable carbo-hydrogens pass over, with empyreumatic matters and a small residue of carbon remains. This property of partial decomposition into gaseous carbohydrogens renders the fats applicable for making illuminating gas.

By dry distillation the acids are separated from the glycerin, and both suffer decomposition; the latter to a large extent, the acids only in small part, acrolein, inflammable gases and fat acids being the products. These fat acids, whatever their source, consist of a concrete fat and a liquid acid approximating to oleic acid in properties.

The more gradually the temperature is raised, the greater will be the amount of solid fat acids in the distillate. The last half of the distillate which passes over is the more fluid portion, the first half having the consistence of butter. The rancid odor which accompanies the distillate may be removed by melting it in boiling water. By pressing it, 50 to 60 per cent. of solid fat acid is obtained.

Distillation, by steam, under pressure, also effects the decomposition of fats into glycerin and fat acids, and Tilghman has applied this principle, originating with him, to the manufacture of stearic acid block upon a large scale. The process is given in the chapter on Stearic Acid Candles.

The action of mineral acids varies with the acid employed; but all behave energetically, especially with the aid of heat. The proportion of acid and its strength are also modifying influences.

Sulphuric acid, for example, in the small proportion of several per cent. of the fat, acts as a defecating agent for precipitating the mucilage and parenchymatous matters, either by rendering them insoluble, or otherwise destroying them. When the quantity of acid is largely increased, its action extends to the abstraction of the glycerin of the fats and the formation of *sulpho-glyceric acid*, the fatty acids being left at liberty. At and beyond the proportion of one-half acids, say three-fifths sulphuric acid to two-fifths oil or fat, a thick reddish-brown magma is formed; in this reaction, the sulphuric acid not only combines with the glycerin, as above, but also with the fat acids, which it separates from their natural base, and converts into the double acids, sulph-oleic, sulpho-stearic, &c. According to Fremy, who was the first to make known these properties, the sulph-oleic and sulpho-stearic acids are well defined compounds, soluble in alcohol and in

water free from alkaline salts or excess of acid. The sulpho-stearic acid is a less stable compound than the sulph-oleic, for its cold aqueous solution decomposes by exposure. The decomposition is promoted by heating the aqueous solution ; and at ebullition both acids lose their sulphuric acid, and become free oleic and stearic acids, which rise to the surface of the water. Nitric acid, like the sulphuric, acts energetically upon oils when in large quantities and aided by heat, converting them at 120° to 170° F. into two series of products, one consisting of volatile, and the other of fixed acids ; among the first are the formic, acetic, butyric, valerianic, caproic, œnanthylic, and capric acids, and of the latter are the succinic, adipic, pimelic, suberic, and sebacic acids. If, instead of dropping oil into the acid, the latter is added portionwise to the former, and in the proportion of two weights to one of oil, and the heat be gradually raised and prolonged, the amount of solid product is largely augmented. By reducing the proportion of acid (38° B.) to 6 or 8 per cent., and the temperature to 70° F., the fats or oils solidify sooner or later, some requiring one hour, and others two days for that change. The solid product is called *elaidin*, and, like the original fat, forms a soap with alkalies. It must be remarked, however, that this solidifying property is peculiar to the fat oils ; for the drying oils are not in that way affected by nitric acid.

Chlorine and bromine form acids with the hydrogen of the fixed oils, and hence they are not of general application in this art; for the same reason, hydrochloric acid is rarely used.

The action of alkalies upon oils is treated of in the chapter on SAPONIFICATION.

CHAPTER IX.

THE essential oils are the odorous principle of plants; in most plants, they exist already formed as a normal secretion, but in some are evolved only by distillation, being generated during a species of fermentation of certain of its components thus induced. As instances of this latter kind, we cite the oils of mustard-seed and bitter almonds. In certain plants, they are found only in the leaves; in others only in the flowers; in others, again, they are found in the rind, or in the wood and fruits, and occasionally in the envelops of seeds, but not in the cotyledons. Some few plants, however, as the thyme and scented *labiatæ*, contain volatile oil in nearly all their parts. It occasionally occurs that different parts of the same plant contain different oils; for instance, the orange furnishes one oil from its flowers, another from the leaves, and a third from the rind or epidermis of the fruit, each varying from the other. In most plants, the oil is contained in little sacs or vesicles, so well confined that the oil is retained during the drying of the plant, and even for some time after, whilst in other species, again, especially in the flowers, the oil is constantly produced at the surface, and escapes at the moment of its formation. A few oils are obtained by expression, such as those of the oranges and lemons, where the oil resides in the epidermis of the fruit; others, again, which are not contained in vessels, such as those of violet, jasmine, &c., are procured by maceration of the flowers in oil of ben, an inodorous fixed oil, and are used in this

state in perfumery.   Volatile oils are distinguished from
the fixed oils by their volatility; and, as they are usually
obtained by distillation, they have been called also essen-
tial oils.   These oils are of an acid, burning taste, and
of a very mild, agreeable, or of a pungent and unpleasant
odor; some are colorless, others are yellow, red, or brown,
others, again, green, and a few blue, and, with the excep-
tion of those of cinnamon, cloves, mustard, and sassafras,
are lighter than water.   They are not greasy to the touch;
and their specific gravity ranges between 0.759 and 1.094,
the first number denoting the density of oil of cori-
ander, and the second that of oil of sassafras.   Most of
them congeal at different temperatures; some acquire vis-
cidity at the ordinary temperature of the atmosphere, and
become solid—for instance, the oils of fennel, anise, &c.
They burn with a brilliant flame and much smoke.   Al-
though they are styled volatile oils, the tension of their
vapor, as well as its specific heat, is much less than that
of water; and, though volatile at the ordinary tempera-
tures, their boiling point usually is not less than 316° to
320° F.   In contact with air or oxygen, they acquire thick-
ness, and are eventually converted into a resin by the
absorption of that gas.   This absorption varies with differ-
ent oils, and gives rise to carbonic acid gas; but no water
is formed.   Light contributes powerfully to this action.
A volume of concrete oil of anise absorbed 159 times its
volume of oxygen gas in two years, and emitted at the
same time 56 volumes of carbonic acid gas; a volume of
oil of lavender, during four of the colder months, absorbed
52 volumes of oxygen, and gave out two of carbonic acid
gas, without the production of water, and without being
even yet completely saturated with oxygen.   These facts
are stated upon the authority of Saussure's experiments.
"It has been observed that the odor of oils is closely
related with this chemical change.   Those which oxidate

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most rapidly have the strongest smell, and the characteristic odor of no oil can be perceived immediately after its distillation in an atmosphere of carbonic acid gas;" essences, therefore, should be preserved in well-stopped bottles.

The essential oils are divided into three classes, those containing only carbon and hydrogen, as oil of turpentine; those containing also oxygen, as oil of cloves; and those containing sulphur, as oil of garlic. Experience has demonstrated that most of the essential oils consist of two oils, each of a different degree of fusibility, but these constituents have no analogy whatever to the olein and stearin of the fixed oils. Bizio called these principles *sèreusine* and *igrusine*, or, in more modern language, *elaopten* and *stearopten;* the latter of which is separable from the former by pressure, when the oil is congealed at a sufficiently low temperature. If the analyses of the essential oils are compared with those of the fixed oils, the difference in their constitution will appear evident; for, whilst the former are richer in carbon, many of them are much more deficient in oxygen, some even entirely destitute of it, and a few, as said above, contain a little sulphur, and nitrogen also, according to some chemists. The proportion of hydrogen varies in different oils, but as a general rule they are more hydrogenated than the fixed fats. The source whence is obtained the gaseous constituency of these oils, and, as a consequence, the nourishment of the plants which yield them, is the atmosphere, for the carbon and nitrogen; water, for the hydrogen, and sulphuric acid for the sulphur; all of which are withdrawn from the surrounding media containing them, by the vegetable organism, and assimilated as above. The stearopten, or crystallizable portion of those oils, thus constituted, is commonly called the *camphor* of the plant, and not unfrequently forms artificially, when

the oils are in contact with water. According to Gerhardt's and Cahour's experiments, the action of fused hydrate of potassa decomposes all oxygen containing essential oils, into an acid and a non-azotized oil.

As regards the camphors of the oils, they vary in properties. Some contain only carbon and hydrogen, while others contain both ingredients, besides oxygen; the stearopten of the attar of rose is an example of the former.

Among the essential oils containing oxygen are those of *bitter almonds, spiræa, cinnamon, cloves, cumin, aniseed, valerian, dill, fennel, parsley, caraway, coriander, pimpernel, peppermint, marjoram, lavender, rosemary, basil, thyme, rue, cascarilla, chamomile, wormwood, tea, cardamom, nutmeg, cajeput, rhodium, rose, bergamot, saffron, sassafras, sweet bay, hyssop, cedar.*

Among those destitute of oxygen are the oils of *turpentine, juniper, savine, lemons, cedrat, oranges, copaiva, pepper, cubebs, storax, elemi.*

Those essential oils containing sulphur are as follows: Oils of *mustard seed, horseradish, garlic, onions, assafœtida, water pepper and hops. Mustard seed* contains also nitrogen.

Omitting any remarks upon the action of the acids and other reagents, we shall only consider here, those oils which react upon the salifiable bases, mentioning, however, in passing, that they are more or less soluble in alcohol and ether. It is evident from experiment that the essential oils have no great affinity for the salifiable bases, that is to say, unlike the fixed oils, they have but little disposition to form soaps with the alkalies. With much time and difficulty a sort of feeble combination of the oils of cloves, cinnamon and cedar wood, with caustic alkali, is effected; the products of which are styled *savonules,* which are, by way of imparting a definition, *those compounds of resin acid and base endowed with sapo-*

naceous properties. That soap called Starkey's may be classed under the head of "*Savonules.*" It consists of soda and essence of turpentine. It is prepared by triturating recently fused caustic soda in a mortar with a little oil of turpentine, added dropwise, until the mixture has acquired the consistence of soap. The compound is to be dissolved in spirits of wine, filtered and distilled. What remains, after the spirit is drawn off, consists of soda combined with a resin formed in the oil during the act of trituration. Here, therefore, it is seen that there is no combination between the actual constituents of the oil and the soda, but merely a union of the soda with the resin developed from the oil by reason of its partial oxidation, whilst being triturated—this resin, like that used for common soaps, being capable, by its acid properties, of combining with alkalies, and dissolving in alkaline solutions.

The following table comprises the most important volatile oils with their characteristic colors and densities, severally affixed. It is necessary to add, however, that these properties suffer modification in proportion as the oils may be adulterated.

Table of the Principal Volatile Oils.

Names.	Botanic name of plant from which extracted.	Color.	The part of the plant which yields the oil.	Sp. grav.
Oil of absinthe	Artemisia absinthium	green	leaves	0.897
" dill	Anethum graveolens	yellow	seeds	0.881
" anise	Pimpinella anisum	"	"	0.977
" ache or parsley	Apium petroselinum	"	roots	
" mugwort	Artemisia vulgaris	"	leaves	
" elecampane	Inula helenium	white	roots	
" badiane	Illicium anisatum	yellow	seeds and fruit	0.987
" angelica	Angelica archangelica	"	root, seeds, &c.	
" Portugal	Citrus aurantium	"	rind of the fruit	0.835
" cinnamon	Laurus cinnamomum	"	bark	1.035
" chamomile	Matricaria chamomilla	blue	flowers	0.924
" cajeput	Melaleuca leucodendra	green	leaves	0.948 at 48° F.
" cascarilla	Croton eleutheria	yellow	bark	0.938
" caraway	Carum carui	"	seeds	0.926
" chervil	Scandix cerefolium	lemon yellow	leaves	
" lemon	Citrus medica	yellowish	rind of the fruit	0.847
" cochlearia	Cochlearis officinalis	"	root	1.01
" coriander	Coriandrum sativum	white	seeds	0.759
" cubebs	Piper cubeba	yellow	"	0.929
" cumin	Cuminum cyminum	"	"	0.860
" dittany	Origanum creticum	brown	flowers	0.946
" fennel	Anethum foeniculum	white	seeds	0.997
" galangal	Maranta galanga	yellow	root	
" genista	Genista canariensis	"	"	
" juniper	Juniperis communis	green	seeds	0.911
" ginger	Amomum zinziber	yellow	root	
" cloves	Caryophyllus aromaticus	"	dry flower buds	1.034
" hyssop	Hyssopus officinalis	"	leaves	
" lavender	Lavendula spica	"	flowers and leaves	0.877
" cherry laurel	Prunus laurocerasus	"	leaves	
" crisp mint	Mentha crispa	white	flowers and leaves	0.969
" peppermint	Mentha piperita	"	"	0.920
" balm mint	Melissa officinalis	"	"	0.975
" motherwort	Matricaria parthenium	blue	"	
" yarrow	Achillea millefolium	blue and green	"	0.92
" marjoram	Origanum marjorana	yellow	"	
" mustard	Sinapis alba and nigra	deep brown	seeds	1.015
" nutmeg	Myristica moschata	yellow	"	0.92
" neroli	Citrus aurantium	orange	flowers	0.930
" pennyroyal	Mentha pulegium	yellow	"	0.927
" rosemary	Rosmarinus officinalis	white	plants and flowers	0.911 and 0.8886
" sage	Salvia officinalis	green	flowers and leaves	0.905
" saffron	Crocus sativus	yellow	pistils	
" sassafras	Laurus sassafras	"	root	1.094
" turpentine	Pinus sylvestris and abies	white	wood and resin	0.872 at 50° F.
" thyme	Thymus vulgaris	yellow or pale green	flowers and leaves	0.905
" rose	Rosa centifolia	white	petals	0.832
" valerian	Valeriana officinalis	green	root	0.9438
" pimento	Myrtus pimenta	slightly yellow	rind of the fruit	1.021
" rhodium	Convolvulus scoparius	yellow	wood	
" savin	Juniperus sabina	limpid	leaves	0.915
" tansy	Tanacetum vulgare	yellow	plant	0.931
" rue	Ruta graveolens	yellow-green	"	0.837 at 64° F.
" bergamot	Citrus limetta bergamium	yellow	rind	0.873
" serpolet	Thymus serpyllum	light brown		

Essential oils, in soap making, are useful solely for their perfume; but as it is requisite to have them pure, we proceed to give some methods for detecting the adulterations which the commercial articles frequently contain. The most prevalent adulterations are fat or fixed

oils, resins, balsam copaiva, and spirits of turpentine and alcohol. Either of the first three may easily be detected, by putting a drop of the oil on paper, and heating it, for if pure, it will evaporate without leaving any stain or residuum; whilst an oil mixed with any of the above substances, leaves a greasy, translucent spot upon the paper. The chief difficulty is to recognize the presence of a cheap essential oil in a dear one, to which it is similar. Here taste and smell are not sufficiently exact tests. By a careful examination of their respective densities, the essential oils may, in most instances, be distinguished; but the wholesale way of "*making them up*" now-a-days, renders necessary some sure method for exposing the fraud; for oils of lavender, lemon and bergamot, often contain as high as 40 per cent. of spirits of turpentine. The essential oils, especially of marjoram, lavender, spikenard, sage, thyme, rosemary, wormwood, and peppermint, are the most subject to this adulteration. A few years since, Mero discovered a process for detecting the presence of spirits of turpentine, founded on the fact that this oil dissolves the fixed oils with great facility; while the essential oils above mentioned, do not. He considers, therefore, that it will serve to indicate the presence of oil of turpentine, mixed with pure essential oils whose powerful smell conceals that of the turpentine. Experience gives the preference to the oil of poppies, for this purpose, because of its uniform consistence, regardless of temperature. About a drachm of oil of poppies is poured into a graduated tube, and an equal quantity of the essential oil to be tested, added; the mixture is then shaken, and should become of a milky white, if the essential oil is pure, whilst it remains transparent, if it contain any oil of turpentine.

The value of this method may readily be determined by first testing a pure essential oil, and then some essen-

tial oil of turpentine; if the essential oil is then mingled with the oil of turpentine, even in proportions so small that no advantage could accrue to traders by the admixture, it is found to act like the essential oil of turpentine itself—that is to say, the mixture is not rendered turbid.

To make the experiment successful, the two essential oils should be very intimately blended. The method employed in commerce for this purpose is as follows: The pure essential oil, and the quantity of oil of turpentine which is to be added to it, are placed in a hot water bath basin, and this is heated until the mixture, which is at first turbid, becomes transparent. The medley which is obtained by adding oil of turpentine in the process of distilling the plants, is detected in the same manner. Mero received a medal for this process from the *Société d'Encouragement*, before the committee of which he proved, by some experiments, that he could determine at once the mixtures which contained five per cent. of oil of turpentine, and was, moreover, able to tell very nearly the proportions of the mixtures. This process, though available for the detection of adulteration in several of the essential oils most in use, is, however, not of general application, for it furnishes no proof of the presence of essence of turpentine in the oils of thyme and rosemary.

M. Voget considers concentrated sulphuric acid as the best reagent for detecting adulterations of essential oils with oil of turpentine. The peculiar color which the former assumes with sulphuric acid is much altered by the intense reddish-brown color which the oil of turpentine yields; and, moreover, the heat evolved with the oil of turpentine is greater than that with other oils. In testing, the oils are best dropped upon a glass plate, beneath which is placed a piece of white paper; five drops of the oil are then added to one drop of fuming (Nordhausen) sulphuric acid, and the two are mixed with a

glass rod. The presence of alcohol may be determined by placing a lump of perfectly dry chloride of calcium in a test tube containing the suspected oil, and shaking thoroughly. If the essence is pure, the chloride of calcium will remain unaltered; but if it contains alcohol, the lump will dissolve and form a dense substratum.

Violet and Guenaud, perfumers in Paris, announced, some years since, an instrument for estimating the value of the essential oils by their specific gravity. It is merely a very sensitive areometer, which, by means of a small weight, was rendered proper for testing those oils heavier than water, and without the weight for such as are lighter than water. Bussy and Chevalier, who reported favorably upon this instrument, verified its exactness by experiments.

RESINS.—The resins are proximate principles found in most vegetables, and in almost every part of them. Their ultimate components are carbon, oxygen, and hydrogen, and hence their assimilation to the oils in that respect. There are many varieties, of which the most are solid, though some are liquid. They are obtained by spontaneous exudation from the trees, or by incision. The solid resins are more or less friable, sometimes colorless, but most generally yellow or brown, and of a warm, sharp, bitter taste. They are mostly heavier than water, their specific gravity varying from 1.0 to 1.2 Their general characteristics are fusibility, inflammability, and solubility in ether and alcohol, and insolubility in water. Many resins, when dissolved, redden litmus paper, combine with bases, and possess all the characters of acids; others, again, are neutral, and do not unite with bases. The compounds which they form with the alkalies are called resinous soaps.

Every resin, says Unverdorben, is a mixture of several resins, which are separable from each other by their un-

equal solubility in hot or cold alcohol, in ether, potassa, and carbonate of potassa, or by the different solubilities of their compounds with metallic oxides in these and other menstrua. This chemist separated from some, five and more resins, all quite distinct substances. The resins become negatively electric when rubbed. "There is every reason to suppose a close relation in composition between the oil and its associated resin, the last being often obviously the product of the oxidation of the former, many of which, by the action of the air, are converted into resins. In this change, the oxidation may be occasioned by a loss to the oil of one part of its hydrogen, which unites with the oxygen absorbed, to form water, and the replacement of the hydrogen lost, by oxygen, in equivalent proportions; or it may occur by the combination of the entire oil, as a radical, with oxygen. The point is not decided by the analytic information at present possessed; but Liebig adopts the following as the composition, for instance, of oil and resin of turpentine:"—

Oil of turpentine, $C_{40}H_{32}$ or $C_{20}H_{16}$.
Resin of turpentine, $C_{40}H_{30}O_4$ or $C_{20}H_{15}O_2$.

The fragrant resins owe their odor to the presence of volatile oils. With the exception of colophony, or common resin, none others are used by the soap-maker, so we do not particularize, but pass on to the composition of that body.

Colophony, or common resin.—The residual product from the distillation of the turpentine balsam of the *pinus sylvestris* and other species of *pinus*. The yield varies from 75 to 95 per cent. Colophony is either brown or yellow, the color being owing to the temperature and extent to which the distillation was carried. Black resin may be whitened by boiling it with water; and this fraud is sometimes practised, not only to improve its appearance, but

to increase its weight. It may be detected by exposing the resin for several hours to a dry steam heat, which does not change genuine yellow resin, but browns the false article.

Colophony is a transparent, brittle mass, of specific gravity 1.07 to 1.08. It softens at 156° and melts at 275° F. By distillation, it yields an ethereal oil and an unctuous oil.

It is largely used in yellow or "Yankee soap," and our supplies are drawn chiefly from North Carolina.

Though this substance forms an important ingredient in the composition of yellow soap, and is a partial substitute for fixed oil or fat, it is not analogous to it in chemical constitution, nor can it, like those bodies, form with an alkali a proper soap by itself. Resin contains no glycerin, nor any equivalent for that substance. Unverdorben divided it into two different resins, which he named *sylvic* and *pinic acids*. The two are separable from each other by means of cold alcohol, of specific gravity 0.867, which dissolves the alpha resin (pinic acid), so called, and leaves behind the beta resin, or sylvic acid. The salts formed by the union of potassa, soda, or ammonia with pinic acid, the title of which is the pinate of each respectively, dissolve in water, but are precipitated by an excess of alkali or the addition of any alkaline salt. The pinates of other bases are insoluble. Pinic acid has for its formula $C_{40}H_{30}O_4$; and, when exposed in alcoholic solution for some time to the air, absorbs oxygen, and becomes oxypinic acid, and possessed of stronger acid properties, and takes as its formula $C_{40}H_{30}O_8$.

The *beta resin, sylvic* or *pimaric acid*, is insoluble in water, but easily dissolves in alcohol, ether, or the fixed and volatile oils. The sylvates of potassa, soda, and ammonia are soluble in water; those of other bases are not dissolved by water, but most of them by alcohol. Its com-

position is, according to Tromsdorff, $C_{40}H_{30}O_4$, which makes it isomeric with pinic acid.

The formation of yellow soap from resin depends on the direct combination of the resin acids with soda. No glycerin is eliminated, there being no proper saponification. The compounds formed, however, by the union of soda with resin, are not separable from their aqueous solutions by common salt, like true soda soaps, nor do their concentrated solutions become mucilaginous or gelatinous on cooling; nevertheless they produce a lather, and, when added to soap in limited proportion, increase its detergency.

By distilling or heating pinic acid, a new resin is formed, *colopholic acid*, with stronger affinities for bases. There is doubtless a small portion present in common resin generated during distillation of the turpentine from it. Pinic and sylvic acids being colorless when pure, the brown shade of resin is therefore due to action of the fire.

CHAPTER X.

THE PROXIMATE PRINCIPLES OF FATS; THEIR COMPOSITION AND PROPERTIES.

In a practical as well as theoretical view, there have been few investigations so fruitful in vast benefits, as those comprising the constitution and properties of the fats. They teem with results alike encouraging to art and interesting to science; and which are the basis of enterprises intimately associated with social comfort and commercial prosperity.

Until 1811, when the present era in the chemical and technical relation of fats was inaugurated by the great Chevreul, there had been but little experiment and no generalizations in this field of study. Then, applying his mind and the principles of chemistry to the work, he evolved a grand system which has enabled his followers to build up, from his materials, a new branch of scientific art. He it was who struck the first spark in the great light which now makes former mysteries so plain; and the profitable issues of his philosophy and labors will cause his name to be remembered and honored as long as history endures.

Since his discovery of the compound nature of fats, it is an easy task to study them intelligibly; for as the various kinds mainly differ in respect to the character and proportion of their components, to carefully consider the distinctive properties of each of the latter comprises nearly all that is necessary to give a perfect understanding of the chemistry of soaps and candles. We shall

therefore proceed to treat of them, commencing with that which is the most valuable for the purposes of our art.

STEARIN.—One of the solid principles of fats isolated by Chevreul, and which takes its name from στεαρ, the Greek word for tallow. It may be best prepared from tallow or mutton suet, by melting them at a moderate heat, washing with ether as long as anything is dissolved, or by mixing melted suet with six times its volume of ether, and subjecting the mass when cold to a strong pressure. In both cases, the olein is dissolved and stearin remains. "*Camphene*" may be substituted for the ether, but in that instance the pressed stearin must be boiled to expel any traces of turpentine retained by it. It is made on a large scale in the process for extracting LARD OIL, by steaming the lard or tallow for some time, and allowing to cool gradually in a temperature of about 100° to 60° F., and pressing or subjecting to centrifugal action, as directed in the chapter on STEARIN CANDLES. Neither of these methods yields the stearin absolutely pure, for exact manipulation is necessary to free it from all trace of palmitin, and other components of the original fat. It is generally in pearly white scales, not at all greasy between the fingers, is insipid and inodorous, fusible at 141° F., easily powdered, and, on cooling, forms a solid non-crystalline compact mass. It is insoluble in water and cold ether, dissolves in boiling alcohol and ether, and crystallizes out on cooling.

Stearin is a double salt of stearic acid with water and oxide of glyceryl. In other words, when stearin is saponified, it is decomposed into the following constituent parts: two equivalents of stearic acid, one equivalent of water, and one equivalent of oxide of glyceryl, the latter being the base in the original fat. According to Arzbæcher, however, the proximate composition of stearin is not always uniform; for he found in the *pure* stearin of beef

tallow 98.15 stearic acid and 8.50 glycerin, whereas that from mutton suet gave 94.90 stearic acid and 8.23 glycerin.

By distillation, it yields stearic acid and derivatives from the decomposed glycerin.

Lassaigne's Table, representing the Points of Fusion and the Proportions of Stearine extracted from the same weight of fat of the Bull, the Ox, the Pig, and the Horse.

Kind of animal.	Part from which the fat was taken.	Color and consistence of the fat.	Point of fusion.	Proportion of stearin extracted from 100 parts fat.
Bull (2 years)	Kidneys	Yellowish-white; firm consistence	106° F.	32.0
	Shoulder	White; less consistent	97° F.	18.5
Ox (7 years); killed by a butcher	Mesentery	White; solid	93° F.	18.0
	Kidneys	White; solid	87° F.	10.0
	Buttocks	Yellowish; very soft	71° F.	2.0
Pig (1 year); killed by a butcher	Mesentery	White	85° F.	4.8
	Kidneys	White	80° F.	4.5
	Lard under the skin	White; very soft	74° F.	2.0
				Proportion of congeated part to fluid.
Healthy horse; death caused by asphyxia during a fire	Mesentery	Yellowish; semifluid	54° F.	62.1 : 37.9
	Kidneys	Yellowish; less fluid	65° F.	93.0 : 7.0
	Under the rib	Yellowish; more fluid	64° F.	90.0 : 10.0

Stearic acid.—As obtained by the usual methods of saponification, this acid is a mixture of stearic, palmitic acid, &c. It may be prepared absolutely pure by Pebal's modification of Heintz's method, which consists in decomposing mutton suet soap with dilute sulphuric acid, dissolving the eliminated fat acid in alcohol of 82 per cent., leaving to crystallize, and pressing powerfully to expel the more fluid acids. The solid cake is then subjected to similar treatment for several times with fresh quantities of alcohol, and lastly dissolved in alcohol of 83 per cent. To this solution an alcoholic solution of acetate of lead is added, but in much less quantity than is required to precipitate the whole of the fatty acids. In this way the fat acids of lower atomic weight and fusing point are left in solution, while the stearic acid, which has the greatest

affinity for the lead base by priority of election, precipitates in combination with it.   The subsident stearate of lead is then to be filtered off, pressed, and decomposed by dilute sulphuric acid, which takes away the lead to form insoluble sulphate of lead, and sets free the stearic acid to rise to the surface of the liquid. It then only requires to be decanted, washed thoroughly with warm water, and cooled. Stearic acid obtained in this way melts at 156.5° F., which is the fusing point assigned to the pure article by Heintz.

Stearic acid is a white, inodorous, tasteless crystalline solid, of specific gravity 1.01, soluble in ether and also in hot alcohol, and dropping from dilute solutions, on cooling, in brilliant broad laminæ.   Fused with palmitic acid in the proportion of six parts of the latter to four of the former, it becomes the *anthropic acid* of Heintz, which melts at 133° F., and solidifies in fine large laminæ. The so-called stearic block from which adamantine candles are made consists of similar mixtures, the two solid fats not being separated by the processes employed in the manufacture of candles, as it is unnecessary for that purpose. These candles, when well made, furnish a brilliant and economical light, and will be further treated of in the second part of this work.

According to Chevreul, in the distillation of this acid only a small portion is decomposed, the products being mostly stearic acid, with some little carbonic acid, water, and carbo-hydrogens. Laurent and Gerhardt, on the other hand, state that it may be distilled entirely without decomposition.   Heintz, with some qualification, confirms the results of Chevreul.

The formula given to stearic acid by Gerhardt and Laurent is $C_{34}H_{34}O_4$. Heintz and Pebal, on the other hand, affirm that it is $C_{36}H_{36}O_4$. In a free state it is always hydrated.

Stearic acid is bibasic; that is, it forms two series of salts. In the cold it decomposes alkaline carbonates slowly and partially, producing a bistearate and bicarbonate. By the application of heat, complete decomposition of the alkaline carbonate ensues, and neutral stearate is formed. The neutral alkaline stearates are perfect soaps, soluble in 10 to 20 parts hot water; but by the addition of a large quantity of water, a part of the potassa becoming free, they are decomposed into acid stearates, which are deposited, and basic stearates, which remain dissolved. For the same reason, a hot solution of a neutral stearate becomes gelatinous on cooling, from the separation of the acid salt. The bistearates contain one atom of water, and one atom of fixed base, and the neutral stearates, two atoms of fixed base. The alkaline stearates, only, are those soluble in water. Neutral stearate of potassa is a firm soap when cold, soluble in 25 parts of hot water, but more soluble in an alkaline solution. When common salt is added to a solution of this soap, an exchange of bases takes place, and stearate of soda is formed—a harder and less soluble soap than its corresponding potash compound.

Stearate of soda.—The compounds of soda with stearic acid correspond with the potassa stearates, there being both an acid and neutral stearate of soda. Their mode of preparation and their properties are also analogous to those of the potassa stearates. All the alkaline stearates are soluble in water and alcohol.

Stearate of ammonia.—This salt is, with difficulty, obtained by exposing stearic acid to an atmosphere surcharged with ammoniacal gas. The salt thus produced by absorption of ammonia is white, almost inodorous, and of an alkaline taste. It is soluble in warm ammoniacal water, from which it falls, on cooling, as a bistearate, under the form of small brilliant scales. Its composition is $NH_3, \overline{St} + 2HO$.

The compounds of stearic acid and the earthy and metallic bases are all insoluble in water and alcohol.

Stearate of lime.—This salt is obtained by adding to a solution of stearate of potassa a solution of hydrochlorate of lime. Stearate of lime is precipitated, and can be collected on a filter and dried. Its composition is $2CaO, \overline{St}$.

Stearate of lead is precipitated when boiling solutions of nitrate of lead and stearate of potassa are mixed together. It is then filtered, washed, and dried. Its composition is $2PbO, \overline{St}$.

MARGARIN.—Is solid and white, with a nacreous lustre, and hence its name, from μαργαρίτη, the Greek word for *pearl;* it is strictly a mixture of stearin and palmitin, and may be prepared by evaporating the ethereal liquor which remained from the undissolved stearin in procuring that body from mutton-suet and tallow, and dissolving the residuum in boiling alcohol. On cooling, it crystallizes out, and may be purified by recrystallization from a hot alcoholic solution; but in these substances it exists only in minute proportions. Its most prolific source is olive oil, from which it is deposited on exposure to cold. It can be separated by pressure; and by solution in alcohol, and crystallization from it, it is purified. It melts at 118° F. Margarin, properly speaking, is the margarate of water and the oxide of glyceryl, and by saponification is separated into glycerin and margaric acid.

Margaric acid is inodorous, tasteless, white, solid, and crystalline; soluble in hot alcohol, and drops from it on cooling in pearly needles, as $C_{34}H_{34}O_4$. Fuses at 140° F.; and, like the stearic acid, forms salts with the bases. Heintz has shown that margaric acid is not a distinct and pure acid, but a mixture of the stearic and palmitic acids in the proportion of one part of the former to 9—10 parts of the latter. Margaric acid cannot be easily changed in composition by recrystallization, because the two acids of

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which it consists are soluble in alcohol in about the same proportions which constitute the mixture with the properties of margaric acid.

PALMITIN.—A component of the solid portion of tallow, palm oil, human, and other fats; may be separated by granulating palm oil, pressing at 50° to 75° F., washing the expressed cake repeatedly with hot alcohol, and crystallizing the residue from solution in hot ether. It drops in white needles, which melt at 118° F., and on cooling congeals into a friable wax-like mass; is insoluble in water, but soluble in hot ether, and also in 600 parts boiling alcohol. By saponification, it yields glycerin and palmitic acids, and by distillation gives acrolein and palmitic acids.

Palmitic acid may be prepared directly from mutton-suet by the process of Heintz, the details of which are given in *Chemical Gazette*, vol. xi. p. 42; is a pearly white solid, very soluble in hot alcohol, and crystallizing therefrom in scaly crystals. It melts, according to Heintz, at 143.6° F., and congeals in aggregated crystalline scales, and has the composition $C_{32}H_{32}O_4$. By dry distillation, it passes over nearly unaltered. It forms salts with the bases, of which those with the alkalies are soluble.

Palmitate of potassa; obtained by melting palmitic acid with carbonate of potassa, dissolving in alcohol, and setting aside to crystallize. It is in pearly white crystals, soluble in alcohol and in a limited proportion of water, but insoluble in ether; an excess of water decomposes it. This and all the salts contain an equivalent of base and one equivalent of acid.

Palmitate of soda is analogous to the potassa salt, but decomposes more readily; crystallizes in large pearly plates.

Palmitate of ammonia is insoluble in cold water.

LAURO-STEARIN, one of the solid constituents of bay-laurel and cocoa-butters, is soluble in boiling absolute alcohol,

and drops out entirely on cooling in small brilliant white silky needles; melts at 113°—114° F., and solidifies on cooling into a compact, non-crystalline, stearin-like block. By distillation, yields acrolein and a fat acid, and by saponification, is decomposed into glycerin and lauro-stearic acid.

Lauro-stearic acid.—Is also called *pichurin-stearic acid*, and is prepared by decomposing a hot solution of lauro-stearic soap with tartaric acid, and washing the eliminated fat acid repeatedly with hot water; is very soluble in ether and alcohol, and drops from its solution in silky white needles, which fuse at 110.5° F., and congeal into a friable, nearly diaphanous crystalline mass.

Its formula is $C_{24}H_{24}O_4$; and it forms salts composed of one equivalent of base, and one equivalent of acid.

The soda salt is in white powder, and uncrystallizable; the laurate of lime is also a white powder.

MYRISTIN.—Is also called *myristicin* and *sericin*, and forms the solid portion of nutmeg-butter; it is also a constituent of cocoa-butter. May be separated by granulating nutmeg-butter, pressing out the fluid portion, and repeatedly crystallizing the solid residue from hot ether. It is a brilliant white solid, fusible at 88° F., and yielding glycerin and myristic acid by saponification; is insoluble in water, and only partially soluble in hot alcohol.

Myristic acid.—Forms silky white laminæ, very soluble in boiling, but only slightly in cold alcohol; fuses at 129° F., and has the formula $C_{28}H_{27}O_3 + HO$. It forms salts with the bases.

Myristate of potassa; a white crystalline solid, very soluble in water and alcohol, but insoluble in ether.

Myristate of lime; a white precipitate.

OLEIN.—This body, discovered by Chevreul, constitutes, for the most part, the fluid portion of oils and fats. From its oily liquidity, it is also called *elain*, from ἔλαιν, the

Greek for oil; olein predominates in olive oil, and particularly in almond oil. It is prepared pure when almond oil is dissolved in hot ether or alcohol, and the solution exposed to great cold; the traces of margarin crystallize out completely, and by evaporation the ether or alcohol may be separated from the olein.

According to Pelouze, Boudet, and Redtenbacher, there are two oleins; and for this reason the liquid portion of those fats which are not drying, but disposed to become rancid, differs from the liquid portion of the drying oils in solubility, and particularly in the transformation which it undergoes, under the influence of hyponitric acid (NO_4), into elaïdine and elaïdic acid; while, under the same circumstances, the olein of drying oils experiences no sensible alteration. The latter is called *linolein*. Olein is a colorless oily fluid of specific gravity 0.9, liquid at 6° F., and crystallizing in needles at —1° F. By distillation, it yields acrolein, sebacic acid, &c.; and with hyponitric acid forms elaïdin. It is this article, perfectly pure, which watchmakers use for greasing their work. In constitution, it approximates to the solid fats, and chemically speaking, is an oleate of the oxide of glyceryl, and when saponified by a strong base, is decomposed into 98.26 parts of oleic acid, and 8.01 parts of glycerin.

Oleic acid.—This acid is obtained by saponifying olein with a strong solution of potassa, decomposing the oleate of potassa, thus formed, by hydrochloric acid, washing the oily layer which separates with warm water, and drawing it off by a siphon into a clean vessel. It is also a product incidental to the manufacture of adamantine candles, and in this impure state is commercially known as "*red oil*." It may also be prepared directly from olive or almond oil, according to Gottlieb's process, which consists in saponifying with potassa, decomposing the soap, washing thoroughly the eliminated fat acids, and heating them

over a water-bath for several hours, with water, and half their weight of finely-powdered oxide of lead. The mixture is then to be agitated with two volumes of ether to dissolve out the oleate of lead, and left to repose. After sufficient rest, the ethereal liquid is decanted and treated with dilute hydrochloric acid, which unites with the lead base, and sets free the oleic acid. This latter being taken up by the ether, arises by its lesser gravity to the surface, and must be decanted and distilled with water to drive off the ether. The oleic acid still contains a little oxi-oleic acid, from which it should be separated by super-neutralizing with ammonia, and decomposing the resulting soap by a solution of chloride of barium. Both the oleate and oxi-oleate of baryta are thrown down, but on treating the washed and dried precipitate with boiling alcohol, only the former is dissolved. On the cooling of the alcoholic solution, the oleate of baryta drops again, and when diffused in water and decomposed by tartaric acid will give pure oleic acid, provided the manipulations have been such as to exclude the air.

Oleic acid is a colorless or faintly yellow, inodorous, tasteless, oily matter, of the formula $C_{36}H_{34}O_4$, perfectly fluid at ordinary temperatures, and of sp. gr. .898 at 60° F. When cooled to 20° F., it solidifies, and this mass dissolved in alcohol drops upon the solution, at 6° F., in crystalline needles, which melt at 39° F. The alcoholic solution barely reddens litmus paper, and the acid itself is without action upon it. Is insoluble in water, but readily soluble in ether and alcohol of .822, and separable from the latter by water. It is also itself a solvent of fatty matters. Exposure to air imparts rancidity, and generates oxi-oleic acid.

Oleic acid undergoes complex changes by heat, sebacic acid being largely formed, along with caproic and caprylic

acids, carbohydrogen, carbon, carbonic oxide, and other products.

By the prolonged action of a large excess of concentrated nitric acid, it is gradually changed into pimelic and lipic acids, which are soluble and crystallizable, and a series of volatile acids. Hyponitric acid converts oleic acid into elaidic acid.

Strong sulphuric acid, added portionwise to oleic acid, converts the latter into sulpholeic acid, provided the containing vessel has been surrounded by a cooling mixture. This acid is precipitated by cold water, but is soluble in alcohol, and forms soluble salts with the alkaline bases. Its other salts are insoluble in water, and only partially soluble in alcohol.

Oleic acid forms salts with the bases, and those which are most prominent will now be described. The neutral salts contain one equivalent of base and one equivalent of acid.

Oleate of potassa.—Prepared by heating together equal parts of potassa and oleic acid in water, dissolving the viscid mass in alcohol, and evaporating to dryness. A white, friable, inodorous, deliquescent salt. It dissolves in anhydrous alcohol and in ether, and also in four parts of water. A greater quantity of water decomposes it into an acid oleate, insoluble in water.

Oleate of soda.—This salt is prepared in the same manner as the preceding, by substituting soda for potassa. In properties it is similar to the oleate of potassa, but deliquescent, a characteristic which, in a measure, determines the difference between the two. Ten parts of water, at 53° F., dissolve this salt; but it is less soluble in alcohol than the corresponding salt of potassa.

Oleate of ammonia.—Oleic acid readily unites with ammonia, and forms a salt soluble in water, which, when boiled, becomes thick or cloudy, owing to the escape of

ammonia.   The salt thus passes into a state of linoleate, the solubility of which is much less.

Oleate of lime.—This salt is made by mixing together the aqueous solutions of hydrochlorate of lime, and oleate of soda.   Double decomposition takes place, and oleate of lime is precipitated as a white powder, which, when separated by filtration, must be dried.   It is pulverulent, and insoluble in water.

Oleate of baryta.—Prepared in the same manner as the preceding salt, from chloride of barium and oleate of soda. A light crystalline powder, soluble in ether and anhydrous alcohol.

Oleate of lead.—A light white powder, which melts into a yellow liquid.   Is prepared from a solution of neutral acetate of lead.   Dissolves readily in hot ether, in naphtha, and in turpentine.

Sebacic acid.—Discovered by Thenard, and constituting the chief part of the solid products of the distillation of olein and oleic acid.   It is obtained more plentifully, according to Bouis, by saponifying castor oil with very concentrated potassa, which converts the ricinoleic acid of the oil into sebate of potassa, hydrogen and caprylic alcohol passing off as distillate.   When separated by decomposing the sebate of potassa, it is a white solid, fusible at 261° F., and in its fused state has a specific gravity of 1.1317. Above 261° F., it sublimes without decomposition.   It is sparingly soluble in cold, and very soluble in hot water, in alcohol, and in ether, and crystallizes in pearly needles, or crystals resembling benzoic acid.   When dark, it may be whitened, says Schliefer, by boiling it with six times its weight of nitric acid, and then adding a large quantity of boiling water.   On cooling, the sebacic acid drops in perfectly pure crystals. Its high fusing point and ready combustibility render it available as an admixture with stearic or other similar candle block.

Sebacic acid has a slightly acid taste, and feebly reddens litmus; and its formula is $C_{20}H_{16}O_6,2HO$. It forms two series of salts, the *neutral* sebates consisting of one equivalent of acid and two equivalents of base; and the *acid* sebates with one equivalent of base, and one equivalent of water. All the neutral alkaline sebates are easily decomposed.

Sebate of potassa.—Obtained by neutralizing carbonate of potassa with sebacic acid. It crystallizes from the solution in papillæ, very soluble in water, and slightly soluble in alcohol.

Sebate of soda.—Is less soluble in water than the sebate of potassa, but otherwise resembles it.

Sebate of ammonia.—Crystallizes and loses ammonia by desiccation, and is very soluble in water. The acid salt of ammonia is only slightly soluble in alcohol.

Sebate of lime.—Precipitates from a mixture of sebate of potassa and chloride of calcium. Soluble in a large quantity of water, and separates by spontaneous evaporation, in brilliant white scales.

Elaidin.—A white or yellowish white solid, isomeric with olein, and discovered by Poulet. Prepared by passing nitrous (NO_4) vapors (generated from starch by the action of nitric acid) through olein or olive oil for a few minutes. The containing vessel must be cooled in ice; and care must be taken not to use an excess of acid, for the solidification of the olein takes place promptly. It may also be prepared by the use of pure nitric acid of sp. grav. 1.50, in the proportion of ⅛ to ¾ of an ounce to every pound of fat under treatment. For the best suet a drachm of acid suffices, but for the fats of soft consistency, the proportion must be largely augmented. The suet is melted over a moderate fire, and the acid is then added, during continual stirring, until the fat has taken an orange tint, when the fire must be withdrawn, and

the mass, when cooled, submitted to the action of an hydraulic press. An oily fluid is ejected by the pressure, and the solid suet remaining, though of a yellow color, is easily bleached by the influence of air and light. Elaidin is solid at ordinary temperatures, melts at 90° F.; and by distillation yields acrolein, elaidic acid, and hydrocarbons. It is insoluble in water, and nearly so in alcohol, but very soluble in ether. By saponification, it is resolved into glycerin and elaidic acid.

Elaidic acid.—Obtained by the decomposition of elaidin soap; but pure and more directly by treating oleic acid with $\frac{1}{200}$ of hyponitric acid (NO_4). As the gas is passed in, the oily acid gradually changes color, and in five mimutes the action is complete. The containing vessel is then set in ice, and in half an hour, its contents will have solidified. The solid mass, after being freed of acid by repeated washings in boiling water, is to be dissolved in its weight of alcohol and set aside. In 12 to 24 hours, the elaidic acid will drop in pearly white crystals. The oleic acid in thus passing into elaidic acid, does not change either its composition or atomic weight, but becomes an isomeric body; that is, changes its properties but not its constitution.

Elaidic acid has a very acid reaction; is insoluble in water, very soluble in alcohol, and less so in ether. It melts at 111°—113° F., and may be distilled almost unchanged; but exposed to air, and a prolonged temperature of 150° F., it oxidizes.

It forms salts with the bases which correspond, in composition, with the oleates. The alkaline elaïdates are crystallizable, and soluble in alcohol and in water; but an excess of the latter decomposes them into insoluble acid salts. The earthy and metallic elaïdates are either wholly or nearly insoluble in water, alcohol, and ether.

Elaidic acid may be prepared on a large scale by steam-

ing "red oil," or oleic acid, and adding just sufficient of pearlash solution to neutralize the sulphuric acid, which it almost always contains. On repose, the oil rises to the top of the condensed steam, &c., and must be drawn off into a wooden tub. To every 2,000 pounds is then added an intimate mixture of 81 pounds of nitric acid of sp. gr. 1.35, and 13½ pounds of molasses; and the whole heated very gently by steam, which is passed in through a dry worm of copper having its terminus above the kettle, as it is not desirable that any water should get into the oily matter at this stage. When red fumes begin to appear, the action must be checked with a drench of 4 to 500 gallons of water; after which an aqueous solution of forty to fifty pounds of acetate of ammonia is added. During all these operations, the mass should be constantly stirred, and after the addition of water, very actively for two or three hours. This is conveniently done by a twirl driven by steam power. The water and agitation withdraw all acid matters, and leave the elaidic acid in a condition to be drawn off, after repose, into small tubs and cooled. Neutral oils, by the same treatment, give elaidin, and this latter, as well as elaidic acid, makes excellent soap and candle stock.

BUTYRIN.—One of the proximate principles of butter. It is to Chevreul that we are indebted for the discovery of this body, which derives its name from a Greek word βουτυρον, compounded of βους, *a cow*, and τυρος, *cheese*, or *coagulum*. It is very difficult to separate it, in a pure state, from its associates. By saponification it yields glycerin and butyric acid.

Butyric Acid.—Is obtained by the decomposition of butyrin soap. It also exists, in a free state, and in combination with glycerin, in various fats, and in the fruits of certain plants, for example, the *ceratonia siliqua ; sapindus saponaria*, and *tamarindus Indica*. Is also a product of

the active oxidation of a large number of organic substances. Fordos and Gelis obtained it largely by adding a small quantity of cheese to a solution of one pound of cane sugar, marking 10° Baumé, and subsequently, also, sufficient carbonate of lime ($\frac{1}{2}$ lb. of chalk) to neutralize the butyric acid as it is generated. The mixture is then left at repose in a temperature of 75° to 85° F. for several weeks, or until fermentation has ceased, as may be known by there being no longer any disengagement of gas. The liquor contains then only the butyrate of lime; which latter is to be tempered with dilute hydrochloric acid, in the proportion of 4 pounds water and 12 to 16 ounces acid, to every pound, and the mixture distilled until about one pound has passed over. This latter is then mixed with chloride of calcium, which divides the liquor into two strata of different densities. The upper one is butyric acid, and must be rectified by a redistillation, taking care to reject the first portions of the distillate, which are mostly water, and collecting only that which passes over at 327° F., the boiling point of pure butyric acid.

Butyric acid is a perfectly colorless, transparent, mobile liquid, of a rather agreeable odor, but very acid, burning taste. It exerts a destructive action upon the skin; is soluble in water, alcohol, and wood-spirit. Its density at 32° F. is .9886, and at 59° F. .9739.

Butyric acid may be distilled without sensible alteration. Concentrated sulphuric acid does not alter it at low temperatures, and even by heat only partially decomposes it. Cold nitric acid merely dissolves it; but by prolonged boiling of the solution it is transformed into succinic acid.

The formula of butyric acid is $C_8H_7O_3$,HO. It forms salts which contain one equivalent of base and one equivalent of acid.

Butyrate of potassa.—This is formed by direct combi-

nation of the acid with potassa. It has a sweetish taste and crystallizes in a confused mass. It is very deliquescent at 59° F.; 100 parts of water dissolve 125 parts without becoming saturated.

Butyrate of soda.—This salt is less deliquescent than the above, but otherwise has the same properties.

Butyrate of lime.—Forms transparent, fusible needles, which easily lose their water of crystallization. It dissolves in six parts of water, producing a peculiar gyratory motion of the liquid.

BUTIN.—According to Heintz, butin constitutes a portion of the more solid principles of butter. By saponification it yields *butic acid*, of the composition $C_{40}H_{40}O_4$.

CAPROIN.—One of the constituents of cow and cocoa butters. By saponification, it yields glycerin and *caproic acid*, of the composition $C_{12}H_{11}O_3$, HO. Caproic acid is a colorless, inflammable, oily liquid, of a pungent, acid taste, inclining to after-sweetness. Its sp. gr. at 59° is .931. It boils at 395° F., and remains fluid at 15° F. Alcohol dissolves it readily, and water at 45° takes up a little more than one per cent. Strong sulphuric acid dissolves caproic acid, but drops it upon the addition of water. Heated above 212°, the sulphuric acid solution blackens and disengages sulphurous acid. Cold nitric acid dissolves caproic acid without altering it.

Caproic acid.—Is found in Limbourg cheese, and certain calculi. It is also a product of the chemical metamorphosis of a large number of organic substances.

The caproates consist of one equivalent of base and one equivalent of acid, and most of them are crystallizable. Those with alkaline bases are soluble. The caproate of lime requires 50 parts of water for its solution.

CAPRIC ACID.—Is found generally as an associate of caproic acid. It is a crystalline, colorless solid, of a slightly hircine odor, melting at 81° F., and very soluble

in cold alcohol and ether, but insoluble in cold, and only slightly soluble in hot water. Its alcoholic solution, on being diluted with water, drops the acid in small needles. Its boiling point is higher than that of the preceding acid. Lerch gives its composition as $C_{20}H_{19}O_3,HO$; and it forms neutral salts, consisting of one equivalent of base and one equivalent of acid.

CAPRYLIC ACID.—Is found generally as an associate of the preceding two acids. Is an oily liquid, of the odor of sweat, and remains fluid to 50° F., when it crystallizes in fine needles. Its sp. gr., at 68° F., is .99; and its boiling point 457° F. Alcohol and ether dissolve it readily, and water only sparingly. Its formula is $C_{16}H_{15}O_3,HO$; and its salts consist of one equivalent of acid and one equivalent of base. The alkaline caprylates are soluble in water, and thus differ from its other salts.

As an appropriate addendum to this chapter, we here include Heintz's table, showing the melting and solidifying points of mixtures in simple proportions of every two of the four acids—*stearic, palmitic, myristic,* and *laurostearic* acids.

A MIXTURE OF STEARIC ACID, AND PALMITIC ACID.		Melts at	Solidifies at	Form of solidification.
Parts.	Parts.			
100	..	156.56°F.	..	Scaly crystalline.
90	10	152.96	144.5°F.	Scaly crystalline.
80	20	149.48	140.54	Finely acicular.
70	30	145.08	136.68	Finely acicular.
60	40	140.48	133.70	Uncrystalline; tubercular.
50	50	133.88	131.00	Laminar crystalline.
40	60	133.40	130.1	Laminar crystalline.
35	65	132.08	129.74	Uncrystalline; shining.
32.5	67.5	131.36	129.2	Uncrystalline; shining.
30	70	131.18	129.2	Uncrystalline; lustreless.
20	80	135.5	128.84	Very indistinctly acicular.
10	90	140.18	130.1	Beautifully acicular.
..	100	143.6	..	Scaly crystalline.

A MIXTURE OF PALMITIC ACID, AND MYRISTIC ACID.				
Parts.	Parts.			
100	..	143.6	..	Scaly crystalline.
95	5	141.98	136.4	Scaly crystalline.
90	10	140.18	132.26	Scaly crystalline.
80	20	136.4	128.3	Fine scaly crystals.
70	30	130.82	121.34	Extremely fine needles.
60	40	124.7	121.1	Uncrystalline; tubercular.
50	50	119.04	113.54	Large laminar crystals.
40	60	116.6	110.66	Indistinctly laminar.
35	65	115.7	..	Uncrystalline; opaque.
32.5	67.5	115.16	111.2	Uncrystalline; opaque.
30	70	115.16	110.66	Uncrystalline; opaque.
20	80	121.1	106.34	Uncrystalline.
10	90	125.54	113.54	In long needles.
..	100	128.84	..	Scaly crystals.

A MIXTURE OF MYRISTIC ACID, AND LAUROSTEARIC ACID.				
Parts.	Parts.			
100	..	128.84	..	Scaly crystals.
90	10	125.54	117.14	Scaly crystals.
80	20	121.28	112.1	Fine crystals, neither distinctly scaly nor acicular.
70	30	116.06	102.2	Fine crystals, neither distinctly scaly nor acicular.
60	40	109.4	102.2	Uncrystalline, with a few shining spots.
50	50	99.32	96.26	Large laminar crystals.
40	60	98.06	92.3	Uncrystalline, with a few shining spots.
30	70	95.18	90.14	Uncrystalline.
20	80	101.3	91.4	Uncrystalline.
10	90	106.34	96.8	Acicular crystals.
..	100	110.48	..	Scaly crystals.

A MIXTURE OF STEARIC ACID, AND MYRISTIC ACID.				
Parts.	Parts.			
..	100	128.84	..	
10	90	125.06	..	Uncrystalline; opaque.
20	80	119.04	..	Indistinctly crystalline.
30	70	118.76	..	Laminar crystals.
40	60	122.72	..	Beautiful large laminar crystals.

A MIXTURE OF PALMITIC ACID, AND LAUROSTEARIC ACID.				
Parts.	Parts.			
..	100	110.48	..	
10	90	106.7	..	Uncrystalline.
20	80	98.78	..	Indistinctly crystalline.
30	70	100.94	..	Small laminar crystals.
40	60	104.18	..	Beautiful large laminar crystals.

A MIXTURE OF STEARIC ACID, AND LAUROSTEARIC ACID.				
Parts.	Parts.			
..	100	110.48	..	
10	90	106.7	..	Uncrystalline.
20	80	101.3	..	Uncrystalline; warty.
30	70	110.12	..	The shining faces of small crystals appearing on the surface.
40	60	123.44	..	Uncrystalline; warty.

Basic Constituents of Fats.—The term base is applied to any body capable of combining with acids to form salts. Organic bases differ from the earthy and metallic bases in being the derivatives of animal or vegetable products. The two classes are also at variance in composition, and in many of their chemical and physical properties. Lime or oxide of calcium, an earthy, and oxide of lead a metallic base, are instances of inorganic bases. The oxides of glyceryl and cetyl belong to the class of organic bases, and are those which more particularly claim attention, as the first named is the almost universal basic ingredient of the simple fats.

Glycerin.—A peculiar neutral, syrupy, uncrystallizable liquid, discovered in 1782, by Scheele, but chemically investigated and defined by Chevreul, Pelouze, and Redtenbacher. Its sweet taste caused it to be called, originally, the "*sweet principle of fat;*" and hence its present name from γλυκυς, the Greek word *sweet*. It is a product of the saponification of most of the fats and oils, and is separated as follows: Mix together equal parts of olive oil and powdered litharge diffused in water; stir well, and keep over fire until all the water has evaporated. When the mixture has acquired the consistence of plaster, add a new quantity of water, and remove it from the fire. Filter the supernatant liquor, and pass through it a current of sulphuretted hydrogen gas, in order to separate the lead. Heat slightly, to expel the excess of gas, then filter, and concentrate the solution over a water bath, and finish the evaporation in vacuo.

It is also a product incident to the manufacture of stearic candles by lime saponification; and may be separated from the mother liquors by Cap's process, which is as follows:—

Concentrate the mother-waters from the lime soap (see Stearic Acid Candles) by evaporation in steam kettles,

or over the naked fire; and after having determined the amount of lime it contains, by the previous assay of a given portion with oxalic acid, add the requisite quantity of oil of vitriol to precipitate the whole of it as insoluble sulphate of lime. After repose, the supernatant liquor is decanted into an iron pot, covered with a leaden lid, and boiled during constant stirring, which must be regulated by a mechanical arrangement. The volatile fatty impurities are thus volatilized, and the liquid gradually loses both color and odor. When it reaches 10° B., it is allowed to cool, and then filtered to separate any residual sulphate of lime. If it contains an excess of sulphuric acid, sufficient carbonate of lime must be added, portionwise, to neutralize it, and the evaporation and stirring continued until the liquor has the consistence marking 24° Baumé. After cooling and filtration as before, the filtrate is a third time evaporated, during constant stirring, until it thickens to 30° Baumé, at 59° F. Another filtration is necessary to separate a new quantity of sulphate of lime, which crystallizes out. The filtrate being then perfectly cooled, and passed through washed bone-black, comes out an inodorous, colorless, syrupy liquid, which is pure glycerin, marking 28° Baumé. By further careful concentration to 31° Baumé, it loses 20 to 25 per cent. of excessive water.

Mr. G. F. Wilson, who repeated Cap's process with great care, was unable to obtain by it a product of absolute purity, but acknowledges that it is a great improvement upon the older methods. He proposes to obtain a superior article, economically, by a modification of Tilghman's process for decomposing fats by the combined agency of steam and pressure. A continuous current of steam, of 600° F., is led into a distillatory arrangement containing a neutral glycerin fat, and in due time produces the decomposition of the latter into fatty acids and oxide of glycerin, which distil over in combination with

their constitutional water. The glycerin, from its greater density, forms the lower stratum of the distillate, and, therefore, may be easily separated from the supernatant fatty acids. As thus obtained, it is generally very dilute, and must be carefully concentrated by evaporation until it contains only four per cent. of water. It then has the sp. gr. 1.240 at 60° F. If necessary, it may be further concentrated to 98 per cent. of glycerin=sp. gr. 1.260.

Glycerin, when pure, is transparent, colorless, and inodorous; soluble in water and alcohol; but insoluble in ether. Its own solvent power is very eminent, and gives it a rank, in that respect, only second to water. It is a very stable body, not liable to spontaneous decomposition, and capable of fermentation only under the most exciting causes, and then only after a lengthy interval. When thrown upon burning coals, it takes fire and burns like an oil.

Glycerin, chemically speaking, is the hydrate of the oxide of glyceryl (an hypothetic radical), and is expressed as follows: $C_6H_7O_5 + HO$.

Nitric acid exerts a lively action upon it, and generates carbonic acid and oxalic acids. Sulphuric acid, added in the proportion of two volumes to one of glycerin, causes a rise of temperature, and produces *sulpho-glyceric* acid, a colorless, inodorous, unstable liquid, which forms soluble salts with the bases. The sulpho-glycerate of lime is crystallizable.

By prolonged evaporation in open air, glycerin is partially decomposed into a brown matter, precipitable by subacetate of lead. Distillation transforms it mostly into inflammable gases, acetic acid, and acrolein.

Acrolein $(C_6H_4O_2)$ is a characteristic product of the decomposition of glycerin or glycerin fats, and is the result of a dehydration of that base. When pure, is a colorless, limpid, volatile fluid, diffusing an acrid, pungent vapor,

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highly disagreeable, and irritating to the eyes and nose. The annoysome odor perceptible, when fats are charred on heated surfaces, is due to the acrolein formed from their glycerin. Acrolein boils at 125.6° F. It is soluble in ether and in 40 parts of water, giving a neutral solution, which acidifies by exposure.

Glycerin, until lately only an article of scientific interest, now plays an important part in the arts and in medicine; and by its many useful properties, is destined to a still more extended practical application. As a vehicle for medicines, it is a most desirable excipient. It is also a valuable antiseptic under certain circumstances; and an efficient solvent remedy for several kinds of urinary calculi. It is also largely employed in photography, and in perfumery—its emollient qualities and freedom from greasiness rendering it an admirable ingredient of soaps, pomade, hair tonic, and cosmetics generally.

ETHAL.—Is the basic constituent of spermaceti; and derives its name from the first syllables of the terms ether and alcohol, to both of which it assimilates in composition. Heintz separates it by boiling spermaceti with concentrated potassa lye, decomposing the hot soap liquor with an aqueous solution of chloride of barium, and treating the precipitated baryta compounds with alcohol, which dissolves out the ethal and traces of baryta salts. To get rid of the latter, the alcoholic liquid must be distilled, and the residue treated with ether. The ethal is thus dissolved alone, and will drop from the ether on evaporation.

Ethal is, chemically considered, the hydrated oxide of a hypothetical radical called cetyl, and has the formula $C_{32}H_{33}O,HO$. It is a white, crystalline, tasteless, inodorous solid, burning like wax, fusible at 120°–121° F., and volatilizing rapidly at 250° F. It is neutral to test paper, and may be distilled unaltered. Is insoluble in water and solutions of alkalies, but soluble in ether and alcohol, and

drops from these liquids in brilliant semi-transparent spangles. Ethal is converted, by the action of concentrated sulphuric acid and heat, into *sulpho-cetylic acid*.

Hydrated oxide of propyl in cod-liver oil, *dœglic oxide* in train oil, and *cerotin* (hydrated oxide of ceryl) in wax, are other less frequent basic principles, of which it is not necessary to give an extended description.

CHAPTER XI.

THE THEORY OF SAPONIFICATION.

As the decomposition of the natural fats into their constituent acids and base is necessarily preliminary to the production of soap, the processes employed to effect it are comprised under the technical term *saponification*, from two Latin words, *sapo*, soap, and *facio*, to make.

There are several modes of saponification: 1. By bases; 2. By acids; 3. By heat; 4. By fermentation.

Before proceeding, however, to the consideration of the different species of saponification, it is necessary to say that the word soap has two definitions. In its general sense it extends to all compounds of fatty acids and bases, and by certain analogies, also, to their compounds with sulphuric acid. In its more restricted and popular signification, it applies only to the fat acids, soda, or potassa salts soluble in water, and which, by their eminent detergent powers, are useful cleansing agents. The earthy soaps or compounds of fat acids with the earthy bases are insoluble, and in themselves unserviceable for washing purposes; so, also, the *plasters*, or salts of fat acids and metallic oxides are only known in pharmacy; and yet though all have, respectively, distinctive names, they belong to the one comprehensive class of soaps.

Having, in a previous chapter, shown that the proximate principles of the natural fats are true salts, consisting of a volatile or fixed fat acid, and a base, both in an anhydrous state, the rationale of saponification becomes very intelligible. The most frequent acids are the oleic,

stearic, and palmitic; and though certain fats have acids peculiar to themselves, yet in the act of saponification, there is no important dissimilarity of behavior in any of them. So, too, while the oxide of glyceryl is almost universally the natural base, there are some few instances in which it is replaced by another; but for all purposes of practical explanation, these differences need not be regarded. We shall, therefore, proceed to treat of—

1. *Saponification by bases.*—This is the kind of saponification used for the direct production of plasters, and of soaps for domestic purposes; and also as a preliminary step in the process of making adamantine candles with lime. It is based upon the law of attraction, which gives to strong bases the power to displace weaker ones. Consequently, when suet, consisting of *olein*, *palmitin*, and *stearin*, is heated with water and soda, for instance, it is decomposed. The latter by its greater affinity for the fat acids separates them from their natural base, oxide of glyceryl, and combines with them to form soda soap, leaving the displaced base to be taken up by the water as glycerin. The annexed diagram will present a more striking view of the changes.

Before Saponification.
Mutton suet. { Oleic acid . . . . .
Palmitic acid . . .
Stearic acid . . . .
and
Oxide of glyceryl
+
Soda lye. { Oxide of sodium
Water . . . .
Water . . . .

After Saponification.
Oleo-palmito-stearate of soda or hard soap.

Hydrated oxide of glyceryl or glycerin.
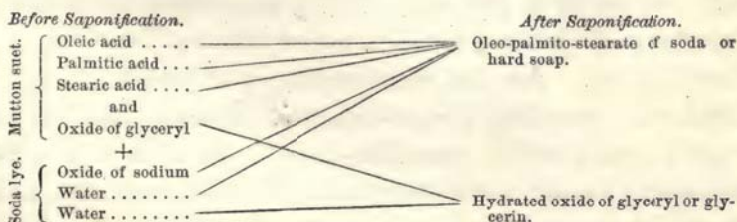
The fat and base are more prompt to combine when the alkali is caustic and free from carbonate; because, in the latter case, time and force would be lost, by the preliminary and necessary displacement of the carbonic acid. In like manner, the alkalies unite more readily with the fatty acids than with the natural fats; and for the reason

that there is no impediment to overcome. For example: oleic acid and caustic soda combine at once. If, however, olein be substituted for the oleic acid, there is an original combination to be broken up before a new one can take place; or, in other words, the caustic soda must first sever the oleic acid from its oxide of glyceryl, previous to combining with the former.

In the process of saponification, the aggregate weight of the products is always several per cent. greater than that of the original fat and alkali united. Thus, as an illustration, 100 parts of stearin will yield 96.5 parts of stearic acid, and 8.5 parts of glycerin. This excess is due to the assimilation of equivalent proportions of water by both the fatty acids and glycerin at the moment of the decomposition of the stearin. In other words, the stearic acid and oxide of glyceryl existing in natural union as stearin are both anhydrous; but the moment the two are separated by saponification, they take up water and become hydrated.

The titles of the soaps made as above noted, are to be varied with those of the fats employed in furnishing them. For example, palmitin, being a compound of palmitic acid and oxide of glyceryl, will, by saponification, become palmitate of potassa, soda, lime, or oxide of lead, as the base may be. For the same reason, lauro-stearin soap is, chemically speaking, a lauro-stearate. If the two principles exist together in the same fat, their terms should be compounded to make a designation for the soap therefrom, and it would be palmito-lauro-stearate of soda, potassa, lime, or oxide of lead, according to whichever of these is the basic principle.

Soaps with alkaline bases, are those exclusively used in the laundry, and for cleansing purposes generally; and, unlike the free alkali which injures while it cleanses, they act gently, but efficiently, in disposing the greasy dirt of

clothes and oily exudations of the skin to miscibility with and solubility in the wash water.

The quality of the water for washing is no trifling consideration, for if it contains earthy salts, they decompose and waste the soap, as in the case of "*hard*" waters. The salts in the latter exchange bases with the soap, an insoluble oleate, stearate, and palmitate of lime or magnesia being formed, and its detergency thus completely nullified.

2. *Saponification by acids.*—This species of saponification is used exclusively in the manufacture of stearic acid candles, as the resulting soaps are not in themselves adapted to any useful purpose. The decomposition is very simple, the fatty acids and their base, glycerin, separate from each other to unite respectively with sulphuric acid (the acid usually employed), to form sulpho-glyceric, sulpho-oleic, sulpho-stearic, or sulpho-palmitic acid, according to the fat, or fat principle saponified.

3. *Saponification by heat.*—The decomposition of the natural fats into their fatty acids is also accomplished by the united agency of heat and steam. In this instance, a distillation is produced, the fat acids are set free from their base, and pass over unaltered, while the oxide of glyceryl which they leave, is more or less decomposed into products held in solution by the water. This mode of saponifying, or more properly acidifying the fats, originated with Tilghman, and promises great economy of time, labor, and cost.

4. *Saponification by ferments.*—Fats are also resolvable into their constituent principles by means of ferments; but this mode is not available for any practical purpose. The principle is analogous to that of other fermentations, a concurrence of water, air, a temperature of $59°$ to $86°$, and an albuminoid substance being necessary. Pelouze has found that an albuminoid or fermentive principle is inherent in many of the oils, and causes their spontane-

ous acidification, even without the access of air, at temperatures ranging from 50° to 77° F. This accounts for the presence of free fat acids in nut, rape, linseed, and other oils; for, however fermentation is produced, the result is always, sooner or later, a disunion of the fatty acid from its base. The natural fats are more readily saponifiable by bases or acids, in proportion to their amount of free acid thus eliminated.

CHAPTER XII.

UTENSILS REQUISITE FOR A SOAP FACTORY.

Steam series.—One of the most requisite fixtures for a soap laboratory, in these times of brisk competition, when every effort should be to improve the economy of a manufacture, is a "steam series;" an arrangement by which the soap is made with steam heat, instead of by the old method of heating the kettle with naked fire. The advantages of the steam process are manifold and evident; for, to say nothing of the saving in fuel, labor and attention, and of the facility of readily arresting ebullition at the desired moment, it embodies other minor conveniences which strongly recommend its superiority. An experience of some years has established its great utility, so that now-a-days, in all well-regulated factories, steam only is used for boiling the soap. On the adjoining page is 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 is attached a pipe and cock

I. Each of these kettles, setting upon a hollow pile of circular mason work M, is furnished with a welded

Fig. 8.
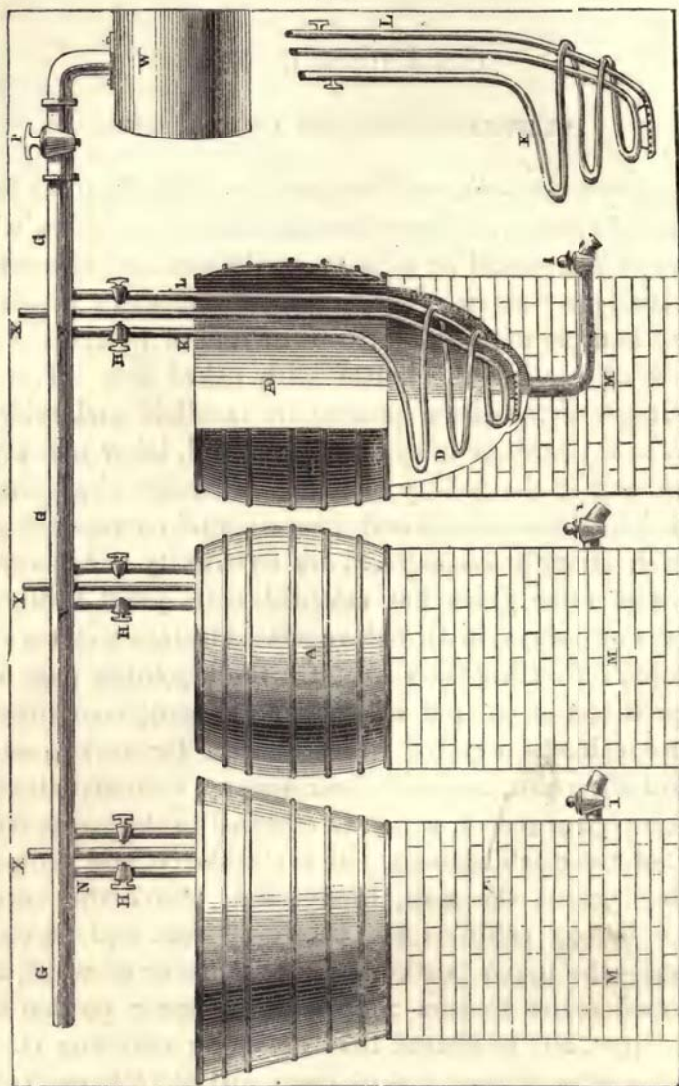
wrought iron worm, which connects with the main feeder at N, and serves as the boiling medium of the soap paste.

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 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 sets 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 be necessarily 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.

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 a suitable arrangement for
that purpose.

Fig. 9.
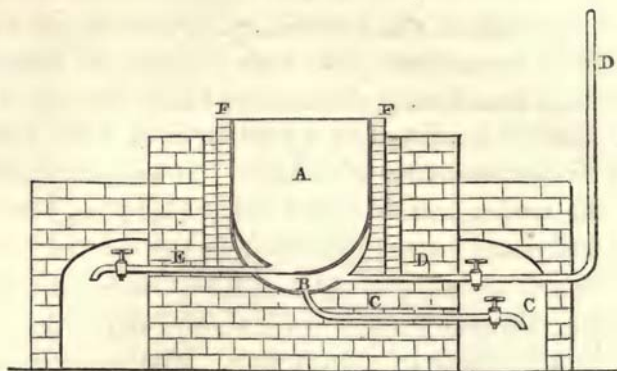
A is the interior of the cast iron kettle, surrounded by
brick work. B is the outer cast iron caldron, which should
fit to the inner kettle tightly, so as to prevent any escape
of steam. D D is the tube leading from the steam boiler,
and conveying the steam to the kettles. It is fitted with
a cock, which 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 affixed to the appa-
ratus. The tube E is the discharge-pipe of the caldron.

The brick work F F is similar to that for other fur-
naces.

St. John's Steam Jacket.—This apparatus, recently pa-
tented by J. R. St. John, of New York, 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. 10. The boiling pan *a a*, is enveloped by a

Fig. 10.
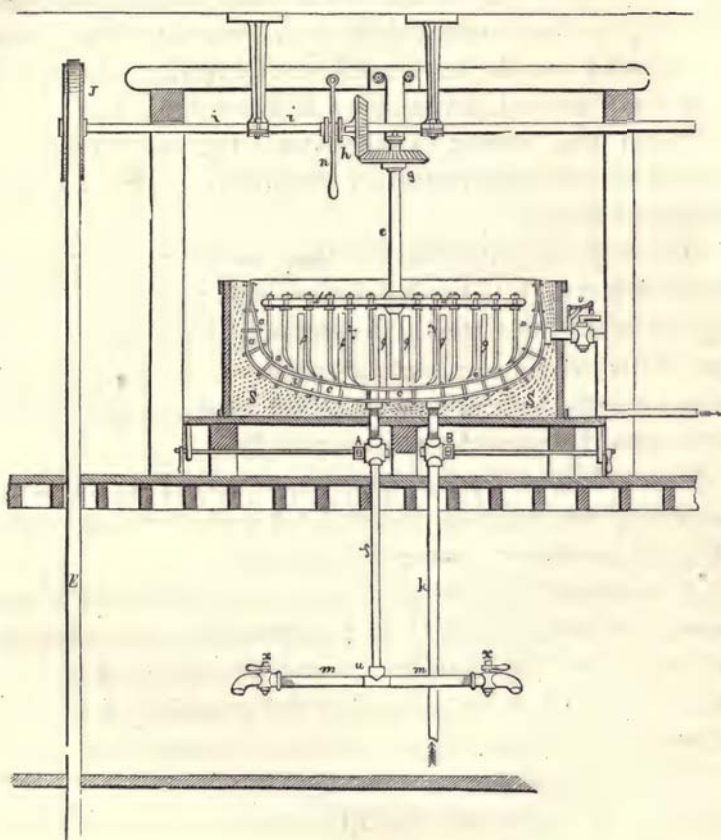
steam casing or jacket *b b*, adjusted to which is a tube *k*, communicating with the steam generator, and leading the steam into the space *c c*, between the pan and outer casing. The exit pipe *n*, with its stopcock *C*, are for drawing off the condensed steam, as may be necessary; and the safety valve *v* is a protection against excessive pressure.

The stirring is accomplished by means of the revolving,

horizontal arm *d d*, carrying teeth *f f 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 *l*, 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, thus 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 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 *D* 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.

Caldrons or boiling pans.—In smaller factories, where the limited capital of the proprietor will not justify an outlay for a steam series, the old mode of boiling the 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 proportional to the amount of soap intended to be made at each boiling. The bottom pan can

be of cast iron, but in England they prefer Swedish wrought iron plate. This bottom pan is consolidated in brick masonry, and is so built around, that the heat acts solely upon its bottom. Fig. 11 shows one of these cal-

Fig. 11.
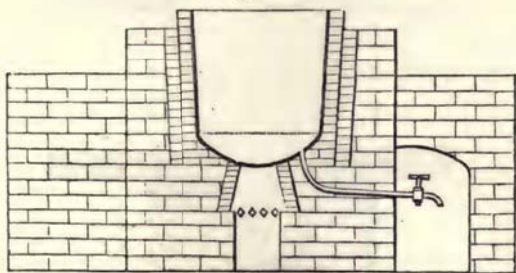
drons. Should there be several, they are placed on a line with each other, and over a furnace beneath. To the caldron a tube of about two inches diameter is adapted, which serves as an outlet for the waste lye which remains under the boiled paste. At the mouth of the furnace is an arcade; and at the bottom of this vault iron bars are placed as supports for the fuel which is to heat the caldron. The arrangement of the mason work 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. 12, 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 closed with mason work.

Fig. 12.
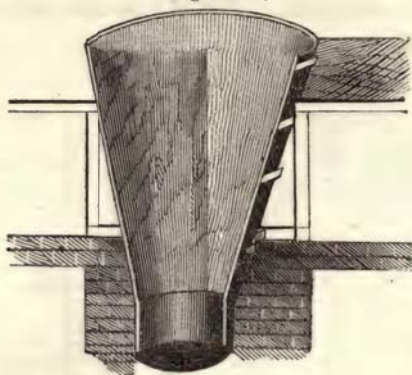
Lye vats.—The lye vats, in very extensive factories, are made of brick work, smoothly cemented within; but much the better material would be lead; for then one set of vats would answer for all kinds of soaps, as the lye prepared in them, not being acted upon by the metal, will be perfectly clean. Large tuns lined with sheet lead, and with a cullendered false bottom, Fig. 13, are perhaps the

Fig. 13.
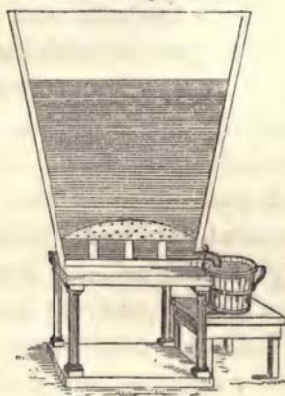
best and most durable fixture of this kind that could be put up. In this case there is a cock fitted near the bot-

tom of each tun, and through it the clear lye collecting in the lower part of the hogshead, 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.

An excellent substitute for the cock, is a long-handled plug of wrought iron, Fig. 14. Its conical tip must be

Fig. 14.
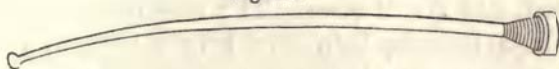
tightly and smoothly wrapped with tow, so that when in use, it may make a tight joint.

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 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, the arrangement being somewhat similar to that described in the chapter on soft soaps. "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

12

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 of 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.

In the apartment containing the lye vats 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 best form of grinding apparatus is Bogardus's ec-

centric mill, Fig. 15; for it does its work economically, both as to time and cost; and, moreover, is not an expensive machine. They are so constructed that "both plates revolve in the same direction (with nearly equal speed)

Fig. 15.
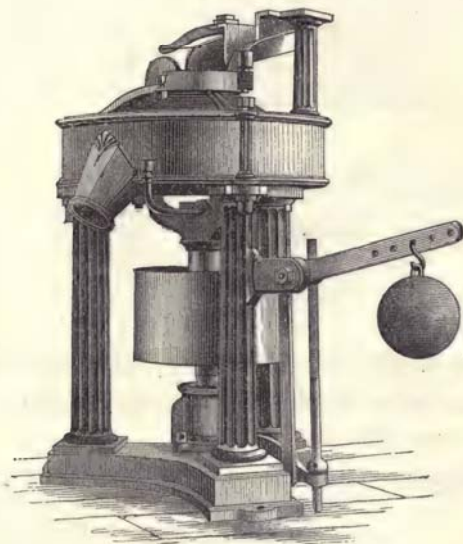
on centres, which are apart from each other one inch, more or less. The centre of the one, or axis thereto affixed, rests and revolves upon a stationary point; whilst the prime mover, by means of a belt or gearing, communicates motion to the other plate. The circles which are cut in the plate, act like 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."

The drum sieve is merely a wooden frame work 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

Fig. 16.
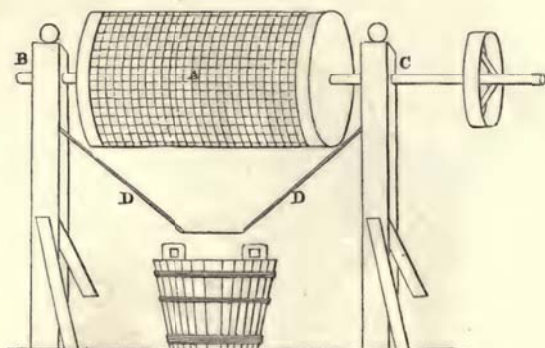
means of the shaft and pulley C. The shelf D is an inclined platform for the delivery of the mixture into tubs, as it passes from the sieve.

Copper dippers, with handles of two feet length, Fig.

Fig. 17.
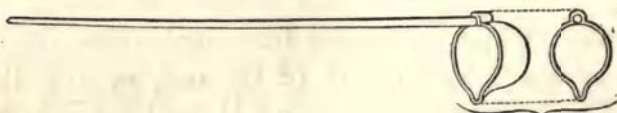
17, an iron spade, and large wooden shovel are also necessary implements for the lye department.

Soap frames.—The frames are reservoirs for the reception and cooling of the hot paste after the completion of the soap in the pan.

In this country they 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 an half inch in thickness; but those of wood should be made of 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, four, or five, Fig. 22, they may form a water-tight well, which will hold the hot paste without leaking. The iron 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. 18 presents a side view, Fig.

Fig. 18.
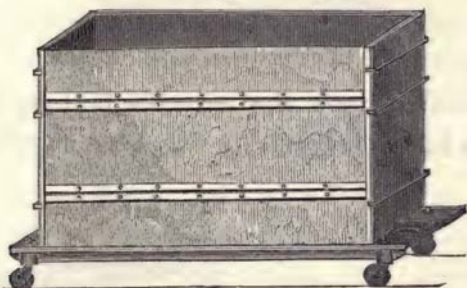
20 the bottom, and Fig. 19 a top view of them, as made by Poole & Hunt, engineers and machinists, Baltimore;

Fig. 19.

and the clamp, which fits on the ends, and which holds them together, is shown by *a*. They are drawn to a

Fig. 20.

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 pro-
motes the cooling and solidifying of the soap paste.

The wooden frames are lifted off, one at a time, and

Fig. 21.
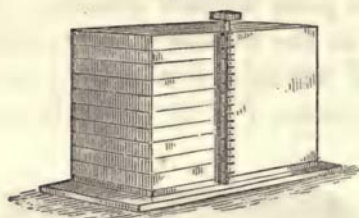
the soap remains upon the movable bottom ready to be
divided into bars, as shown by Fig. 22. Fig. 22, 1, shows

Fig. 22.
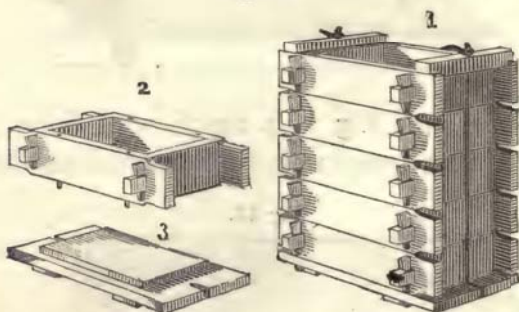
the well of five frames, ready for receiving the soap paste.
The bottom of the well and a single frame are severally
presented in Fig. 22, 3 and 2.

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.
23 and 24. Their floor is also movable; and is shown in
longitudinal section, by Fig. 25, and in breadth by Fig. 26.

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

Fig. 23.
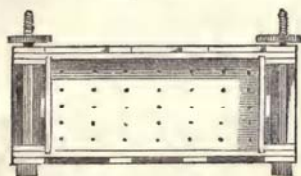
Fig. 24.
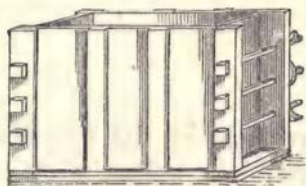
the inside by cross-pieces. All the sides are strengthened by supports. When the several parts are put to-

Fig. 25.
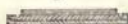
Fig. 26.
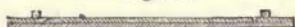
gether, the bolts, screw cut at the other end, having only to be inserted through the projecting parts of the longer sides, and made fast by the nuts at the ends, to form the whole into a solid box. A cloth spread over the bottom prevents any soap from passing the holes, through which the lye drains off. A frame with its sides and ends down is shown by Fig. 27. By the side of it is

Fig. 27.
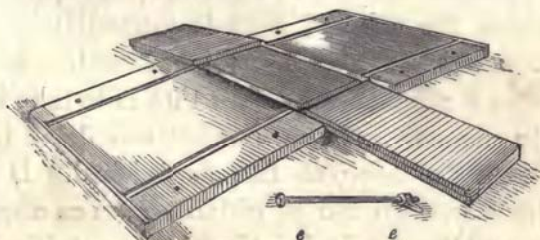
the clamp used for holding the different parts in position when the frame is set up.

The minor implements of the soap laboratory are, a

crutch, Fig. 28, composed of a long wooden handle adjusted, at the end, to a board, and used for stirring the

Fig. 28.

soap paste in the operation of "*mottling;*" large, cullendered, iron ladles, with long, wooden handles (Fig. 29)
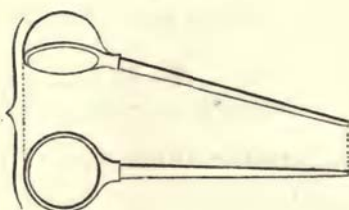
Fig. 29.   Fig. 30.

for dipping out the hot paste from the kettles, and copper buckets, Fig. 30, for conveying it to the frames.

Every manufactory of soaps should also be supplied with presses, for compressing the tablets of soap. One suitable for toilet soaps is shown by Fig. 31, which clearly exhibits its construction. It has two spiral springs A and B, by which the cake of soap is immediately expelled from the box C as soon as it is pressed. The workman knocks it off with the tablet that is to take its place; and so the pressing goes on without any delay in removing the tablets of soap as fast as finished. D is a rope suspending a wooden rod E, which serves as a support to the bottom of the die during the pressure. The box C is movable, being merely fastened by screws; and, when necessary, may be replaced by others of different sizes. This is a great convenience, for the size and form of the tablets may be varied by merely changing the box. The

die from which the tablet is to receive a device, or the impress of the manufacturer's name, is screwed to the top

Fig. 31.
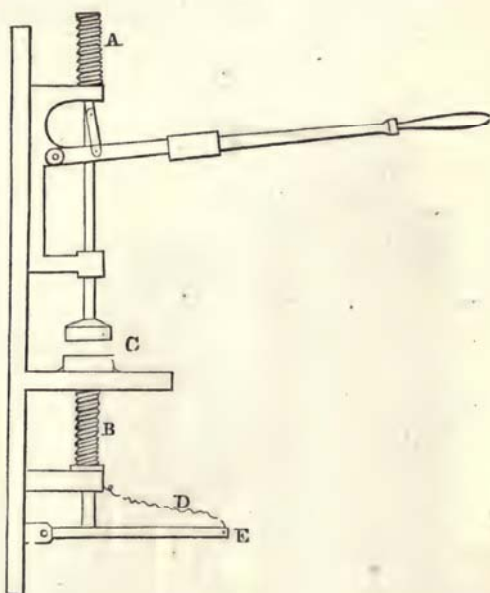
of the box C, and may also be changed, as fashion, or caprice, or taste shall dictate.

The first floor of a soap factory should always be appropriated to the boiling tubs and lye vats. The cutting and drying apartment may be on the second or third story, for it is very easy to run the soap frames upon a platform and hoist them up through a hatchway. This loft should be well ventilated, of moderate warmth in winter, and cool in summer; and may conveniently adjoin the packing room.

It is, for many reasons, preferable to use steam for heating purposes. It is not only more economical and convenient than the naked fire, but it contributes, in many incidental ways, to the comfort and facilities of the fac-

tory. It may be made not only to boil the kettles, but to furnish power for grinding, stirring, pumping, &c. Moreover, the waste steam may be made to give a comfortable warmth to the apartments, and to furnish hot and distilled waters. Fig. 31 shows a very compact

Fig. 32.
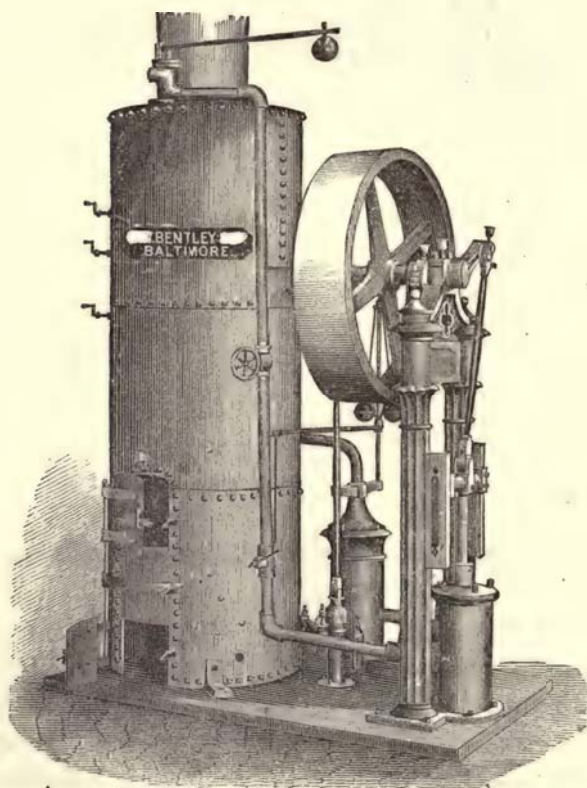
form of boiler and engine, devised and constructed by C. W. Bentley, machinist, of Baltimore. The machine is portable, and is otherwise of very simple construction. It stands on a cast iron plate, seven feet long by three and one-half feet wide; and the frame of the engine consists

of two fluted columns, which, with the pillar, blocks, cylinder and slides, are cast in one piece. One end of the fly-wheel shaft rests on the top of the frame, and the other is supported by a bracket attached to the boiler. The boiler is tubular and fuel-saving; and the steam and other pipes are of wrought iron.

No brick work is required in setting these engines. A sheet-iron smoke-pipe placed on the top of the boiler, or the draft turned into a flue, where one is convenient, with an elbow, is all that is necessary.

They are made from three to five, eight, ten, and fifteen horse power; and are applicable for any purpose where power is required.

CHAPTER XIII.

OILS and fats, of both vegetable and animal origin, are usually employed as soap material; but they are not alike applicable. The oils, with potassa as the base, are the type of soft soaps; and the more solid fats, with soda, constitute the hard soaps. *Semi-soft* soaps are formed of oils and soda; and *semi-hard* soaps of soda and solid fats thinned with a portion of oil. The hard are technically termed *soda soaps;* and the soft *potassa soaps.* Both are soluble in alcohol and water, but in a different degree.

The soda soaps require eight or ten parts of water for solution; whereas the potassa soaps form a jelly with as little as two parts, and wholly dissolve in four parts.

The soft soaps are more caustic than the hard, and can be converted into soda or hard soap by means of chloride of sodium, which exchanges base with the former, transforming them from oleo-stearate of potassa into oleo-stearate of soda.

Soda soap is insoluble in a dense solution of common salt, and this property, as will be shown hereafter, is an important consideration in the process of making soap.

The mucilaginous matters of vegetable oils, if held in solution by the oil, rather add to the emollient properties of the soap which is made from them.

The manufacture of soap is divided into several progressive steps, which we shall describe in their regular order, as follows :—

1. *Preparation of the lyes.*—Lye is an aqueous solution

of caustic soda or potassa, and by its agency the chemical decomposition of the fat and its conversion into soap are effected.

Wood ashes were formerly the material employed for making lye, but since the introduction of soda ash into commerce, they have almost entirely been replaced by it. Even for soft soaps, lump potash is generally employed in preference to the wood ashes. Still, in some localities, it is desirable and economical to use these latter, and therefore we commence our remarks upon lye with reference to that material; presuming that the water for all kinds of lye should be as pure as possible, and preferably distilled water, or condensed steam from the boiler.

Lye from wood ashes.—The ashes having been gathered as wholly as possible from hickory and oak fires, are to be sifted in the drum, Fig. 16, to separate coal and other rough matters that might injure the color of the soap. The sifted ash is then heaped up on a platform especially reserved for this purpose, and then pushed out towards its circumference so as to form a large opening in the centre for the reception of the lime, which is used in the proportion of fifty to eighty pounds to every one thousand pounds of wood ash. The lime being drenched with water, is left to slake; and when it has fallen in powder must be thoroughly mixed with the ashes. In the mean time, the vat, Fig. 33, must be gotten ready by covering its false bottom with a layer of straw, to prevent the clogging of the holes by the mixture of wood ash and lime, which is next introduced in layers of six or eight inches, alternating with straw to facilitate the percolation of the liquor through the mass which otherwise would be so compact as to prevent its passage. When the vat is filled to within eight or twelve inches of the top, water is poured upon its contents, the cock below being in the mean time left open for the exit of confined air which is driven out by the

water. As soon as liquid begins to run from the cock, it must be closed. This mode of dissolving out the soluble alkaline portion of the ash is called solution by displacement, the first portion of liquid running through being

Fig. 33.

displaced by the force of atmospheric pressure by a following portion, so that the liquid which is the earliest to traverse the mass and fall into the receiver below is the strongest. When the first addition of water has sunk into the mass, another must be poured on, and so water must be repeatedly supplied until the ash is exhausted of soluble matter, as will be known when the runnings are white, and leave only a slight residue when a drop is evaporated to dryness upon a platinum spatula. The runnings decrease in strength from the first, so that this mode is available for procuring lyes, simultaneously, of different degrees of strength. The last running is generally so weak, that it should be used as the first water for a freshly charged vat.

The admixture of lime with the ash is for the purpose of abstracting all the carbonic acid from the latter, which universally contains a portion, it being absolutely neces-

sary that the alkali in the lye should be free or *caustic,* in order to a complete efficiency in saponification.

Lye from soda ash.—The commercial soda ash, and potash, also, invariably contain more or less carbonates and other foreign salts. These latter are less important impurities than the carbonates, which it is necessary should be completely removed. The agent employed for the purpose is, as before mentioned, lime, which, by a superior affinity for the carbonic acid, abstracts it from the potassa, forming insoluble carbonate of lime which precipitates, while the soda, thus rendered caustic, is left as a hydrate, and in a condition for the prompt decomposition of the fat. Tennant & Co., of Scotland, the extensive manufacturers of soda ash, have directed " a layer of fresh burnt lime, say five measures of one hundred and twelve pounds each, to be laid equally over the bottom of the vat, and a few gallons of water to be thrown upon the lime, until it begins to slake or fall. This layer is then to be covered immediately with six hundred weight of soda ash, the next layer with four measures of lime slaked as before, the fourth layer with the same quantity of soda ash, the fifth layer with lime as before, and the last layer with the same quantity of alkali.

" After standing two hours, the vat is to be stanched by filling it with water or weak lye of a former vat; this to be done gradually. After standing about fifteen or sixteen hours, the plug is to be gently loosened so as to allow the lye to run off or trickle clear and caustic after infiltration through the beds of lime. This is called the first runnings. As soon as the lye ceases to run, the plug is to be tightened, and the vat again covered with water, and after standing a sufficient time, to be run down as before. This is the second runnings, and worked together with the first runnings in the soap pan, is an excellent lye, and works freer and better than if used separately. After the

vat is run dry, it is to be turned over into another empty vat, covered with water, and again run down. This lye is very weak, and is seldom worked in the soap pan, being used instead of water, to stanch or fill up the strong or first set vats. As soda ash is not all equally soluble, it is sometimes necessary to turn the contents of the vat over a second time in order to obtain all the free alkali; but experience and care are the only sure guides. The receivers for the lye are generally much smaller than the vats, but it is preferable to have them of the same size, it being at all times desirable to have a sufficient supply of strong caustic lye.

" Should the lye in the course of the process of boiling the soap close, as it is termed, with the materials, and not separate, a small quantity of common salt, thrown with care into the boiling soap, will effect a separation; but this is always to be avoided if possible.

" The lye may be taken out of the vat with a pump or siphon. A third running may be taken from the first vat to stanch with."

There is always a risk in preparing the lyes in the cold, because of the uncertainty of freeing the alkali, in this way, wholly of carbonic acid. If the liquid, after having passed through the vats, still effervesces on the addition of a drop or two of hydrochloric acid, or gives a cloud when a clean portion is poured into clear lime-water, it still contains carbonated alkali, and must be poured back over the lime and passed through it once or twice more, as may be required, to render it perfectly caustic. If this is not attained by a second percolation, then it will be necessary to add some fresh lime to the vat previous to running it a third time.

There are other disadvantages in this mode of preparing lyes, one of which is the impossibility of obtaining the alkaline solution beyond a certain strength, thus exacting

subsequent concentration, by evaporation, when a greater density is needed. Moreover, it is an established fact that less than ten parts of water to one of alkaline material will hinder the chemical action of the lime upon the carbonated alkali; and hence, as the first runnings through the vat must exceed this strength, they are but partially, if at all, acted upon by the lime accompanying the alkaline material which is under process of leeching. Under all circumstances the more convenient and economical plan for preparing lyes, will be by boiling the materials directly by steam, as follows:—

Steam lyes.—The vats, as before used, will answer very well for this process, it being only necessary to discard the use of the false bottom. The manipulations are the same for either soda or potassa lye. In making the first, however, fifty pounds of lime are required to the hundred of soda; whereas, for the same quantity of potassa, eighty parts of lime must be used. The proportion of water is twelve parts to one of potash, and something less for soda, which is made caustic more readily than potash. The alkaline material (soda ash or potash) and the proportional quantity of water and of lime previously slaked into powder with hot water, are shovelled into the vat, and then boiled by a current of steam for several hours, until a portion, taken out and left to repose, gives a supernatant liquor, which does not effervesce with hydrochloric acid, or give a cloud with clear lime-water. The intimate mixture of the lime and alkali greatly promotes the chemical action upon which the causticity of the solution is dependent. Moreover, it will contain less lime impurity than cold made lye, for lime is not as soluble in hot as in cold water. After the boiling is completed, the mixture is allowed to repose until the carbonate of lime subsides, when the supernatant clear liquor is drawn off through a siphon into the reservoirs. After it has all been removed,

13

the residue is to be stirred up with a quantity of fresh water, for the purpose of washing out any remaining alkali, and again left to repose. The liquor from this settling being weak, must be set aside for diluting strong lyes when necessary, or for use as the first water in a new boiling of fresh materials.

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. 34, and consists of

Fig. 34.
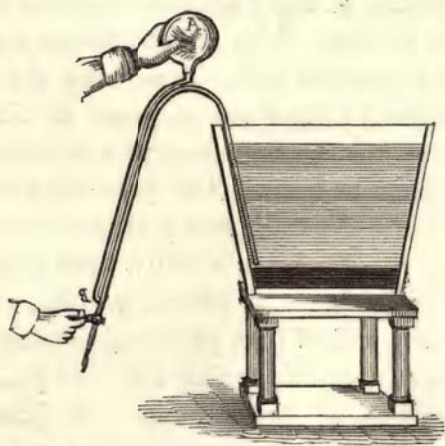
a bent tube, one leg of which is longer than the other, and a smaller lateral tube B, capped with a large, hollow India rubber ball A. The long leg has also a stopcock near its lower end. It is put in operation by closing the cock, compressing the bag, and quickly immersing the short leg in the clear 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 a diminution of the elastic force of the internal air by expelling the most of it, so that as soon as the hand is re-

moved 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.

2. *Paste operation.*—This is a preliminary operation by which, with the aid of heat, the oil and alkali are converted into a homogeneous magma; and it requires careful management, else lye will be unnecessarily wasted, and the cost of the soap be needlessly high. Intelligence and experience, combined with some theoretical knowledge, will, however, regulate this matter, for it depends mainly upon the strength and apportionment of the lye. We will, for the sake of greater intelligibility, make an explanation with reference to the manufacture of "OLIVE OIL SODA SOAP." It must be remembered, therefore, in starting, that every 100 pounds of oil require 54 pounds of caustic soda lye of 36° Baumé, for their saponification; and that as 54 pounds of the lye contain in round numbers 15.50 of solid caustic soda, care must be observed in graduating the strength of the different lyes that this proportion of soda is not exceeded in the whole amount of lye used for the 100 pounds of oil.

It follows, then, that the first step is to determine the strength of the lye, which is done by means of a little glass instrument called Baumé's hydrometer, Fig. 35, and particularly described in a separate chapter. Therefore, begin by filling the kettle to one-third its capacity with a lye making 10° to 11° (when the hydrometer is immersed in it) for thin oil; but only 8° or 9° for that which contains much solid ingredient, as is the case when it contains lard oil, lard, or other solid fat. The lye is adjusted to this strength by the dilution of strong lye with water, or by the mixture of

Fig. 35.

weak and strong lyes; and it must be entirely free from chloride of sodium, or common salt. Heat is next applied to the kettle, and when its contents boil, 1,600 pounds of oil are added, in one batch, during constant stirring. An emulsion, or paste, is immediately formed by the reaction of the hot alkali upon the oil. Should it happen that too much oil has been added, the excess will show itself upon the surface, and is a hint of the necessity of more lye, which must be added. On the contrary, if the paste is very thin, and there is no appearance of uncombined oil, then the alkali is in excess, and more oil must be added to neutralize it. The temperature falls when the cool oil is added, but soon rises again, until the mixture froths and boils; and this heat must be steadily maintained for eighteen to twenty hours. As evaporation increases the strength of the lye, and the preliminary action of the alkali and oil is only perfect when the paste is held in solution by the lye, it is necessary to add weak lyes, during the boiling, as the paste thickens, for it is not soluble in strong lyes. These additions of weak lye are made after the drawing off of the spent lye, and must be repeated as the mass thickens, until the stock is entirely "*killed*," or whenever the previous portion has lost its causticity in the kettle. In every instance, the addition must be made during constant stirring. After four or five treatments, the mixture assumes a uniform soapy consistence, which hardens between the fingers, and this state indicates the completion of the first operation; and the fire must then be temporarily discontinued.

If the lyes should contain common salt, as is often the case with those made from inferior soda ash, the operation will be sluggish, as it retards, and if in large quantity, even prevents the perfect union of the oil and caustic alkali. In this contingency, soap-scraps are sometimes

thrown in the kettle to promote the completion of the process.

In boiling by steam, or in double-bottom vessels, there are no precautions necessary with regard to the management of the heat; but in using the naked fire, the paste, as it thickens, is apt to scorch from contact with the over-heated sides of the kettle. In such an event, jets of black smoke will burst forth over the surface of the mass; and the fire must consequently be lowered at once, and several gallons of strong lye stirred into the kettle. This latter, by causing a partial separation of the paste from the lye, interposes a protective medium between it and the metal, and thus prevents any injury by the fire. The crutch is the most convenient implement for stirring.

3. *Salting operation.*—In the previous operation, all the alkali is consumed by the oil, and the exhausted lye remains in the paste as water, holding in solution glycerin and the saline impurities of the original soda ash. This water interferes with the subsequent steps of the process, and must consequently be removed. The presence of such a quantity is unavoidably incident to the preliminary use of weak lye; for strong lyes are not applicable to this kind of saponification, as they would prevent the perfect solution of the soap paste as it formed, and thus materially retard the mutual action of the oil and alkali. This latter property of insolubility of the soap in strong alkaline or saline solutions is, therefore, taken advantage of in separating the soap paste from the "spent" lye and solution of glycerin. Common salt being a cheap and abundant article of commerce, is the agent employed, and which is used in dense solution, or thrown in by handfuls, during constant stirring, until the salt has acted and the soap coagulates in flakes, which generally occurs after five to ten hours' boiling—more or less, according to circumstances. The previous handful must have dissolved before a succeeding

one is put into the kettle, and enough salt will have been added when the paste in the kettles separate from the clear watery liquid in a distinct grain, and forms a clear, stiff "curd." This stage is evident when, on taking a sample upon a knife, the aqueous portion is observed to run off from the lumps. Any further boiling will concentrate the salt liquor too much, and impart too great stiffness to the curd, and cause it to set at the top and obstruct the escape of vapors in the boiling liquid beneath. When the paste curds or grains, as above, it has given up a sufficient portion of its water to the salt, and obstinately retains only its constitutional amount. The fire is therefore extinguished, at that epoch, and the mixture allowed several hours' repose for settling, after which the waste liquors are to be drawn off from below through the cock. If it is desired to make the soap take up more water, the paste must be "filled" with the desired quantity immediately after it is put in the cooling frames, and while still hot; which is done by stirring until the incorporation of the two is complete.

There are certain soaps, that from cocoa butter as an example, which, being more soluble in salt solution than ordinary soap, require a greater amount of salt in the salting operation; and they must be dosed accordingly.

4. *Clarifying or finishing operation.*—Water, free alkali, and saline impurities of the lye still adhere to the soap. Moreover, there are some particles of it which have not entirely undergone saponification. To remove the first, and remedy the latter, therefore, it must be subjected to another operation, in order to cleanse it. This is done by boiling it in a liquor, which acts on the deteriorant substances without dissolving the soap itself.

If the spent lye can be wholly drawn off from beneath the soap, it may remain in the same vessel; otherwise the paste must be scooped out into another kettle. It is then

to be dosed with lye of 18° to 20° Baumé, and containing eight or ten per cent. of salt, a quantity just enough to coagulate the soap sufficiently to prevent its adhering to the sides of the vessel. After gently boiling, during frequent stirring, until the lye has lost its causticity, repose is allowed, and the settled waste lye drawn off. This treatment must be repeated with fresh lyes until the latter ceases to lose alkalinity. Approaching this point the hitherto steady ebullition becomes rather tumultuous and foamy.

When the odor of violets is recognized, and the soap has no longer the smell of oil; and when, by pressing a little of the paste between the fingers, it scales without adhering to them, the clarifying is complete. In winter it should take eight or ten hours, but in summer ten or fifteen hours will be requisite; however, the length of time generally depends upon the quantity of paste to be operated upon. As soon as the clarifying is perfected, the fire should be withdrawn, the mass allowed one or more hours' repose, and the waste lye again drawn off. The soap thus finished is firm, white, and contains 16 to 25 per cent. of water.

Sometimes, when the lyes are not perfectly pure, but contain iron and sulphur, the soap takes a dark tinge from the particles of metallic soap pervading the mass. In such case, after the soap is clarified or "filled," as above, it must be heated very moderately with weak lye. This dark soap, or "nigre," not being soluble at low temperature in such a liquor, and having a greater density, subsides, when the kettle is left to repose under cover, and forms a substratum from which the upper layer of white soap may be readily scooped into the cooling-frames.

5. *Mottling operation.*—The mottling, or marbling, as it is sometimes termed, results from a chemical reaction which takes place between the alumina, iron, and sulphur impurities of the lye and the soap. When they are in

large quantity, they impart a decided slate tone. The fat
acids of the soap exchange bases with the saline impuri-
ties; and insoluble, dark-colored, *alumino-ferruginous soap*
diffuses itself throughout the mass, along with precipitated
black sulphuret of iron.   Being held in intimate suspen-
sion by the thick paste, it forms bluish veins in the white
ground, and thus gives to the soap the appearance of mar-
ble.   These bluish veins are formed by the protosalt of
iron, and by the sulphuret of iron, both of which become
oxidized into brown oxide by exposure to air; and this is
the reason that a freshly-cut surface of mottled soap turns,
in time, from a blue to brown; blue being the character-
istic effect of proto, and brown that of persalts of iron.
When the lyes contain a large quantity of these impuri-
ties, the mottling is produced without any further addi-
tion.   Generally speaking, however, they do not, and
further treatment is necessary; and, therefore, when the
clarifying of the paste is finished, the operation is to com-
mence, without separating the "*nigre*," by adding 4 ounces
of copperas (proto-sulphate of iron) for every 100 pounds
of oil in the soap.   The copperas is dissolved in the weak
lye, which must be added for thinning out the paste, and
the mixture be allowed to cool gradually, so as to promote
the uniform dissemination of the colored soap throughout
the white mass.   It is particularly necessary that the paste
shall be barely thinned with weak lye; and also that the
cooling shall not be too rapid or too slow.   If too dilute,
and cooled too slowly, the marbling falls to the bottom.
Rapid cooling, on the contrary, closes the colored veins
too much, and detracts from the good appearance of the
soap.

Mottled soap, made as above, is the "*Castile*" soap of
commerce, and contains less water than curd soap; be-
cause the presence of the coloring matter is contingent

upon a high density of the paste, and, consequently, incompatible with the usual state of hydration of white soap.

This mode of mottling is quite distinct from the method used for coloring toilet soaps by the mechanical admixture of mineral pigments with the paste. Sometimes, however, this latter means is made auxiliary to the above described process, as, for example, in the addition of a little powdered colcothar (red oxide of iron) when it is desired to impart the effect called *Manteau rouge*, or *Manteau Isabelle*, which intersperses the blue with red veins. It is only necessary to stir in the powder thoroughly after the marbling in the regular way.

6. *Cooling operation.*—When the paste in the kettle is brought to completion, and while it is cooling down a little, the frames must be gotten ready by forming them into wells, or sesses, covering the bottom of each well with a piece of coarse crash, dusting their interior with finely-powdered lime, to prevent adhesion of paste to the sides, and wheeling them to the side of the kettle. The paste is then, while still soft and warm, lifted from the settled lye in cullendered ladles or scoops, and poured into them, there to remain until it is sufficiently firm for cutting, which will be from one to four, five, or even six days, according to the kind of soap and the weather—summer being a more unfavorable season than winter. The ladles are cullendered (Fig. 36), so as to promote the running off of any lye that might be mixed with the paste at the time of dipping it from the kettle. So, also, will the cloth and holes at the bottom of the frames afford outlets for any residual portion that may settle during the cooling.

To promote the homogeneity of the soap paste, it should be well crutched or stirred in the frames some time previous to its having cooled. It is at this time, also, that any extra water, which it is desired to give it, must be added and thoroughly incorporated with the paste.

As soon as the frames are filled, they are immediately run upon a platform, and hoisted to the drying room,

Fig. 36.

which is generally in the upper story, to remain there until the soap is ready to be cut into bars and tablets.

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, corre-

Fig. 37.
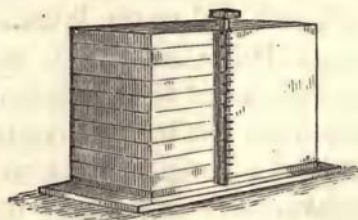
sponding in size with the interior of the wells, as shown by Fig. 37. It is then divisioned off on the sides by means of a scribe, Fig. 38, which is a wooden slat, carrying on its smooth side a number of slender iron teeth. The workman, then taking a brass wire, Fig. 39, directs it in the track of the teeth, and thus cuts off one slab of the pre-arranged thickness, as shown by Fig. 40. When the whole block is thus divided into slabs, the latter are in their turn re-

Fig. 38.
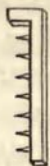
duced to bars and lumps of smaller dimensions, the usual size of the bars being 12 to 14 inches long, by 3 inches every other way. The pound lumps are about 5 or 6

Fig. 39.
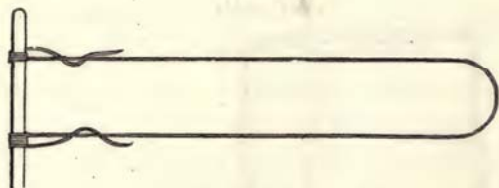
inches long, 3 inches deep, and the same width. The size of the slabs must, therefore, be regulated accordingly;

Fig. 40.
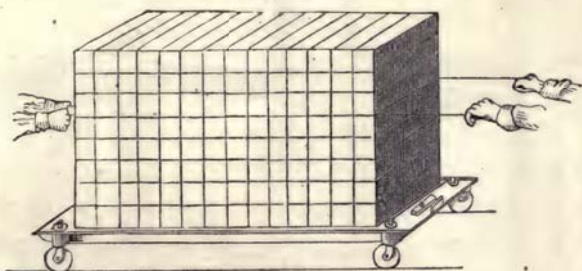
and, therefore, it is convenient to have a scribe with several sets of teeth, as shown in Fig. 37. Such an instrument is used in the factories, and is nothing more than a piece of hard wood, about two inches square, with each of its four sides smoothly planed, and bearing slender teeth. On one side they 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 recently by Van Haagen, of Cincinnati, and which requires the use of two pieces of machinery, as shown by Figs. 41 and 42. The first is called

Fig. 41.
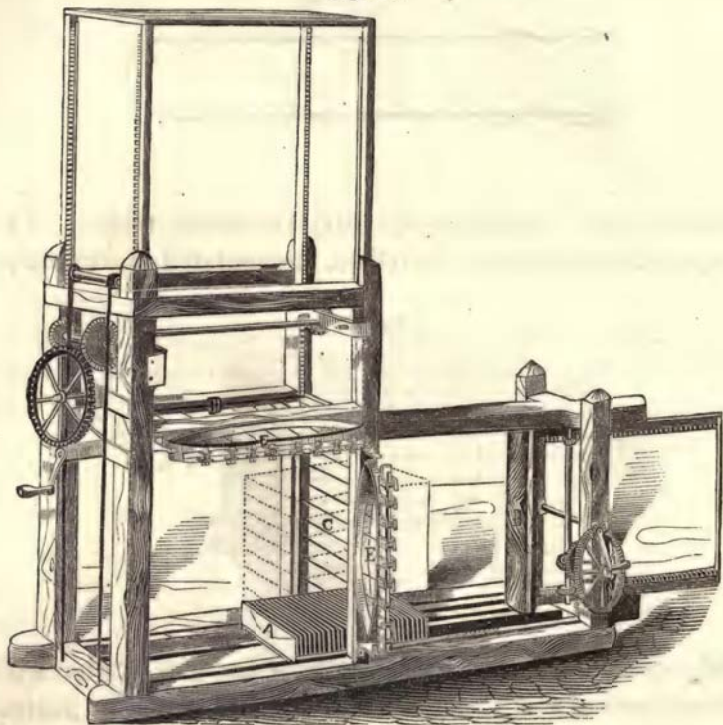
the *slabbing and barring machine,* and consists of " a carriage A, which is so grooved at the top as to allow the wires to pass entirely through the block of soap. This carriage is then moved back to the driver B, and on it is placed a whole block of soap as it comes from the frame. This is done by a peculiar truck, as shown on diagram No. 39, 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 dispatch, and by the same power.

"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 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. 42.

"The slabs are placed in as great a 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,

Fig. 42.
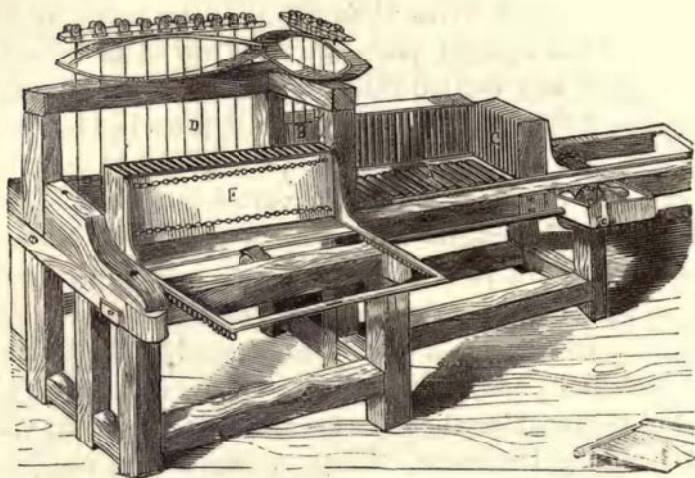
and, by displacing it from the one, it gears itself into the other. The wires are arranged in the same manner as in the slabbing machine. They may be readily shifted so as to cut any desired shape or size."

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.

8. *Drying operation.*—The bars, lumps, tablets, and cakes cut as directed by either of the preceding methods, are then carried to the drying-room, and placed on slat-work frames, made of wooden uprights and cross-pieces, as shown by Fig. 43. The openings between the slats permit the free access of air, and thus promote the drying. Sometimes the bars of commoner soaps are placed on the floor crosswise, in piles of several feet high, with

intervening spaces between each bar for free circulation of air; but damage is apt to ensue from the slipping of the bars and the tumbling down of the piles.

Fig. 43.
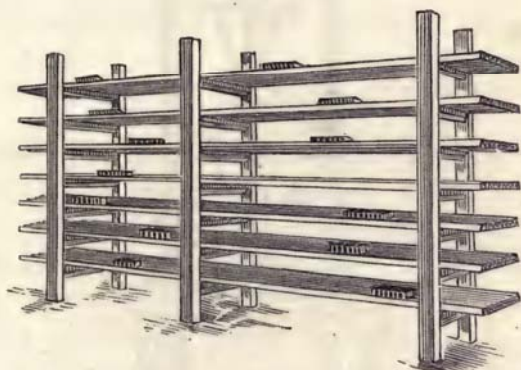
The drying drives off any excess of water, and prepares the soap for packing in boxes. The time required for this operation depends upon the weather and the ventilation of the drying-room. Dry, windy, and moderate weather is the most favorable.

When the soap is to be impressed with any device or lettering, it is subjected to the operation after it has acquired sufficient firmness to sustain pressure. For this purpose, the press, Fig. 44, with a suitable box and die are used. As the coarse soap in pound lumps is generally stamped only with the owner's name, or words expressive of its kind and quality, this is more expeditiously put on by hand-work than by pressure. The implement is shown by B, Fig. 45, and consists of a stereotype plate, bearing the inscription, and screwed to the face of a wooden handle. It is used as represented in Fig. 46, by holding it on the soap, and giving a gentle tap to the upper end with a mallet, which sinks a clear impression of the lettering, as shown by the lump of soap, A, Fig. 45. Boxing is the final

operation; and the boxes, made of wood for common and of fancy paper for toilet soaps, differ in proportion with

Fig. 44.
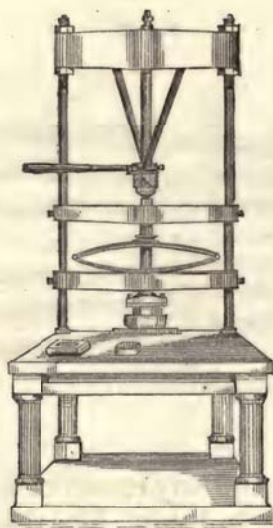
the size and number of bars, lumps, or tablets which are to be packed in them. The present custom is to divide the

Fig. 45.

A   B

common soap blocks, uniformly, into pound lumps, and to pack them in boxes of thirty-six pounds.

Fig. 46.

CHAPTER XIV.

HARD SOAPS.

ALL soaps having soda as their basic constituent, are classified under the generic term hard soap. Their chief characteristics are firmness, neutrality, and eminent adaptation for toilet and domestic use. Soft soap, on the contrary, embraces soaps with potassa base; and these latter, being much more caustic than the former, are only employed in the rougher kinds of cleansing operations.

All the saponifiable fats will make hard soap with soda, but their respective products vary in consistency. The hard soaps made from the oils, excepting palm and two or three other oils, are mostly a mixture of oleate and margarate of soda, whilst those made with animal fats, in addition to the foregoing, contain also a large portion of stearate of soda, which may be regarded as the type of hard soaps. Hence the hardness of soda soaps is in proportion to the amount of stearate and margarate they contain, and the softness of the potash soap in a ratio corresponding with the amount of oleic component.

As a general rule, however, the soaps from drying oils are generally pasty, even though made with soda. The comparative value of the different oils and fats, as soap stock, is shown from the results of experiments by Darcet, Lelièvre, and Pelletier, which are arranged in the following—

14

*Table of the Quantities of Soap obtained from Three Pounds of Oil,
Saponified with Subcarbonate of Soda rendered caustic.*

Names of the oils or fats.	Color of the soaps.	Quantity obtained as taken from the frame.			Loss of weight in			Time.
Of olive	white	7 lbs.	10 oz.		5 lbs.			2 months.
" sweet almond	"	5 "	11 "		4 "	6 oz.		"
" colza	lemon yellow	5 "	14 "		5 "			15 days.
" rapeseed	white	6 "	8 "		5 "			20 days.
" beech-nut	dirty gray	5 "	4 "		4 "	13 "		2 months.
" poppy	gray	4 "	8 "		4 "	6 "		1½ months.
" hempseed	green	5 "			4 "	14 "		15 days.
" nuts	deep yellow	4 "	7 "		4 "	6 "		"
" linseed	yellowish	5 "			4 "	12 "		1 month.
" sperm	dirty gray	4 "	12 "		4 "	10 "		15 days.
" fish	reddish brown	4 "	11 "		4 "	8 "		1 month.
" cod-liver	dirty gray	4 "	14 "		4 "	12 "		15 days.
" suet	white	8 "	4 "		6 "			2 months.
" lard	"	8 "	3 "		5 "			"
" rancid butter (unsalted)	"	11 "			7 "			"
" horse fat	"	9 "	8 "		6 "			"

Olive oil takes the first rank among the oils as soap
material, the soap from it possessing a combination of
excellent properties, which render it peculiarly suitable
for toilet purposes.

The soap of *sweet almond oil*, is next to the olive oil
soap in consistency. It is very white, uniform, and of an
agreeable odor.

The soap obtained from *colza (brassica campestris) oil*,
with soda, is less solid, and yellowish gray. It retains the
odor of the oil, and does not acquire the hardness of the
preceding, and can also bear a greater quantity of water.

The *oil of rapeseed* soap is of a grayish yellow; more
consistent than that of colza oil; and of the peculiar odor
of the oil from which it is made.

Oil of beech-nut soap is of a dirty gray, softer than the
preceding, and of the odor of the oil. It is greasy, pasty,
and clammy, and when exposed to the air, becomes yellow.
By associating these oils with proportionate quantities of

suet, mixtures will be formed of which soaps of proper quality and consistence can be made.

The soaps made from *poppy oil* are of a dirty gray, without any disagreeable odor, of a medium consistence, and clammy. They become yellow in the air, and soften at the surface when exposed to cold. This oil, mixed with the suets, furnishes a soap which much resembles that of olive oil.

Hempseed oil soap is green in color, very pasty, and so soft, that the least addition of water renders it liquid. Exposed to the action of air, it loses its green color exteriorly, bleaches, and then takes a brown color.

Nut oil soap is of a yellowish white, with but little consistence, greasy and clammy, and takes a brown color by exposure.

Linseed oil soap is whitish at first, but becomes yellow by exposure. It is rather soft, greasy, clammy, and strong-smelling. A very little water will dilute it into a thin paste.

Sperm oil soap is only moderately firm, and retains a fishy odor. Though of a dirty gray color at first, it becomes reddish brown in time.

Soap from other kinds of fish oil do not materially differ from the above.

All the soaps from *suets* and *solid* fats are firm, and except in a few instances white. By exposure they sometimes become very hard, and, with few exceptions, are without any very perceptible odor. Soap from *butter* is one of the exceptions, its odor being characteristic, more particularly when the butter is rancid. *Palm oil* soap, which, even when the oil is previously bleached, is colored, also has an odor which is agreeable and peculiar to it. *Lard* soap is hard, white, and inodorous, and very superior when it has been mixed with a portion of olive oil.

Cocoanut butter soap has the great advantage of being,

to a degree, soluble in saline solutions, and is, therefore, well adapted for washing in salt or sea water.

Soaps from *castor oil* and *spermaceti* hold the first rank in emollient properties, and are especially adapted to toilet use.

Human fat gives a hard soap, which dries quickly, and becomes yellow.

Bone fat, though slushy, makes an excellent common soap when mixed with a portion of more solid fat.

Horse-fat soap is hard, white, and without disagreeable odor.

Red-oil soap is the so-styled "chemical olive soap," but contains a portion of more solid fat, which increases its firmness.

Following, are detailed descriptions of the most approved processes for making the several kinds of hard soap.

CURD, OR WHITE SOAP.

1. *By the old German method.*—As a preliminary operation, the tallow or suet, which is the kind of stock employed, is made into a potassa soap, and the latter subsequently "cut" into soda or hard soap. The product is of excellent quality.

The grease being melted, is drenched with potash lye of 20° Baumé; and the milky mixture thus formed, is boiled with such care as to prevent scorching when it commences to thicken. The proportion of lye to fat is not regulated by weight, as a very little observation will dictate when enough has been added to produce complete saponification. This stage is attained, when the potassa soap forms a clear, transparent, thick, syrupy solution in the spent lye. If there should be any deficiency of lye, it will become evident, during the boiling, by the cloudiness of the liquid, which is caused by the unsaponified

fat suspended in it. It should be remarked, however, that when the lyes contain any free lime impurity, the cloudiness may possibly arise from that source; and hence, before adding more lye, the question must be determined. This is done by diluting a portion of the liquid with water, and then adding a little *carbonate* of potassa, which will dissolve the cloudiness, if it proceeds from the lime impurity of the lye, and the soap is, in technical language, "*overdone*." On the contrary, if the cloudiness does not disappear on the addition of carbonated alkali, the indication then is a want of lye; and an addition, but of weaker strength than the first portion, must be added, and the boiling continued.

When the liquid will drop in a continuous thread from the stirrer, and jellifies on cooling, it is ready for the "cutting" process. This consists in throwing in salt by handfuls, during boiling, until it dissolves and begins to act. Double decomposition of the salt and potassa soap ensues; the salt gives its chlorine to the potassa of the soap to form chloride of potassium, which dissolves in the spent lye; while the deserted fat acids of the soap unite with the deserted soda of the salt, and make a white flocculent curd, which, by sufficient repose, entirely separates from its mother liquor. The latter being drawn off, the soap is then ready to be transvased into the cooling-frames.

2. *By the modern method.*—Charge the kettle with 190 gallons of lye of 13° Baumé, and 2,000 pounds of best melted suet. When the mixture becomes milky, keep it at a gentle ebullition for two hours, and then put out the fire, and after two hours' repose draw off the lye. Continue the operations as directed above. When it forms, by pressure between the fingers, clean, solid scales, cool the magma by throwing in some buckets of lye, and soon after it has settled draw it off clear. After the fire

has been withdrawn pour into the kettle nine or ten gallons of lye, and, when fusion is complete, make a trial of the paste with the spatula. If it runs from the lye, add water—if it does not run, boil it a little more, adding a bucket of water, containing a third of its weight of common salt in solution, in order to effect the separation of the soap from the water. When this separation appears to be perfect, after half an hour or more repose, the water which contains the greater part of the alkaline lye remaining from the first boiling, and generally of a very deep bottle-green color, is then drawn off. Replace the fire under the kettle, and turn in about eight buckets of water, and when, after a continued boiling, the incorporation is complete, examine with the spatula if the soap runs from the water. If it does, add water in small portions until it ceases, and the pasty liquid moves tremulously like melted gelatin. To finish the operation, give a good boiling to the contents of the kettle, and unless the soap has a bluish tint (in which case it should have another washing) extinguish the fire entirely, carefully cover the kettle, and leave the whole to rest for a day or more, and then ladle it off into the frames.

Curd soap is generally very hard, and slow to dissolve and froth in water. It has, therefore, been proposed to add to the finished curd about ten per cent. of tallow oil soap, made with potassa lye of 6° to 8° Baumé.

Anderson's process.—In making yellow or resin soap, the process is that of boiling the materials upon successive portions of alkaline lye until they become, technically speaking, "strength," after which the curd so produced is subjected to a purifying operation, or "fitting," which is thus performed: The lye used in boiling to "strength" is carefully pumped off from the soapy paste, and the latter is diluted with weak lye or water, and boiled to that requisite consistence well known to soap boilers; after two

days' repose, it settles out of the perfect soap, and there is found below it a certain substance (inferior or second quality of soap) called "niger" or "nigre." The perfect soap is cleansed or lifted off carefully from this niger into the cooling-frames—the niger itself being added to the next operation, or concocted into an inferior yellow soap. The process followed in making curd soap is to boil the materials upon successive lyes until they become "strength," after which, and when the curd is of proper consistence, it is cleansed off carefully into the cooling-frames without further treatment.

In making curd soap, Mr. Anderson says, no fitting process has hitherto been practised; therefore these details are entered into in order to facilitate the description of the invention, which is as follows: When curd soap is boiled to "strength" and subjected to the "fitting" process used for yellow soap, there separates from it a peculiar substance analogous to the niger of the yellow soap, and that, by removing this niger, as it shall be called, and boiling the remainder of the materials into curd soap, a product is obtained, of better quality than could be without this operation. The niger removed is particularly fitted for making a mottled soap, and to this purpose it is applied. The invention starts from that point of the usual mode of making soap where the materials are boiled to "strength," and "ribbon out" well on the finger; but at this stage, instead of boiling out the head and finishing as heretofore practised, commence the improved process by pumping out or drawing off the strong lye on which the materials have been boiled, and treat them with successive portions of weak lye or water, and boil them together, until they assume the appearance of a fitting yellow color. This condition being arrived at, stop the operation, and allow time for the niger to be deposited, say twenty-four to forty-eight hours. To separate this niger,

either pump it off from under the purified compound, into an adjacent kettle, or carefully remove the upper stratum of "clean soap" with basins or buckets. Either way, the material thus freed must now receive the proper finishing lye for curd soap, which is added, and the whole boiled until the soap becomes of sufficient consistence to be cleansed off into frames.

When the ingredients operated with or upon, are very impure, the above fitting or purifying process is repeated one or more times, in which case or cases, after separating the niger from the materials, as described before, add to the residual partially purified goods, a lye of moderate strength only (instead of the finishing lye for curd soap), and boil, taking care that no "head" is formed; then pump or draw off this lye, and again treat the materials with weak lye or water, until sufficiently diluted, so as to perform the fitting process; after which, allow time for subsidence, then separate the niger, add the finishing lye, and boil to a curd as before described.

The treatment of the niger and its conversion into mottled soap, are effected by adding to it the usual finishing lye for a mottled soap, and boiling until it is fit to be transvased into frames. The quantity of niger obtained from one fitting or purifying operation, is not enough to be conveniently boiled by itself, therefore it should be saved, and six or more batches operated upon at a time. Occasionally a portion of bone-fat may be added, and the soap finished as an ordinary charge of mottled soap.

MARSEILLES, OR VENITIAN SOAP.

Olive oil soda soap, as made in the South of France, and North of Italy, is known by the above titles. The process for making it, in those countries, varies very little from that given at page 195, and is as follows:—

For a "boil" of about 12,000 pounds of soap, 40½ bar-

rels of olive oil are required in summer, and 40 in winter. The lesser quantity suffices in winter, because the oil is thicker at low temperatures, and requires more lye for the finishing of its soap.

When the oil is dirty and cloudy, it must undergo a preparatory treatment; and that is a gentle boiling, with two barrels of lye; and in case of being very thick, the ebullition should be prolonged. A precipitation of the impurities indicates that the clearing is accomplished; and the clear limpid oil on the top is to be drawn off by means of a siphon, into suitable receiving vessels, and one-half transvased into a second kettle, and treated with 80 gallons of strong soda lye, or a mixture of 40 gallons strong, and 40 gallons second strength lye.

The oil bubbles and boils with the lye which has been added, and the workman must be attentive, during the ebullition, to exactly note the movements, for it is upon observations made at the commencement that he decides what is necessary to follow. The remaining half of oil is now to be added. As soon as the charge has changed to a magma, it spatters, and throws out jets of paste in such a manner as to exhibit throughout the mass oily spots; this is a sign that the paste is thirsty, and that the lye heretofore added has been consumed.

Lye is needed, when thick vapors ascend from the boiling matter, or when the paste, which is upon the oil, remains sunk and motionless; and 40 gallons of the same as first added, are then poured in. But in adding it, be careful to distribute well throughout the mass, because if it all goes in one place, the cold lye precipitates to the bottom of the caldron, rarefies snd spatters, and throws the paste against the sides of the kettle. By diffusing it over the surface, when pouring it in, it heats gradually before reaching the bottom, and without bubbling or throwing out the mass: The 40 gallons of lye having been added,

the workman is again attentive to the behavior of his operation. When the same indications as before present themselves, another 40 gallons of strong lye must be thrown in. Continue supplying this lye, gradually, as wanted, and little by little, until all the oil is converted into paste.

When no more uncombined oil is apparent, then the paste is complete. If the materials of the lye used are good, this process generally takes about thirty hours; but when the lyes are weak and defective, nearly two days elapse before the paste is completed, and even then, only after much fuel and lye are consumed.

To know if the paste is good, homogeneous and perfect, the workman takes a kind of wooden spatula, three or more feet long, and one and a half inches wide, and dips it in, and then draws it out and cools it. If, upon examination, the paste is well united, white, and without defect, and shows no particles of uncombined oil, he then pushes up the fire, and maintains an ebullition during the whole day; for, though the paste is complete, the soap is not yet perfected.

When the workman observes, by the escape of thick fumes, that all the lye is consumed, he adds 80 gallons more, and always of the strongest lye. The paste which was thick, then becomes soft. Whilst one workman revives the fire in the furnace, another pours the lye into the kettle from time to time, until the whole 100 gallons have been added. Some pretend that the soap is made handsomer and more profitably by dosing the oil in the commencement entirely with strong lye. This, however, is a mooted point among soap boilers, each adopting his own views in practice; and each avowing, that though a good soap can be made by such and such a method, yet his own is much the preferable plan.

When the above quantity of strong lye has been consumed, which requires thirty-six to forty-eight hours, ac-

cording to the quality of the material of which the lye is formed, then the paste sinks and remains motionless in the caldron, thus indicating that the lye is exhausted. Previous to this stage, it ejects its mushy particles against the side of the kettle, and then the fire must be moderated. If it should not boil readily, it must be dosed with five or six buckets of that lye which is left in the kettle when the soap is transferred to the cooling-frames; and which is generally drawn off and preserved for this purpose, though, as is seen, its use is not always necessary. If the charge, after being boiled over a moderate fire, for two or three hours, is observed to have contracted, it is then to be dosed with fifteen buckets of the second lye. It then melts, and is converted into red paste, but in half an hour becomes white—a change by which it is known that the soap is not perfect. Increase the fire, in that case, so that combination with the lye may be effected, and the paste acquire more body, and continue boiling until much of the water has been evaporated off, as is determined by rubbing a little of the paste with the finger in the palm of the hand, and examining it. If this test does not prove the paste of the requisite qualifications as to beauty, freedom of water, and completeness of saponification, then pour in 30 gallons more of strong lye, which have been, and should always be reserved for such a contingency as this. After three or four hours' boiling with a reasonably hot fire, again serve it with 150 gallons of the *second* lye. The paste again commences to become red, and must be boiled briskly until it mounts nearly to the top of the kettle— care being taken to stir it well, so as to admit air to the mass, and prevent its foaming over.

When the paste has been boiled for an half hour, it becomes white and free, and by continuation of the fire, assumes the form of dry grains. If, however, this boiling should possibly fail to grain it, it is owing to the weakness

of the lye, and 30 gallons of strong lye must be added—
an addition which seldom fails to put it in that state. If,
by continuing the fire, it is seen that the paste splits, or
parts asunder, the workman takes in his hand a sample
to examine its state of coction, and whether it is perfect
or not; he also tastes the spent lye in the kettle, and if
this has but little taste, the paste is then drenched with
strong lye. If, on the contrary, the lye is of a strong and
piquant taste, then instead of drenching with strong lye,
pure water must be used. It is towards the end that the
workman must be most observing, for his judgment upon
a sample of paste kneaded between the fingers must decide
whether the lye to be added should be strong or weak, and
when the fire is to be augmented or lessened. These ope-
rations are repeated four or five times, until it is seen that
all the paste has been " coagulated" by the salt, and that
its water has sufficiently evaporated.

When thick vapors are emitted, it is a sign that but
little water remains under the paste, and it is dosed with
lye to prevent its falling to the bottom. If the intention
is only to melt the paste in order to continue its coction,
then weak lye must be used, for the strong lye will granu-
late it anew.

When, by employing weak lye, the paste becomes too
soft, the fire must be increased. Such are the different
treatments given to the paste; and they must be con-
ducted as personal observation may suggest, for it is im-
possible to give minute directions. Finally, when the
paste separates from the lye, and is perfect, it is allowed
to repose for a day or two in the kettle, and after having
sufficiently cooled, transvased into the frames. Some
manufacturers use a certain percentage of poppy oil with
the olive oil. It has been supposed that forty barrels of oil
have been used at one boiling, but the quantity can be in-

creased or decreased, according to the amount of soap required to be made.

The process of saponification is of duration, longer or shorter, according to the quality of the raw materials. It generally takes some hours of boiling for the material to react, become white, and thicken. This ebullition is continued for about eight hours, adding from time to time weak lye, and four or five hours after, the second lye, and from that passing on to the strong lye. It is important to keep a constant watch over the operations, for the least negligence or inexactness can vary the results.

COCOA SOAP.

Cocoa-butter, though not a familiar article in this country, is largely used as soap stock, both in England and Europe. In many respects, it is a valuable material, the soap which it makes being brilliant, white, very hard and light; and, to a larger extent, soluble in saline and alkaline waters—thus rendering it serviceable for washing in salt water, whence its name "*marine soap.*" It is also capable of taking up about one-third more water than tallow soap, without showing the excess; and this property makes it an appropriate fat to be mixed with tallow—the best proportions being 60 parts of cocoa butter and 40 parts of tallow. The addition of tallow or palm oil is indeed necessary to promote saponification, for cocoa-butter alone is very slow to unite with lye, and gives, besides, too much hardness to the soap. Moreover, the mixture masks the otherwise peculiar and disagreeable odor of the soap.

The peculiarity of the soap, in being dissolved by weak lyes and saline liquors, renders necessary a large amount of salt for its clarification. So, also, the lyes must contain a portion of potassa, and be of high strength to effect saponification; and used in exact proportion to "kill all

the oil" and no more. The soda ash, from which the lye is made, should, consequently, give 85 to 90 per cent. of caustic alkali, and for the double reason, that if it contains any saline impurities, they will show, as an efflorescence, on the surface of the soap when it dries.

1. We give a modification of Sturtevant's process for making this soap. It consists in steaming 2,100 pounds of cocoa-nut oil in a wooden vessel, with 6 pounds of oil of vitriol and 12 pounds of hydrochloric acid, to remove the disagreeable odor of the grease. The latter is then drawn off, mixed with 200 pounds of tallow oil, or palm oil, heated in the soap pan, and treated with 10 gallons of soda lye of 24° Baumé. When the mixture has boiled for a short time, another 10 gallons of lye are added; and so on the additions of lye are repeated until 375 gallons are consumed—care being taken to maintain uninterrupted ebullition during the whole time. When the whole of the soda lye is in, and the mixture has boiled an half hour or more, 60 gallons of potassa lye of 20° are added in like manner, and the boiling continued for twenty or thirty minutes. Eighty-five pounds of common salt are then sprinkled over the surface; and after an half hour's additional boiling, the fire is withdrawn. The soap is allowed to cool, and afterwards finished in the usual way.

2. Another method is to heat together a mixture of half and half cocoa-butter and bleached palm oil, or tallow, with an equal volume of perfectly caustic soda lye of 27° Baumé, to which must be added a third of a volume of caustic potassa lye, of 10° Baumé, in order to promote the commingling of the materials during the first boiling. If this should ensue from the above prescribed quantity of lye, then a little more may be added, but not much more than one degree of strength. The heat, during this operation, should be about 180° to 190° F., and of two hours' duration, by which time the lye will be nearly exhausted

or spent, and must be re-strengthened by a fresh addition of a little weak lye. Powdered salt is then sprinkled over the surface and stirred in until the paste, on cooling, shows out clean, dry, and free from greasiness. When it will not show these signs, and there is no causticity, then more lye must be added. This generally proves effectual; but if it should not, more salt should be added.

The heat should not be allowed to exceed 180° to 190° F., because too great liquefaction takes place, and causes a precipitation of the cocoa soap from the tallow or palm soap. .This behavior also occurs when there is a large excess of salt or lye present; and, in the latter contingency, the fire is withdrawn for an hour, and a little cocoa oil added during constant raking. In this way an intimate mixture is promoted. The heat must be continued for five or six hours, in order to insure a thorough reaction among the materials, and the mass should be frequently stirred. The soap, after being made, is to be left over night in the kettle, and re-heated towards the close of the next day, experience having demonstrated that this treatment closes the union of fat and alkali, and produces a harder and better soap than if it was at once transvased into the cooling-frames. Even when finished, the paste should be left to cool in the kettle to 155° F., before it is poured in the frames; and when in the latter, it ought to be well crutched, in order to produce homogeneity; but this operation must not be continued when the paste has cooled down to near 130°, for then it would, under the circumstances, separate from the lye.

It must be mentioned, that after the night's repose above prescribed, the soap occasionally proves to be short of strength; in which case more lye is needed, and must be added in sufficient quantity to impart slight causticity. If this does not give firmness, strong salt brine, previously heated, is to be slowly added and well stirred in, until the desired effect is accomplished.

There is still another method by which the yield of soap is twice the weight of fat employed. The product, too, is white, firm, and washes well.

The preliminary step is the preparation of a cocoa soap from one volume of 100 pounds of cocoa oil, one and a half volumes of soda lye weighing 190 pounds; and 110 pounds salt brine at 12°. The soap, when finished, should be allowed to stand several days, when it is heated to 170° F., and added in the cooling-frames to the freshly finished curd of 600 pounds of tallow previously raised to the same temperature, and the mixture thoroughly accomplished by crutching.

If the stirring is done while the paste is too warm, the cocoa portion separates. On the other hand, a too low temperature impairs the lustre of the soap. The exact time is best determined by testing a sample of two parts of tallow with one part of cocoa paste. A thinness of the resulting mixture indicates that the pastes were too warm; and thickness is an evidence of their having been too cool. But when it has the characteristics of true soap, then they are in the proper temperature—condition for complete union.

ROSIN, OR YELLOW SOAP.

This kind of soap bears the name also of "Yankee soap," from its having been first largely manufactured in this country. The property in rosin, or colophony, of combining readily with caustic or carbonated alkalies to form resino-alkaline liquors of some detergent power, renders it an economical and useful ingredient of common washing soap. This combination of resin and alkali separates, like tallow soap, from its liquor when salt or excess of alkali is present, and forms a slimy, brown mass, containing about 15 to 16 per cent. of dry caustic soda. Yellow soap, containing a moderate proportion of rosin, is firm,

light-colored, of slight terebinthine odor, and lathers well without dissolving too rapidly in the wash-water. Fifteen per cent. of rosin answers a good purpose; but, beyond that limit, the soap is depreciated in color, firmness, and quality. Even for the cheapest grade, the quantity of rosin should not exceed 33 per cent., for otherwise, the soap will be clammy, soft, and unprofitable to the consumer. The commercial grades of yellow soap are regulated by the proportion of rosin which they contain. The grease stock of which this kind of soap is generally made consists of "kitchen fat," "soap grease," "bone fat," and "red oil," either separately with the rosin, or in admixture of two or more of them, according to the convenience of obtaining them. Some inexperienced manufacturers melt the rosin with the grease in the commencement of the boiling for soap; but this mode makes inconveniences in managing the paste when it approaches completion, and moreover, yields soap of inferior excellence.

1. *The common method.*—The usual mode of making rosin soap, is to bring the tallow, or grease paste to the point when the last lye is to be added, and then to mix in the rosin, previously powdered. The boiling is afterwards continued, during frequent stirring, with sufficient lye to finish the paste; which is known when it separates from the under lye, is consistent, without clamminess, and is free from resinous feeling. The final treatment is to withdraw the spent lye, and to precipitate the impurities of the rosin, &c., by slight additions of weak lye. The soap is subsequently ladled into the frames after the usual manner.

2. *English method.*—Charge the pan with 2,000 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, heat up the mixture to ebullition, being careful to stir all the while to prevent the adherence of the resin to the bottom and sides of the

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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 substituted, and the whole again boiled for three hours more. Another repose of six hours is allowed, and the spent lye again drawn off and renewed by fresh additions. The boilings are thus continued from day to day 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 lye, and two hours after, draw off the liquor. 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, taking 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, 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 regarded as finished.

If it is desired to give a pretty color to this soap, about 20 pounds of palm oil may be added, and after two days

it must be run into frames, whence, after a week, or less, it should be taken and cut into bars.

Dunn's process.—This plan, described by the author with reference to steam as the heating agent, is as follows: Into each of the ordinary boiling kettles, a circular ring, of one and a half inch pipe, and perforated with holes, is fixed in the well of the kettle, just far enough above the bottom to allow the free movement of a stirrer beneath it, when it becomes necessary to stir the contents below. The circular ring of pipe is supplied with atmospheric air from a cylinder blast or other suitable forcing apparatus; this circular ring being connected with such forcing apparatus by means of a pipe attached thereto, and rising up to the top of the kettle, where it is furnished with a stopcock and union joint for the purpose of connecting or disconnecting the parts of the pipe within and without the copper. For a clean, yellow soap, put into the kettle 90 gallons of lyes of specific gravity 1.14, made from strong soda ash. The fire being kindled, the kettle is charged in the usual way with, say, 2,050 pounds of grease, and as soon as the lye is hot and on the boil, or nearly so, the blast is set in action, keeping up a good, brisk fire, so as to continue the materials in the kettle as near ebullition as possible. When the lyes are exhausted, as is easily known, more lye is gradually added until the grease, oil, or fatty matter is killed. Then add 550 pounds of fresh rosin, a bucketful at a time, with more lye occasionally, until 300 gallons of the strength above mentioned have been used, keeping the blast in action the whole time if the fires draw well; but if not, it is advisable to stop the blast for a short time, before adding the rosin, to allow the contents of the kettle to approach to ebullition. When the whole of the rosin is melted, and completely mixed with the soapy mass, and the strength of the lyes taken up, stop the blast and give a brisk boiling to the contents

of the caldron, and let it rest that the spent lyes may separate and settle, which being now drawn off, the soap is then brought to strength on fresh lyes, as in the ordinary process of soap boiling.

During the operation of the blast, the soap must be kept in what is technically called " an open or grained state," and for this purpose, salt or brine is to be added when necessary. Experience proves that it is better not to make a change of the lye during the operation of the blast, where lye of the strength before mentioned is used, but if weaker lye is employed, one or more changes may be made, as is well understood. It is found desirable that the soap should be kept in what is called a weak state, during the action of the streams of air through the materials; otherwise, the soap is apt to swell up, from the air hanging in the grain; and this is found troublesome to get rid of, requiring long boiling. If dark-colored materials are used, it is well to keep the blast in operation three or four hours after the rosin is melted, provided the soapy mass is kept weak and open or grained. When a charge is to be worked upon a nigre, such nigre should be grained, and the spent lye pumped, or drawn off as usual, and the fresh charge added in the manner before mentioned, using less lye in proportion to the quantity and strength of the nigre, taking care not to turn on the blast until there is sufficient grease present to make the nigre weak.

4. *Meinicke's process.*—This method requires that the soap-pan should be constructed with a still-head and cooling-worm, as the rosin is added in the form of white turpentine, which, during the boiling, gives off its volatile oil as a distillate, to be condensed and saved as an incidental product, and thus decrease the expense of the soap. A thousand pounds of white turpentine are melted in the kettle, by steam, with 800 pounds of tallow, or inferior fat; and when the mixture reaches 108° F., it must gradually

receive, during constant stirring, 800 pounds of caustic soda lye, containing 30 per cent. of dry soda. The union of the materials is very prompt, at the above temperature, says the author—the acids of the resin and grease being completely neutralized and converted into liquid melted soap. The essential oil of turpentine is set free at the same time, and in order to promote its vaporization, salt brine is added. The head being then luted upon the pan and adjusted to the worm, and the mixture brought to a boil, the steam and spirits become involved, pass over into the worm, and are condensed. When all the essential oil is distilled over, the remaining soap is finished in the usual way.

5. Experience has shown that the greatest excellence in rosin soap is not to be obtained by adding the rosin directly to the oil or paste. The best plan is to make the grease and rosin soaps separately, and then to mix them in proper portions. The rosin soap is first prepared by stirring 80 pounds of powdered rosin, portionwise, into 100 pounds of soda lye, of 25° Baumé, and boiling until perfect solution. The acid properties of the rosin render the combination easy and prompt, even when the lye is carbonated. This resino-alkaline solution is then to be well raked into the finished tallow paste while it is still in the kettle; but its temperature should not be above 135° to 140°, otherwise perfect homogeneity of the mixture cannot be accomplished. In this way 15 per cent. of rosin may be introduced without materially darkening the color of the tallow soap. Moreover, the quality of the product is good. Sometimes several per cent. of starch or bran are used to assist the combination of the two soaps.

When the soap-mixture is worked with fire, the boiling should be continued gently until the paste is uniform throughout, and then salt is to be added.

PALM SOAP.

Palm oil is extensively employed as soap stock in this country, but is rarely used without an admixture of some other kind of fat. When well made of pure articles, palm soap has emollient properties, which, combined with an agreeable odor, render it very useful for toilet purposes. It is very firm, and of a grayish-white color when the oil is bleached, but yellow if used in its natural state. This color disappears when the soap is exposed to light and air for some time.

Palm soap may be made after the manner of tallow soap, from a mixture of three pounds of palm oil and one of tallow. An inferior article, called "demi-palme," is obtained from one pound of palm oil with four pounds of tallow. Of the processes specially arranged for the saponification of palm oil, those which follow are the most practicable.

1. *Walterson's process.*—This method consists in mixing or combining the palm oil and suet, or other fat, with caustic soda, and in subsequently adding water for the purpose of converting such mixture or produce into soap. The inventor says, that the soap is thus rendered purer and more efficient, and that a considerable economy of time is effected in the operation, the soap being sufficiently hard for sale or use in the course of a few hours, instead of several days, as is the case under the ordinary process of manufacturing. The caustic soda lye must have 22 per cent. strength; and the water should be free from earthy and metallic impurity.

Take 784 pounds purified or bleached palm oil, and as soon as it has become fluid in the pan, add thereto, gradually, 407 pounds, more or less, of liquid caustic soda, of strength above named, taking care to mix the ingredients thoroughly by stirring. The heat must then be

increased, and the mixture constantly moved about to prevent it from caking on the bottom of the pan. After continuing the operation for three or four hours, the mixture assumes a whitish appearance, and by continuing the heat, the whole of the aqueous part is entirely evaporated, and the mass reduced to a perfectly dry state. The heat is now increased, and in a short time the mass again becomes of liquid form and changes to a brownish color, which indicates that the combination of the oil with the alkali is effected. The fire is then speedily withdrawn, and the stirring is continued so long as any fear of scorching is apprehended. When this is over, the first part or day's operation is concluded, and the pan may be left to cool. The second part of the operation consists in breaking up the product, now in a solid form, into powder. To this add about 45 gallons pure water, and thoroughly agitate the mixture for about half an hour. The heat is then applied, and the contents of the pan raised to ebullition, and kept so for about three hours, during which time the stirring and agitation must be continued. So soon as the evaporation has been carried to the required extent, and the soap appears of the proper consistency, it is allowed to cool gradually. The whole contents of the pan (no lyes or waste accruing from the operation), while yet in a liquid state, are now put into the ordinary frames and left to cool. The day following, the contents of the frame will be found hard enough for cutting into bars, &c., in which state it is ready for sale or use.

2. *English palm soap.*—This is a clear, unsalted soap, of which the basis is a grain soap made by boiling a mixture of 50 pounds of tallow, or soap grease, and 30 pounds of palm oil with a strong soda lye. While in paste, it is mixed with a rosin soap prepared as follows: Twenty pounds of white turpentine, previously melted and strained, are boiled with soda lye of 15° B., until the soap

separates from the liquor, when it is ladled off into the grained soap. The mixture is then boiled with several waters until the paste becomes firm and acquires the properties of true soap. It is then left to repose; after which the spent lye is drawn off, and the soap thinned out with weak lye, of 3° B., and boiled for twenty to thirty minutes. The fire being then put out, the pan is covered with a lid and woollen cloth, to keep up the warmth until next day. After removing the scum, the polished grain soap forming the next layer is carefully transvased into the frames. The lower stratum of soap is the dirty sediment precipitated by the lye.

WINDSOR SOAP.

This celebrated soap, which is particularly applicable for bathing purposes, was formerly made wholly of mutton suet; but experience has shown that an addition of lard, or olive oil, in the proportion of twenty to thirty-five per cent., will greatly improve the stock. Not only is saponification promoted, but the soap is bettered in quality. Windsor soap originated in England, but is now made largely in France; and of inferior quality, also in this country. The several kinds are as follow:—

Plain Windsor is made with lard, in the manner of saponifying olive oil, and perfumed just before being poured into the frames with oil of caraway, in the proportion of nine parts to every one thousand parts of soap paste. Two parts of the oil of caraway may be replaced by a mixture of one part of oil of rosemary, and one part of oil of lavender.

Violet Windsor is composed of fifty parts of lard, thirty-three parts of palm oil, and seventeen parts of spermaceti, and perfumed with essence of Portugal, containing a little oil of cloves.

Benzoin Windsor.—This is the plain Windsor to which,

while in paste, are added flowers of benzoin, in the proportion of six ounces to every one hundred pounds of soap.

Palm Windsor.—This soap is made with palm oil, containing a small proportion of lard. To increase the odor, add a little essence of Portugal, and oil of cloves.

Rose Windsor.—This soap is the plain Windsor, colored with vermilion or oxide of iron, and aromatized with essence of roses. But in this instance the perfume must not be added until the soap has been poured into the frames, else loss will accrue from volatilization.

French Windsor.—So long as the French adhered to the old English plan of making Windsor soap with only mutton suet, its quality was inferior; for it became rancid and yellow by exposure. By their present method of mixing with the suet a certain quantity of olive oil or lard, the product is superior.

When the soap quits its waters, and the paste in separating from the lyes, coagulates, that is, forms into granules, that instant the fire must be discontinued, in order to facilitate the complete deposition of the lyes. This operation requires at least twelve hours, at the end of which time, and while the soap is still hot, entirely liquid, and perfectly neutral, pour into every 2,000 pounds of paste, 18 pounds of the following mixture :—

```
12 pounds oil of caraway
 3    "      "   lavender (fine)  } Laugier's proportions.
 3    "      "   rosemary
```

Then stir the mass well, and incorporate the essences thoroughly throughout every part of it, taking care not to reach to the lye that has settled at the bottom. After two hours' delay, ladle it off and put it in the cooling-frames. Twenty-four hours generally suffice for the solidification of the whole mass, which is then to be cut and divided into bars and cakes. This mode of perfuming is pursued for large quantities of soap. When the amount

does not exceed several hundred pounds, it is better to dip out the paste and put it into a water-bath caldron, (Fig. 47), and when heated sufficiently, to stir in the

Fig. 47.
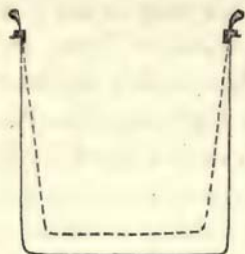
essences. In this way the incorporation is more complete, and the danger is avoided of mixing in a certain quantity of lye, by accidentally stirring too deeply into the caldron containing the paste, after its completion.

Bleaching soap.—This is made by converting a mixture of 30 pounds of tallow and 45 pounds bleached palm oil into a hard grained soap, by boiling with soda lye. The lye being then drawn off, 25 pounds cocoa-nut oil are added to the soap in the pan, and the mixture brought to boiling. Soda lye, of 15°, is then added, until the paste tastes slightly caustic, when salt enough must be added to *partially* separate the lye. The kettle is finally covered and left to cool for a day or two, when the soap is poured into the frames. Ten pounds of hot soda lye, of 3° B., are then thoroughly raked in, to give firmness to the soap.

CHAPTER XV.

SOFT SOAPS.

ALL soaps made with potassa are more or less gelatinous and pasty; and hence, in contradistinction to the hard or soda soaps, they have been given the title of soft soaps. Though highly detergent, their disagreeable odor and strong alkaline properties restrict the application of them to the coarser cleansing operations, such as scouring floors, wooden vessels, and woollen goods. This odor, though modified by the various oils used in the manufacture of soft soaps, is not wholly derived from them. Being eminently hygroscopic, they attract moisture rapidly in damp atmospheres, and even in the dryest cannot be wholly reduced to a solid form.

Their manufacture is based upon a principle somewhat different from that of hard soaps, for they are not true soap, but an impure solution of potassa soap in caustic lye, and contain the eliminated glycerin, and all the matters used in their preparation; while, in the hard soaps, the latter are removed in the clarifying and filling. Any attempt to clarify them with salt, as in the case of soda soaps, would produce their decomposition into hard soaps upon the principle of the "cutting" process, as set forth at page 213. Colza, hempseed, poppy, rapeseed, fish-oils, olein and oleic acid, or red oil, comprise the materials usually employed as stock. Lye of potassa is that invariably used for real soft soap. When it is desired to stiffen the consistence, measurably, portions of soda lye are used. The drying oils yield a much softer soap than the fat oils.

The name of "green soap," sometimes given to soft soap, originated from the color imparted by hempseed oil, from which it is largely made in Europe. The green may be artificially produced by means of a boiled paste of finely powdered indigo. Fish-oil soap is naturally brown.

Sometimes a little tallow is used to give a granular appearance to this soap, which proceeds from the somewhat solid grains of stearic soap throughout the mass. The process is called "*figging*," and only shows its effects in cold weather; and not even then until the soap has several weeks' age. Cocoa-nut oil is also becoming a favorite fat for soft soap stock. The lyes must be stronger in winter than in summer, to prevent the soap becoming thick and clotted. One part of potassa is required for the saponification of four parts of oil, and the resulting soap contains from fifty to sixty parts in the hundred.

1. *Common method.*—The pan being heated and charged with oil, caustic potassa lye, of 9° to 11° B., made from American potash, after the manner of soda lyes, is gradually sprinkled over the surface. As soon as the mixture reacts, it swells and intumesces, and must then be beaten down with the crutch, and sprinkled with lye, to quiet the commotion and prevent running over. Care and experience are required on the part of the workman to conduct this operation skilfully. An excess of lye in the first instance, delays combination of the oil and alkali; and too great strength renders it premature, causing a clotting instead of a thickening of the mass. In the latter instance, a remedy is applied by the addition of weak lye. On the other hand, when lyes are too feeble, the combination ensues so tardily, that a part of the superabundant water of the lye must first be evaporated before a perfect union of the oil and alkali is effected. In this case, the waste of time and material is much more considerable.

The activity of the ebullition depends mainly upon the

manner in which the fire is regulated. When the combination is perfect, and the froth has subsided, a sample is taken out, and if it is thick and viscid, the soap is ready for clarification; otherwise the boiling must be continued until it acquires those properties. The clarification consists in additions, from time to time, of stronger lye until the paste loses its turbidness, and becomes clear and transparent. At this point the chemical union is perfect; and to determine the matter, a small test sample is taken out after stirring and subsidence of the foaming, and allowed to fall, dropwise, on a white earthenware plate. If, on cooling, the paste is fine grained, clear, and not ropy between the fingers, then it is finished; but, a gray rim on the margin, and more or less fluidity, indicate a want of lye, which must then be supplied. An excess of lye, on the contrary, causes a dull appearance to the grain, a gray skin over the drops, and a loose adherence to the plate. To ascertain, with precision, when the proper stage has arrived, it is best to test samples at different periods of the boiling.

It must be remembered that the end in view is to produce a reaction between the oil and potassa, by keeping the soap constantly dissolved by the lye. A certain quantity of water must, therefore, necessarily be present, but not too much; and therefore, if there should be any excess, the heat must be raised, and evaporation promoted by constant beating, or whipping, which introduces dry air from without, to displace the moist vapors within. When the paste has quietly settled, and gives off only occasional large bubbles, it may be considered finished, and the fire is to be extinguished; provided, however, a sample quickly cooled and examined before the moist air has time to act upon and change it, is of jelly consistence, and wholly or nearly free from any opaque zone. It is then to be left to cool in the kettle. The cooling may be hastened by

adding a ton of ready made cool soap. This, in becoming melted, by that law of caloric which asserts a general tendency to equilibrium of temperature, abstracts a portion of the heat of the recently made soap, and thus makes the degree of that and its own, uniform. The foaming having ceased, the soap is then ready to be racked off into barrels, which must not be headed until their contents are thoroughly cool.

In making soft soap, it is better that the boiling should be too much than too little protracted. Soap which is not sufficiently cooked, changes and spoils; whilst the only disadvantage an excessive boiling produces, is a diminution of the quantity of product. The usual time requisite for a charge, is six or seven hours, but varies with the strength of the lyes, the temperature of the atmosphere, and incidental circumstances.

Crown soap (1st quality).—In England, the lyes are made perfectly caustic, and of two strengths, the weakest being 8° Baumé, and the strongest 25° to 30°. For eighteen barrels, prepare 400 gallons of lye, with good potash and 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 in repose 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 oil, the sample should not be viscid, too white, or 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 (2d 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 anew, add in 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 soap."—Two hundred and seventy-three gallons of whale or cod oil, and 400 pounds of tallow are put into the soap pan with 250 gallons of potash lye, containing 250 pounds of dry caustic potassa. Heat being applied to the pan, the mixture froths up very much as it approaches the boiling temperature, but is prevented boiling over by being beat 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 be now introduced about 42 gallons of a stronger lye, containing 55 pounds of potassa, 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 6,400 pounds, from the above proportions of materials.

Russian soap.—The lye is made in the usual manner, but from a mixture of one-fourth pearlash with three-fourths Russian or American caustic potash. Being adjusted to a strength of 10° Baumé, it is then equally divided into two portions; one of which is directly added to the oil in the boiling kettle; and the other allowed to trickle slowly and uninterruptedly into the mass from a reservoir above, during the boiling. When the paste has acquired the usual properties, the soap is finished, and is left to cool in the kettle after the fire has been extinguished.

Medicinal soft soap.—The impurities of the commercial soft soap render it unfit for medicinal purposes. Olive oil and lye made from pure caustic potassa, are the ingredients for pure soap. The lye is gradually added to the oil, during boiling, until the mixture becomes gelatinous and transparent, care being taken to add no more lye than is necessary to bring it to this finished state. The excess of water is to be driven off, as usual, by evaporation.

Bran soap.—The soap made from this article is said to possess great excellence, and may be used alone, or as an admixture with hard soaps. Broomans directs that it be made by boiling 100 pounds of wheat or other bran, during stirring, with 2 pounds of lye, marking 11° Baumé; and, after the action of the heat, straining through a sieve to separate the ligneous residue. The soap, on cooling, is ready for use.

Oleic soft soap.—The oleic acid, or "*red oil*," which is a product incidental to the manufacture of adamantine candles, may, when purified, be very advantageously used as soap stock. To remove the disagreeable odor, it must be subjected, for two or three hours, to the action of steam at 400° F. As it generally contains some sulphuric acid, the lye must be very strong. In summer, one-fifth of

bleached palm oil may be advantageously mixed with the
red oil, as it improves the consistence, color, and odor of
the soap.   Boiling is commenced with potassa lyes of 20°
B., and finished with that which is as high as 25°, or even
28° B.

White soft soap.—Whale oil and tallow, or tallow oil,
are first mixed together, in the proportion of 40 volumes
of the first, and 60 volumes of the latter; and then boiled
with 150 pounds of caustic potash lye of 22° B., until the
mixture becomes clear and short. If the above quantity
of lye does not produce the desired condition, then more
must be added; and when it is attained, 2 pounds of salt,
dissolved in sufficient water to make a brine of 28° B., are
poured in during constant stirring. This latter addition
is to whiten and clear the soap, and must be made without
boiling the soap.

"*Economic soap.*"—This is the Belgian soft soap so ex-
tensively and advantageously employed, in scouring fine
woollen textures, by the cloth manufacturers of that coun-
try.   Being very alkaline, it acts promptly, but should
be replaced, in the second scouring or milling of the cloth,
by a less caustic soap. Potassa is the base of the soap,
but it is not made in the usual manner of soft soaps; and
moreover, it is firm, brown, and transparent. The stock
may consist of either of the three following mixtures :—

1.		2.		3.	
Tallow	380	Tallow	225	Tallow	150
Oil of colza	70	Tallow oil	225	Bleached palm oil	300
Cocoa oil	150	Cocoa oil	150	Cocoa oil	150

The lye, in either case, must be perfectly caustic, and in
three portions of different strength. The whole quantity
required for 600 pounds of mixed fat, will be about 750
to 775 pounds, of which one-third should mark 18°, an-
other third 24°, and the remainder 30° Baumé. The
cocoa oil, being held in reserve, the other two fats are

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melted together in the pan and boiled first with the
weaker third of lye. Following this, must be the lye of
24°, and lastly that of 30° Baumé; but all should have
been poured in at the end of two hours, by which time
mixture will have ensued and chemical action begun.
Ebullition is then continued until the paste leaves the lye,
and when tested by sample flows from the spatula like
salted soap. When this condition is being attained, the
boiling paste throws up smaller bubbles, thins and froths,
and becomes turbid. At this stage the fire must be ex-
tinguished, and the paste transvased into a second pan, to
promote the deposition of lye. After repose, the soap is
returned to the soap kettle, and treated with the cocoa oil,
previously melted and strained, and also a sufficient quan-
tity of lye to clear it and render it caustic—a condition
attained when the paste sets firmly on the test-plate.

The soap may be sufficiently caustic, and yet not hard;
in which case, a portion of the water must be evaporated
by continuing the boiling. Again, when the soap is soft
and the causticity also feeble, the indication is a want of
lye. When the paste has reached completion, it must be
left to cool in the kettle, and then transvased into shallow
frames of about twelve inches depth, and of the usual
dimensions in other respects.

The separation of the lye, in this process, carries off all
the saline impurities of the potash, and improves the keep-
ing qualities of the soap. The yield from the above quan-
tity of stock will be twelve to fifteen hundred pounds,
and it should be thinned out with six to eight parts of
cold water previous to use.

SODA SOFT SOAPS.

According to Gentele's recent experiments upon a large
scale, the potassa base of soft soaps may, *in part*, be re-
placed without disadvantage to the resulting soap. The

product has the characteristics of soft soap, but contains a little more water. The lyes must be free from salt and other saline impurities, as they prevent the clarifying of the soap. The best proportion is one part of soda to four parts of potassa lye, and the first should be made from crystallized sal soda. A mixture of 100 pounds of red oil, 50 pounds of tallow, and 3,750 pounds of hempseed oil, makes a good stock for this soap.

White soft soap.—A soft soap, of firm consistence, may also be made economically by the following process, which yields, from the prescribed quantity of materials, a product of about four hundred pounds :—

Melt together 75 parts of tallow, or tallow oil, and 25 parts of cocoa oil, and boil the mixture with lye until the paste sharply bites the tongue. At this stage, salt solution of 20° Baumé is added, to give consistence to the paste, and the soap, on cooling, is then ready to be barrelled.

Soap for silks and prints.—According to Calvert, the soft soaps usually made for dyers' use are not indiscriminately applicable for all colors. To produce the maximum effect in brightening the shade, the soap should be composed of—

	For madder purples.	Madder pinks.
Fatty matter	60.4	59.23
Soda	5.6	6.77
Water	34.0	34.00

For removing the glutinous coating from silk, soap may be replaced, says Bolley, by borax. The silk, first boiled with half its weight of this salt for one to one and a half hours, and subsequently with soap, is white, soft, and unimpaired in strength. The borax may be recovered.

CHAPTER XVI.

SOAPS BY THE COLD PROCESS.

THIS class of soaps being made without boiling, and by direct combination of the fatty matter with its equivalent of alkaline base, has received the designation of "*little pan soap*," as large quantities can be made in comparatively small vessels. These soaps contain the minimum of water, and are, consequently, hard. When well made, they are a serviceable washing soap, and cleanse well without wasting away in the water. This mode is well adapted to the saponification of cocoa oil and red oil, and is becoming popular, even for common soaps. It has, since its origin, been employed for the finer qualities of toilet soaps. Those of the latter kind made in this country, rival in beauty and quality the very best French soaps. The process of manufacturing them is founded upon the strong affinity of fatty matters for the alkaline base when presented in a dense liquid form; for, after several hours' contact of these two materials, there results a solid of some consistence, assisted in its formation by the elevated temperature attendant upon the chemical reaction between the oil and the alkali.

Lard soap.—To prepare this soap, weigh out 112 pounds of lard, and 56 pounds of caustic soda lye at 36° B. After having melted the lard by a gentle heat, add half of the lye, stirring it well in, and continuing the agitation, without allowing the mixture to boil. When all appears to be well incorporated, then pour in, little by little, and during constant stirring, the other portion of the lye, and be

careful not to augment the temperature above 149° F. The paste should be well united, homogeneous and of some consistence. Pressed between the fingers, it should be mild and unctuous, without being greasy. When it has reached this state, it is run into the frames, and in two days ought to have acquired sufficient solidity to be cut up into tablets and pressed. The perfume must be added whilst the soap is yet in paste. This soap is of a very brilliant whiteness and flinty consistence.

Beef-marrow soap.—To 500 pounds of beef-marrow, add 250 pounds of caustic soda lye, of 36°, and stir constantly and gently heat the mass until it becomes soluble in water. In this state, dilute with 2,000 parts of boiling water, and then pour in 1,000 parts of brine, holding in solution 180 parts of common salt, during uninterrupted raking, and then leave to repose. After some time, pour into frames, and leave it for a day or two to set thoroughly.

Sweet almond oil soap—(medicinal soap).—This soap, by reason of the high price of the oil, is only manufactured for the toilet or medicinal purposes; and, consequently, the choice of the best materials must be insisted on—select oil of almonds, free of rancidity, and pure carbonate of soda. Dissolve the latter in water, and add the third of its weight of hydrate of lime, frequently stirring the mixture during an interval of some hours; after which filter the clear lye running through, and concentrate it by evaporation until it marks 36° B. Then take 12 parts thereof to 25 of oil, placing the lye first in the vessel and gradually incorporating therewith the oil, added in small quantities, at a time, and well and continually stirred in until the mixture has the appearance of a soft grease. In two or three days its consistence becomes such, that it can be turned into porcelain moulds. When placed in a temperature ranging between 68° and 72° F., it acquires in a month sufficient solidity to be taken from the

moulds. The temperature of the lye should be 50° to 60° F.; but to prepare the soap quickly, it is necessary to place the mixture over hot coals, being careful to prevent the concentration of the lye by additions of water proportional to the quantities evaporated.

This *amygdaline* soap, well prepared, is beautifully white, and of a very mild odor. It becomes so hard, that when dry it is easily pulverizable.

The other oils are but seldom used for soda soaps, because they saponify less easily, and give a product less solid than olive and almond oils.

Hawes' soap.—The invention of Mr. Hawes has for its object, the intimate combination and admixture of the soap ingredients by mechanical means, and without boiling, and the inducement of perfect saponification of the fat with the alkali, without recourse to that high degree of heat requisite in making soap by the usual methods, and at a great cost of fuel. The following is a description of the process by himself:—

"I take any given quantity of tallow, say two and a half tons, and having melted it, keeping the temperature as low as possible, I mix it with the quantity of alkaline lye which is required to completely saturate the tallow and convert it into soap; and such mixing I perform by mechanical means, and the apparatus or machinery I employ is hereafter described. I use the ordinary lye of soap boilers, preferring that made from the strongest and purest alkali.

"The saponification of the tallow or other fatty matter, may be ascertained by the absorption or combination of the tallow or fatty matter with the lye, care having been taken in the first instance to use sufficient quantity thereof; or about 20 gallons of lye of 17° B., to every 100 pounds of tallow. It is necessary to state that the proportion of alkali varies with the different fats and oils.

The combination of the fatty matter and lye may be effected in an ordinary boiling caldron, with the addition of a machine to produce an intimate admixture and the minute division of the tallow. The whole apparatus is represented by Figs. 48, 49, and 50. It consists of an upright shaft A (Fig. 48), from which arms, *a a a a a*, ra-

Fig. 48.
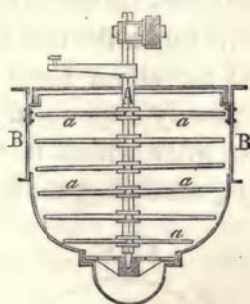
diate to the sides of the caldron B. This shaft, either permanently or temporarily fixed in the copper, may be of wood or iron. The mode of fixing the apparatus and the materials used first, will depend on the nature of the caldron, and the convenience of the manufacturer. An oscillating motion, or rotatory motion may be given to the shaft and connected arms by any of the ordinary methods of communicating mechanical power; or a cylinder may be employed with a shaft C (Fig. 49) passing through it

Fig. 49.
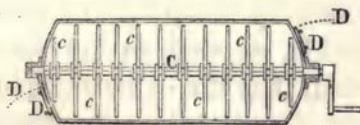
horizontally, and from which arms, *c c c c c c*, may radiate, when a rotary motion will thoroughly incorporate the fatty matter and the lye.

"The size of the cylinder, for two and a half tons of tallow, will be about six feet in diameter, and twelve feet in length. It must be provided with convenient doors, D, for charging and emptying. Motion being communicated to the machine, and the caldron having been previously charged with the tallow, the lye is to be gradually added thereto, and in a short time every particle of the fatty matter will be brought into intimate contact with alkaline lye, and by such means saponification will take place. The stirring is continued for about three hours, or until the tallow appears completely saponified, as is indicated by the mass thickening, after which it is allowed to stand from one to four days, according to the quantity of paste.

Fig. 50.
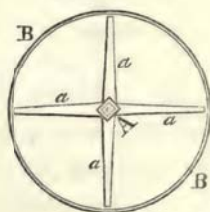
"Should a cylinder be used, then immediately upon its being charged with tallow, at a temperature just high enough to keep it fluid, the lye is run in and motion communicated to the shaft, and continued from three to four hours, or less time, if the mass becomes thick sooner. As the benefit of this process arises mainly from the saponification of the ordinary materials in a comparatively cold state, it is desirable, as soon as the mass thickens, and the lye is absorbed, that the cylinder should be emptied, and the contents turned into an ordinary caldron, preparatory to being finished and converted into yellow soap, by the addition of rosin; or into mottled soap or white soap by the operation of finishing lyes, as at present practised by soap boilers generally. By this transfer from the

cylinder to the ordinary caldron, time is allowed for the combination of the tallow and alkali to become perfect."

The above process is described as for tallow, but the inventor declares it as well applicable to the oils or other fats usually employed as ingredients of soaps.

Macquer's soap.—Take two parts of good soda, and one of lime, and boil them together in an iron kettle with twelve times their weight of water. Filter the liquor, and concentrate it by evaporation until it weighs one and a half ounce. Dilute the lye with just one ounce of water, and mix one part of it with two of olive oil, in a glass vessel, and stir the mixture constantly with a wooden spatula. It soon thickens, takes a white color, and in seven or eight days becomes a very firm white soap, differing nothing from that described by Baumé as "*medicinal soap.*"

With the oils of linseed, hempseed, &c., soaps are obtained in the same way, but of inferior quality.

Extempore soap, by Darcet, Pelletier, and Lelièvre.—Place in a shallow wooden or stone vessel, six pounds of olive oil, and one and a half pints of caustic lye 8° B., and briskly stir the mixture with a paddle for fifteen minutes at least. Then add one and a half pints of lye at 18° B., and agitate again for an hour, after which pour in three other pounds of this last lye and renew and continue the agitation until the material has acquired a good consistence. After two or three days' repose, it must be malaxated in an open vessel with a wooden pestle, and then put into the frames. In a few days it is fit to be taken therefrom, and in a month or more afterwards, is sufficiently firm and solid for use.

If oil of rapeseed, or colza, is substituted for olive oil, then the lyes must mark 20° instead of 18° B.

Another mode of saponifying olive oil by the cold process, is to heat 100 pounds in the pan to 100° F., and

gradually add, in a thin stream, 100 pounds of caustic soda lye, of 22° B., and previously warmed to 80° F. The mixture is raked constantly during the running in of the lye, and afterwards until the mass thickens and binds the lye. Being left in the boiler until next day, the paste will have acquired firmness, and must then be heated to separate the lye, which will subside, while the grained soap rises to the surface.

Chemical olive soap.—This popular soap, according to an assay by myself, contains only a little more than 16 per cent. of water. From other circumstances, the inference is that it must be made by the cold process, and probably from red oil and tallow oil, with a certain proportion of tallow, palm oil, or cocoa oil. The rosin is probably added to the extent of 10 per cent. by dissolving the finished soap paste in an alkaline solution of rosin.

Red oil or oleic soap.—Thirteen hundred pounds of soda lye, of 18° B., are put into the kettle, heated to boiling, and treated, portionwise, during constant stirring, with 1,000 pounds of red oil, or oleic acid. The oil is rapidly taken up by the lye, and the reaction is so lively that it is necessary to keep down the foam by an uninterrupted raking. As long as the paste continues strongly caustic, it must have new additions of oil, to be continued until only slight alkalinity is left—for it is necessary that the paste should retain a slight excess of soda. In case it should be too feeble, in this respect, after two or three hours' repose in the kettle without fire, it must have 50 or 100 pounds more lye. The fire is then extinguished, and the paste, after remaining in the pan twenty-four hours, transvased into the cooling-frames, which should be very shallow, as this soap sets slowly.

KURTEN'S TABLE.

Showing the Composition and Yield of Soap by the Cold Process, from Concentrated Lye, and mixtures of Cocoa Oil with Palm Oil, Lard, and Tallow.

Kinds of soap.	Tallow.	Cocoa-nut oil.	Palm oil.	Lard.	Lye.	Degrees.	Salt water.	Degrees.	Potash.	Degrees.	Product.
Cocoa-nut oil, No. 1 .	...	100	...	...	56	36	...	...	...	...	153
Paris toilette (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	...	...	...	...	120	27	...	...	...	...	214
	33	34	33	...	...	...	...	...	...	...	...
Shaving, No. 2 . .	33	34	33	...	120	27	12	12	...	...	226
Washing, No. 1 . .	60	40	...	...	...	...	...	...	...	...	...
or	...	...	...	...	125	27	25	12	...	...	244
	30	40	30	...	...	...	...	...	...	...	...
Washing, No. 2 . .	40	60	...	...	...	...	...	...	...	...	...
or	...	...	...	...	135	27	50	15	...	...	278
	...	60	40	...	...	...	...	...	...	...	...
Ordinary cocoa-nut oil	...	100	...	...	...	...	...	...	...	...	...
or	...	...	...	...	...	...	...	...	...	...	...
	10	90	...	...	225	21	75	12	...	...	400
or	...	...	...	...	...	...	...	...	...	...	...
	...	90	10	...	...	...	...	...	...	...	...

CHAPTER XVII.

SILICATED SOAPS.

THESE soaps are admixtures of silex with the paste, either mechanically, in the form of white granules of sand, or, as silicate of soda (liquor of flint), well stirred in with the soap whilst still hot and pasty. The peculiar characteristic of these soaps is their great detergency and causticity. Under this head are also comprised those soaps, admixed with pipe-clay, and such like materials; and, though not strictly silica soap, still, having that material as part of their composition, properly belong to the class of which we speak.

The money value of soap is depreciated in proportion to the quantity of adulterant which introduces water with itself. It is doubtful, too, whether this loss is compensated by any improvement otherwise in the quality of the soap. Most certainly, those containing the silicious matter in a state of suspension only, are not fit for washing clothes; though they will answer for cleansing the hands, and for other toilet purposes. Perhaps in soluble form the silicate mixture may be less objectionable, for the alkali being in feeble union with the silica, loses much of its corrosive property without being impaired in detergency.

Sand soap.—This soap has a grayish color. It is heavy, flinty, rough to the touch, feels like sandstone when the hand is passed over it, and when rubbed between the fingers, it abandons its sandy constituent, the granules becoming apparent to the sight. It is made by melting any of the white soaps, and while in paste, thoroughly

incorporating therewith seven or eight per cent. of fine sifted white sand. As soon as it has entirely cooled, it is taken from the frame and cut into tablets or moulded into balls.

Sulphate of baryta, white porcelain clay, or powdered pumice stone, may be substituted for the sand.

Silica soap (from liquor of flints).—This soap in appearance differs entirely from the preceding, being mild to the touch, smooth like the ordinary soap, and does not at first sight betray its adulteration, but when washed with, it is slightly gritty, somewhat caustic, and leaves upon the skin a fine deposit. Otherwise, it is very detergent, cleanses perfectly, and imparts a fineness to the skin, which, however, becomes, after a short time, dry and rough.

Sheridan's process.—To one part of ground flint or quartz, thinned out with about 20 per cent. of water, are added two parts of caustic soda lyes, of 20° Baumé. The mixture being thoroughly incorporated, is to be boiled about eight hours, during constant stirring, until it becomes a homogeneous mass, having the appearance of saponified matter, an experience soon accustoming the eye to recognize this state. The mixture is then ready for application in the process of soap making, and is technically termed "detergent mixture."

When the ingredients for making soap have undergone the usual process, and, being perfectly saponified, are in the proper condition to be cleansed (a term familiar to soap makers), they should be placed in a pan or vessel, and dosed with the detergent mixture, progressively added, a pailful at a time; care being observed after each addition to stir or "crutch" the contents, so as to intimately blend the whole together. The detergent mixture when added, should be in temperature as nearly

equal as possible to that of the paste. For soft soap the detergent mixture should be prepared with potash lye.

The quantity of this mixture to be added to a given amount of saponaceous matter, depends on the strength required in the soap being manufactured.

In curd soap, equal quantities by weight of each, will answer best; in yellow soap, about one-tenth more of the detergent mixture may be used; and in soft soap, two-tenths less; but the workman can better inform himself how much a soap will receive by taking a number of uniform sized small frames, say of half pound capacity, and putting in each, a portion of the ordinary materials of soap perfectly saponified and ready to be "cleansed," and intimately blending with each separate measure of soap, different quantities of this detergent mixture, and allowing the same to cool. In this way are obtained several samples of soap, each having different quantities of the detergent mixture, and from them the workman can judge as to the quantity that should be used, to obtain the soap of quality desired. The proportions, however, given in the preceding method, are about right, and supersede the necessity of any test trials. The contents of the pan having been thoroughly crutched—if hard soap, the paste is poured in the ordinary frames, and if soft soap, into tubs.

The flint or quartz for these kinds of soap may be readily reduced to powder, by heating, then quenching with water, and grinding in eccentric mill, Fig. 15, heretofore described.

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 in 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 transvased into the frames. The temperature of both glass and soap paste should be about 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. When the mixture has cooled to 150°, 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 proportion 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 "cleansed."

"This apparatus consists of a circular tub, or vessel, marked A in the drawings hereunto annexed, having the shape of an inverted cone, and an internal diameter of about two feet and two inches at its lower part, and three feet and six inches at its upper part, and a depth of about six feet. I adapt to this vessel 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. I adapt a bevelled cog-wheel to the upper part of the said upright shaft, and I provide a horizontal shaft, supported by suitable bearings attached to the said tub or vessel, and on such horizontal shaft I adapt 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. I also fix
a driving pulley on the said horizontal shaft, and by means
of a band passing around such driving pulley, also around
another driving pulley, which is caused to revolve by
some mechanical power, I communicate revolving motion
to the driving pulley on the said horizontal shaft, and
through this to the bevelled wheels and upright shaft. I
prefer to arrange the speeds and diameters of the pulleys
and wheels employed, so that the said upright shaft may
be caused to make from sixty to eighty revolutions per
minute. I fix on the said upright shaft a closed tub or
vessel (marked F, in Fig. 51, 1, of the drawings hereunto
annexed), which said tub or vessel is of such diameter as

Fig. 51.
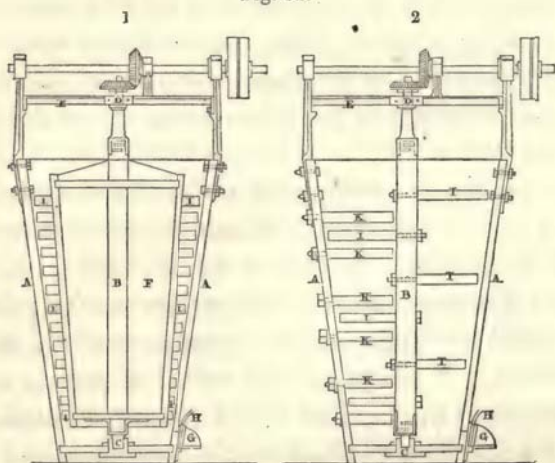
to admit of its being placed in the larger tub or vessel A,
and to leave a space of about two inches between the said
two vessels at their lower part, and a space of about six
inches at their upper part. I attach to the outside of such
inner tub or vessel (by means of screws or otherwise) a
number of projecting blades marked I I (made by prefer-
ence of sheet-iron), of such length as to approach within

about half an inch of the inside of the larger tub or vessel A. I attach a spout G, having a movable stopper H, to the lower part of the vessel A, through which I can run off the contents of such vessel. In place of fixing a smaller tub or vessel on the upright shaft B, on which to attach projecting blades, I can attach projecting blades to the said shaft as shown in Fig. 51, 2. When this arrangement is adopted, I prefer to adapt other projecting blades, marked K K, 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, as shown in Fig. 51, 2, of the drawings hereunto annexed. When I am about to use my improved apparatus for the production of compound soap, by mixing genuine soap with viscous solution of soluble glass, I 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. I then prefer 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. I then transfer the contents of such preparatory mixing vessel into my improved mixing apparatus, and cause rapid revolving motion to be given to its vertical shaft, which communicates corresponding motion to its projecting arms or blades. I then withdraw the sliding stopper of the said spout to such extent as to allow compound soap, in the state of perfect mixture, to flow from such mixing apparatus, and I supply further quantities of genuine soap and viscous solution of

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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 my improved mixing apparatus), I prefer 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 I have 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 I am desirous 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, I cause a portion of the alkali contained in such solution to be combined with rosin or with fatty or oily acids obtained from tallow or oil by well-known processes. I effect such combination 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 I 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 ingredi-

ents, in a shorter time, with less waste, and at a diminution of expense.

Take the materials for soap in the usual proportions,
say for *yellow* soap, 7 cwt. of tallow, 3 cwt. palm oil, 3
cwt. of resin, and 140 to 150 gallons caustic soda lyes,
21° B., and place the whole in a steam boiler, such as is
represented by Fig. 52. The boiler should be furnished

Fig. 52.
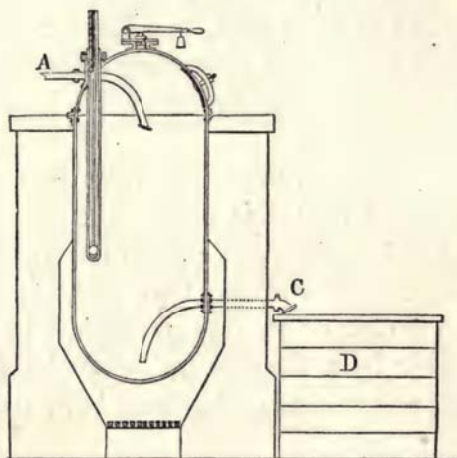
with a man hole, safety valve, and all the ordinary appendages of such an apparatus, with a thermometer
plunged into a mercury chamber. There should be a feed
pipe as at A, and a discharge pipe as at C, through which
the soap may be discharged into a pan or frame as at D.
The fire being kindled, the pressure on the valve should
be such as to allow the temperature in the boiler to rise
gradually to about 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 potassa lye, in the proportion of one cwt. of silica to 100 gallons of lye, of 21° B., is placed in a steam-tight boiler, with apparatus, such as above described, and the whole is heated to a temperature of about 310° F., and kept under steam pressure of about 50 to 70 pounds to the square inch, for about three or four hours, when it is discharged and cooled down, and a silicate is thus obtained, of potassa or soda, according to which alkali has been used, in solution; and this solution is added in the proper percentage quantity of 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 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 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 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 ex-

pectations 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, pipeclay 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 they 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 they are 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 pipeclay, and 112 pounds of calcined soda or pearlash, all reduced to powder and 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 pasty 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 procured 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.

It is, as before said, a matter of doubt whether the addition of silica or silicated materials to soaps really enhances their detersive properties; and if it does, the advantage must be due to the mechanical action of the finely divided silica. In such case, then, the abrasive power of the grit must render it destructive of clothes, and consequently is a serious offset to any desirable properties it may otherwise possess. It would be false economy, therefore, to buy a soap of cheap price, when the saving in cost between it and soap of good quality is to be counterbalanced by the damage it occasions to the clothes which are washed with it.

CHAPTER XVIII.

ALL soaps of fine quality and emollient properties which are manufactured of pure and choice materials, and with great care and cleanliness, belong to the class of toilet soaps. They may be made hard or soft, and with potassa or soda base. Those with soda are generally formed of olive oil, palm and sweet almond oil. Of the solid fats, those most used are lard and suet. As this last fat always communicates a disagreeable odor to the soap, it must be well purified before being used. The potash toilet soaps are prepared almost exclusively with lard; and care should be taken to get it as neutral as possible. This branch of the art, though it seems simple, nevertheless requires much experience and information as to the best modes of conducting it successfully.

As most of the ordinary toilet soaps are made from the better species of white soap, we describe below the cleansing and refining treatment, requisite to make it applicable for the purpose.

Purification of soaps.—When it is intended to make a toilet soap, the foundation or body should be as white and of as excellent beauty and quality as can be imparted. To obtain a superior soap from white soap, reduce the latter to thin shavings and melt it over a water bath with rose and orange flower water and salt. To twenty-four pounds of soap take four pints of rose water, four pints orange flower water, and two large handfuls of salt. The next day, if it is entirely cooled, cut it up into small bars,

and dry it in a shady place. Then melt it anew as before, in the same quantities of rose and orange flower water, and strain it. Cool and dry it again; and this done, the soap is exempt from bad odor. It must be powdered, exposed again for several days to air, but out of the way of dust. It is now ready to receive the intended perfume, and to be moulded and pressed into forms as may be desired.

Another method of purification is to melt six pounds of best white soap in three pints of water, and when liquid, to strain it through a linen cloth. Replaced in a kettle with a pint of water and a tablespoonful of salt, a brisk fire is kindled thereunder, and by whipping or stirring, the contents are made to foam and froth. The fire must then be put out and the batting continued until the mass is sufficiently inflated. The fire is again kindled, and the kettle kept on until its contents swell and foam, then it is to be withdrawn and emptied into the cooling frames. When the soap has solidified, it is taken out, cut into cakes and pressed.

By either of these plans any of the other toilet soaps can be refined. To color the soaps yellowish brown, use either dead leaves or powdered orange peel, thinned, and rubbed with water into smooth paste. After adding the coloring matter, the soap is strained again, put upon the fire, and perfumed, *à la bergamotte*, with two drachms of the oil to every pound. When other scents are added, let them be in proper proportion. The odors are, however, multifarious, and generally designate the soap; for instance, soap perfumed with a mixture of essences, is called *savon au bouquet;* and so on, titles may be altered to suit both taste and fashion, by merely varying the perfume.

Toilet soap—by admixture of olive oil and suet soaps.— Weigh out fifteen pounds handsome olive oil soap and ten pounds of suet soap. After having reduced the whole to

thin shavings with a plane, place it in an untinned copper kettle, heated by water bath, and moisten with two and a half pounds water. The quantity of water varies, however, with the state of dryness of the soap, but ought always to be as little as possible. The temperature, during the operation, must not exceed 212° F., and the process should be completed as rapidly as possible. In this way the soap is prevented from becoming too brittle—a property which hinders its being moulded and pressed into tablets. Upon these preliminaries depends, mainly, the preparation of perfumed toilet soap, known as cake soap. The only requisite now, is to determine the coloration of the soaps, and the proper proportion of perfume. We confine ourselves to a few examples, as the process is similar for all the principal toilet soaps.

Savon à la rose.—To twenty-five pounds of first quality white soap, either lard, Windsor, almond, or the above soap, add whilst in a melted state, six ounces three drachms of vermilion, and mix it in as thoroughly as can be, and as soon as the mass is poured into the cooling frame, add the perfume in proportions as follows :—

Essence of rose						1 ounce 3 drachms.
"	cloves					4 "
"	cinnamon					4 "
"	bergamot					1 ounce 1 drachm.

We must remark, that in pouring the paste into the frames, it should be passed through a cloth or very fine hair sieve, to separate impurities and undissolved particles. After twenty-four hours' cooling, the soap is ready to be cut into cakes and pressed.

Savon au bouquet.—This soap is obtained as is the preceding, except that the color is given with three ounces five drachms of impalpably fine powdered brown ochre. The perfume is the following mixture :—

Essence of bergamot	.	.	.	2 ounces.		
" cloves	.	.	.	.	1 ounce 5 drachms.	
" neroli	.	.	.	.	6½	"
" sassafras	.	.	.	1	5	"
" thyme	.	.	.	1	5	"

Cinnamon soap, or savon à cannelle.—Is prepared by liquefying a mixture of fifteen pounds suet soap, and ten pounds palm oil soap, and coloring the paste with eight ounces of yellow ochre. The perfume is—

Essence of cinnamon	.	.	.	3 ounces 4 drachms.	
" sassafras	.	.	.	6	"
" bergamot	.	.	.	6	"

Musk soap is colored with brown ochre, and in the perfume, tincture of musk should predominate.

Orange flower soap, or savon à la fleur d'oranger.—This soap is made of a mixture similar to the foregoing, and among the essences composing its aroma should be that of Portugal. The color imparted is an orange yellow inclining to green. As to the other perfumed soaps, they are prepared in like manner, the difference being in the essences used as the perfume.

Benzoin soap, or savon au benzoin.—Benzoin is a dry, fragile, inflammable resin, of a penetrating agreeable odor, especially when burned. It exudes spontaneously or by incision from a large tree, the *styrax benzoin*, growing in the islands of Java and Sumatra. By sublimation, the benzoin gives a white, silky, crystalline acid, called "flowers of benzoin." This acid is employed as a perfume, and by some is pretended to have the property of effacing freckles and splotches. Benzoin dissolved in alcohol gives a tincture, some drops of which, when thrown in water, render it milky, thus making a mixture formerly much used as a cosmetic, and called *lait virginal.* Its admixture with soap is only as a perfume. To prepare the soap, take purified white or palm soap, and after

having melted it thoroughly, stir in a sufficient quantity of benzoic acid.

Cologne-water soap, or savon à l'eau de Cologne.—First prepare the Cologne by solving in ten pints of alcohol, sp. gr. 0.849, the following essences :—

Essence of bergamot	. . . . . .	4 ounces.
" cedrat .	. . . . . .	1 ounce.
" lemon .	. . . . . .	1 "
" lavender	. . . . .	2 drachms.
" rosemary .	. . . . .	2 "
" cloves .	. . . . . .	1 drachm.
" thyme .	. . . . . .	1 "
" neroli .	. . . . . .	1 ounce.

The mixture, after having stood several days and been frequently well shaken during the interval, must be filtered. When the alcohol is good, and very strong, excellent Cologne is made without recourse to distillation. The purified white soap is melted and perfumed with this water in the same manner as by the essences.

Another excellent receipt for Cologne water is the following. To three quarts of alcohol, sp. gr. 0.849, add of

Essence of cedrat .	. . . . .	2 drachms.
" bergamot	. . . . .	2 "
" lemon .	. . . . .	2 "
" lavender	. . . . .	1 drachm.
" rosemary	. . . . .	1 "
" neroli .	. . . . .	½ "

After eight days' contact, and frequent shaking during that interval, the mixture is filtered.

Vanilla soap, or savon à vanille.—The vanilla emits one of the most agreeable and aromatic odors known. It comes as a bean or pod, and the plant upon which this pod grows is the *epidendron vanilla*, a tree of Mexico, Peru, &c. There are three kinds of vanilla : the first, the pod of the *vanilla pompono* or *bora* of the Spaniards. Its length is from five to six inches ; breadth from one-half to three-fourths of an inch. It is brown, soft, viscid, almost

always open, and of a strong smell, but less agreeable than the *leg*. The second is the *legitime*, or *vanille de lev*, or *vanille leg*, and is most esteemed in France. It is about six inches long, from a quarter to one-third of an inch broad, narrowed at the two ends and curved at the base, somewhat soft and viscid, of a dark-reddish color, and of a most delicious flavor, like that of the balsam of Peru. The third species, *vanille simarona*, or *bâtarde*, is a little smaller than the preceding, of a less deep brown color, drier, and not so aromatic. · It·is brought from St. Domingo, and is said to be the product of a wild plant.

The second species is that almost exclusively made use of. By means of alcohol all the resinous odorous part of the vanilla can be extracted. Some spoonfuls of this tincture impart to soaps a most agreeable perfume.

Musked soap (savon musqué), for whitening and softening the hands.—Take four ounces marshmallow root, well cleansed and dried in the shade, and reduced to powder; four ounces starch, four ounces wheat bran, two ounces peeled almonds, one and a half ounces orange seeds, two ounces oil of tartar, and oil of sweet almonds, and half a drachm of musk. All being intimately mixed together, and rubbed down to fineness, add in a half ounce of pulverized orris root, to every ounce of powder. Then take of rose or orange flower water, in which fresh marshmallow root has been macerated for a day or more, and therewith form into a paste, the aforesaid powder. This paste is to be shaped into forms or balls, and dried. Nothing, it is said, is more softening to the hands, and more promotive of their whiteness.

French toilet soap.—Seventy-five pounds of lard, and twenty-five pounds of the best Ceylon cocoa oil, previously melted and strained—being put in the pan and heated to 122° F; fifty pounds of caustic soda lye, of 36° B., and made from crystallized sal soda, are then allowed to flow

slowly into the fluid fats, during uninterrupted stirring. When the paste thickens, it is to be transvased into the frames, and kept well covered, to confine heat, until saponification is perfect.

This soap is hard, of beautiful glossy whiteness, neutral, and does not crust or shrink. Moreover, it gives a rich lather, and answers for washing even in very cold water. When cut and dried, it may be pressed into tablet form.

Cocoa Windsor soap.—A very superior product of two hundred pounds is said to be obtained by the following process:—

Two parts of tallow and one part of cocoa oil, previously melted and strained, being heated in the pan to 122° F., are then treated with an equal weight of caustic lye, made by mixing together nine parts of soda lye, of 30° B., with one part of potassa lye, at 20° B. If this quantity of alkali should render the soap too caustic, a little more fat will rectify it. The pouring in of the lye must be gradual, and during constant stirring; and when, in about fifteen to twenty minutes after it has all been added, there appears upon the paste a skin, or film, the soap must be transvased into shallow frames, and kept closely covered until the reaction between fat and alkali is completed. The heat should not be allowed to descend below 100° F. at any time during the mixing operation. The perfume given to this batch of soap, consists of oils of bergamot and lavender, six ounces each; oil of Portugal three ounces, and oil of thyme three ounces.

Naples soap.—Into a copper basin, pour of strong lye, twelve pounds, lamb suet three pounds (previously purified with rose or orange-flower water), oil of ben or olives, one pound. Boil these materials until they have acquired a sufficient consistency to be transvased into another large shallow and broad vessel. Cover this vessel with glass, and expose it for six days to a strong solar heat, taking

care to stir the contents several times daily. At the end of this time, perfume by adding four ounces tincture of ambergris, one ounce tincture of musk, and one and a half ounces of some essential oil. After two months, the soap has acquired its proper consistence.

Kasan soap.—This article, improperly written Kesan and Keesan soap, is peculiar to that portion of the Russian empire bordering on either side of the Volga, and called Kasan. Its superior properties for shaving use, and the rich and durable lather which it gives, have made it a favorite with purchasers, so that its consumption is such as to make it a profitable item of importation. It is said to be made of the fat of some animal peculiar to the country of its production, and by long exposure of its mixture with lye, to the heat of the sun on the roofs of houses. It is a rich looking soap, and in color is very little dissimilar from that of lump gamboge. Not knowing the exact mode of its preparation, our supplies are necessarily drawn from abroad.

SAVONNETTES.

These are made of the preceding soaps, which, instead of being shaped into cakes, are moulded in circular forms, and are known by the title of "wash balls." The necessary implement is shown by Fig. 53. It is nothing more

Fig. 53.

than a brass handle with a hollow bowl-shaped trimmer, the edges of which are smooth and thin. The soap ball being roughly reduced to the proper size and form, is

then, with a rotary motion, pressed against these edges, until it assumes a true spherical shape, and is perfectly smooth on the surface.

FLOTANT SOAPS.

Under this title are designated those soaps which, when in a state of paste, are batted or inflated with air, by which means its buoyancy becomes such, that the soap floats in the water. It is a favorite soap, not only on account of whiteness and mildness, but the facility with which it gives a lather. These soaps are colored and perfumed exactly as are the toilet soaps generally. It must be remarked, however, that the olive, palm, and sweet almond oil soaps are the only ones that can be converted into flotant soaps, it being impossible to inflate those soaps made of suet or lard. They are prepared from either of the preceding soaps, by cutting it into thin shavings and melting over a water-bath, with twelve pounds of water to every fifty pounds of soap. When the mass is in perfect fusion, it is agitated with a twirling fan (Figs. 54, 55), until it froths and foams to the top of the vessel.
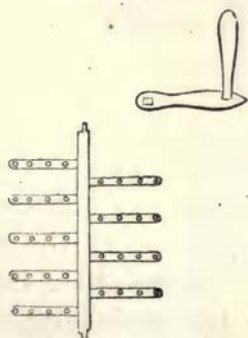
Fig. 54.   Fig. 55.
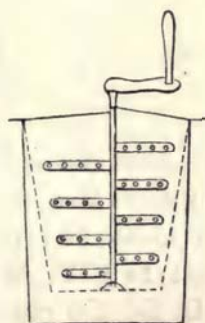
Fig. 54 represents the twirling fan detached from the water bath; it is made to revolve on a pivot, and to be

taken on or off at will. After the perfume has been added, the contents are emptied out into cooling frames or moulds.

TRANSPARENT SOAP.

This beautiful soap, so much admired and used, is generally shaped into savonnettes or cakes, and when well prepared, assimilates in appearance to handsome transparent candy. The method of manufacturing it was for a long time unknown. It is made by dissolving suet soap in alcohol. For the purpose, the soap must be in thin shavings and *perfectly dried* so as to be entirely freed of any water which it may have retained. Thus prepared, fifty pounds are placed in the water bath B (Fig. 56) of the still A. After having also poured in twenty-

Fig. 56.
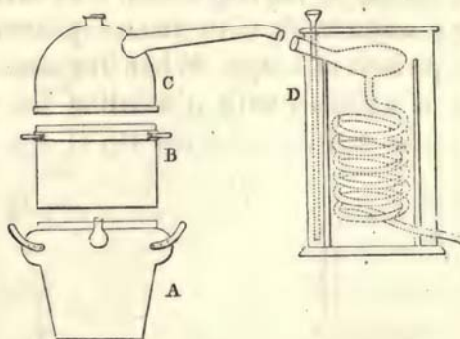
eight pints of alcohol, sp. gr. 0.849, put on its head C, carefully close the joints with lute made of whiting and flaxseed meal, and raise the temperature of the water bath just to 212° F. To the still is affixed a cooling worm, D, for the condensation of the alcohol vapors as they pass off. It is placed in a barrel, the water in which is kept constantly cool by fresh additions. If the heat be too brisk, a certain quantity of alcohol volatilizes,

without the solution of the soap being completed. In
the first operation only distil off about five pints of alco-
hol; and, after being assured of the perfect liquefaction
of the mass, allow a repose of some minutes, and then
turn the liquid into the moulds or forms, destined and
arranged to receive it. The capacity of these moulds
should be one-third larger than the intended size of the
form which they contain, because allowance must be
made for the shrinkage which this soap undergoes. After
having cooled and become sufficiently firm to be taken
from the moulds, the soap is then placed in a very airy
place, in order that its drying may be facilitated. When
it has been cooled in frames, after eight or ten days, ac-
cording to the season, it is taken out and cut up into bars,
and these again subdivided into tablets, which are pressed
against dies (Fig. 57), bearing on one side some orna-

Fig. 57.
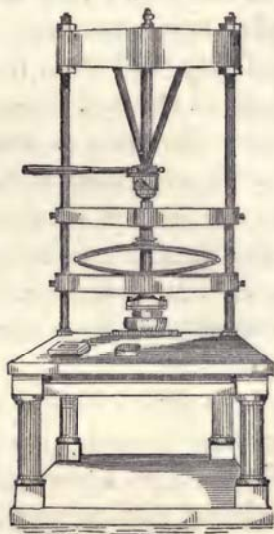
mental device, and upon the other, the name and place
of business of the manufacturer. These tablets or pressed

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cakes are then dried in a moderately heated room. When colors are required for the transparent soaps, an alcoholic tincture of alkanet for red; a tincture of turmeric for yellow; a mixture of the two preceding tinctures for orange; alcoholic tincture of chlorophylle for green; and an alcoholic solution of indigo carmine for blue, is used. By admixture and modification, the shades can be varied or multiplied. Thus, the conjunction of blue, yellow, and red furnishes a cinnamon color; yellow and blue, differently proportioned, give all the tints of green, &c. &c. The perfume is the same as for the other soaps and in like proportions.

Toilet soft soap.—We generally meet with this kind of soap under the name of "*shaving cream*." It is admirably adapted for the beard, and for this purpose, has very justly been accorded the palm of superiority. Its preparation is attended with some difficulties. To make it, take fifty pounds of lard, and mix it with seventy-five pounds of caustic potash lye, marking 17° B. This mixture is then heated slowly, and when the empatage is completed, and the whole of the lye thoroughly united with the fatty matter, carry the mass to ebullition, but arrest it as soon as watery vapors cease to be given off. This signal indicates the completion of the operation, and is confirmed also by the matter becoming so thick that it can hardly be stirred. It is then run into frames and cooled. Generally speaking, these soaps are perfumed, but not colored.

Pearl soft soap.—It is only within a few years that the process for making this elegant soap has been known. The mode differs but little from that above described, the beauty of the soap being due to very careful and exact manipulation, and which we will endeavor to explain clearly and comprehensively. Weigh out, first, twenty-five pounds of lard, and then twelve pounds of potassa

lye, 36° B. Melt the lard in an enamelled vessel or stone jar, heated by a sand bath, the temperature of which should be managed. Stir continually with a wooden spatula, and when the grease is half melted and looks milky, pour in half of the lye, still stirring and keeping the temperature constant and uniform. The reaction takes place gradually; and, in about an hour the fat tends to the surface in an oleaginous stratum, and the granulations of soap fall to the bottom. It is then that the second portion of the lye must be added;—the paste is immediately restored, and the granules disappear. After conducting this operation for four hours, the paste becomes so compact that it cannot be conveniently stirred, and must be then lightly batted or beaten. At this time the fire under the sand-bath must be extinguished, and the vessel set in a basin of warm water, so that its contents may cool gradually. The soap itself is now finished, but its pearly aspect is a physical property, to be developed by a strong and constant trituration of the paste, in a marble mortar. All the parts which before seemed separated, unite and form a perfectly homogeneous soapy mass. The perfume almost universally imparted, is essence of bitter almonds, or otto of roses; hence the two titles usually given it, "rose" and "almond" shaving cream. The first is generally of a pink shade, obtained from a little carmine, or better, of tincture of alkanet.

Following is a list of the soaps, with their fashionable titles. It is not inconsistent with the accustomed morals of the trade, frequently to sell one kind of soap under two, or even a half dozen different names—the only change being in the labels and envelopes. In this way olive oil soap, with an additional essence to its perfume and new and rich coverings, is made to pass for *savon au bouquet, savon de blanc de baleine, &c. &c.*

LIST OF THE PERFUMED SOAPS.

Savon à l'ambre.
"   aux mille fleurs, or au bouquet.
"   à la frangipane.
"   à la fleur d'oranger.
"   au réséda.
"   à la tubéreuse.
"   à l'acacia.
"   à la julienne.
"   au pois de senteur.
"   au jasmin.
"   au narcisse.
"   à la jacinthe rose ou bleue.
"   à l'hémerocalle.
"   au jasmin jonquille.
"   au chèvre-fenille.
"   au gaïac.
"   au vitiver.
"   au storax.

Savon au baume de Peru.
"   au benzoin.
"   au chypre.
"   à l'œillet.
"   à la menth fine.
"   à la menthe Anglaise.
"   à la lavande.
"   au romarin.
"   à l'héliotrope.
"   à la violette.
"   à l'iris.
"   à la jonquille.
"   à la rose royale.
"   à la palymyrere.
"   à la giroflée.
"   à la mousseline.
"   aux fleurs d'Italie.

Savon de blanc de baleine (spermaceti).—This soap, when really made of spermaceti, is superior and emollient, but much that is sold under the title is merely refined white oil or suet soap. The genuine soap, made after Guerlain's process, is composed of—

Pure spermaceti	.	.	.	.	.	45 pounds.
Oil of sweet almonds	.	.	.	.	.	11 "
Potassa lye of 36° B.	.	.	.	.	.	27 "

The materials, being converted into soft soap after the usual manner, are to be thinned out with seven or eight gallons of water, boiled, and gradually treated with three gallons of brine, holding in solution twenty pounds of common salt. The boiling is continued, after this addition, until the paste is clear and perfect. The fire is then extinguished, and the soap left in the kettle, under close cover for twenty-four hours, to cool slowly.

The perfume to be added consists of a mixture of oils of lavender, white thyme, rosemary, rose, and caraway, in nicely adjusted proportions.

All the preceding titles can be altered to suit the pre-

valent taste of the times, and altered back again whenever the freak of fashion renders it politic. For instance, if a soap sells slowly under one title, it may be made popular by changing its form and envelop, and calling it *savon de Monterey*, *savon amolissant*, or *savon des houris*, or otherwise, as fancy may suggest. As an aid to the savonnier, we annex a list of synonymes, for any of the soaps in the preceding list :—

Savon du zephir.
"   du Diane.
"   des nymphes.
"   du baigneur.
"   des Circassiennes.
"   Oriental.
"   Virginal.
"   à la passiflore.
"   à la campanule—lilas.
"   aux bluets.
"   au zinia.
"   au datura.
"   au camélia.
"   au dahlia.
"   au bouton de rose.
"   au bouquet de violette.
"   à la rose blanche.
"   au jasmin amande.
"   au beurre de galaam.

Savon d'albâtre.
"   perlé.
"   à l'étoile d'amour.
"   à l'ambroisie.
"   des sultanes.
"   à la maréchale.
"   à la pervenche.
"   aux liserons roses.
"   aux *pensez-a-moi*.
"   à la belle de nuit.
"   à la balsamine.
"   à la grenade.
"   à l'hortensia.
"   aux chrysanthêmes.
"   au myrte du Canada.
"   au myrte des amours.
"   au géranium.
"   à la rose du Bengale, &c. &c.

The shade, label, and envelop of the soap should always correspond. On those soaps, named after flowers, it will be in good taste to have the plant represented upon the wrapper, or else on the die with which the soap is compressed. Everything, however, depends upon the taste of the manufacturer; and an ingenuity in these respects, diligently observed, will bring a corresponding reward.

The present advanced state of the art has entirely varied the old form of tablets of soaps, so that now, instead of the square cakes, the paste is moulded of oval or any other shape that the fancy of the savonnier may de-

sire.   There is, indeed, a great deal of taste exercised
also in the adornment of the wrappers, which, independ-
ent of the quality of the soap, and the really beautiful
designs impressed thereupon by the dies, are frequently
specimens of art worthy minute examination and liberal
admiration.   The effect of a tasty arrangement in the
wrapping of soap is quite evident in the preference so
often given to such by purchasers.

CHAPTER XIX.

PATENT SOAPS.

THE term Patent Soaps applies to those so-called new inventions which are registered in the Patent Office. Comprising, as they do, so large a number, it would be impossible to give even their titles in this volume; and so we content ourselves by describing only types of the principal kinds. The judgment and experience of the soap manufacturer must be the criteria by which the merits or demerits of them are to be estimated; to which, however, we will propose some assistance in remarks, hereafter, upon FRAUD AND ADULTERATIONS IN THE MANUFACTURE OF SOAP.

Snell's (dextrine) soap.—This soap is nothing more than ordinary soap admixed with a greater or less amount of vegetable matter, obtained either from potatoes or other sources. This plan, it is said, is preferable to the old method of combining farina with alum and soda, in the manufacture of soap, because of its insuring the perfect incorporation of the admixture with the saponified fats and oils; whereas when they are previously acted on by alum and soda, their tendency to union is partially impaired. The vegetable matter or dextrine and fibre, as Mr. Snell calls it, is obtained from potatoes as follows: The washed potatoes are reduced to as fine a pulp as possible by a revolving cylinder furnished with parallel plates of steel or iron. These plates have fine teeth like saws, the teeth rising just above the surface of the cylinder, that revolves rapidly under a hopper, which receives

the potatoes. The pulp falls on sieves or screens below, and passes over the upper sieve, which is a plane of five feet breadth and eight feet length, slightly inclined, with four bars the whole length and one or two cross-bars, covered with a wire cloth of thirty holes to the inch. At the top and about midway down the sieve are pipes containing water, to be placed so that the water shall run from the pipes through small holes, the whole breadth of the sieve; the finer parts of the potato flowing through the meshes of the sieve with the water, and the coarser parts running over the sieve into a vat. The finer parts (dextrine) which fall on a wood plane placed under the second sieve (but inclined in a contrary direction thereto), are received in vats, where they are repeatedly washed over sieves of finer wire cloth until cleansed from all its impurities. The grosser parts (fibre) are washed over coarse sieves. The finer parts having precipitated, are taken up in buckets and are fit for use; the coarser parts remain in a vat covered with water until wanted, or the dextrine may be dried by any convenient means, and in the dry state kept till required for use. Three to 350 pounds mixed with 150 pounds of water to every ton of saponified tallow or oil are the usual proportions. This admixture of water and dextrine, having stood an hour, should be further treated with 600 pounds of boiling water, as hereafter described. The white soap should be made of tallow, and by steam heat, and when as much alkali has been added as can in the usual way be taken up, and when the soap is in a fit state to cleanse in a frame, as is well understood by soap-makers, to each ton of saponified matter in the caldron, take 450 to 500 pounds of dextrine in its wet state, added to which are 600 pounds of boiling water, or enough to make it into a thick paste, and pour it by pailfuls into the soap, stirring well the mixture all the time. When the mixture is

completed, and has been heated, it is fit to be cleansed into a frame for cooling and cutting up in the usual way. Before the dextrine is added, the spent lye must first be pumped or drawn off from the caldron. When yellow soap is made with resin, in the usual way, and is what is called " fitted," it should be heated with steam, and dosed with dextrine in manner and proportion as above directed. If no resin is put in, a larger quantity of dextrine may be used, and with or without fitting the soap.

In making common soap, either yellow or brown, by using the fibre mixed with as much water as will make it a very thick mush, the product will, especially when containing an excess of alkali, be improved in quality and color, and waste and consume much slower in hot water. The preference given to steam for heating soap to be thus mixed, is owing to the liability of the dextrine to become carbonized over a naked fire. The patentee has named the ingredient which he uses, dextrine; doubtless he means starch, for the former term is very frequently but inappropriately applied to the latter article. Starch, before it can become dextrine, must be peculiarly modified by the action of acids or heat, and converted thereby into mucilaginous starch. As regards the fibre, this probably acts upon the skin and in washing, as bran does, by reason of certain detergent properties which it possesses.

Normandy's (salinated) soap.—This is another of the admixed soaps, the sophistication being sulphates and carbonates of soda and potassa, added whilst the soap is yet in paste. The advantages gained are said to be hardness and economy. For eighty pounds of soap, the dose is twenty-eight pounds of sulphate of soda, and four pounds carbonate of potassa, or two pounds of each of the last two materials. Or, if the substances are used singly, then only thirty-two pounds of sulphate of soda for eighty pounds soap; fifteen pounds only of sulphate

or carbonate of potassa for eighty pounds of soap, and ten pounds only of carbonate of soda for eighty pounds soap. The application of these well pulverized materials, alone, or in admixture, is made, to the soap, while still in a liquid or hot state, and just as it is finished and ready to be taken from the boiler into the frames. The whole is well crutched and incorporated until the mass is perfectly homogeneous.

It appears from the composition of this soap that it might be a valuable one for marine uses, as the excess of soda which it contains would neutralize the *hardness* of sea water.

CHAPTER XX.

FRAUD AND ADULTERATIONS IN THE MANUFACTURE OF SOAP.

THE prevalence of fraudulent soaps creates the necessity of some remarks upon the means of distinguishing them. We propose to do this by first describing the properties of true soap, which consists of definite proportions of water, alkaline base, and fatty acids. It should be neutral; that is, all the alkali and all the fat ought to be in chemical combination, so as to prevent any excess of either ingredient. Moreover, it must not be greasy to the touch or to paper. It should also be free from saline matters, and superfluous water, as is known when it is firm, and does not shrink, and there is no frosting or efflorescence on the surface after exposure. True soap, moreover, dissolves readily in alcohol, leaving scarcely ever more than one per cent. of insoluble matter. It is also soluble in boiling water, giving a gelatinous liquid, which, on cooling, partly decomposes into free alkali and insoluble bi-oleo-stearate of soda, to which is owing the cloudiness of wash waters. In like manner cold water, in dissolving soap, decomposes it.

The extreme limit of water, in hard soap, is 20 per cent. for mottled, 25 per cent. for white curd, and 32 for yellow resin soap. The proportion of alkaline base is from 8 to 9 per cent. and that of the fatty ingredient from 60 to 70 per cent. for each kind. In the yellow soap, a part of the fat is justifiably replaced by 10 to 20 per cent. rosin; and in soaps made from cocoa oil there is naturally a much larger amount of normal water than in tallow soap.

But the foregoing proportions may be considered standards for comparison, and whenever they are lessened or increased by substitutes for one or other of the normal components of the soap, the quality of the latter is depreciated in the ratio of the amount of that substitute; unless, perchance, experience may have proved it to be a serviceable addition. This exception, however, in our present knowledge, does not apply strictly to any of the diluents now used for swelling the weight and volume of soap. Soap, properly made, will do its cleansing work faithfully, without wasting away in the water, and there is no need, therefore, of its being dosed, as has been recommended, with dried sulphate of soda, or any other salt, to prevent its too rapid solution. So, also, will it produce a sufficient lather without an excess of alkali; save in the use of "hard" waters for washing purposes. In this latter case, the partial inertness of the soap may arise from its decomposition, as fast as dissolved, by the lime salts of the water, which convert it into insoluble flocculæ of earthy soap, and send it in that form to the surface of the water; or it may proceed from the undue proportion of saline matters which depreciate the solvent action of the water upon the soap. In either of these contingencies, a little carbonate of soda may be properly added to precipitate the lime as insoluble carbonate of lime, and to promote otherwise the solubility of the soap. Mottled soap, made in the regular way, can never contain more than its normal amount of water, as any excess is incompatible with the marbling process. But when the veins are produced by dexterously incorporating earthy or metallic pigments with the paste, excess of water may simultaneously be introduced. Another mode of surcharging with water, is to soak the bars in salt brine, which imparts hygroscopic property, by which they absorb water from the moist atmosphere, and thus gain in

weight. Soft soap, to be of good quality, should not contain more than 55 per cent. of water. The annexed table presents the composition of a variety of soaps.

HARD SOAPS.

Name.	Specific gravity.	Oil.	Pasty fat.	Suet.	Rosin.	Fat and rosin.	Cocoa oil.	(Salt) chloride sodium.	Lime and insoluble residue.	Soda.	Potassa.	Water.	
Castile soap (genuine)	1.0705	76.5	..	..	..	..	..	..	..	9.0	..	14.6	Ure.
" " (imitation)	0.9669	..	75.2	..	..	..	..	..	..	10.5	..	14.3	"
Perfumers' white soap	..	..	..	75.0	..	..	..	..	..	9.0	..	16.0	"
Glasgow white soap	..	..	..	60.0	..	..	..	..	..	6.4	..	33.6	"
" brown resin soap	..	..	..	..	..	70.0	..	..	..	6.5	..	23.5	"
Colgate's yellow soap	..	..	..	..	..	56.2	..	3.8		9.0	..	31.0	Morfit.
" "	..	..	..	..	..	64.0	..	..	..	7.29	..	28.71	Kent.
"Marine soap" (London)	..	..	..	..	..	..	22.0	..	..	4.5	..	73.5	Ure.
Poppy oil soap	..	76.0	..	..	..	..	..	..	..	7.0	..	17.0	"
Marseilles soap	..	60.0	..	..	..	..	..	..	..	6.0	..	34.0	D'Arcet.
English curd soap	..	..	..	52.0	..	..	..	..	..	6.0	..	42.0	Ure.
Old curd soap	..	..	..	81.2	..	..	..	..	..	8.5	1.7	8.4	Heeren.
American curd soap	..	..	..	67.5	..	..	..	..	traces	7.7	..	24.2	Morfit.
French white soap	..	..	..	50.2	..	..	..	..	..	4.6	..	45.2	Thenard.
Marseilles soap (mottled)	..	64.0	..	..	..	..	..	..	..	6.0	..	30.0	"
White Marseilles soap.	..	68.4	..	..	..	..	..	..	..	10.2	..	21.3	Braconnot.
White soap (Leipzig)	..	..	..	76.3	..	..	..	..	..	8.8	..	14.7	Abendroth.
" " "	..	..	..	50.0	..	..	..	..	..	9.4	..	29.8	"
Marbled soap "	..	..	..	45.0	..	..	..	..	..	9.8	..	38.0	"
Beatty's soap (patent)	..	..	..	..	..	37.0	..	0.5		5.5	..	52.0	Morfit.
Butterfield's soap "	..	..	..	22.0	10.5	..	..	1.7	2.0	9.2	..	55.0	"
"Nonpareil" soap "	..	..	..	..	..	36.2	..	5.25		5.2	..	51.8	"
Holt's yellow soap	..	..	..	..	..	74.0	..	..	..	7.08	..	18.92	Kent.
American Soap Co.'s soap	..	..	..	..	..	35.0	..	..	40.00	5.00	..	20.00	"

SOFT SOAPS.

Name.	Specific gravity.	Oil.	Pasty fat.	Suet.	Rosin.	Fat and rosin.	Cocoa oil.	(Salt) chloride sodium.	Lime and insoluble residue.	Soda.	Potassa.	Water.	
Common soft soap	..	..	44.0	..	..	..	..	..	..	..	9.5	46.5	Chevreul.
" "	..	..	42.8	..	..	..	..	..	..	..	9.1	48.0	"
" "	..	..	39.2	..	..	..	..	..	..	..	8.8	52.0	"
Savon vert	..	..	44.0	..	..	..	..	..	..	..	9.5	46.5	Thenard.
Scotch "economical" soap (semi-hard).	..	..	..	62.0	..	..	..	..	..	..	11.5	26.5	"
London soft soap	..	..	45.0	..	..	..	..	..	..	..	8.5	46.5	Ure.
Belgian green soap'	..	36.0	..	..	..	..	..	..	..	..	7.0	57.0	"
Scotch soft soap	..	..	47.0	..	..	..	..	..	..	..	8.0	45.0	"
Rapeseed-oil soap	..	51.6	..	..	..	..	..	..	..	..	10.0	38.3	"
Gallipoli soft soap	..	48.0	..	..	..	..	..	..	..	..	10.0	42.0	"
Fulling soap (semi-hard)	..	..	..	62.0	..	..	..	..	..	..	11.5	26.5	Verviers.

Fraudulent soaps are, in most instances, patented inventions, and sold under euphonious titles. The advantages claimed for them are, in many instances, set forth in ignorance; but not unfrequently, in a venal spirit, and with the express design of fraud.

The foreign bodies most frequently mixed with soap, may be enumerated in groups, as this form of expression

will facilitate an intelligible explanation of the mode of analyzing soap :—

Group 1.	Group 2.		Group 3.
	Soluble salts and organic matters.	Inorganic and insoluble matters.	
Water.	Sugar.	Sand.	Free rosin.
	Borax.	Silica.	Free fat.
	Carbonate soda.	Sulphate barytes.	
	Sulphate soda.	Plaster of Paris.	Fat soap.
	Chloride sodium.		Rosin soap.
	Carbonate ammonia.		
	Alum.	Pipe clay.	
		Chalk.	
	Starch.	Lime.	
	Glue.	Magnesia.	
	Dextrin.		
	Bran.		

To determine the amount of water, it is necessary to make sure of a fair average of the sample of soap by taking very thin scrapings, proportionately, from the interior and exterior, and drying a given weight of it (100 grains) in the presence of oil of vitriol, under a receiver exhausted by an air-pump. When its weight, after several trials, becomes constant, that weight is to be deducted from the original weight to get the amount of loss, by drying, which expresses the whole amount of water in the soap.

The usual mode of drying in heated air, or over a water-bath, is tedious and uncertain.

The next step is to place the soap scrapings in a glass flask with a long neck and wide mouth. Three ounces of absolute alcohol are then added, and the whole heated to boiling over a water-bath. By this action all the true soap, and any free fat, free rosin, with a part of the ammonia, are dissolved out by the alcohol, which leaves the whole of Group 2 untouched. To separate these latter, the hot alcoholic liquid must be filtered on a weighed filter, kept hot by a surrounding water-bath, and washed

with absolute alcohol. The filtrate A, containing the free
fat rosin, and true soap, and some ammonia, is set aside
for the present, and the filter B, after careful drying, is
weighed to get the total amount of solid foreign matters.
To separate these latter, the filter with contents, is care-
fully replaced on the funnel, washed with *cold* water until
all the matter soluble in that liquid is taken up. This
soluble matter may consist wholly or partly of sugar, bo-
rax, carbonate of soda, sulphate of soda, chloride of sodium,
alum, and carbonate of ammonia, and possibly sulphate of
lime; and the filtrate containing them is to be reserved as
C. In the mean time, the washed filter is to be dried and
weighed, as before, to ascertain its loss, which expresses
the amount of soluble saline matter and sugar, if any are
present. The filter is then a third time replaced in the
funnel, and washed repeatedly with *boiling* water, to re-
move the starch, dextrin, and glue; after which it is dried
and weighed as before. The loss indicates the joint
amount of those substances if all are present.

The glue may be detected in the wash filtrate by its
peculiar odor, the sugar by its taste, and the starch and
dextrin by the blue or purple color they take, on the
addition of solution of iodine. By burning the filter to
ash, and allowing for its weight and that of its ash pre-
viously determined from a filter of the same weight, and
weighing the residue, the amount of bran burned off is
determined by the loss. All the organic matter of the
filter being now disposed of, the residue consists of one or
more or all of the inorganic or fixed matters enumerated
in the second column of Group 2. Of these latter, the
first four are insoluble in hydrochloric acid, while the
latter four are soluble in that liquid. Thus, by digesting
the residue in this acid, filtering, washing the filter with
hot water, drying and weighing it, the amount of totally
insoluble matters is obtained, while that of the inorganic

matters soluble in acid is expressed by the loss or difference between the last and previous weights. For all practical purposes, however, the whole of Group 2 may be considered as insoluble matter, corresponding to fraudulent or foreign matters.

The reserved filtrate C contains, as carbonate of soda or potassa, any free alkali that may have existed in the soap. To estimate its amount, the liquor must be boiled until all the carbonate of ammonia is volatilized, and then treated according to the directions given in the chapter on ALKALIMETRY. The free alkali, though originally caustic, soon becomes carbonated by the action of the atmosphere.

The filtrate A must be relieved of its alcohol by careful evaporation over a water-bath, and during this process the presence of any ammonia will be revealed by its peculiar odor; for, being volatile, it will pass off with the alcohol.

After the vaporization of the alcohol, the concentrated liquid is to be diluted with water, which will throw any free rosin or grease to the surface. These latter are separated by filtering the liquid, upon a weighed filter, washing with hot water, drying the filter in vacuo, and weighing. The weight, less that of the filter, expresses the amount of free fat and rosin in the soap. The filtrate now contains only the fat soap, with the resin soap, if any is present, and must be treated with sulphuric acid, as directed in the chapter on ALKALIMETRY, for the quantitative estimation of the basic or constitutional alkali. In this reaction, the soap solution is decomposed; the fat and resin acids being displaced for their alkaline base by the sulphuric acid, rise to the surface, and must be filtered through a weighed filter, washed with hot water, dried in vacuo, and weighed. The weight expresses the joint amount of fat and resin acids in the soap. *Cold* alcohol will dissolve out all of the fat acid, with a small portion

of the resin acids from the filter, and the latter, on being dried in vacuo, and weighed as before, will give, approximately, the amount of resin in the soap.

To determine whether the base is soda or potassa, the filtrate from the eliminated fat acids must be concentrated by evaporation, and treated with alcohol and chloride of platinum, when a yellow precipitate will be formed in the case of potassa; whereas, soda will not show any reaction under the same circumstances.

The odor developed by the fat acids, at the moment of elimination from their base, by sulphuric acid, may serve to distinguish the fat of which the soap is made. Consistence and the melting and congealing points, may also be taken as guides.

The fat acids, being hydrated in a free state, will make the results of the analysis reach above 100; for, when in combination, they are anhydrous, and the excessive figures will represent the water they have taken up in the process.

The observance of the foregoing directions will enable the operator to detect and estimate any or all the usual adulterants in one and the same sample of soap.

CHAPTER XXI.

CANDLES.

ARTIFICIAL light, by means of splinters, torches, and lamps, was doubtless known in the earliest periods of the world; but the first mention of candles is made by Pliny, who, in referring to those of Greece and Rome, describes them as flax threads, coated with pitch and wax. In the fourth century, Constantinople was illuminated on Easter eve, by order of Constantine, with lamps and wax candles. At a later epoch, in the reign of King Alfred, they were made of definite lengths, so adjusted as to mark the time of day by their burning, each candle being consumed in exactly four hours. They were, at this time, also employed in religious offices; and Candlemas-day—a feast instituted by the early Christians in memory of the purification of the Virgin Mary—was so named because all the candles intended for holy purposes were consecrated on that day. In 1357, during the captivity of John of France, a wax candle of six miles length was kept burning, continuously, in the church of Notre Dame, until his return, as a peace offering, in accordance with the prevailing custom of that period.

A Wax Chandlers' Company was incorporated in England, in 1484, and wax candles came into general use among the noble and wealthy throughout Europe, as did those of tallow among the poorer classes. Mould candles, as made in our day, originated with Le Brez, of Paris. Bolts first made them of *pressed* tallow, in 1799, and Braconnot of stearin, in 1818. Spermaceti and adamantine candles are

of very modern origin; the latter having been introduced as lately as 1825, by Chevreul, Gay-Lussac, and Camba-ceres. Since then, the art of candle making has advanced rapidly in improvement, and scatters its products far and wide, at moderate prices; so that now the comfort of a good candle is, comparatively, a matter of trifling cost.

A candle is, as is well known, nothing more than a fusible solid cylinder, with a wick of cotton in its centre to aid its combustion; but, as the melting point of the several kinds of candle stock varies, so also do the candles differ in quality according as their material is more or less fusible. The artificial light which a burning candle emits is dependent upon the combustion of the materials of which it is made. This being melted by the radiated heat of the flame, and drawn up whilst fluid to the heated part of the wick, in consecutive portions, by the power of capillarity, serves as food, which is immediately consumed to make way for successive portions. A candle may, in truth, be called "a portable gas apparatus," because it carries its own nourishment or combustible, and melts it in quantity as wanted, hence the necessity of apportion-ing a proper wick. The more fusible fats require a large wick, because it must be of sufficient size to suck up and consume all the melted fat which accumulates in the cup formed at the top of the candle, otherwise there will be a running or guttering. This proves the superiority of the harder fats for candle stock, because, being less fusible, they require a thinner wick, and consequently, whilst the intensity of light is unimpaired, there is a less consump-tion of combustible matter. Candles with unsuitable wicks are defective. If the wick is too large they give a flaring and a smoky flame; whilst a deficiency in its size and number of threads, causes the candle to burn dimly and gutter. The burning quality of candles is propor-tional to the fusibility of their combustible matter. The

materials of which candles are manufactured, will hereafter be noted separately; and the requisite directions for purifying and improving them, detailed under their respective heads.

The great advantages of cleanliness and portability procure for good candles a very extensive consumption, more especially in those places where the limited population has as yet prevented the introduction of gas. We cannot tell the quantity manufactured per annum; but, as the trade in sperm and stearic candles belongs extensively to the United States, which, in that of tallow, also has a lion's share, it can be judged how extended and important is this branch of art, when there is scarcely a ship that leaves for a southern port, but is partially freighted with candles.

Notwithstanding the improvements in lamps, and the invention of burning fluids, there is no probability of any great decrease in the consumption of candles, for new regions are being populated so rapidly that there will always be, as at present, a market for every pound that is made. Besides, there are certain circumstances, under which there is no substitute for them except gas; for instance, in the working shops, and other situations where the operative requires a light immediately neighboring to him, it would be too expensive to furnish a lamp for each. Moreover the tidy housewife will gladly banish from her parlor or sitting-room a greasy, troublesome lamp, when she can obtain a graceful looking, handsome candle at as economical a rate.

As it may sometimes be desired to contrast the relative value of different candles as illuminating agents, the determination can readily be effected by means of a *photometer*, or measurer of light.

Photometry.—In determining the relative intensities of the light from different lamps and candles, several methods

are used ; some depending on the brilliance of light, either
direct or reflected, cast upon a white paper screen ; others
by the depth of shadow projected upon a similar screen
by an interposed rod or ball ; others, again, by the peculiar
effects manifested when the light in question has been
polarized.

But of all these, the easiest of application for approxi-
mate determination, is the mode proposed by Rumford,
which will be better understood with the accompanying
Fig. 58. In this, *ta* represents an ordinary table, or any

Fig. 58.
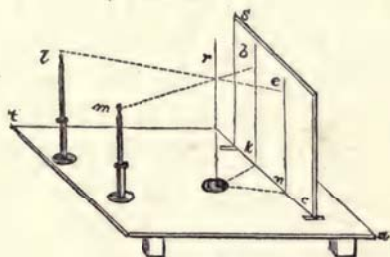
suitable stand, upon which is set, vertically, a screen, *sc*,
of white paper, or pasteboard, either in an appropriate
frame or supported in any convenient manner from be-
hind ; *rd* is a small, straight rod of iron wire, for instance,
which is best to be black on the outside, either on a spe-
cial foot or, if more convenient, suspended above the
table ; *l* and *m* are the lights to be compared. It is very
plain that when the lights are burning they will cast, re-
spectively, shadows of rod *rd* on the screen ; the light *l*,
for instance, will make a shadow *en*, while *m* will make
the shadow *bk*. If these lights are of equal intensity,
and at equal distances from the screen, they will, of
course, cast shadows there of equal depth. If, when the
depth of the shadows is, as nearly as can be judged, the
same, the distances of the lights from the screen are un-
equal, then it follows, according to well-known laws of

optics, that the intensities of light are as the respective distances squared. The experiment is then made by moving the candles or the rod, or all three, until the two shadows are evidently of the same depth, and afterwards measuring the distances between the candles and the screen; the square of those distances gives the intensities respectively. Thus, suppose a case, when, after the shadows have been made equally dark, the distance $l\ re$ is 2 feet, and the distance $m\ rb$ is 1.5 feet. The squares of these distances are, respectively, 4 and 2.25; and the relative intensities are directly in the same ratio, or l is to m as $4 : 2.25 = 1.78$ nearly : 1. The light l is then 78 per cent. more intense than m. It is desirable, for the accuracy of the determination, that the shadows should be made to come as near together as possible without touching. And it is also to be observed that the precision of the method becomes less and less as the difference in the intensities of the lights becomes greater. In such case the weak light has to be placed very close to the rod, and the shadow becoming wider becomes also less sharp and well defined, and of course more difficult to be judged of.

But in general the mode is of such ready application, and the apparatus can be arranged with things so commonly at hand to give a sufficiently approximate practical result, that for ordinary purposes it is the only one that need be here recommended.

CHAPTER XXII.

ILLUMINATION.

ARTIFICIAL illumination, the economical production and diffusion of which are matters of general interest, is obtained for domestic purposes from such materials as will by combustion afford a permanently luminous flame. The term combustion, as usually applied, is a rapid combination of a combustible body with oxygen, with an attendant disengagement of heat and light, resulting in the destruction of the burning body and the formation of new compounds. We cannot positively state more in explanation of the causes which lead to this disengagement of heat and light, because the conflict of the various plausible theories leaves a doubt upon the subject. Certain it is, however, that chemical combination is always a source of heat and light ; but whether these phenomena of combustion are explicable upon certain changes in the amount of latent heat in bodies entering into combination, or, by Berzelius's theory of its origin, " from the oppositely electrical substances neutralizing one another, in the same manner as the electric equilibrium is restored, during the discharge of a Leyden jar," we will leave to the decision of philosophers, as it is not in the author's power to settle this mooted point.

Oxidation is a species of combustion, but in this process the union with oxygen is not sufficiently rapid to produce a *perceptible* evolution of heat and flame. A body having so great an affinity for oxygen, that its union therewith will be attended by an emission of heat, is called

a *combustible,* and the oxygen or other gas in which it is burned, is styled a *supporter* of combustion. The evolution of heat is apparently proportional to the amount of oxygen consumed, but varies with the nature of the material. A candle burns much faster in an atmosphere of oxygen than in that of common air, but the increase of heat and light is in a corresponding ratio. That species of oxidation taking place with those bodies, which burn with flame, at a heat less than that of redness, is called *low combustion.* Thus, when tallow or oil is thrown upon a heated iron plate, not visibly red-hot, it melts and emits a pale lambent flame, only perceptible in the dark. The same occurrence is evident, when a portion of oil is heated in an iron capsule until it catches fire, and the flame then extinguished; the hot oil still continues in a state of low combustion, and is ready for thorough ignition immediately upon the application of an atmosphere of oxygen; and so also a candle recently blown out, although no point of the wick remains red, is, upon the same reasoning, sometimes rekindled in oxygen. Here we have the explanation of the apparently unaccountable causes of frequent fires in store-houses for woollen and other rags more or less imbued with oil. The large surface exposed to the air so facilitates this low combustion, that the oil becomes converted into resin, and the rapid absorption of oxygen producing this change, generates sufficient heat to cause a spontaneous ignition of the combustible. This affinity of combustible bodies for oxygen is active only at high temperatures, and hence in most cases it must receive a *start,* if the expression may be used, or, in other words, to commence the combustion, the combustible should be heated to a certain point, but as this degree is far below that emitted during the combustion, it follows that when once ignited, it continues burning until its entire destruction. But it is not meant to

convey by the word destruction, the idea of the total loss of the material, or the perfect annihilation of any particle thereof, for this would be contrary to fact; nothing is lost, there being merely a change of state or a resolution of the solid or liquid bodies into gaseous matter and vapor.

The modes by which artificial light is at present produced, are three, viz: gas, lamps, and candles. The principles upon which their illuminating power is based, are identical in each of them. The variation in fatty material and the modification of the burning apparatus, are foreign to the theory of combustion, their part and object being only to facilitate its progress, and thus influence the economy of the light. Granting, then, that all the ordinary substances from which we obtain light may be represented by gas and oil, let us proceed to explain the rationale of their combustion, which furnishes us the flame that bears so importantly upon the domestic economy; for without it, to say nothing of the pleasure and convenience it affords, there would be a loss of that time now vouchsafed to us by these means, and which would otherwise form an incalculable deficit in the life period of mankind.

In the language of Prof. Faraday, let us suppose we have at hand for the purpose of obtaining light, both oil and olefiant gas. Although wax, tallow, or anything of that sort, be used for the purpose, yet they all fall under one or other of these denominations, inasmuch as they are like the vapor of oil. These are the two substances to which we generally refer the light. The oil contains carbon, hydrogen, and oxygen, and the gas only carbon and hydrogen. The composition of oil, that from the sperm whale for example:—

Carbon	78.0
Hydrogen	11.5
Oxygen	10.5

The olefiant gas is that made from coal, and burned in our streets and stores as a means of illumination. Its composition, per cent., is

Carbon	7C.
Hydrogen	3C.

Let us suppose that we have these two things represented, one by a vessel containing hydrogen, and the other by a piece of charcoal existing separately, and in their elementary states.

The constituents of the two bodies are given now, but the oxygen present in one of them will be passed by, inasmuch as it merges into the other bodies when burning in the air. Consider the hydrogen, which is a very light, gaseous body, as burning; the carbon is ready at hand, and the combination of the two will be explained directly. The charcoal can be burned in the oxygen of the air, or pure oxygen prepared for the purpose. The oxygen of the air is identical with the gaseous oxygen, and these two instances illustrate all the modes in which is burned every one of the combustible substances, either in the ordinary way, or by extraordinary means, for the production of light. Whether we burn the oil or the gas, the same thing happens in all these cases, the same final result takes place as in this particular instance. For example, there are the carbon and hydrogen, combined in the form of gas, and its combustion partakes 'n its character of the two compounded—viz: of the flame of the hydrogen, and the luminosity of the carbon, combined in one act.

Now when these two bodies are burned, as they are in either the oil or gas lamps, the hydrogen produces water, which is a compound of hydrogen and oxygen, and carbonic acid, constituted of carbon and oxygen, as is proved by receiving the products of the combustion of a lamp into a glass jar, and testing them. But what are the changes in the atmosphere, which, under all these cir-

cumstances, is supporting the combustion of the light, and what is it that is thrown into that atmosphere from the oil or gas which is burnt? The oil, by reason of the hydrogen it contains, produces water by the union with that portion of oxygen which it takes from the atmosphere, a fact very easily determinable by holding a glass jar over a jet of ignited hydrogen. The light takes the oxygen from the atmosphere, and forms with it water which condenses in vapor upon the sides of the vessel. The carbon by the same cause is converted into carbonic acid, a vicious gas, destructive of life and insupportable of combustion, and hence the dimness of light, after a lengthy burning in close apartments, is partially owing to the presence of this body, and partly to a deficiency of oxygen, by reason of the absence of all inlet for fresh air, the source which furnishes it.

The committee of the English House of Commons, having proposed the inquiry as to the relative vitiation of air by the breathing of men and the burning of candles, received from Mr. Ure, one of the chemists to which it was addressed, the following reply:—

" Wax contains 81.75 parts of carbon in 100, which generate by combustion 300 parts of carbonic acid gas. Now, since 125 grains of wax constitute the average consumption of a candle per hour, these will generate 375 grains of carbonic acid, equivalent in volume to 800 cubic inches of gas. According to the most exact experiments on respiration, a man of ordinary size discharges from his lungs 1.632 cubic inches of carbonic acid gas per hour, which is very nearly double the quantity produced from the wax candle. Hence the combustion of two such candles vitiates the air much the same as the breathing of one man. A tallow candle, three or four in the pound, generates nearly the same quantity of carbonic acid as the wax candle; for though tallow contains but

79 per cent. of carbon instead of 81.75, it yet consumes so much faster as thereby to compensate fully for this difference. When a tallow candle of six to the pound, is not snuffed, it loses in intensity in thirty minutes, eighty hundredths, and in thirty-nine minutes, eighty-six hundredths, in which dim state it remains stationary, yet still consuming nearly the same proportion of tallow. A wax candle attains to its greatest intensity of light when its wick has reached the greatest length, and begins to bend out of the flame. The reason of this difference is, that only the lower part of the wick in the tallow candle is charged with the fat so as to emit luminiferous vapor, while the upper part remains dry; whereas, in the wax candle, the combustible substance being less fusible and volatile, allows a greater length of the wick to be charged by capillary attraction, and of course to emit a longer train of light."

The illuminating power of a candle is greatest as soon after the lighting of the wick, as the fat begins to melt and flow freely; and previous to the crusting of the wick. As soon as the latter condition commences, the intensity of the light decreases.

All kinds of artificial light are designated by the term terrestrial light, in contradistinction to solar light, or that proceeding from the sun. The chemical agency of each is analogous, though the terrestrial light is much the feebler of the two. The source of this latter kind of light is the combustion of inflammable matter, the excessive heat, given out during the process of which, renders the burning substance luminous. This luminosity increases proportional to the intensity of the heat, and augments from a dull red to one of shining brilliancy, and to this incandescence of their material in a gaseous state, are to be attributed the different kinds of flame, for instance, of candles and gas light, serving for the purposes of illu-

mination. In conclusion, therefore, the illuminating power of the coal gas and of oils and candle materials, is due to their constituency of carbon and hydrogen, assisted by the oxygen of the atmosphere, which converts the first into carbonic acid, and the latter into water. It must be remembered, however, that temperature is not the sole cause of luminosity in burning bodies; for this property varies with the chemical and physical constitution of bodies—density playing an important part. For example, metals, when heated, emit a vivid light, while gases are scarcely incandescent, when there are no particles of solid carbon suspended in the flame.

CHAPTER XXIII.

THE PHILOSOPHY OF FLAME.

It has already been written, that the temperatures at which bodies enter into rapid combustion, are very various, but when this kindling or *accendible* point, so called, is attained by inflammable materials, they take fire and burn with a flame. All flames, as already stated, are not equally luminous; for instance, that of pure hydrogen gas is scarcely visible in the daytime, but still is so hot as to impart a white heat to a piece of metal brought in contact with it. The luminosity of flame, therefore, does not depend upon its temperature, but is due to incandescent solid matter, ignited by the inflamed hydrogen of the combustible bodies; and this solid matter, to which the light of all the common flames is owing, is finely divided carbon. Davy called a luminous flame, *solid matter heated to whiteness,* and as an illustration of this fact we have the " Drummond light," which is produced by the projection of ignited hydrogen gas in contact with oxygen upon lime. The instance of the combustion of metallic zinc illustrates the incandescence of flame as due to the solid particles of the oxide of that metal diffused throughout the flame, and serving as radiating points for the light and heat. The flame of gas is then owing to the particles of carbon which compose it being rendered incandescent by the ignited hydrogen, and in that state burned and passed off as invisible carbonic acid gas. In all instances, therefore, of a bright light during combustion, there is evidence

of one of the combustible bodies being solid, for to its incandescence the flame is owing.

In a candle flame, a portion of the carbon is in a solid form, that of smoke, without which the light given out would be very limited, for it is this portion of heated carbon that radiates the light. When, however, the supply of air is insufficient, the imperfect combustion of this smoke causes a disagreeable increase of unconsumed particles, which, escaping in their heated state, cool the flame by an abstraction of its heat, and thus create a loss of the burning material, and an unpleasant atmosphere in the apartment where it is burned.

To provide against this inconvenience in the case of oils, the Argand lamp was constructed, so as to perfect the combustion of the excessive carbonaceous matter by allowing a current of air through the centre of the flame; because, in order to a clear and brilliant flame, there must be a complete consumption of the carbon, or, in other words, it must have oxygen enough to convert its carbon into carbonic acid gas. The larger the flame, the greater the quantity of light, and its brightness is increased by every circumstance promotive of the rapidity and intensity of combustion; for instance, as in the Argand burner, by a stream of air, or, as in the Bude or Gurney light, by a current of pure oxygen gas. The light is not only thus augmented by the accelerated combustion, but by the carbon being more highly ignited by the increased temperature of the flame.

" In an ordinary flame, such as that of a spirit lamp or candle, the gaseous matter is in free contact with the air only at the exterior of the flame, where alone perfect combustion takes place. In the interior, combustible gases still unburned exist. That such is the structure of the flame may be easily seen by depressing it upon a sheet of wire gauze of small mesh (through which the

flame is unable to pass), so as to view it in section. The combustion is then seen to be limited to the margin of the flame, because it occurs only at the point where the two substances which enter into union are in contact. But if the structure is examined a little more minutely, it is seen to consist of three parts, which are represented in Fig. 59.

Fig. 59.

1. The shaded interior represents the unburned combustible, and may be styled the cone of vaporized combustible; 2, around this is the brilliant part of the flame, or the flame, strictly so called; 3, on the very exterior is another portion, perceptible, with attention in the flame of a tallow candle:—this is the sphere of complete combustion."

" In b, where the supply of air is insufficient for complete combustion, it is the hydrogen, principally, which burns, the carbon being liberated in solid particles, which are heated while hot, by the combustion of the gas. The sphere b is the luminous part of the flame, in truth, for the light depends entirely upon the deposition of carbon arising from the consecutive combustion of the two elements of the vapor. The carbon does not burn entirely until it reaches the exterior of the flame."

According to Berzelius, flame consists of four distinct parts :—

1. The inner cone.
2. A luminous envelope.
3. A blue envelope.
4. A faintly luminous curtain surrounding the entire flame.

A series of careful experiments in confirmation of this view, are reported by Hilgard (*Ann. der Chim. und Pharm.*, 1854); and the reader is referred to his paper, which also contains original facts in regard to the chemical composition of flame.

To maintain a steady continuance of the flame and a uniform light, there should be consecutive supplies of the combustible material, which serves as its fuel; and in the instance of candles, the fat or fuel which must be in a liquid state, is conveyed to the flame by means of a wick a, Fig. 60, where it is volatilized and raised to its accendible point c. The fat is rendered fluid in that part of the candle d, immediately below the lighted end of the wick, by the radiant heat of the flame, and forms a cup or reservoir x x, of which the hard circumference of the candle constitutes a rim. As soon as that portion taken up to the point of combustion is consumed, another consecutive portion melts and arises to take its place, and so the candle, when once lighted, continues to burn until it is spent. The dim light given out on first being inflamed, is owing to the deficiency of food; but as the size of the flame increases, more fat is melted, and the wick is then better, and more perfectly supplied with fuel. If the wick is either too large or too small, the burning quality of the candle will be impaired. The continued and uniform flow of melted fat is supplied to the wick by the force of capillarity, the interstices between the threads and fibres forming a number of capillary spaces.

Fig. 60.

The smoke arising from the burning of badly made candles, consists of unburned carbon in a state of very minute division, and is occasioned by a deficiency of oxygen to the centre of the flame. The water produced by the burning candle is dissipated throughout the atmosphere in the form of heated vapor, and the carbonic acid simultaneously generated, makes its escape in a gaseous form. In close apartments, surrounded by a cold atmosphere, the water is condensed upon the window glasses or the walls, and where a large number of lights are burned,

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is in such quantity as to moisten a cloth rubbed over a limited space, whilst the carbonic acid, being destructive of life, vitiates the atmosphere, proportionally as it accumulates;—hence the necessity of a thorough ventilation of those lighted apartments that are occupied by crowded assemblies.

These remarks, together with those upon ILLUMINATION AND WICKS, will serve to present an intelligible idea of the principles upon which the illuminating effect of oil and candles is based.

CHAPTER XXIV.

ON THE RAW MATERIAL FOR CANDLES.

THE fat of animals, in its natural state, is always enveloped and associated with cellular tissue and other foreign matters, which must be separated before the fat can be available for candle stock. The principal agent employed for this purpose is heat, and the process is termed *rendering;* the temperature being regulated by the melting point of the fat under treatment. The heat, by expanding the fat of the cells, causes the latter to swell, and ultimately burst. The globules of fat thus set free, are at first cloudy, owing to the water and animal matters naturally associated with them. As the water evaporates, however, the animal matter coagulates, and the fat becomes clear.

The fat, in its natural form, is known, technically, as "rough suet;" and, as soon as taken from the animal, should be melted, and not left in heaps to spoil.

In country towns, the chief source of the rough tallow is the butcher, and the only way to amass any amount of stock is to collect it from the stalls on market days. In large cities, the butchers save the profit of refining by associating, for the purpose of rendering their own stock; and to this end they have large foundries to which they send their rough tallow. At the close of the year each member receives of the profits in proportion to the amount of fat deposited by him. At the West, whence much of the tallow comes, there is a refining room to every packing house, and the daily produce of rough suet is there

rendered, and packed in barrels and hogsheads to take the same course of the meat whence it was extracted, viz: either to an eastern or foreign market.

Although the butchers' and packers' foundries furnish a large moiety of the tallow consumed, yet there are many chandlers who prefer refining their own stock,—as their experience and supervision will secure a better selection of rough material, and insure greater care in its purification;—both matters of importance, when it is considered that there is often much loss and inconvenience to the chandler by the bad quality of tallow. The rough fat as it comes from the animal is warm, but by suspension in a drying-room, it cools and congeals. The blood and membranes becoming dry, the suet can then be extracted more readily. Care should be taken not to leave it too long; nor must the temperature of the room be elevated, for the muscular parts and membranes of the rough fat will decompose under the circumstances, give off putrid emanations, and infect the fat itself, which, in its turn, will evolve volatile acids, and become impaired in odor and quality. The danger of these defects happening, is much diminished when the fat is dry. It is in this state carried to the melting-room; but, before proceeding further, we will describe both apartments, which, for convenience, should adjoin each other.

French process.—The drying-room is an apartment with long poles stretched across its breadth, and suspended to the ceiling by cords at their ends. The walls are pierced on either side with holes, for ventilation and free circulation of air. It is important that the drying should be promptly effected, in order to avoid putrefaction. It is upon these rods that the rough tallow is hung as soon as it is taken from the animal. Fig. 61 shows the arrangement. A corner of the drying-room should be appropriated to the chopping-board, for, by this arrangement,

independent of the convenience it affords, the workman is enabled to reject the undried portions, and hang them up again for further desiccation, without much loss of time. The chopping-board is a strong table A (Fig. 62),
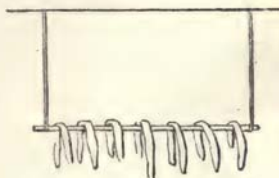
Fig. 61.   Fig. 62.

upon which is fastened, by one of its ends, a chopping-knife B, propelled vertically, but in a circular direction around the centre C. This knife is more convenient and expeditious than a cleaver, which is sometimes used, and by awkward management becomes dangerous in unskilful hands. It is advantageous to fix upon the table where the edge of the knife constantly comes down, a piece of beech wood plank (D) of an inch thickness, and fastened by screws, so that when it becomes worn out by repeated hacking, it can be replaced by a new piece. In this way the top of the table is saved, and the board can be renewed, when necessary, at a trifling cost. It is this economy in small matters that leads the proprietor to prosperous fortune, and it is only by a strict adherence to such a practice, that success is to be attained in any branch of manufacture. As a labor-saving substitute for this implement, it will be judicious to employ the machine especially constructed for the purpose, and shown by Fig. 63. The knives a are set vertically on the circumference of a cylinder, which is driven by steam power; and hence the work is accomplished thoroughly and rapidly. The hopper b is the receptacle for the rough fat, and serves as a feeder to the knives. With this, or the first named ma-

chine, a workman cuts the rough fat into small pieces, and
collects them in a basket E, placed under the table for

Fig. 63.
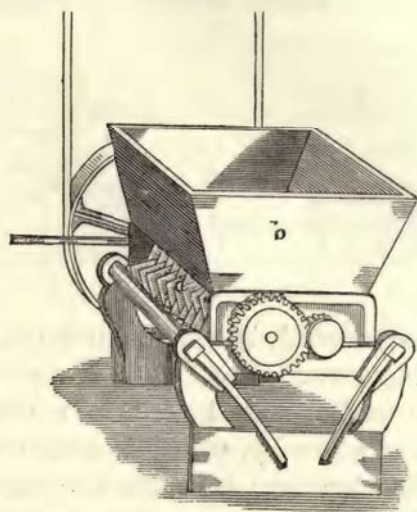
their reception. This basket, when full, is carried to the
melting caldron, which is placed in a brick-work furnace
arranged against one of the walls of the melting-room,
and neighboring to a window. In a moderate sized factory,
this caldron is about three feet in diameter, and two feet
two inches deep. Its borders incline inwardly, that the
tallow which, in melting, may scatter and spatter upwards
against the sides, shall fall back again into the caldron.
Fig. 64 shows the whole arrangement. At the base of
the furnace are some steps C, which give facility to the
workman in stirring or taking out the contents of the
kettle. At A the furnace, and at B the caldron are
seen. The hearth is not visible in the figure. Its
mouth is behind the wall, against which the furnace
is built. This precaution is necessary to prevent incon-
venience of smoke, and to save the workman from being

incommoded by the heat proceeding from the fire doors. The caldron is of copper, egg-shaped at the bottom, and so built in, that the heat only operates upon its base, and not upon its sides. There is always a bath of melted suet

Fig. 64.
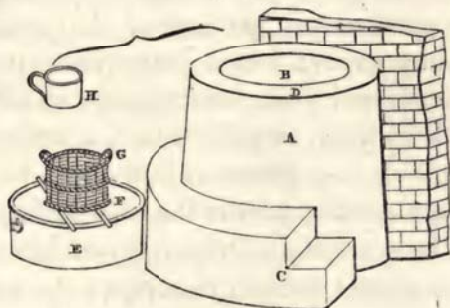
on the bottom, and this protects the metal from injury by fire; but the precaution alluded to is necessary, else the pieces of unmelted suet, coming in contact with the sides, would become scorched and acquire a brownish tint, of which the whole melting would partake, and thus the suet get so colored, that no mode of bleaching could restore its primitive purity and whiteness. As soon as the workman commences to charge the caldron with minced fat, the fire should be kindled under it, and continued moderately until near the close of the operation, when it should be very gentle. Moreover, during the whole operation, constant stirring must be kept up by a semicircular blade of thin copper or iron plate, adjusted to the end of an upright shaft, which is geared with cogs, and propelled by steam power. As the stirrer revolves, the edges impinge gently upon the bottom and sides of the pan, and by agitating the contents, lessen the liability of their becoming scorched. This mode is peculiar to our country. New portions of rough suet are added, as the melting proceeds, and the same manipulations repeated again and

again until the kettle becomes two-thirds full. The suet must be perfectly melted before being drawn off into large copper coolers, E, Fig. 64. Upon each of these is placed a frame F supporting a tallow sieve G, through which the melted suet is strained. The sieve is most generally a fine willow basket, of cylindrical form, and so closely plaited as to prevent the passage of the membranes and other rough impurities; but a better substitute would be a copper box pierced with innumerable small holes, like a strainer or cullender, or still better, a brass wire sieve; in this way much less grease is lost, there being none of the fluid tallow absorbed, as is the case with willow twigs. The frame F is merely four strips of wood jointed together, and should be strong enough to support the weight of the sieve when it is full. There are some workmen who place the sieve in the caldron and dip out the clear fluid which rises through its meshes, but this is not the proper way. As soon as a vessel is filled, it is taken into the foundry, and an empty one substituted. Cover each as it is filled, and allow sufficient repose that any foreign matters which it contains may, by their greater specific gravity, subside. As soon as this occurs, and before the tallow has congealed, the supernatant clear liquid is ladled off with the pail H into the small wooden pails 1, 1, 1 (Fig. 65),

Fig 65.
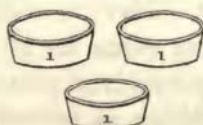
ranged in a row upon the floor of the foundry, and at some distance from the furnace. The dipper for ladling out the melted tallow should be of copper, with a long, wooden handle. As this latter becomes greasy, the use of dry sawdust, upon it and the hands, will prevent slip-

ping. When the tallow is to be exported, it should be run into casks, which, after their contents have thoroughly cooled, are to be tightly headed up and coopered. This then is *rendered* tallow. The form of the small cooling vessels is that of a flattened truncated cone, to afford facility in ejecting the block of cooled tallow, by merely upsetting them after the contents have congealed. The dregs remaining are technically called *cracklings*, and consist of the impurities contained in the grease. To extract any remnant of fat that may still be retained by the *crackling*, it is thrown into boiling water. The grease melts and rises to the surface, and can be ladled off, whilst the dirt, &c. falls to the bottom of the caldron. The membranous matters which are left upon the sieve, still retain fatty matter, which is only separable by strong pressure. The remaining marc after pressure, is used as food for hogs, but more generally, by reason of its nitrogenous constitution, for the manufacture of prussiate of potassa and Prussian blue. I have seen lard cracklings resulting from the old methods of curing lard, which contained enough percentage of greasy matter not only to pay for the expense of its extraction, but their original cost additional.

The kind of press used for the purpose of refining the cracklings, is shown by Fig. 66. It is formed of two strong upright stanchions, and two proportionably strong cross pieces, firmly jointed in the side beams. The upper cross piece carries a box through which works an ordinary press screw, in the usual manner. Upon the lower cross piece is placed a wooden trough A (Fig. 67), at least two inches deep, and to the front of which is adapted a gutter B for the conveyance of the liquid fat, which assembles in the trough, to a vessel E placed at and beneath its mouth. Upon and within the trough is placed a wrought

iron boiler plate cylinder. This cylinder is formed of two semi-cylinders joined together. Throughout its height,
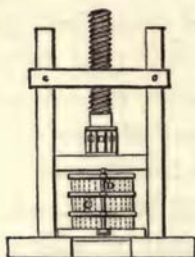
Fig. 66.   Fig. 67.
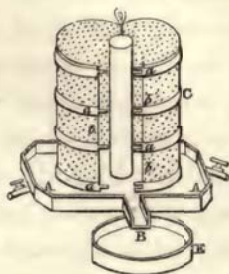
it is divisioned off, alternately, into equal parts by zones or belts. The zones *a a* are a full inch broad; the partition, *b*, &c., four or five inches in width. The top, as well as the lower zone, is narrow. All the wider divisions are cullendered, throughout their circumference, with innumerable small holes through which the liquid suet is to flow when pressure is applied. All the narrow zones are secured by a strong wrought-iron ring, formed of two pieces working on a hinge adjusted at the back. Upon the front is a movable broach D, which bolts them together, and makes the cylinder compact, so that it can resist the pressure applied. When the marc is exhausted, by drawing out the broach D, the circumference of the cylinder is loosened or extended, so that its contents can be removed without difficulty.

Whilst the marc or cracklings are yet warm, they must be taken from the sieve and placed in this cylinder and pressed out by the power of the screw, until nothing more of fluid fat will exude, even with the force of two men upon the lever or a tourniquet which can be arranged by the side of the press. The tallow runs into the gutter B, and through a sieve, which should be properly placed for the purpose, into the vessel E, and thence emptied,

after it has settled, into the conical tubs 1, Fig. 65. The residual marc of exhausted cracklings is, as said above, easily emptied out by loosening and removing the pin D, but it is better not to disturb it or relax the pressure until it has entirely cooled. It is very doubtful whether, by this operation, all the grease is separated; hence some other plan is requisite, and consists as follows. The shape of the cylinder need not be altered, but its diameter must be increased four inches. In the centre, and upon the trough, is fastened a cylindrical wrought-iron steam tube reaching in length just about an inch above the top of the cylinder. The tube, tightly fastened, and luted to the trough, is hermetically closed, and connects with a pipe leading from a steam boiler, which furnishes steam as may be wanted. A tube fitted with a cock, placed at the bottom, leads off the steam as soon as it condenses into water. There should also be a stopcock in the steam conduit, so that the steam may be shut off when necessary. By these means the heat requisite to maintain fluidity being uniformly supplied, the screw pushes out every portion that can be extracted.

The different kinds and qualities of suet should be rendered separately, and without salt, for it decrepitates during the combustion of the candles, and causes them to run. The tallow keeps well enough without being salted, as the disagreeable odor it acquires by age is inevitable.

American process.—The method of rendering in the open pan, as followed in this country, does not differ materially from the preceding.

Our pans are of cast iron, instead of copper, and hemispherical in form. They are, moreover, covered with movable tin plate hoods, Fig. 68, which are adjusted by means of pulleys, ropes, and counterweights, to allow their being raised or lowered optionally. These hoods

serve to conduct off the disagreeable vapors arising from the heated fat.

Fig. 68.
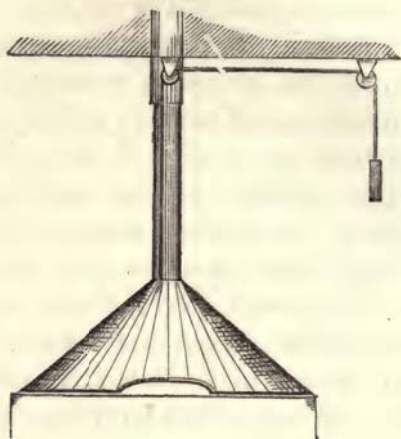
Our presses, too, are somewhat different, being either hydraulic machines, or else the much cheaper but very convenient and powerful wheel-press, shown by Fig. 69. The cullendered box is square, and of wrought iron, as is seen by Fig. 70, which shows the pressed cake b, at the time of its removal. For convenience of emptying the cullendered box, the sides c and ends d, as is seen in the drawing, are made to fall apart. During the pressing, they are maintained in upright position by flat-faced ribs projecting from the interior of the outer casing of cast-iron A, and thus form a channel between the two for the flow of the fat. The cracklings are not unfrequently heated and pressed a second time, but the product thus obtained is inferior, and only serviceable as soap stock.

The plan of rendering in the open pan, over the naked fire, is, in many points, very objectionable, since it not only endangers the whiteness of the fat, and imparts a stronger odor to it, but also occasions during the process a plentiful amount of offensive and unhealthy vapors,

which justly constitute a serious nuisance to the neighborhood. Moreover, it only imperfectly accomplishes the

Fig. 69.
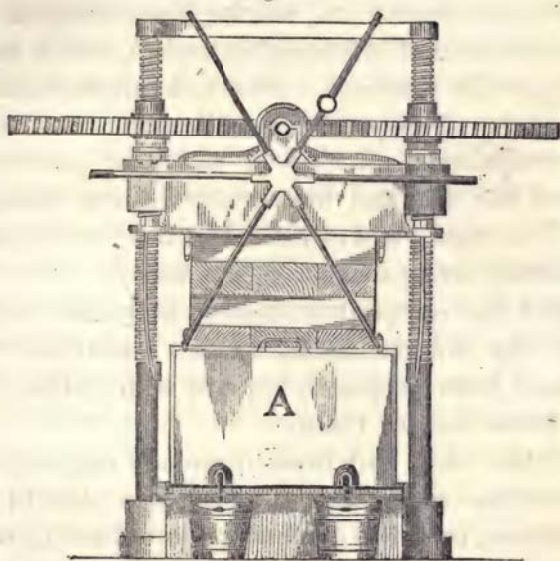
object of the rendering operation, for the cellular matter is either only partially destroyed or so hardened that the

Fig. 70.
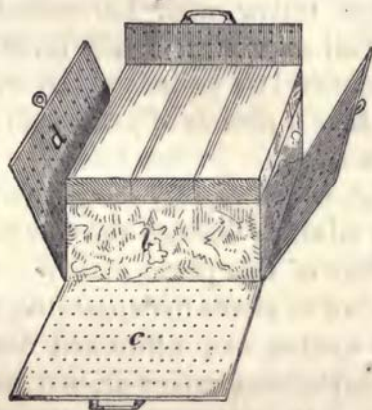
strongest pressure is insufficient to expel all the fat from the cracklings. There is also a difficulty in maintaining

a uniformity of temperature throughout the contents of the pan, even with the use of the stirring scraper, heretofore described at page 311 ; and hence the bottom, sometimes, becomes overheated, causing a scorching of the fat and the evolution of inflammable vapors, which endanger the safety of the premises.   Scorched tallow, it should be mentioned, is not very readily whitened.

The preliminary mincing of the suet facilitates the melting of the fat, and measurably lessens these objections.   The usual yield of refined fat is 90 to 95 per cent., the remainder being cracklings and water.

To quiet the complaints so frequently and justly arising from the aforementioned causes, numerous improvements have been proposed, but not with perfect success even as to the best of them.

One of the early and most ingenious suggestions, was to conduct the rising vapors, which are rich in carbon and hydrogen, over the fire under the rendering pan, and thus neutralize their odor by converting them into fuel for maintaining the heat of the pan.   Of the others, there are—

1. *D'Arcet's process.* — This consists in heating 350 pounds of rough tallow, with 150 pounds of water and 15 pounds of oil of vitriol of 66° B., in a close vessel, under a pressure of 100 pounds to the square inch ; but it is probable that 5 pounds of acid would answer the purpose, with less water.

The frothing, which rapidly ensues, and which forces a portion of the mixture through the valve, seriously affects the practicability of this plan.

Still, in taking to pieces the apparatus, the suet is found to be entirely melted, and white and firm when cooled. Though the unpleasant vapors are not prevented by this plan, yet it must be confessed that the odor given off is changed in its nature, and much less deleterious than

usual. This experiment, performed in an *open pan*, gives the same results both as to the odor and quantity of suet. The melting ensues, in due time, and the residual cracklings or marc do not appear to retain any particular greasiness. The many advantages to be gained from this mode of rendering tallow, both as regards improvement of quality, economy of time, readiness of execution, &c., suggested to D'Arcet the policy of an arrangement for burning the fetid vapors as they were emitted, and thus rendering this process still more satisfactory. To evade the necessity of stirring the contents to prevent their scorching, and also the frequent opening of the vessel for this purpose, it had placed within, at about an inch from the bottom, a cullendered copper diaphragm, so that the materials were saved the danger of a too close contact with an overheated metallic surface. Into the digester thus arranged, was placed the same quantity as before, of rough suet, water, and acid, and the whole hermetically closed—the vessel being, however, fitted with a tube so crooked that its mouth of exit led into the hearth of the furnace, and served as a conduit pipe for the vapors. This experiment was entirely successful as to the odor, which was almost nullified; the vapors rushing forth freely through the pipe after having traversed the fire, retained only the smell analogous to that given off by water when thrown upon hot iron. The suet drawn out after half an hour's ebullition, was completely melted, and, on cooling, became white, firm, and sonorous. The proportion of crackling remaining in the strainer was very small. As the suet did not act upon litmus paper, the absence of all acid was conclusive. As, however, much dense smoke is produced by the combustion of the gases, and there is danger of a conflagration from a too rapid flow of them from the digester, this process is objectionable.

The preceding experiment having prompted the idea of

condensing the vapors instead of burning them, and thus evading the above-mentioned contingencies of accident, the following essay was made as a test.

2. *Rendering by the still.*—Into an alembic furnished with a worm, 170 pounds of rough tallow or suet were heated with an equal quantity of water. No odor was perceptible during the whole operation, and the water resulting from the condensation of the vapors which passed over into the receiver, was clear and retentive of scarcely any smell of grease.

As the fusion of the fat progressed rather slowly, it was thought advisable to add a portion of sulphuric acid, which promptly expedited the process. In this experiment the cracklings weighed only 5 pounds. The tallow of these last processes, wherein sulphuric acid was used, was considered by competent chandlers, to be of superior quality, and furnished candles firmer, and whiter than those from the ordinarily prepared tallow. These candles burned with a slightly diminished flame, perhaps, but without running, or any disagreeable smoke, and moreover, endured longer than candles from tallow prepared without sulphuric acid.

Thibault repeated these essays on a large scale, and obtained 8 per cent. of cracklings; whilst a like quantity of the same suet, rendered simultaneously by the ordinary process, gave 15 per cent. In these two essays, conducted in an *open pan*, instead of a digester, the odor emitted, though strongly disagreeable, did not present the peculiar characteristic of that which escapes during the process usually practised. D'Arcet's plan is, therefore, advantageous in producing tallow economically, and of good quality. There is, moreover, no necessity for a press, for the acid in the cracklings so acts upon the woof of the cellular tissue, that the greasy particles which they retain are readily separable by boiling in water. Steam heat is

sufficient, but the boiling must be continued until the separation of fat from cellular matter is complete.

The method of rendering, in the open pan, though very general in this country, is not universally adopted; for there are many extensive packers in the West who follow Wilson's process, which turns out a much larger product, in less time, than the other plans. It may be called—

Rendering by steam.—The apparatus consists of a series of steam-tight digesters, each of 12 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 itself (Fig. 71) 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 tallow or 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 essay 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 case it is then requisite to immediately open the regulating cock X and draw off the condensed steam, through it, into the receiving tub T, until the fatty matter ceases to

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Fig. 71.
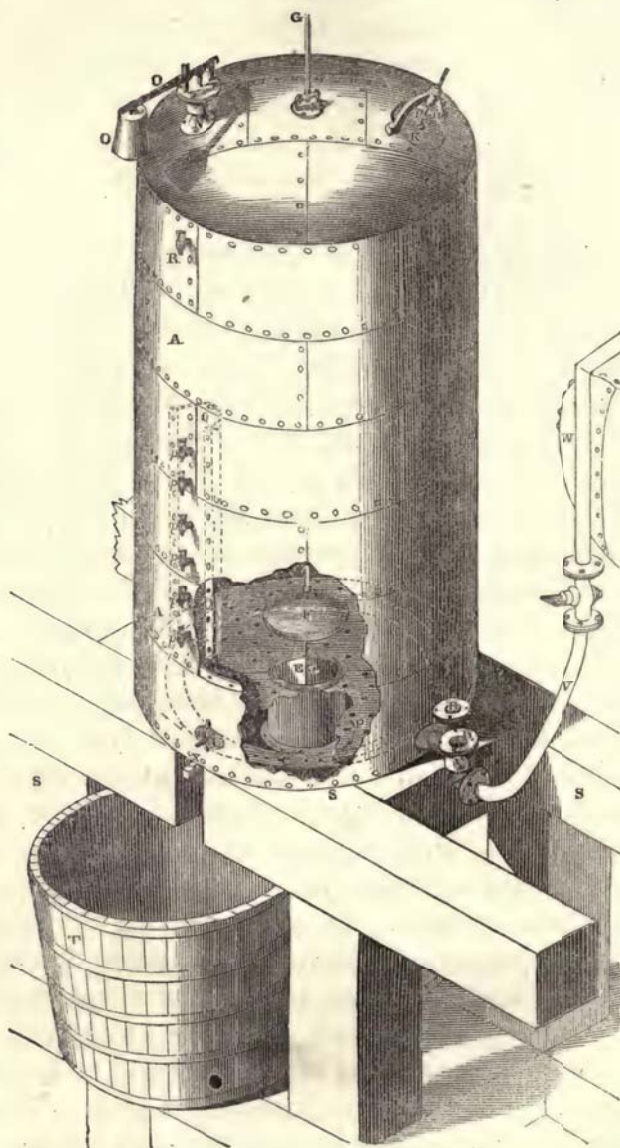
run from the try-cock aforesaid. After ten or fifteen hours' continued ebullition, the steam is stopped off, and that excess already in and uncondensed, allowed to escape through the try-cock and safety-valve. After sufficient repose, the fatty matter separates entirely from water and foreign admixture, 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 or tallow 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 anything of fat, it must be again returned to the tank, when they are being filled for a fresh operation. Experience has determined that, to produce the best re-sult, the steam pressure should not be less than fifty pounds to the inch, though the weight generally used is seventy-five pounds, and may be augmented to one hun-dred pounds, when it is desired to expedite the operation. I 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 in-discriminately with the rough suet, would be to deterio-rate 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, &c. are made to yield all their oleaginous or fatty matter, there is no action occasioned which will convert them into a contaminating 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 of the 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 admixed with bog or street earth, and gypsum, makes manure equalling the best guano.

A 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 temperature of *large* volumes falls so slowly, that partial granulation ensues and softens its consistence.

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 settling, would remedy this defect in a great measure.

Evrard's process.—This method, like that of D'Arcet's, has for its object the solution of the cellular tissue by chemical means; and, also, to do away with the preliminary operation of mincing the rough suet. It is said to give a very handsome product of superior quality, and to be especially adapted to the rendering of rough fat already in a state of incipient decomposition, as it prevents all those unhealthy vapors incident, more or less, to other

processes, and may be economically practised on a scale of any extent. These boasted advantages, however, as will be learned hereafter, from Stein's experience, are not without qualification.

The operation consists in the use of an upright cylindrical kettle, with a cullendered false bottom, and the employment of weak caustic soda lye, in the proportion of 25 gallons to every 250 to 350 pounds of rough tallow. The quantity of caustic soda in the lye must be one to one and a quarter pounds. The mixture is then boiled by the waste steam of the engine boiler, which enters at the bottom of the kettle, and finds its way into the charge through the holes in the false bottom. When the boiling is completed, the alkaline lye will, by its greater density, deposit beneath the false bottom, after a little repose, and must be drawn off from the oil through a cock at the base of the kettle. This being done, the fluid fat is boiled twice, with successive portions of fresh water, and the wash-water each time drawn off in the same manner as the alkaline lye. It is then left for twenty-four hours in a warm liquid state, before being drawn off into coolers; this precaution being necessary to promote the subsidence of all the water. The solid impurities of the fat do not pass through the cock, but are arrested by the false bottom, which serves as a strainer.

The alkaline-wash liquor contains little more than the volatile fat acids, so that there is rarely any greater waste of neutral fat than ½ to 1 per cent. The limited amount of alkali employed insures a restricted action to the foreign matters, which are more sensitive to it than the fat itself, and consequently none or very little of the latter is lost by being saponified.

Stein, who made a practical examination of this and several of the preceding processes, correctly remarks that the cracklings, by the chemical processes, are not adapted

for feeding stock, or for making prussiate of potash as are those by the open pan process. Moreover, while Evrard's method answers admirably for fresh fat of good quality, and yields a beautiful product of mild odor, at the same time leaving the cracklings clean, it is not well adapted for that of medium or inferior quality in which putrescence has already commenced. Both of the latter require a longer time for cleaning the cracklings, as the melting proceeds slowly; and in each instance there is the usual offensive odor. In both cases, too, the addition of sulphuric acid is necessary to complete the operation; and even then, as regards the inferior suet, the product is dingy, and the cracklings require a second treatment for separation of residual grease. For these latter kinds of rough fat, the sulphuric acid process is preferable, for though it does not wholly prevent the offensive emanations, it is particularly applicable when the rough fat contains much membranous, fleshy, and other foreign matters liable to be scorched in the open pan, and to yield, from this cause, a tallow inferior in quality, quantity, and color. The product, by the acid process, is white and abundant.

In the course of his study of this subject, Stein tried many experiments, with the view to a process supplying all the requisites for producing good tallow economically. Acting, at first, upon the idea that, by intercepting the oxygen of the air by intermedia more sensitive to its action than the impurities of the rough fat, he would thus divert its force, and prevent decomposition of the latter, sulphurous acid was employed, but with only partial success. Thinking next, that, in presenting the rough fat to the action of nascent oxygen, he would be able to produce the rapid transformation of cellular matters into inodorous compounds, and thus prevent putrefaction and offensive emanations, an experiment was tried by heating 100

pounds with 1 pound of bichromate of potassa, dissolved
in a mixture of 10 pounds of water and 2 pounds of com-
mercial oil of vitriol. This treatment arrested all offen-
sive odor, but the gelatin dissolved by the aqueous liquid
held the fat suspended as an emulsion, which it was very
difficult to clear.

The use of lime-water, of sufficient strength to abstract
the volatile odorant products of decomposition without
saponifying any of the fat, was next tried, but with a less
favorable result than that afforded by either of the pre-
ceding essays. Finally abandoning this train of experi-
ment, he resolved upon a very simple expedient, which,
as supplementary to either the sulphuric acid, or naked
fire process, produces most gratifying results. We will
consider it under the distinctive head of—

Stein's process.—This is based upon a chemico-mechani-
cal arrangement, and consists in the use of a mixture of
slaked lime and small lumps of freshly burned charcoal.
It must be spread upon coarse crash cloth, stretched over
a hoop of two inches depth, and of circumference corre-
sponding with that of the pan, immediately above which
it is to be placed during the process of rendering. For
this purpose it may be securely adjusted by suitable
catches at the bottom of the hood (p. 316). The ema-
nations from the rendering pan, in necessarily passing this
sieve, are either neutralized or disinfected, and thus all
cause of complaints against tallow foundries as health-
destroying nuisances, is effectually removed.

PURIFICATION AND BLEACHING OF SUET.

The inferior quality and color of much of the rendered
suet, as found in commerce, creates the necessity of a pre-
liminary treatment for purifying and raising it to the
proper condition of candle stock. We will proceed to de-
scribe the several means recommended for this purpose.

Dunn's process.—Mr. Dunn proposes to subject the melted tallow to streams of atmospheric air forced below the surface thereof, so that the agitation caused by its entrance, may facilitate the dissipation of the impure odors, and, at the same time, bleach the fatty matter under process. To carry out this plan, the tallow or other fatty matter to be purified, must be kept heated by steam pipes or other means, from 170° to 230° F., in any convenient vessel, over which should be placed a hood leading into the chimney, and serving to conduct off any disagreeable vapors. By means of perforated pipes, placed at the bottom of the vessel, streams of air are injected from a forcing apparatus through the melted fat, for a length of time varying with the kind of grease under treatment. Thus, in treating different qualities of tallow, the impurities of smell are quickly dissipated, and the bleaching perfected in ten or fifteen hours, whilst, when operating upon palm oil, fifteen to twenty-five hours are required to perfectly destroy its color. The period of action must, however, be determined by the amount of material under process, the nature of its coloring matter, and the extent of whiteness required. This process might be advantageously modified by adding a small portion of pearlash, and, after its completion, allowing sufficient repose to insure a perfect separation of the oil from the substratum of saturated water.

Watson's process.—A better process, however, for bleaching and cleansing rendered tallow, is that devised by Mr. Watson, an English chemist, the agent used being the oxygen evolved from the manganate of potassa, or chameleon mineral, in its act of decomposition. The rationale of the bleaching operation is, that the coloring matter, insoluble in itself, becomes so changed and altered by the absorption of oxygen, that it can be and is abstracted by the assistance of water or other menstrua. This process

. is equally applicable to other fats and oils, and to the dirty stearin residuum after the pressure of inferior lard for its oil.

The tallow or fatty matter is melted either in a leaden vat made without being soldered, or a strong deal wood cistern, and therein commingled with an aqueous solution of one-twentieth part of its weight of chameleon mineral, chemically known as manganate of potassa.

To this mixture is gradually added and intimately incorporated so much sulphuric acid, diluted with four or five times its bulk of water, as will impart to the liquor which separates, after a good stirring and a few minutes' repose, an acid taste. The temperature of the mixture is then raised to and kept at about 150° F., or from that to 212° F. After an hour's agitation, the heat is discontinued, and a rest allowed, so that the oleaginous matter may rise to the surface, and be drawn off from the lower deposit of acid liquor and oxide of manganese. Thus is bleached the tallow or greasy matter. An increase of chameleon is sometimes necessary to produce a whiteness of extra brilliancy. The quantity of water used for its solution is not material,—it may be as much as twenty times the weight of the chameleon. Tests of the state of efficacy of the process may be made during the operation by taking out small samples of the suet and cooling it. Its degree of whiteness can then be observed, and the process regulated accordingly. When steam is used for melting the greasy matter, the conduit pipe should be fitted with a stopcock so that it may be shut off or let on at pleasure.

The mineral used in this process is called chameleon, because, like the animal whence its title is derived, it is remarkable for the changes of color which, in solution, it spontaneously assumes. It exists in two states, as a manganate and oxy-manganate of potassa, the latter salt hav-

ing for its acid a more highly oxidized manganese than the former. When it is prepared by strongly igniting peroxide of manganese with caustic potassa or carbonate or nitrate of potassa, the extra atom of oxygen required for the conversion of the peroxide into manganic acid, is derived, in the two former instances, from the air; but when the latter is used, the nitre itself supplies the oxygen, and an increase of product is obtained if the process is conducted in open vessels.

The manganate or real chameleon mineral is prepared by calcining together at a red heat in a covered crucible, a mixture of one part of the black peroxide of manganese, with three parts of fused potassa. The mass is of a green color when cold. It is to be dissolved in cold water and the solution allowed to clear by settling, and not by filtering, for fear of its becoming decomposed.

Dr. Gregory's process is to intimately mix four parts of finely powdered peroxide of manganese with three and a half parts of chlorate of potassa, and add thereto five parts of hydrate of potassa (caustic potash of the shops), dissolved in a small quantity of water. The mixture is evaporated to dryness, powdered, and afterwards ignited in a crucible at a low red heat, insufficient for fusion. Digested in a small quantity of cold water, this affords a deep green solution of the alkaline manganate.

The oxy-manganate of potassa is made by fusing with a strong heat, a mixture of equal parts of peroxide of manganese and hydrate of potassa, or one part of peroxide and two parts of nitre. This mass is to be dissolved in water, and if the solution be green, it should be reddened by the cautious addition of a few drops of nitric acid. The clarified liquor is to be evaporated to the point of crystallization.

Both the manganate and oxy-manganate of potassa are readily decomposed by organic matter, the least portion of

which, when added to a solution of either salt, reducing
its acid to a peroxide state. Hence its bleaching power,
resulting from the ready disengagement of oxygen, and
the consequent destruction of many vegetable and animal
colors.

The change of color which a solution of chameleon
mineral spontaneously undergoes, a change that has origi-
nated its name, is thus explicable. The first green color
of the solution is due to its being wholly of manganate of
potassa; the consecutive red color to its rapid partial con-
version into per-manganate, and the purple tints to a
mixture of these two degrees of oxidized manganate of
potassa. The manganic acid has three atoms of oxygen
to one of manganese; the per-manganic, seven atoms of
oxygen to two atoms of metal. Manganic acid cannot be
obtained by itself, and upon its tendency to decomposi-
tion in an uncombined state depends its bleaching power,
because, as soon as it is set free from its connection with
the base potassa, it becomes a hydrated peroxide, and
evolves oxygen, which exerts all the influence in whiten-
ing oils. This salt is particularly efficient in bleaching
those stearins of dark color which pertinaciously resist
the action of other blanching agents; but its expense is
a consideration which prevents its general application to
the cheaper qualities of fats and oils.

Vaxeme, or summer tallow.—This kind of stock is
made by granulating and pressing ordinary tallow. The
separation of a portion of the olein, in this manner, im-
proves the quality and hardness of the tallow, and adapts
it especially to the manufacture of candles for the West
Indies and warm climates. The process consists in steam-
ing the tallow in wooden tubs for several hours, drawing
off the upper clear portion, after sufficient repose for
settling, and gradually cooling in large tubs at 70° to
80° F. These tubs must have a cullendered diaphragm,

about six inches from the bottom, and which should be covered with coarse flannel cloth. During repose, the solid portion of the tallow separates, in granules, from the superstratum of liquid olein, and subsides upon the diaphragm, thus allowing the olein to infiltrate through, upon the opening of the cock at the bottom, and be drawn off into receivers. The solid residue, upon being subjected to pressure in Russia canvas bags, yields more olein, and becomes hard and white.

It is these pressed cakes which constitute the stock for summer candles; and its quality and appearance may be still further improved by subjecting it to a regranulation and hot pressing, or, by further carrying it through the process given for Stearin Candles, in Chapter XXVIII.

The pressed olein is a thick, mushy oil, admirably suited to the manufacture of the finer kinds of soaps, and will bring very nearly its original price, for that purpose. It is commercially known as "*tallow oil.*"

The hardening and whitening of tallow may be accomplished by other means than pressing, and we here annex a description of those which are most practicable.

Before proceeding further, it is proper to remark that other modes than pressing in bags have been proposed for the separation of the liquid from the solid portion of granulated fat. Without intending, however, to vouch for their practicability, we annex descriptions of the two which seem to have the most merit:—

Durnerin's Press.—Fig. 72, *a*, shows a vertical section of this apparatus at A B, Fig. 73; and Fig. 73 is a horizontal section through the body of the press at C D, Fig. 72. Fig. 72, *b*, is a reduced view of several filters, combined into one apparatus; and Fig. 72, *c*, a side view of the filtering cylinder.

"A is a cylinder of wood in two semicylindrical parts, bound together with divided hoops of iron, Q, which are

drawn tightly round the cylinder A by the long metal wedge R, which has a projection, S, to withdraw it when required, as shown at Fig. 72 and Fig. 72, c; this

Fig. 72.
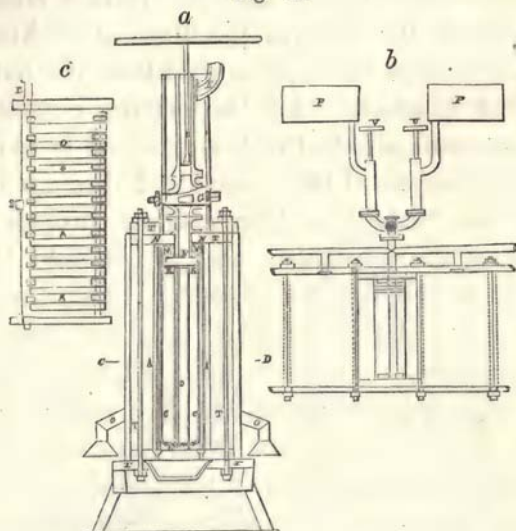
cylinder is grooved longitudinally, as shown at Fig. 72, and is lined, interiorly, at B, with wire cloth, which is

Fig. 73.
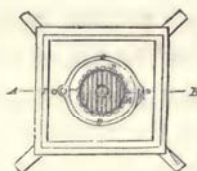
fixed on the top of the grooves. Inside the wire cloth is another lining of woollen or other fabrics, C. D is a mandril of wood, grooved and coated in the same manner as the cylinder A is lined. K is a cross-piece of wood to support the mandril at its upper part. L is a circular piece of wood into which the mandril is fixed at its lower end; it

is grooved and covered with filtering material in the same manner as the cylinder and mandril. M is a round piece of wood, similar to L, and also grooved on its under side, and round the circumference of which the upper edge of the filtering fabric is tightly bound. N is a strong piece of wood forming the head of the filter, and which has a circular hole in the centre, through which the barrel F of the large cock G passes. I is the exterior clothing of the filter, by means of which the temperature is kept at the desired point, heated oil being admitted through the holes O O. F F are tie-bars of iron passing through the top and bottom of the apparatus, and which hold the parts firmly together. H is a piston, which is worked up and down by a steam engine, or other convenient means, and which has a table, V, on its upper end, upon which can be placed weights when required. E is a tube by which the matters to be filtered come from the cistern P, to the pump cylinder; it is closed by a slide, which is drawn up to admit the matter to the cylinder, when the piston has risen above the mouth of the tube. G is a cock, worked either mechanically or by hand, which is opened during the descent of the piston, and closed during its return.

"From the preceding description, the manner in which the filter operates, will be easily understood. When the piston H has arrived at the upper part of the pump cylinder, the matter to be filtered is allowed to enter by the tube E; the piston then commencing to descend, the cock G is opened, and the matter is forced into the filtering cylinder, and the liquid portions escape through the filtering material, down the grooves in the cylinder into a trough placed below. The cock G is now again closed, while the piston rises, and is again opened during its descent, and thus another portion is forced into the cylinder A. When this cylinder A is quite full of solid matter

from which the fluid portion has been separated, the cylinder must be opened and emptied of its contents."

Centrifugal mill.—Another device for the separation of the fluid from the solid portion of fat, is centrifugal force—an ingenious suggestion of recent date; but little is known of its practicability, as no trials of its efficacy have yet been made in this country, or elsewhere, to any great extent. The proposed apparatus consists of a drum A, Fig. 74, with a circumference B of gauze wire. There

Fig. 74.
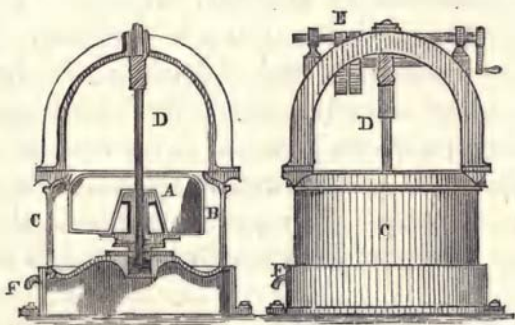
is also an exterior casing, or jacket C, and the drum is attached to a shaft D, driven by the gearing E.

The granulated tallow, or lard, being placed in the drum A, the latter is put in motion by the gearing E and steam power, which drives the shaft D at a speed of 500 to 1,000 revolutions per minute. The centrifugal action throws the granulated fat against the wire gauze of the cylinder, which arrests the passage of the solid particles, while it permits the escape of the fluid or oily portion through its meshes, and whence it falls into the outer jacket, and is to be drawn off through the cock F. Ten minutes suffice to dry a charge of 200 pounds of granulated fat.

The whole machine is about four and a half feet diameter, and requires only one horse power to drive it.

Hardening and clarifying with alum.—Melt together 2 gallons of water and 100 pounds of rendered tallow by a gentle heat, and, at the moment of fusion, sift in 5 pounds finely powdered alum, in four equal instalments, at fifteen minutes interval for each. The alum, in sinking through the hot molten fat, precipitates all impurities which are found at the bottom with the water on the cooling of the tallow. If necessary, the proportion of alum may be increased.

Hardening and whitening with cream of tartar.—Cream of tartar (bitartrate of potassa), employed in the same manner as alum, produces even a better result. It should be very finely powdered and intimately mixed with one-fourth its weight of finely pulverized calcined borax. The borax in union with the cream of tartar renders this latter salt soluble in the water when it reaches it, this being a point of importance. The powder is dusted similarly as the alum. The suet drawn off when cool, is white and dry.

German method of clarifying.—Take 24 pounds of mixed suets, coarsely minced, which place in a caldron of boiling water, and proportionally as the water evaporates, supply the deficiency. Strain the contents of the kettle through a clean cloth, after which heat the suet for half an hour with two pints of pure water in which one ounce and a half of alum, two ounces of potash, and eight ounces of common salt have been dissolved. The whole being again strained, the same quantity of water is to be added; and, moreover, to every eight pounds of tallow, half an ounce of saltpetre, half an ounce of sal ammoniac, and one ounce of alum, all finely powdered and thoroughly mixed together. When the mixture has been heated, or rather gently boiled, until bubbles cease to form, the surface becomes smooth, and a small transparent place is perceptible in the centre, and at this stage the fire is to be withdrawn,

and the whole left to cool. As taken from the caldron, the lower surface of the blocks is covered with the precipitated impurities, to separate which, and give a final cleansing to the tallow, it must be melted anew with two drachms of fine saltpetre ; and, after the scum that rises to the surface is removed, the clear tallow is run into proper vessels. It is said that the candles made of suet thus rectified, endure two hours longer than ordinary candles ; and, when furnished with wicks half and half cotton and hemp, soaked in alcoholic solution of camphor, last still longer, and without running or guttering.

Another process for improving tallow, very similar indeed to one of the preceding, is that which provides for the melting of the suet together with one-fourth its weight of water. It must be well stirred, and skimmed of all dirt that may arise during the heating operation. The water is added to prevent the suet burning at the bottom of the kettle, but it must not be poured in whilst the suet is melted, else a commotion will ensue, and the hot material be ejected to all points. The melted tallow being strained through a cloth or fine hair sieve, is replaced in the kettle with the same quantity of water in which have been dissolved, to every twelve pounds of tallow, three-quarters of an ounce of saltpetre, three-quarters of an ounce of sal ammoniac, and one ounce calcined alum. The mixture, being slightly boiled until the surface becomes smooth and free of bubbles, is then drawn off and cooled. The solid blocks, after the dirt is scraped from their bottoms, are again melted carefully and settled, so that all impurities may deposit. Drawn off clear and cooled, it is then fit to be made into candles.

Cappeccioni's process.—The tallow being hot and perfectly fluid, is treated, portionwise, with seven thousandths of its weight of sugar of lead, dissolved in water, and stirred constantly during the addition. The fire is then

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extinguished, and, after some time, but while the fat is still fluid, fifteen thousandths of powdered incense, and one thousandth of essence of turpentine, are thoroughly mixed with it. The insoluble portions of the incense deposit with the water, after sufficient repose, and the clear supernatant tallow may then be drawn off through a siphon or cock.

This treatment is said to give greater hardness and brilliancy to the tallow, and to improve its odor and quality as candle stock.

CHAPTER XXV.

WICKS.

THE object to be attained in making a candle is to form a cylindrical tube of combustible material, which, upon being ignited, will throw out a sufficiently steady and uniform flame, with as little consumption of material as possible, and without any emission of smoke or disagreeable odor. For this object, there is placed in the centre of the candle, throughout the whole length, a spongy cord or bundle of soft spun threads, serving as its axis, and technically styled its *wick*. The wick, on being lit at the top protruding beyond the candle, becomes imbued with the melted tallow just below the point of combustion, and draws it up by capillary attraction in small consecutive portions to be burned, and thus serves as a means for the regular supply of requisite aliment to the flame.

The material of the wick is an important matter, as it must assist in imparting those qualities so essential to the free burning of the candle, and the production of the maximum of light. It should, therefore, be made in filaments of eminent absorbent power and great uniformity, and which, on burning, leave a very light ash, of inappreciable quantity. Hair, wool, silk, and the like animal substances crisp and carbonize so readily that they are unsuited for this purpose; and though there are several materials of vegetable origin that might answer, there is none possessing the requisites in so large a degree as cotton, which is almost universally employed.

That the wicks may be suitable, the cotton threads should be finely and uniformly spun, white, well cleansed, and without smell; for the least unevenness occasions, during the combustion of the candle, a coal, which, becoming detached from the wick, falls into the cup, and, by its high temperature, produces an excessive amount of fluid fat, thus causing it to overflow; hence candles are said to "*gutter*" or "*run*." The finer the cotton, the greater will be the number of capillary tubes formed by the threads, the more perfect the suction of the melted grease and the more considerable the white portion of the wick below the point of combustion.

Candles of best quality require a fine and carefully made wick, but for the commoner kinds, such as "*dips*" and the lower grades of "*moulds*," a wick of coarser thread and cheaper quality may be employed. In both cases, however, they must, as above directed, be perfectly cylindrical, and free from unevenness.

Capillarity, which is the power by which the wick acts, may be rendered intelligible by the following explanation :—

Experience has proved that when a small glass tube, open at both ends, is plunged into a liquid, that liquid immediately rises in the tube, higher in proportion above the level of the same liquid in the vessel into which the tube is dipped, as the bore of the tube is decreased in size, so that this effect is most conspicuous when the width of the hole of the glass pipe is so small as to resemble a hair. To this action has been given the name of capillarity, and to the small tubes which are used, capillary tubes, from the latin word *capillus*, signifying a hair. The rise of the oil in the wick of a candle or a lamp, is due to this action. "Capillary action is, in short, only an instance of the operation of that species of attraction which is exerted among

the elementary particles of matter within very small or insensible distances, and which is called *molecular attraction*."

It thus follows, that a bunch of cotton threads forming a wick, is nothing more than an assemblage of cylinders, so arranged together, that their intervening interstices may each operate as a tube. It is not necessary that the tube shall be absolutely capillary, in order that capillarity may manifest itself, for this property is evident in pipes of even two and a half lines diameter. It is an established fact, that the smaller the bore, the higher the liquid rises; nevertheless it is not to be inferred from this, that the rise of the liquid in capillary tubes is in direct proportion to their diameter, or that the exact height to which it will ascend in a tube of given diameter can be calculated from a knowledge of the height to which it rises in another standard tube more or less large, and which served to make the experiment. It requires, for that, to know the cause which produces this effect, and as yet it has not been satisfactorily explained. Whatever it may be, one thing we know, the effect exists, and it is this only which has a bearing on our subject. This law of capillarity applies to all bodies sufficiently porous for the admission of liquids, such being in fact a mere assemblage of capillary tubes. For instance, if a piece of sponge is placed in contact with water at one of its ends the fluid immediately passes through and entirely moistens it. It is also by this effect of capillarity, that the sap of the plant mounts from the root to the tip of the branches, and as before said, the liquid grease is drawn up through the wick to its extremity, and there decomposed by combustion; its elements producing the flame which illuminates. We will not here enter into a detail of the theory of combustion; what has been written is only to show the

falsity of the idea that it is the act of combustion which
draws up the liquid fat through the wicks.

After these remarks, it is evident that when the wick
is formed of large threads of cotton, the interstices between
each being larger, the grease is less elevated than if the
threads were finer ; but this is not the only consideration
that should induce the preference of fine spun cotton for
the wicks. As a matter of evidence, take, for example,
two candles of equal dimensions, and made of the same
tallow, each with a wick of like diameter, but in the first
candle A, formed of ten threads, and in the second candle
B, of one hundred threads. For greater intelligibility,
and to facilitate the calculation, let us suppose that the
wick of the candle A presents ten capillary tubes, and
that of the candle B one hundred capillary tubes, and
that both of them have been lit simultaneously. The
difference will soon be evident.

The melted tallow rises abundantly in the tubes of the
wick of the candle A, which are very large, but in a
greater quantity than can be consumed by the flame; but
the heat at the focus is so strengthened, that it volatilizes
the excess of fat and converts it into a dense smoke ac-
companied by a disagreeable acrid vapor; and the waste
of tallow is considerable. The wick of the candle B, on
the contrary, consisting of capillary tubes ten times smaller,
nevertheless occasions the ascent of the melted tallow in
the same proportion; but as the threads by their greater
fineness become better and more uniformly impregnated,
the combustion is consequently perfect, without smoke or
vapor, and with less consumption of fat. It is then not
to be wondered at, that, notwithstanding the two candles
were lit simultaneously, B should outlast or burn longer
than A. By a repetition of this experiment, it will be
also observed that the candle with the finer wick requires

but very little snuffing, burns well, sheds a beautiful light, and does not run.

The size of the wick must be adjusted to that of the candle, and upon the principle already stated, of consuming the fluid fat in the reservoir below the wick as fast as melted by the radiated heat of the flame. Moreover, the wick itself should be wholly consumed at the temperature of the flame, to which end it must have free access of air. This is only partially accomplished by means of the straight wick of the common tallow candles, and, consequently, frequent snuffing is indispensable to maintain a good light. A single wick woven so that its lateral tension will be relaxed when the tallow melts around it, would answer much better; for, in burning, its end would bend and reach the action of the atmosphere. So, also, by twisting the strands double, the wick will uncoil during the burning of the candle, and present its two ends at the side of the flame and within the atmospheric influence.

PLAITED WICKS.

The many defects of the common wick are, in a great measure, remedied by the use of plaited wicks, a useful invention which has hitherto only been applied to candle-stock of high melting points, such as vaxeme, ceromi-meme, stearic acid, &c. This is because the end of the wick, in bending to reach the air, during combustion, would unduly heat that side of the candle to which it inclined, and cause it to gutter if made of very fusible fat.

According to Morgan, the failure to use plaited wicks, successfully, for tallow candles, is because they are made of too many plaits for the purpose; and he has recently announced a plan for making them of proper adjustment, and which he describes as follows:—

Morgan's wick for tallow candles.—This kind of plaited

wick, intended for "*moulds*" and "*dips*," is described as follows by the inventor :—

"In the manufacture of mould candles, made wholly or for the most part of tallow, I prefer to employ platted or plaited wicks composed of double yarn (though single yarn may be used) ; that which I have employed for the purpose is No. 18, double unbleached cotton yarn, such as has heretofore been employed in making other platted or plaited wicks for candles. And in the manufacture of dip candles, made wholly, or for the most part, of tallow, I prefer to employ single yarn ; and I have used No. 5, unbleached cotton yarn, such as has heretofore been employed for making other platted candle wicks, but finer or coarser yarn, or double yarn may be used in making the description of wick which is to be used for "dips" to carry out my invention. The quantity of wick used in a candle, whether 'mould' or 'dip,' will, as heretofore, depend on whether the candle is desired to burn quickly or slowly. For ordinary purposes I employ, in the making of mould candles, called 'short sixes' and 'long fours,' a wick consisting of three strands, with ten double No. 18 yarn in each strand. These strands are platted together, each plat or link of the plat being about five-sixteenths of an inch in length, that is, about four links or plats in one and a quarter inch length of the wick. It is not essential that this exact length of link or plat should be observed, but a material departure therefrom will prevent the wick burning well in a mould candle composed wholly, or for the most part, of tallow. In making other sizes of candles, I use proportionately larger or smaller quantities of yarn in each strand, according as the candles are of larger or less diameter than what is above mentioned ; but I retain, in all cases, as near as may be, the same length of link or plat. And if I wish the candles to burn faster or slower, and therefore to give a greater or lesser

light than will result from the use of wicks, such as are above mentioned, then I use more or less yarns in each strand of the platted wick. In making dip candles, 'eights' and 'sixes,' I ordinarily use a plat of three strands, each strand being composed of eight No. 5 single unbleached cotton yarn, and I vary the quantities of yarns in the strands proportionably when for candles of larger or less diameter; and also, when the candles are desired to burn faster or slower than will result from the quantities above mentioned. In all cases, however, the wicks are to be platted with links or plats of about three-eighths of an inch in length, that is, that there shall be about four links or plats in an inch and a half of the length of the wick when the wick is in the natural or un-distended state. I would, however, remark that, although I believe three-eighths of an inch to be the best, yet some slight departure may be made without destroying the utility of the wick when used in a tallow candle; but, in all cases it is essential, according to my invention, that an inch of the length of the wick used should consist of less than four links or plats, as by such manufacture of can-dles, whether 'moulds' or 'dips,' the wicks will sustain themselves when burning, and will turn out of the flames sufficiently to be consumed without snuffing or causing the candle to gutter on the side to which it inclines.

"In using these wicks, they are to be held distended, and free from twist when in the mould, and until the candles are cold and firm. So, also, must the same pre-caution be observed in making 'dips.'"

Kempton's wick.—The inventor of this wick claims that the combination of bobbin, braid, cord, and yarn, with the common plaited wicks, adds great advantage to the latter, and renders them alike applicable to tallow, stearic, and other kinds of candles. He describes his improvement in the following language:—

" If the cord, braid, bobbin, string, or yarn, is to be combined in the plaited wicks, I cause it to follow the course of one of the strands. In making a plaited wick, the cord, braid, bobbin, or other string may be used and incorporated therewith, in which case I cause two of the strands, or the three strands, each to contain a cord, braid, bobbin, or string, of a substance or manufacture different from the yarns used in compiling the plaited wick, the object being to restrain the too great tendency of plaited wicks to turn out in one direction, particularly when common tallow is used for making candles with plaited wicks; and in thus naming cord, braid, bobbin, or string, I do so in order to state that the object of the invention is to restrain the bending of plaited wicks by the application of fibrous materials in a manufactured state, and in addition to the ordinary materials of plaited wicks used in making candles. And when the cord used is to be affixed to the plaited wick after it is made, I bind tightly around the ordinary plait and the additional cord, at intervals, a fine cotton or other thread, and thus combining the plait and the cord together. Care must be taken that whatever be the description of the cord or bobbin, affixed to, or applied in a wick, that it shall not be of such a strength and relative dimensions in respect to the plaited wick employed as to prevent that plaited wick turning sufficiently out of the flame, in order that the burned end may be dissipated. In affixing a cord, bobbin, &c., to a plaited wick for a candle, care is to be observed that it is on that side of the wick where the strands of which the plait is composed, run upwards and from the centre outwards to the edges of the plait, for it will be found, on examining a plaited wick which is burning in a candle, that the wick at all times bends on that side where its component strands run in a direction upwards from the sides of the plait into the centre thereof. This will be better under-

stood by reference to the figures. Fig. 75 exhibits part of a plaited wick on a magnified scale, in which the strands run upwards and outwards from the centre to the

Fig. 75.　　　　　　　　Fig. 76.
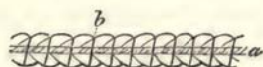
sides, *a* being the small hard twisted cord which is attached to the plaited wick by a binding thread *b*, which I believe is the best mode of attaching the cord to the plait. Fig. 76 shows a view of part of a plaited wick on a magnified scale, taken on the reverse side to that shown in Fig. 75, and it will be seen that the strands of which the plait is composed, proceed from the side upwards, and to the centre of the plait, and it is this side on which the plait will bend when being consumed in a candle. These plaited wicks are of ordinary construction, but not so tightly plaited. They are composed of three strands of soft cotton yarn, with several yarns in each strand, which are simply laid side by side, and in that state the three strands are plaited, and the twisted cotton cord which I am using, therewith consists of three strands of cotton yarn, each strand consisting of three yarns of cotton, the strands being twisted separately at first and then afterwards the three together; and I find that, taking any length of wick and the same length of cotton cord, that the plaited wicks weigh eight and a half parts and the cord three parts. I am thus particular in giving such exact quantities, because much attention is required in seeing that the twisted cord or other preparation of fibres into a cord or yarn should not be too strong for the wick with which it is used, otherwise the wick will be pre-

vented turning out sufficiently, and it will be desirable, when commencing with any cord, to try a few candles first, to ascertain whether the combined wick is too strong, or too weak, and when properly adjusted, the manufacturer may constantly continue using the same materials, and the workman, after a little practice will quickly judge of the proper using of my invention, and plaited wicks will require less controlling by the cord used; and when the matter of which the candles are made melts at higher temperatures, the wicks and cords above described, are for common tallow candles.

"It has already been stated, that when the ordinary plaited wicks are burnt in common candles, the excess of heat arising from the preponderance of flame on one side of the candle causes the tallow or other substance to melt rapidly on that side and gutter or run down. Now, by the addition of the twisted cord, or other preparation of fibres into a cord, when the same is incorporated in the plaited wick, it will prevent the wick bending too much out of the flame; and when it is affixed to one side of a plaited wick, it causes the flame to descend lower on the side of the wick opposite to that which turns outwards, in addition to its preventing the wick bending so much outwards, thus counterbalancing the excess of heat on the other side, and the candle burns evenly, steadily, and brilliantly. In some cases I find it advantageous to use two plaited wicks in the same candle, each wick having a cord or thread as above described, the cords or threads of the two wicks being towards each other when in a candle, by which arrangement it will be evident that the two wicks will turn out from the flame in opposite directions, and for this purpose, I prefer to use hempen yarn or twine."

In making mould candles, the combined wicks are to be inserted in the moulds in the usual manner, taking

care, however, that the wicks are right end upwards, as above described and explained. When making " dips," the wicks are plunged successively in the tallow, as usual, keeping the cotton straight at the commencement of the dipping.

Tindall's wick.—This invention consists in a peculiar mode of applying plaited wicks to candles by means of a flat metal rod, wire, or instrument; the object being to make the candles with double wicks, which will turn from the centre whilst burning, and be consumed without requiring any snuffing. It is well known that the lighted end of an ordinary plaited wick bends over upon that side in which the strands run upwards from the outer edges to the centre; whilst on the opposite side of the wick the same strand will be found to run upwards from the centre to the outer edges; and the patentee takes advantage of this circumstance, and arranges the wicks accordingly upon the instrument employed for inserting them in the candles. The ordinary plaited wicks may be used, and the instrument may be made in any manner that will answer the purpose; but the form used by the patentee is represented in the margin. It is a thin narrow rod, of steel, brass, or other metal, rather longer than the candle intended to be made, having two flat sides, with a handle at one end, and a notch at the other. The following is the mode of employing the instrument:

Fig. 77.

The plaited wick is first placed against one of its sides, commencing near the handle *a*, in such a manner, that the strands on that side of the wick which comes next the instrument, shall run upwards towards the notch *b*, from the centre of the wick to the outer edges; the wick is carried up to the notch and then twisted, or turned half round; which twisting or turning enables the operator to conduct the wick from the notch along the oppo-

site side of the instrument, with the strands on that side of the wick which comes next the instrument running upwards from the centre to the outer edges, in the same manner as the strands on the other side. Both ends of the wick being then fastened, by thread or other means, to the instrument at *c*, it is ready to be placed in the candle mould.

Palmer's wicks.—This is an arrangement of two similarly plaited wicks in the same candle, and in such a manner that they will both turn in the same direction out of the flame. It is accomplished in making the wicks by forming one or more strands into a linked or looped plait, as represented at Fig. 78, the strand or strands being

Figs. 78, 79.
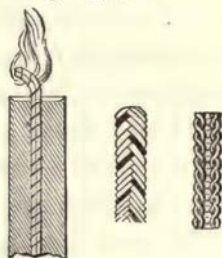
composed of several yarns, either loose, or formed into a cord, or otherwise combined.

"The machinery used in making the linked plait, is of the kind called 'warp lace machinery;' it should be of a coarse gauge, and have only one row of guides; that is, one guide to each pair of needles on the needle bar; each guide is to lap over two needles, in order to form one loop thereon—which, being carried under the beards of the needles, the work that was previously on their stems is forced off, and thus each pair of needles will make a linked plait or cord."

The wicks are strengthened or gimped by binding a thread or yarn around them in a spiral direction, as seen

at Fig. 78. The face or bending surface of one wick comes against the back of the other, and they will thus incline out of the flame in the same direction.

Doudney's wick.—According to the inventor, the plaited wick used in "vaxeme" and stearic candles, so advantageously, on account of requiring no snuffing, and supplying other desiderata, have failed in applicability to tallow candles, owing to their mode of manufacture; they having, in the first place, been too small, and when increased by an additional quantity of the same description of fine yarn, failed to yield a better result. Such wicks, plaited with one hundred to one hundred and twenty fine yarns to each, become overloaded, fall, and consequently cause the candles to gutter or run on one side. It is contended that a plaited wick of a limited number of coarser cotton yarns, having only enough twist to retain them in the form of yarn whilst being worked into a plait (it being desirable to have the cotton soft in the plaited wicks), will be free from objection. The cotton yarn must be bleached, and of such size that one pound avoirdupois will measure from 5,000 to 5,050 yards. If the thread or yarn be finer, then its applicability is proportionably lessened. For both mould and dipped candles the sizes most preferable are the following: "For 'short fours,' the wicks are formed of three strands, each composed of thirteen yarns; for 'long fours,' and 'short sixes,' three strands of eleven yarns each; for 'long sixes,' and 'short eights,' three strands of eight yarns each; and for 'long eights' and 'short tens,' three strands of six yarns each. If a greater degree of light is required for any of these sizes of candles, the number of yarns is increased, or coarser yarns are used; but coarser yarns are used in all those cases where the increased size of the wick would require more than forty yarns, of the degree of coarseness above mentioned.

"In making the wicks of such yarns, the strands are to be plaited together tightly; and thus made, when used for dipped candles, are each supplied with a thread loop."

Waller's wick.—This wick, which is applicable for both dipped and mould candles, is plaited together "with two sets of three strands, in such manner that two plaits of three strands each are produced and joined together at their selvages, whereby the central portion of the combined wick is made thicker than the two outer edges or selvages. Such plaited wicks are made by a braiding or plaiting machine."

We will not enter into a description of a braiding machine, but only explain how the tappets work to cause the pipes to interplait their strands so as to produce two three strand plaits joined together.

Fig. 80 shows an outline sketch of three braiding heads

Fig. 80.
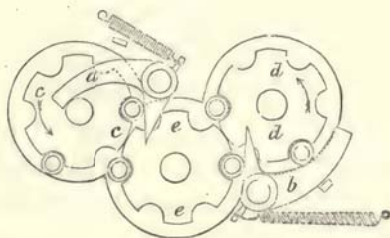
or tables, each having six notches, there being six pipes; the only peculiarity of the arrangement is in the use of the tappets *a, b,* constantly drawn on by their springs, as shown. In the revolution of the heads, *c* and *d,* in the direction of the arrows, they will each produce a three strand plait, and these plaits will be joined together by means of the head *e,* into which the pipes for the time being, that are producing the selvages or edges, pass, so

as to link their strands, and by so doing join the two plaits.

The other working of the machinery will be well understood by the workman experienced in the management of such apparatus, or will be explained by the machinist who builds it.

One feature in this invention is, that in applying the plaited wicks to dipped candles, the cost of fastening loops at the upper end of each is dispensed with, and iron wires or rods substituted. These wires, which should be pointed, are run through the upper end of each plaited wick, thus suitably suspending the wicks for the process of dipping.

Plaited and braided wicks are made to order, after any pattern, by the manufacturers in New Bedford, New York, and Philadelphia.

WICK-CUTTING MACHINES.

The wicks for tallow candles are generally cut by a machine; and there are several forms of the apparatus. The simplest is shown by Fig. 81, and it consists of a

Fig. 81.
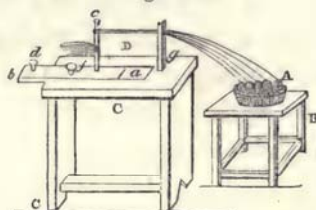
strong table C C, the board forming the top of which is surmounted by a second plank, with a longitudinal opening a, along its centre, serving as a groove for the sliding shelf b, carrying the iron broach c, vertically fastened on. A wooden knob d, placed at the end of this shelf, answers as a handle to draw it in and out. The key f

23

opposite, is to fasten the shelf, and consequently the iron broach, at any convenient point, proportional to the length to be given to the wick. At the end of the table, on the left of the workman, is firmly fixed a knife, g, the edge of which is turned towards D.

At the side of the table is placed a stand B, and upon it are set the baskets holding the balls or clews of thread. The workman, generally a woman, occupies a stool before the bench, and adjusts the lengths that the wicks are intended to have, by regulating the distance between the knife g and the broach c accordingly, and with the screw f, which renders the latter, as well as the slide, immovable. The wicks are then cut in proper manner, and of uniform length, so that their ends will be even.

The wick is then placed between the palms of the hand without being removed from the broach, and twisted slightly by gliding one hand over the other, so as to prevent the threads from separating, and to shape around the rod a kind of loop or eye. Afterwards, and without raising the wick off the rod, it is placed upon the end of a table at the right. In this operation, the workman must hold on steadily to the ends of cotton which remain in his right hand after he has cut the wicks; and when he has thus prepared a number of wicks sufficient to fill a rod, they are laid flat by the side of each other, and then inspected; but without being taken off the rod. If any thread is seen detached, or detaching itself from the bunch, it must be picked out, and all the ends of the wicks being assembled together, the workman clips them evenly, and with the pressure of one hand near the loop, forms an indentation around which a fastening is placed, and the packet is then thrown towards the end of the table.

These packets are not all composed of the same number of wicks; they vary according to their size, or what is the same thing, according to the number of candles to the

pound. Each consists of twelve where the candles are to be four to the pound; of fourteen for fives; fifteen for sixes, and sixteen for eights, and so on.

In preparing the wicks for mould candles, the rod is filled as full as it can be without regard to number, and then emptied of its load upon sundry smaller rods. It is from these latter that the workman threads the moulds.

As to the wicks for the dipped candles, when the rod is full, its burden is distributed upon smaller wooden rods, smooth throughout their length, and sharp pointed at one end so as to facilitate their entrance through the loops of the wicks. These wooden rods are always of two and a half feet length.

Another cutting machine, possessing all the advantages of the before-mentioned, and many others additional, is that manufactured after an English pattern by Mr. Brock Watson, Philadelphia. It cuts, spreads, and twists the wick in one operation, and so rapidly, that a dexterous workman can prepare for 1,000 pounds candles per hour. The machine is neither costly nor complicated, and the mode of working it both simple and easy, as its management can be so regulated as to occupy only the intervals between the moment of charging the melting kettle with tallow, and the time it is ready for dipping use. In this way the wages of one man are saved, for, by the old plan, a separate hand is required exclusively for cutting and preparing the wicks. Being very compact, and readily taken apart, it is also convenient for transportation, and when put up, occupies no more space than an ordinary counting-room desk.

Fig. 82 represents the apparatus. A is the body of the machine, serving as the bed of the upper works, in the interior of which are the pulleys that regulate the movement of the carriage B, worked by the treadle G. The carriage B, a kind of framework running on wheels,

contains a range of boxes, placed shelfwise, as receptacles for the balls of wick, one of whose ends runs through a notched reed below H, and comes forward upon the twist-

Fig. 82.
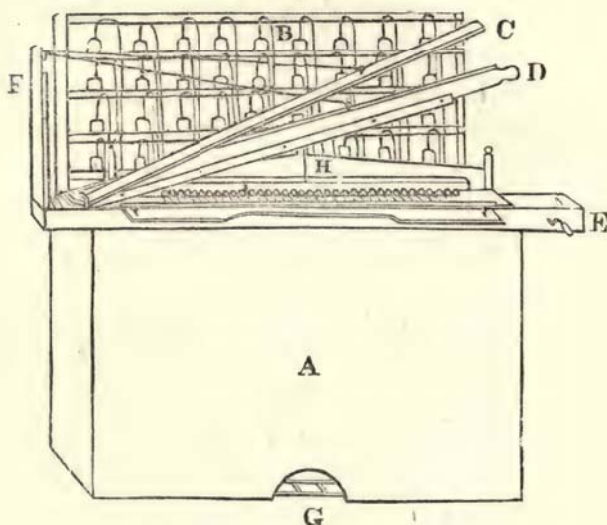
ing board E having fastened to its back edge a knife serving as the under blade of the movable clipper D. This, when drawn down vertically, severs the wicks evenly. The twisting box E C consists of two boards hinged, and moving on rollers. A turn of the crank near the end communicates that motion which twists the wicks after they have been cut by the knife E, and this knife having effected its purpose, is immediately drawn upwards again by a counterpoise F. At the front of the twisting box D, is a sliding board so fixed, that it can be graduated to regulate the required length of the wicks.

Motion being communicated to the machine, the wick yarn is then cut, spread, and arranged on the rod simultaneously, and in complete readiness for dipping; as soon as the workman removes it, another rod rolls into

its place. When either the wick or rods give out, a fresh supply must of course be substituted.

A third form of cutter is intelligibly presented by Fig. 83. The wick cord, consisting of the number of threads

Fig. 83.
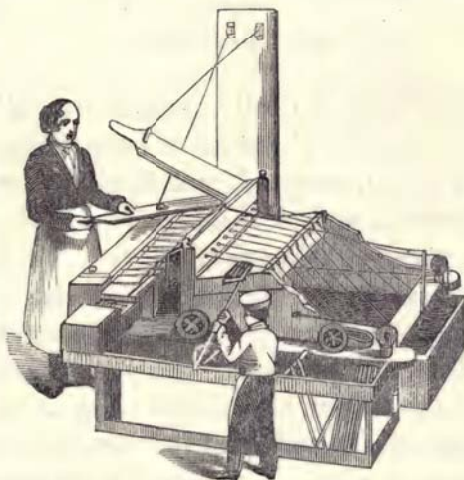
requisite for the size of candle under process, is reeled upon spools which are placed in a drawer at the rear of the machine. The ends being then drawn over a rod, and adjusted to the proper length, the knife is drawn down and cuts, evenly, a whole range of wicks at one operation; the action of the machine giving them, at the same time, a slight twist. The rod is then removed and replaced by an empty one, to be in its turn filled, and, like the first, hung upon a wooden framework made for this purpose, until preparations are completing for dipping them. The recent improvements in candle-moulding machinery has rendered the cutter unnecessary, except for the wicks of " dips."

CHAPTER XXVI.

DIPPED CANDLES.

THESE candles, technically termed "dips," in contradistinction to "moulds," are made by stringing a certain number of wicks upon a rod, and dipping them in melted tallow, repeatedly, and at intervals of sufficient duration to allow the successive layers of tallow to harden. When the candles have acquired the desired size by these repeated coatings, they are finished. A careful manipulation is well repaid in the improved appearance of the candle; and the tallow, too, should be clean and hard, to insure a product of good quality; but, as these candles are the cheapest kind, and hence mostly used by the poorer classes, they are not unfrequently made of inferior tallow.

Dips and moulds, as made from common rendered tallow, have a yellowish shade when first made, but they soon bleach by time and exposure. Those made from inferior tallow "run," and are greasy. Pressed tallow makes the best candles for warm climates; but, whether used in this state, or unpressed, a mixture of mutton and beef tallow will make a stock superior to either of the two kinds separately.

There are three methods in use for melting the stock, viz: melting over the naked fire, in a steam bath, and by steam.

Melting by the naked fire.—This plan requires a copper kettle, mounted in brick-work, and similar to that shown by Fig. 64. To prevent injury to the tallow and candles,

from dirt and smoke, the fire-door must be on the outside of the apartment. This arrangement, likewise, protects the workman from the discomfort of immediate proximity to the furnace, and lessens the probabilities of accident from fire.

Presupposing that the tallow is of refined quality, and has already been brought to the condition of candle-stock by some one of the processes given in Chapter XXIV., it is now necessary, before putting it in the kettle, to reduce it to small lumps with a suitable knife or cleaver. This precaution will facilitate its fusion, and, consequently, prevent it from being scorched and colored by a too lengthy contact with the heated sides and bottom of the kettle. Sometimes a little water is added as a protecting medium against undue heating, and in such instance the kettle should have a cock near the bottom for drawing it off, after the fusion of the tallow. Any dirt or dust that may be contained in the tallow will, by its greater density, precipitate as the tallow melts, and be carried away with the water. The heat must be so regulated that the contents of the kettle shall not attain a temperature above 212°.

This plan of melting is, for evident reasons, objectionable, and should never be adopted when it is convenient to use the method of—

Melting by steam-bath.—In this arrangement the melting is effected by steam heat, as will be seen by the following drawing.

Fig. 84.
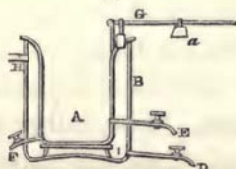
A is a copper caldron, enveloped by a second caldron,

or jacket, of copper or iron, in such a manner as to leave an intervening space or chamber of three to five inches. The bottom of the jacket is exteriorly concave, and the two kettles are hermetically fitted together at their mouths. A tripod I, which rests upon the bottom of the jacket, serves as a support for the weight of the inner kettle. At a point the most convenient near the bottom of the kettle, is placed a tube D, fitted at its outlet with a cock, through which is drawn the condensed water. The interior kettle carries two tubes, each fitted with a stopcock, the one E, about two inches from the bottom, serving as an exit pipe for the clear rectified tallow floating upon the substratum of drossy deposit; while F, which is even with the bottom, is an outlet for the settled water and impurities. G is the safety-valve.

The steam is conveyed from the steam boiler of the establishment through a tube coupling with the nozzle H. In small factories, where the use of an engine is not required, steaming may be economically accomplished by means of one of Bentley's portable generators, which are very compact, convenient, and inexpensive, as they need no brick-work, can be removed at will like a stove, and consume comparatively only a small amount of fuel. The drawing, Fig. 32, gives a view of the apparatus.

There is no need of any water on the bottom of the inner kettle, as its contents do not acquire a temperature above 212° F; and, consequently, there is no possibility of the tallow becoming scorched.

Melting by steam.—This method consists in the use of an upright vat of copper or of an iron-bound wooden tub, into which, and down the sides, interiorly, runs a copper pipe through which the steam is introduced directly from the boiler or generator. The tallow being placed in the copper or tub, steam is then let on, and its flow regulated by a cock in the conduit just above the top. When the

fusion is complete, sufficient repose is allowed for the thorough deposition of the condensed steam before commencing to draw off the supernatant fluid fat, for the least water will impair the burning quality of the tallow.

This and the preceding method, permit the regulation of the temperature to any desired degree below 212° F., which is the highest heat required for the present purpose. In working over the naked fire, it is not so easy to manage the heat of the pan. The containing or boiling vessels should always be kept strictly clean.

The annexed drawing shows the arrangement for boiling directly with steam.

The steam boiler or generator is seen at A; and it can be charged with water through the funnel hole E, which is fitted with a screw plug; or, it may be still more conveniently fed as directed at B and N. The fireplace is at K; and the movable dome F, covering the flues with the aid of an attachment of stove-pipe, carries off the smoke. Either wood or coal may be used as fuel, but the former renders necessary a semi-weekly swabbing of the flues, to remove the accumulated soot. The dome being movable, makes this operation very easy. The gauge cocks are h h, the upper serving as a guide for the maximum, and the lower for the minimum height of the water in the boiler. The safety-valve D is so arranged as to prevent all possibility of explosion, provided the water is not allowed to get above the upper nor below the lower gauge-cock h h.

The cast-iron chamber, or box L, with its damper G, is for the admission and regulation of the draft. The pin L, which is movable, supports the grate, and, by being drawn out, allows the removal of the ashes and cinders as may be necessary. When the damper G is pushed closely against the opening in the box L, the draft is stopped, and the boiler may be left without fear of any accident.

The cask, or reservoir B, contains the water for feeding

the boiler, and which is kept warm for that, and other purposes of the factory, by means of a steam pipe. A
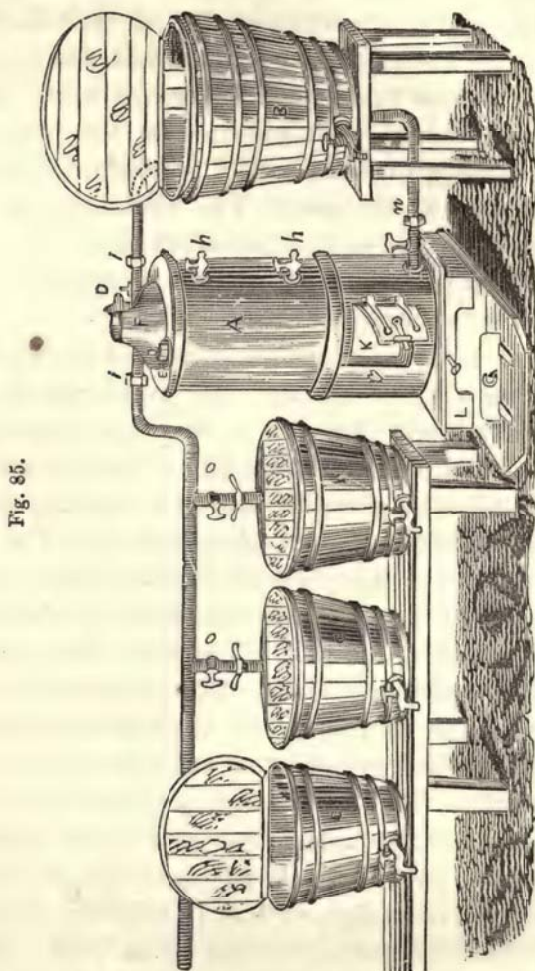
Fig. 85.

pipe and feed-cock N, at the bottom of it, serve as the conduits, the pressure of the superincumbent mass of water being sufficient to keep up a supply of water in the boiler. By leaving the feed-cock n partly open, the water will at all times be forced into the boiler in propor-

tion as its charge is being exhausted by conversion into steam. The gauge-cocks will show when water is needed, and the cock *n* can be opened or closed as may be necessary.

The boiling-tubs, or kettles, are shown at C C C, resting upon a platform, and heated by means of the branch-pipes *o o o*, connecting with the main stem. The coupling *i i* connect the tubes conveying the steam to the range of tubs.

Sometimes the melting is accomplished by the indirect application of steam upon the principle of the steam bath, but in a different manner. The arrangement consists of tubs, as above mentioned, with a coil of copper pipe laying close to the sides and bottom of the tubs, and connecting with a waste pipe on the outside as a conduit for waste steam and water. It is not cullendered, nor does it admit the steam into the tallow. The melting is accomplished by the heat radiated from the metallic coil. In some factories the boiling tubs, usually of wood, are lined with copper.

The dipping trough.—This is a tightly jointed or dove-tailed walnut or cherry trough for receiving the fluid tallow, to be used as the dipping bath. Its form is shown by Fig. 86; the opposite side, *a*, being three feet long by

Fig. 86.
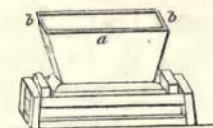
two feet high; and the opposite ends *b* of the same height, and twelve to eighteen inches breadth at the top. The width of the trough should gradually lessen downwards, so that the bottom may have only six to eight inches. On each end is a handle, for the convenience of moving the trough from place to place when necessary; though it is generally kept stationary; for which purpose it is

mounted upon a wooden platform. The ledges are slightly inclined, so that the suet which falls upon them can run off into vessels placed beneath to receive it. When the trough is not being used, it should be closed with a cover, made especially for the purpose, so as to exclude all dust and dirt.

The workman commences operations by filling the trough with hot tallow, and thus forms the bath into which the wicks are to be dipped, as follows : He takes ten or twelve rods, each strung with wicks as shown by Fig. 87, and dips them simultaneously into the liquid suet,

Fig. 87.
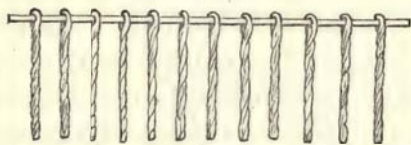
and lets them soak thoroughly. It is necessary that the tallow should be hot, in order that the absorption may be more complete. But it is not solely on this account that the suet should be hot for the first dip ; for the dry wicks sink more easily into the well heated and consequently more fluid tallow, and distend more readily and perfectly, than if the suet is too cool and dense. The wick, which is flabby on entering the liquid fat, does not afterwards fully straighten out, and hence causes the candle to be defective. The first dipping having been made, the batch of rods are rested upon the ledges of the trough, and one after the other lifted up and examined. After having separated such of the wicks as may have matted together, the workman carries the whole batch of rods to the neighboring frame, represented by Fig. 88.

This frame is formed of four upright and four cross pieces of wood, well and solidly jointed together. The

rods are placed upon the cross pieces a b c, and the uncongealed tallow dripping from the wicks falls into the

Fig. 88.
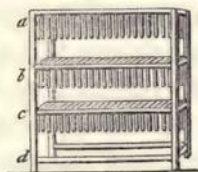
basin d, beneath. Whilst the workman is preparing another batch of rods and dipping them, those first dipped have so far cooled that but very little tallow drops from them. In the same manner, he continues until he has soaked all the wicks prepared to be dipped. This quantity should not exceed in number more than can be managed between the time of soaking the first batch, and the period when the tallow of that batch has cooled sufficiently for a repetition of the dip. If the tallow be too hot, the layer which attaches to the wick will be too thin, and the candle become, in the workman's language, spotted. If, on the contrary, the tallow is too much cooled, the layer is irregular, and the candle is rough. The proper degree of heat is reached when the tallow commences to congeal on the sides of the trough. If, during the operation, the tallow has cooled too much, the temperature must be equalized by stirring in an addition of hot tallow. By a renewal of hot tallow, from time to time, the bath is kept at a uniform degree of heat and liquidity. The stirring paddle serves also to scrape the bottom and the corners of the trough, and when clotted with cold suet, it is relieved with a copper trowel or iron spatula. The same trowels serve also to collect together the tallow which accumulates upon the ledges of the foundation.

Some chandlers use a dipping bath, made of metal,
and heat it with coals placed beneath. This mode is not
to be condemned, provided it can be so managed as to pre-
vent a too great fluidity of the tallow, and consequently
a hindrance to the consecutive dips following the first
soaking. Two or three rods are the usual number handled
at once in the second and subsequent dippings, but the
fatigue consequent upon this mode of dipping by hand is
so uncomfortable that several inventions have been made
for doing the work more conveniently and expeditiously.
One is shown, in end view, by Fig. 89. It consists of a
strong bar of deal wood two inches longer
than the rods, and two to three inches
breadth. This suspension bar is of one inch
thickness throughout its length. At the
ends are two iron hooks, *c f*, and in the centre
are two other hooks which serve as supports for the rod.
It may be made to carry two, four, or more rods. The work-
man shakes each rod to separate any of the wicks which
may have adhered together, dips them into the melted
tallow, and, upon lifting them out, gives each rod an ex-
pert movement so as to disentangle the wicks which have
adhered together. This dipping operation is a delicate
one, and requires experience and dexterity, for if two or
more wicks mat together during the cooling of the tallow,
there is much time lost in making them follow the proper
direction; and, moreover, such candles are badly shaped.
This dip being completed, the rods are placed upon the
lower tier of the frame, in order that the drops of tal-
low which trickle during the congelation shall not fall
upon any other candles more advanced to completion, and
thus damage them, particularly if they are nearly finished.
As soon as the tallow is at the proper temperature, as be-
fore explained, then the other dips are proceeded with.
The second dip is more easily made than the first, because

Fig. 89.

the wicks, having acquired a consistence, sink much better into the tallow. After dipping the wicks once, they are lifted entirely out of the tallow, allowed to drain a moment, and then dipped their whole length anew.

The tallow is apt to aggregate at the lower end, and form an ill-shaped butt; and to prevent this, the candles are plunged two or three times consecutively, to a third or a fourth of their length, in order to melt off the excess of suet and render them more truly cylindrical. This operation requires care and expertness; and, if it happens that the tallow is not sufficiently hot to melt off the excessive suet, the action of the bath must be continued until the size of the butts becomes uniform with the upper part of the candle.

It is impossible to prescribe the exact number of dips that should be given to the candles, as it depends upon the size they are to have, and on the temperature of the tallow. Experience will teach when the candle is finished. At the last dip, the workman forms the neck of the candle by plunging it deeper into the tallow; and, by thus imbuing the tip of the wick which has not been previously soaked, there is formed a small cone through which protrude two small ends of the wick, to facilitate ignition.

It is hardly necessary to repeat here, that the workman should, after every dip, carry the rods loaded with candles to the dripping-frame, and place them in tiers, the more elevated as he approaches the end of the operation.

When all the layers are very thin, the base of the candle forms an unsightly point. In such case the candles should be pared off so as to be made of uniform length, and for this purpose, a particular kind of scraper is required. It is represented by Fig. 90. In the top part of a strong legged, and tightly jointed table A, is adjusted a kind of bottomless hopper B. Between the legs of the table, and upon the lower cross pieces C rests an iron plate

D with raised edges, supporting a small square sheet-iron furnace E, which, when filled with ignited coals, furnishes

Fig. 90.
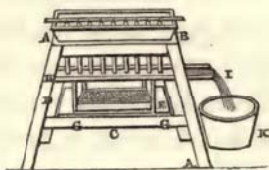
the requisite heat. The iron plate D sustains, by four small columns G G, a copper platten H I, a little inclined towards I. This platten has a raised edge of six lines on every side except I, which terminates in a spout for the safe conveyance, without waste, of the suet into the vessel K.

The hopper B, is intended solely to protect the body of the candle from the effect of the fire, but it can be made to serve another purpose, and that is, to prevent the paring of the candles more than to a definite extent. To effect this, the machine must be so constructed, that it can be let down so as to have, at will, a distance from the top to the surface of the copper platten H I, proportional to the lengths the candles are to receive. This is easily done by piercing the two smaller ends of the hopper with holes at different heights; and two holes in each of the upper cross pieces of the foot. It is adjusted at the proper point with pegs.

This generally terminates the operations for dipped candles, there being naught else to do, except string them in pound packages for the market. The dipped candles, as is well known, are very uncouth and unequal in their appearance, and but seldom perfectly cylindrical and neat looking. To obviate these disadvantages, a method has been planned, by which they are made to assume exteriorly, a similarity to mould candles. The

process is to pass the candles through a kind of draw-plate, and is practised as follows. A box-wood board, twelve inches long, two inches broad, and four or five lines thick, is bored its whole length with ten holes, distant from each other six lines. Fig. 91 shows this draw-

Fig. 91.
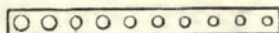
plate. The first hole is perfectly round, and in diameter equal to that of a five mould candle. The holes are neatly beveled on one face, so as to give a sharp edge to the other. These edges being well smoothed, the plate is complete. There should be one for each sized candle, the dimensions of the holes varying accordingly.

When the candles are well dried, they are caught one at a time by the loop of the wick with a small iron catch, and drawn through the large hole of the plate conveniently and firmly fixed to a table. In this way, some excess of tallow is pared off. By repeating the manipulation through all the holes consecutively, the candles are reduced to a uniform size, and become more agreeable to the sight. A little experience enables a rapid dexterity on the part of the workman, so that much more can be accomplished in a day than would be supposed by the reader.

For those who work at benches, such as shoemakers or tailors, there is a kind of candle made by the union of three dipped candles, after the third plunge. Thus joined, they are dipped together as one candle, which, when finished, presents three wick heads. Each being ignited, the whole throws out an economical light.

Another improvement for dipping candles, is shown in
24

front view and profile and plan by the annexed drawings, Figs. 92, 93, and 94.

In this machine, the rods, loaded with wicks, are ar-

Fig. 93.

Fig. 92.
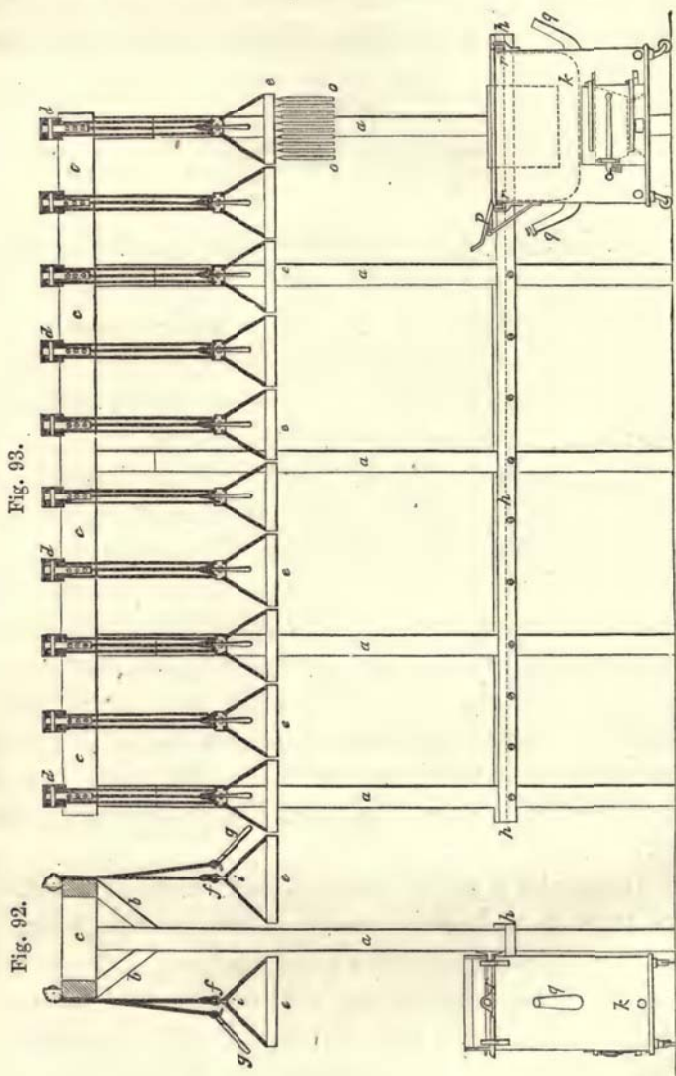
ranged in movable frames suspended by cords over two vessels or baths, one inserted within the other. The

larger, or outer bath, with its charge of tallow, is gently heated, by the furnace beneath, to 90°–95° F., so that the inner bath, deriving its heat from it, may have a tempera-

Fig. 94.
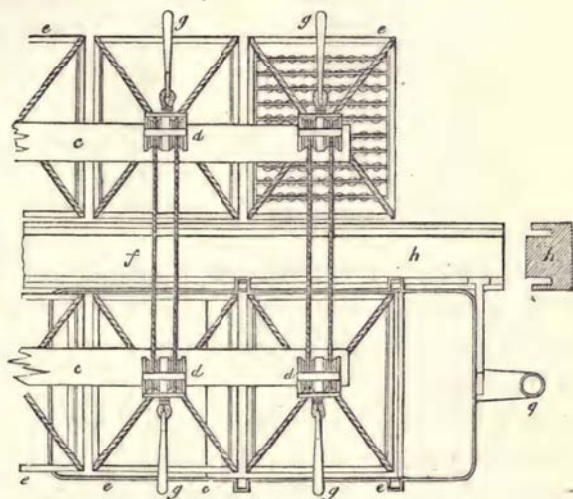
ture of from 55° to 60° F. A workman raises and depresses each frame alternately with the hand, and thus dips and re-dips the candles until they have attained their proper size.

The framework consists of five oak-wood beams *a*, each bearing, near its top, two abutments *b*, connected together by the long cross pieces of an horizontal frame *c*, throughout the length of which are five small traverses, and into each of which is tenoned and mortised one of the beams or posts *a*, of the frame.

The iron caps *d d* are fixed upon the sides of the long cross pieces of the frame *c*, and each has two brass pulleys. The fastening or connection of one of these caps is seen both by front view and profile, Figs. 95, 96. Each pulley receives a cord *f*, at the end of which is suspended a small

wooden, rectangular frame, double grooved interiorly, for
the reception of the rods which carry the candle wicks.
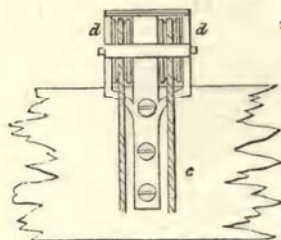
Fig. 95.   Fig. 96.
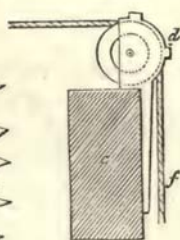
The wooden handles of the cords *g g* have each a hook
fastened in a hole in the centre of a small rectangular
iron plate *i*, to which are attached the cords of the pul-
leys, and the frame *e*.

The long traverse or cross piece *h*, is grooved on each
side to facilitate the movement of the furnace, seen in
vertical cut at Fig. 97. This furnace runs on four casters,

Fig. 97.
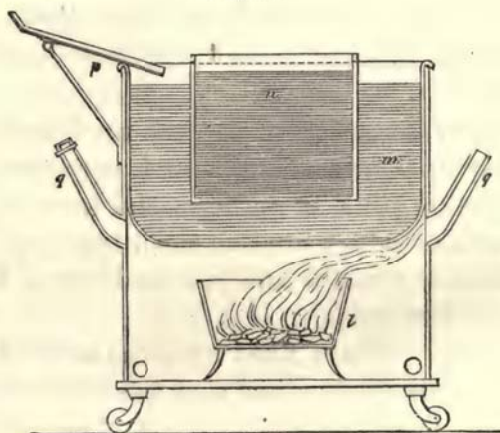
so that its position may be readily changed; and it has
two doorways for the service of the small furnace *l*, which

holds the coals for maintaining the fusion of the tallow m, contained in the larger tinned copper basin. This tallow, thus kept at a temperature of 90° to 95° F., imparts sufficient heat (50° to 60° F.) to the contents of the smaller or inner basin, to insure the adherence of the tallow to the candles o (Fig. 93), each time they are dipped therein. Upon the ledge of the larger basin is an iron drainer p, on which such portions of tallow fall as have not congealed, when a frame of candles is being brought into the smaller basin. The tallow which drops, is, by the inclination of the drainer, directly conveyed into the large basin.

The furnace is fed by two currents of air, admitted through two draught ways q, which are opened and closed at will. The crotchets r, work in the groove of the cross piece h, and serve to conduct the furnace from one frame of candles to another.

The mode of operating with this machine is to fill the two baths with suet and tallow, mixed in proper proportion, and heat them to temperatures before directed. The furnace over which they are placed is then pushed forward until it stands immediately beneath one of the frames e, to which are suspended the wicks destined to form the core of the candles. These wicks are then lowered into the small basin, and dipped and redipped several times successively, until the candles have attained the proper size. This point reached, the frame is raised and left suspended by fastening the hook of the handle g through the centre of the piece i. When the candles of a frame are finished, and whilst they are cooling and hardening, the furnace is to be pushed beneath the succeeding frame, and the previous manipulations repeated.

This machine does its work rapidly, and is said to improve the appearance of the candles.

Another apparatus for making "dips," is shown by Figs. 98, 99, 100.

a is a longitudinal view of the copper, and b an inner
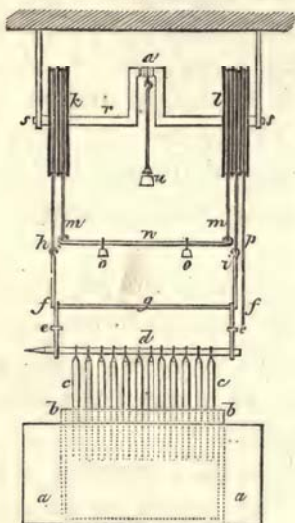
Fig. 98.   Fig. 100.
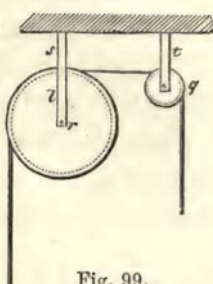
Fig. 99.
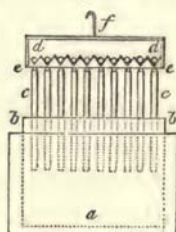
casing; c, the candles; d, the round wooden rods which carry the candles. There are ten of the latter, placed equidistant upon the same horizontal plane, as shown at Fig. 99. Two supports e, seen in profile at Fig. 99, and each notched to receive and firmly hold the ends of the rods d, are severally fitted with a hook f, catching at both ends of an iron bar g, suspended by means of two cords h and i.

The cord h is attached at its upper extremity to the circumference of a double-grooved pulley k, and works in one of the gorges. The cord i is also fixed at its upper end in the middle groove of a three gorged pulley l, a face view of which is given at Fig. 100. There are two other cords m, the upper ends of which are attached, one to the second groove of the pulley k, and the other to the interior

groove of the pulley l. The lower ends of these cords carry an iron bar n, on the length of which are hung the counter weights o.

The guide cord p, passes in the gorge outside of the pulley l, and in the gorge of another pulley q (Fig. 100); r is the horizontal beam upon which are fixed the two pulleys k and l, their trunnions or spindles being received in the two supports s, firmly fastened to the ceiling.

The pulley q is suspended by a cap, also fastened to the ceiling. The beam r forms, in the centre of its length, a crank or double elbow, to which is suspended a counterbalance u, having a weight at its lower end. The movable ring is mounted upon the tip of the crank, and carries a hook to receive the catch of the balance u.

To set this machine in operation, the workman draws the cord p, at each end alternately; this motion turns the pulleys k and l, and consequently raises or lowers the supports e, which dip the candles into the bath b, and draw them out successively. The balance u facilitates the movement, by hurrying on the crank after it has passed the vertex, the bar n, forming a counter weight, and serving to establish the equilibrium.

With this machine, candles can be made at all seasons; and when practice has rendered its management familiar and easy, its use is a great saving of time and labor, for one workman can turn out twelve hundred pounds per day, whilst by the old method, not a third that quantity could be made in the same length of time. It acts upon the same principle as the preceding apparatus, but being simpler, is particularly adapted for smaller factories. It will throw off one hundred and twenty candles at a time, that is, supposing every frame to carry ten rods of twelve candles each. In working by hand, only three rods can be managed at once; hence there is a saving by this machine of three to one.

Fig. 101 gives a perspective view of a part of another machine constructed for the accomplishment of the same ends as the two preceding apparatus. The upright beam *a*, revolving upon a pivot, has near its upper end a

Fig. 101.
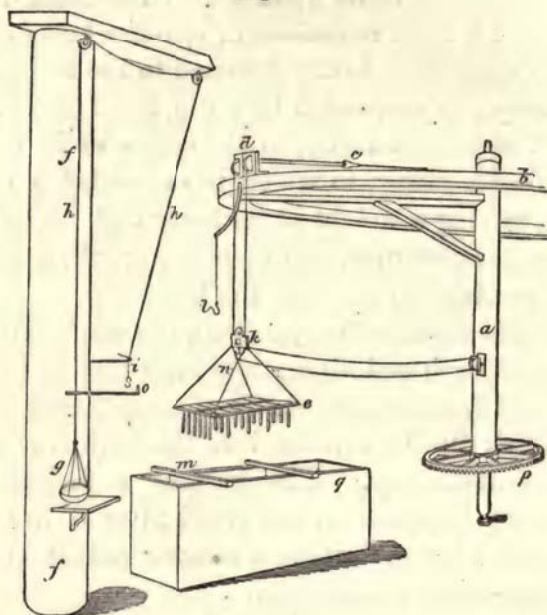
large horizontal wooden wheel *b*, divided off into twenty equal parts, by the cords *c*, passing upon the pulleys *d*, and carrying at their ends the suspended frames *e*, each bearing twenty rods of candles. The equilibrium is maintained by a weight affixed to cords and pulleys; but, as this is insufficient when the candles have acquired additional heaviness by successive dippings, there is another balance *g*, suspended by a cord *h*. This cord runs upon two pulleys, and has at its end opposite to the balance, a hook *i*, that is hitched, at will, in one of the holes of the square iron *k*, to which the frame is hung. This arrangement of a second counter weight gives a facility of re-

establishing the equilibrium which otherwise would. be destroyed, proportional as the candles acquire weight by successive dippings.

This operation terminated, it is necessary to secure the hook of which we have spoken, within a hook *l*, suspended above the frame, for without that, the candles which have been dipped, being heavier than those which counter-balance them, would otherwise descend to the floor. The frame suspended to this new hook should be drawn to-wards the pivot, that the workman may fill the bath *m*, with suet. This is done by pulling a cord, one end of which is attached to the frame carrying the candles, and the other passing over one of the pulleys, whose casings are screwed to the pivot. The frame is hooked on to a catch beneath the square iron *k*, by means of a ring *n*.

After having drawn this cord forwards, the workman hitches it by its ring to the hook *o*, in the pillar behind him.

A cog-wheel of iron, copper, or wood (Fig. 102), is
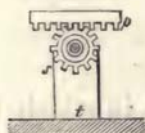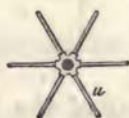
Fig. 102.   Fig. 103.   Fig. 104.
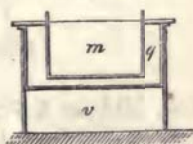
placed near the lower end of the beam *a*, and, aided by a second smaller wheel *s*, in which it catches or works, serves to give motion to the beam *a*. It is set in motion by slightly pressing one hand upon the catch fitted to the beam carrying the second smaller wheel *s*, and pushing the other against one of the six branches of the winch A (Fig. 103), which is placed upon the end of the shaft of the small pulley *s*.

This shaft or beam is so arranged by the side of the basin *q*, containing the suet, that the workman can turn

it without leaving his place. The horizontal beam or shaft which carries the small wheel *s*, has a pivot at each end. These pivots are supported by two pieces of iron or wood (Figs. 102, 105), firmly fastened to the ceiling, with both ends equidistant therefrom, so that the beam shall be evenly horizontal. At one end of the shaft the smaller wheel *s*, is so fixed that it works into the cog *p*, as is clearly exhibited by Fig. 102. At the other end of this same beam is the spring catch, which, as particularly arranged, is seen at *x*, Fig. 105; and the winch with the six arms, Fig. 103, which is movable, and can be taken off when the machine is not in use. These two pieces are firmly fastened to the square of the shaft by means of screw nuts. The winch enables the turning of the shaft by the hand, and it is placed near the workman, about four inches from the place where the frame holding the rods of candles descends.
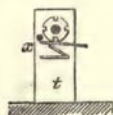
Fig. 105.   Fig. 106.
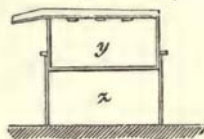
Fig. 104 is a vertical cut of the bath *m*, in which the candles are dipped; *q* the basin, and *v* the furnace which heats this basin.

An iron trimmer, or scraper, is a part of this apparatus, and is shown at *y*, with a water-bath *z*, beneath, heated by a small furnace. All danger of scorching the tallow is thus removed, and the work facilitated.

This iron should be placed at the side and very near to the wheel with the catch.

With the above machine, a single workman in cold seasons, can easily put through 800 rods of candles.

To make our book as complete as possible, we shall de-

scribe another apparatus for dipping candles, which is said to possess many advantages. A front side-view of it is seen in Figs. 107 and 108. It consists of a wagon-like

Fig. 107.
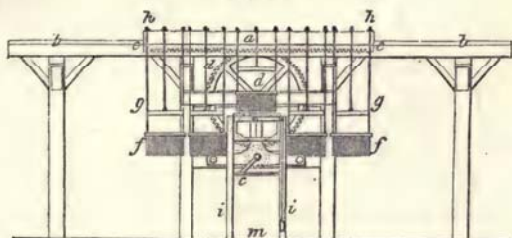
Fig. 108.
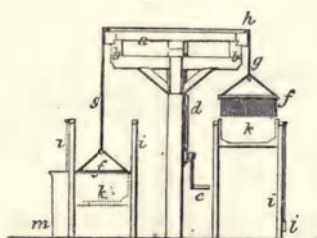
apparatus a, sliding upon the side pieces b, by a rotatory motion communicated with a winch c, to a cog-wheel d, working and catching in the teeth of an horizontal rack e, setting against the bottom of the wagon. At f are ten wooden frames each bearing twenty rods, from which severally hang fifteen wicks ready to be dipped. These frames are suspended by cords g, passing upon the pulleys h. The conductors i, are formed of four wooden stanchions, and of a movable frame k, which has a constant tendency to rise by reason of the counter weight l.

The mode of working the machine is as follows: After having arranged the wicks upon the frames, the workman, by means of the winch c, directs the first frame over the conductors and fixes it upon the movable frame with

small nails; then, by pressing on the frame, he causes it
to descend vertically into the bath m, and having thus
effected the dip, allows it to remount, and thus continues
until the completion of the operation.

The cord placed in the middle of the frame, serves to
give a control in the management of its course.

With this machine a workman can, in cool seasons, dip
about 10,000 candles daily.

In addition to the foregoing, Ure, in his *Dictionary of
Arts*, gives a drawing of another, very similar to one
which has been already described. It is that which "has
been long used in Edinburgh, and is composed of a strong
upright post A A (Fig. 109), with turning iron pivots at

Fig. 109.
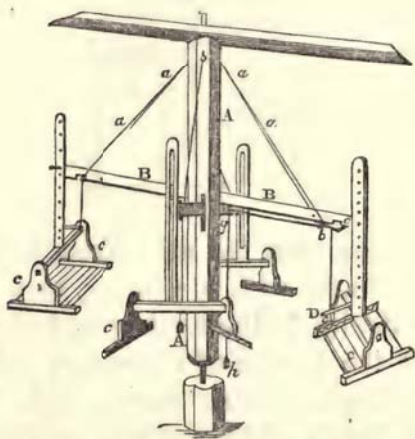
its two ends. Near its middle six mortises are cut at
small distances apart, into each of which is inserted a long
bar of wood B B, which moves vertically upon an iron
pin, also passing through the middle of the shaft. The
whole presents the appearance of a large horizontal wheel
with twelve arms. A complete view of two of them only
is given in the figure. From the extremity of each arm

is suspended a frame or port, as the workman calls it, containing six rods or baguettes, on each of which are hung eighteen wicks, making the whole number upon the wheel, twelve hundred and ninety-six. The machine, though apparently heavy, turns round by the smallest effort of the workman, and each part, as it comes in succession over the dipping mould, is gently pressed downwards, by which means the wicks are regularly immersed in melted tallow. As the arms of the lever are all of the same length, and as each is loaded with nearly the same weight, it is obvious that they will all naturally assume an horizontal position. In order, however, to prevent any oscillation of the machine in turning round, the levers are kept in a horizontal position by means of small chains *a a*, one end of which is 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 one end of the levers must be depressed at each dip, the square piece of wood is thrown out of the notch by the workman pressing down the handle D, which communicates with the small lever *e*, inserted in a groove in the bar B. In order that the square piece of wood, fixed in one extremity of the chain, may recover its position upon the workman's raising the port, a small cord is attached to it, which passes over a pulley inserted in a groove near *c*, and communicates with another pulley and weight, which draws it forward to the notch. In this way, the operation of dipping may be conducted by a single workman with perfect ease, regularity, and even dispatch. No time is lost, and no unnecessary labor expended in removing the ports after each dip; and besides, the process of cooling is much accelerated by the candles being kept in constant motion through the air. The number of revolutions which the wheel must make in order to complete one operation, must obviously depend upon the state of

the weather and the size of the candles; but it is said, in moderately cool weather, not more than two hours are necessary for a single person to finish one wheel of candles of a common size. Upon the supposition, therefore, that six wheels are completed in one day, no less a number than 7,776 candles will be manufactured in that space of time by one workman."

The last dipping machine we shall speak of, is one described by Knapp, and of which the annexed drawing presents a very intelligible view.

Fig. 110.
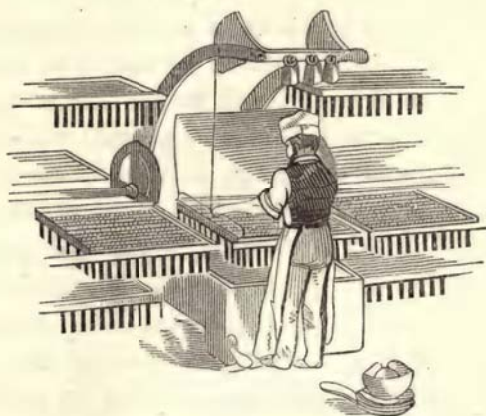
Forty frames, and each containing thirty loaded rods or broaches, may be suspended on the same machine, which thus allows the making of many thousand candles at one operation.

" A vessel of melted tallow is placed in front of each machine, and the frames are brought, one after the other, immediately above it 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 lower ends of the candles. A kind of steelyard to which each frame is in turn attached, indicates the successive

increase of weight, and enables the workman to ascertain when the candles have been dipped a sufficient number of times, after which they are set aside to harden and dry."

Dipped candles, though much less used than formerly, owing to the improved facilities for making mould candles which are much handsomer and only a very little higher in price, are still made, however in large quantities, for sale to the poorer classes.

CHAPTER XXVII.

MOULDED CANDLES.

THIS kind of candle differs from the "dips" in being more sightly, and made, generally, of better stock. They derive their name from the mode in which they are manufactured, and which consists in casting the molten tallow in cylindrical moulds of the proper size and shape. When care and good materials are employed in their preparation, the candles burn well, and have a neat appearance. Their comparatively low price renders them a favorite article with the poorer classes.

The apparatus used in the manufacture of mould candles differs in part from that already described for the "dips," and is as follows:—
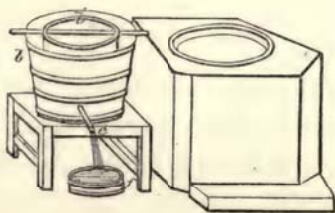
Fig. 111.   Fig. 112.

The melting-copper mounted in brick work is very intelligibly shown by the above drawing (Fig. 111.)

The copper-bound bucket *b*, at its side, is mounted upon a platform sufficiently high to allow a free passage of the feed-can (Fig. 112) under the cock *c*.

The feed-can is filled with melted tallow by placing it

in the pail, *f*, which is there to catch any stray drops of suet that may leak from the exit hole, and would otherwise be wasted. The workman is elevated upon a step in order that he may the more easily dip the tallow from the kettle, and pass it over upon the sieve *i*. Directly opposite to each other are two handles, through which passes a stick of wood, itself resting on the edge of the tub, and in turn holding up or suspending the sieve.

The mould-stand, or frame (Figs. 113, 121), is formed

Fig. 113.

of an oaken top two feet long by nine inches wide. It is pierced throughout its length with four ranges of holes, into which the moulds, slightly conical, fit easily. The top of the stand is supported at each end by two upright pieces of plank *b*, firmly joined to the top and the pedestal *c*. As the top of the stand has to support the whole weight of the moulds and their contents, it should be made of good solid walnut or oak wood. Between the legs or side pieces are placed the drainers *d*, for the reception of any portions of suet that may accidentally fall from the top of the stand.

Instead of wooden tops, the mould-stands sometimes have metallic bed-plates, in which the heads of the moulds are soldered. This is a much neater arrangement, and, coupled with the present plan of having an additional cross-piece B, Fig. 121 (bored correspondingly and proportionably as the upper bed-plate), to receive the tips

25

of the moulds, and thus render their position more steady, makes the apparatus both complete and convenient.

There should be a large number of these stands, furnished with moulds of assorted sizes; one portion being filled with sixes, another with fours, another with eights, another with twelves, and so on to complete the series requisite to make all the numbers of candles called for in the market. A stand will hold 48 moulds for candles of 12 to the pound, and a proportionably smaller number for those of larger size. It is not advisable, however, to have the moulds too crowded, as it retards the cooling of the candles.

The feed-can (Fig. 112) is the vessel from which the moulds are filled with liquid tallow. It is supplied from the tub (Fig. 111) through the cock c.

The moulds, Figs. 114, 115, 116, are slightly conical tubes made of iron, bronze, pewter, or a mixture of lead and tin, and occasionally of tin alone. They are even made of glass in some countries, and but for their fragility, these, uniting all the desirable qualities, are far the most preferable. As before said, there should be a large assortment of moulds on hand, first because the variety of sizes requires it, a different dimensioned mould being necessary for each number of candle; and secondly, a large stock of the same size is requisite, especially in extensive establishments, for as the candles cannot be drawn until they are entirely cooled, much delay and loss of time would be occasioned in working with a too limited number of stands.

French moulds.—These moulds are somewhat different from those used in this country.

Each mould consists of two parts, the shaft or body, and the cup or head-piece. Fig. 114 shows these two parts separately. The shaft *a a* is conical at its lower end *b*, to give form to the tip of the candle.

The mould is pierced, at *b*, with a hole sufficiently large to allow the entrance through of the wick. The shaft *a a*,

is widened at its upper end for the reception of the barrel
m, of the head-piece d. The head-piece is a kind of small
cup through which the liquid tallow runs into the mould.
Fig. 115 shows these two pieces united together, and Fig.
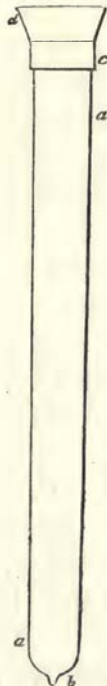
Fig. 114.   Fig. 115.   Fig. 116. Fig. 117.
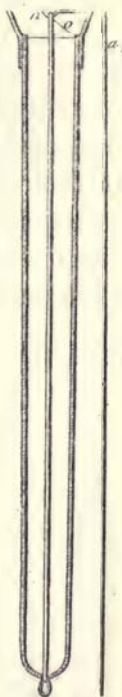
116 represents the position of the wick in the mould pre-
vious to the pouring in of the tallow. The greater dia-
meter of the mould at its upper extremity is indispensable,
in order that the candle, when it has cooled, may be easily
drawn from it. At the top of the cup will be observed a
small iron hook n, soldered upon the side, and sometimes
supported by a small iron or copper triangle o, soldered
interiorly to the side of the cup, and enabling the hook n,
the better to resist the tension of the wick. This hook
should be exactly in the centre of the mould, so that the

wick may be uniformly enveloped with tallow throughout its whole length and circumference. The moulds of metal are bored out as accurately as possible, by machinery, so that their interior shall be perfectly true and finely polished.

American moulds.—Figs. 118, 119, 120, represent the shape of the candles, as generally cast in this country. It will be observed they are of a graceful shape, the tip especially being very neatly formed. These are run in American moulds, the superiority of which consists in their being burnished by a vertical instead of rotary motion, and thus freed of those rings and imperfections which in common moulds offer a resistance to the free egress of the candle. The composition, too, is of a better kind, and more intimately combined, whilst the workmanship is more elaborate than that upon moulds generally. They consist of only two pieces, the shaft and the tip, the latter being sometimes made of brass, or bushed with brass, so as to resist the abrasive effect of the threading wire and wick pegs.
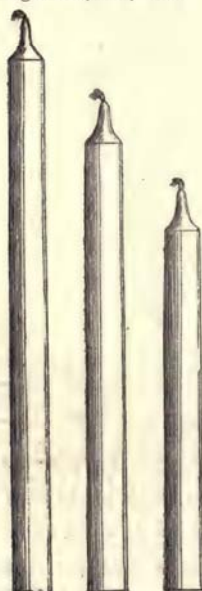
Figs. 120, 119, 118.

The alloy for tallow candle moulds is composed of tin, with a sufficient proportion of lead, to render the former free of grain, and easy to be worked. A greater quantity will make the moulds inferior.

For mould candles, five sizes are made, viz: 16s, 12s, 10s, 8s, and 6s.

For sperm candles, the moulds are made of the same metals as the aforementioned, with the addition of a little hardening. The usual size for these are 4s, 5s, and 6s, as represented by the figures.

Fig. 118 is a 6 candle, and its dimensions are 8⅛ inches in length, and ⅝ inch in the diameter of the shaft; the tip in this, as in the rest, being 1 inch high.

Fig. 119 is a 5 candle of 10¾ inches length, and ⅝ inch diameter in the shaft.

Fig. 120 is a 4 candle of 12¾ inches length, and ⅞ inch diameter in the shaft.

The moulds used for the stearin and stearic candles are of the same size, but made of tin and antimony; lead being omitted because it not only smuts these candles, but prevents their easy withdrawal. These moulds should be made with care, and with as little metal as possible, and some manufacturers, in order to remove all impediments to the rapid cooling of the fluid candle, have the moulds turned smooth on the outside. This seems expensive, but as there is no more metal bought than is actually required, the amount of their cost does not much exceed that of the same number of rough heavy moulds. Occasionally, the dimensions of the moulds are altered to suit the directions and taste of the purchaser.

Moulding by hand.—Fig. 121 exhibits a stand of twelve moulds. A A are the two upright ends of wood, which support the two cross-beds B B, that serve to hold the moulds in an upright position. The upper bed is of metal, this material being better than wood, to which the redundant tallow sometimes adheres so tenaciously as to cause a delay in its removal. C C are the broad side-pieces, which, with the upper ends of the uprights, form a receptacle for the melted tallow when the moulds are being filled. One of these side-pieces slides in a groove so that it can be moved downwards to afford facility, first in threading the moulds with wicks, and again in removing with a knife the excess of tallow which congeals upon the metallic bed. The whole arrangement is very convenient.

At *d*, are seen the wires which traverse the upper bed of the stand, immediately over the mouths of the moulds, for the purpose of suspending the wicks. Each stand is

Fig. 121.
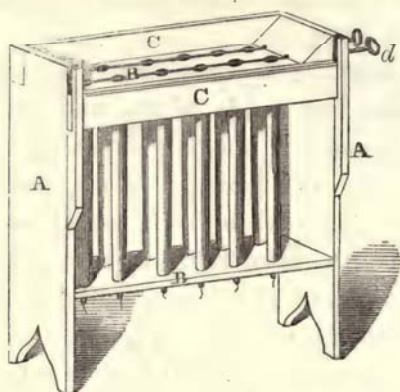
of a convenient size, and by an expert workman can be rapidly and dexterously threaded with wicks, in manner as follows, supposing the wicks to be already cut and prepared, previously to commencing the operation.

The threading needle is shown at *a b*, Fig. 117. It consists of a stiff iron needle, crooked at the upper end, so as to make a hold for the finger in handling it. At the lower end is a slight catch for holding the wick. It should be several inches longer than the mould, and sufficiently slender to pass readily through the eyes of the moulds. The workman lays the frame upon its side on a neighboring table, and holding in his left hand a quantity of wicks, with the right takes the wire needle and introduces it within the mould. As soon as the catch appears at the eye *b*, Fig. 115, of the hole in the tip, the looped end of the wick is hooked on, and is carried through into the mould by immediately drawing back the wire needle. A small pointed wire running across the diameters of the moulds,

in each row over the whole length of their upper bed, is passed through the loop of each wick as it is drawn up, and serves to suspend the wicks and prevent their falling back into the moulds, when the frame is placed in an upright position. This manipulation is generally done by a female, who, as soon as every mould in the stand has been strung, stretches and straightens each wick, by pulling at the lower end and fastening it in the hole of the tip with a little wooden peg made and kept for the purpose. The stand being in an upright position, and the loops being also adjusted over the upper wires by which they are suspended, so as to exactly centre the moulds, all is in readiness to receive the melted tallow. To succeed well, the temperature of the tallow must neither be too high nor too low when it is poured in the moulds, and the latter must also be filled to overflow. If too hot, it heats the mould, and thus causing the candles to "stick" or adhere tightly, renders it difficult to draw them; and when drawn, the candles are full of cracks and unevenness.

In such case the moulds must be doused with warm water after they have cooled, and the candles dexterously drawn out. When, on the contrary, the tallow is too much cooled, the candles are not uniform in appearance, but granular looking.

The proper moment for casting the tallow is, when a skin begins to form upon its surface near the sides of the kettle, which is about a temperature of 100° to 120° F., according to season or climate.

The moulds are filled from the feeder (Fig. 112), and, being stopped at the mouth of the tip, there is no waste of tallow by leakage. So soon as the feeder becomes empty it is refilled from the tub. For mould candles, most chandlers do not use the wooden pegs to keep the wicks distended in the moulds; but, in such cases, after having poured in the tallow, that portion of the wick

which remains beyond the tip of the mould, is laid hold
of with the fingers, and straightened by pulling before
the tallow congeals, else the wick will shrink up and thus
injure the quality of the candle. As one of the general
properties of caloric is to dilate bodies, so accordingly the
tallow as it cools occupies less space than whilst hot and
fluid. For this reason the mouth of the mould, which,
after semi-congelation of the contents of the mould, is not
so full as it was at first, and ought to be, that the candle
may be even and of full length, must be replenished with
more melted suet. The moulds should not be handled,
but set aside in the frames to cool. When the
tallow has entirely congealed, the wires laying
upon the top bed of the mould stand, and serv-
ing to suspend the wicks, are carefully drawn
out, the overplus of tallow scraped from this bed
with a spatula or trowel, and the wooden pegs,
if they have been used, removed from the open-
ings in the tip. This being done, the workman
goes along with a kind of bodkin in his hand,
and, after pressing against the bottom of each
candle with his thumb to loosen it, an effect re-
cognizable by a simultaneous snapping noise as
the candle becomes detached, catches this bodkin
in the loop of the wick, and draws out each can-
dle successively from its mould. Or, from those
moulds having cups, the candles are readily
drawn by raising this cup. Some chandlers pur-
sue the better plan of cutting them at the junc-
tion of the cup with the shaft of the mould, and
then pulling the candles attached to the cup.
Fig. 122 represents a candle as drawn from the
French mould. Those from Dyre's moulds are
shown at Figs. 118, 119, 120. The stands of the moulds
must be kept in an upright position during the cooling,
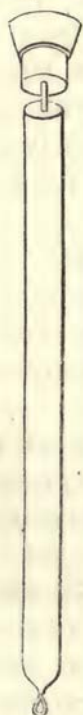
Fig. 122.

which should be completed as rapidly as possible; and, to that end the use of ice will be necessary in summer temperatures.

In all the manipulations of moulding candles, a little experience will impart surprising dexterity. The rapidity with which a stand of moulds can be threaded with wicks by one girl, dexterous in that particular branch of the work, is almost incredible. The amount of moulding to be accomplished, therefore, in a day, is in proportion to the activity and expertness of the manipulators.

Tallow candles, either dipped or moulded, as made from ordinary material, are always more or less yellowish when recently made, but acquire a whiteness by age. But this whiteness is only skin deep, if we may use the expression, and is not of that desirable brilliancy which the ambitious chandler takes a pride in imparting to his product. The best means to provide against any imperfect appearance is to make the candles of tallow refined by some of the aforementioned processes; but when this is not done, then other means are resorted to for remedying the neglect.

Most factories are so built as to have surrounding porches in which to expose the candles in the open air to the influence of the dew and shade, but free from the rays of the sun, and for this purpose they should have a movable canvas covering, so that it can be put on and taken off at will. The bleaching thus acquired is only superficial, however, the white layer being very thin, and if yellow tallow has been used, is very soon overshaded by the inner strata. The best way, then, as above said, is to make the candles of tallow previously bleached by any of the methods heretofore given. When such tallow has been used, the candles, on exposure to air, acquire a brilliant whiteness, and improve in quality. The rationale

or theory of this bleaching by exposure is not definitely known, or rather has not been satisfactorily explained.

The atmospheric air, assisted by the influence of light, produces the change of color, perhaps, by reason of its oxygen, which being given up to the coloring matter of the material, unites either with it or its elements, carbon and hydrogen, and thus effects a bleaching of the candle.

It has been said that tallow candles whiten by age; this is true, but there is this inconvenience and disadvantage in keeping them, and that is, they become rancid and smell unpleasantly after a time. When, however, storing is compulsory, it is best to keep them in boxes lined with brown paper, or, better still, to envelop them in packages of two, four, or six pounds each, and preserve these packets in clean closed cases. The whiteness which they thus acquire, is more durable than that obtained by exposure to air. Some chandlers have carried into practice, for whitening tallow, that process followed for bleaching wax, viz: ribboning and spreading it upon cloths, but the tallow is thus deteriorated in quality, and the candles, made therefrom, run. This mode, therefore, is not applicable to tallow, and has consequently been abandoned.

Moulding by machinery. — The greatest improvement which has been made in the manufacture of mould candles, is in the mechanical part of the process. The old tedious and inconvenient method of making by hand has given way to the rapid and economical plan of moulding by machinery. For this purpose, there have been many different kinds of apparatus constructed; but, without further remark, we will describe those best known, and let the judgment of the experienced chandler decide upon their practical advantages, respectively and comparatively.

Leubel's moulding machine.—This apparatus is arranged to produce 396 candles at one operation. The same num-

ber of moulds are ranged in a stand, similar to the ordinary mould frame, on the top of which is a second stand, but ledged and of cast iron or composition 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 which moves a cogged rack, it can be lowered or raised at will. When the candles are about to be cast, the metal stand is lowered until the funnel-cups touch in the top of the moulds, and the fluid tallow being then poured upon this stand, runs through the funnel-cups into the 396 moulds. After perfect congelation, the metallic plate is raised up by the winch, and with a long knife, the candles are all cut at a single dash. In warm weather, the moulds are cooled simultaneously in a vessel of ice water, elevated so high that the moulds filled with tallow may dip their whole length in the water. Figs. 123 and 124 show a front elevation and plan of the

Fig. 123.
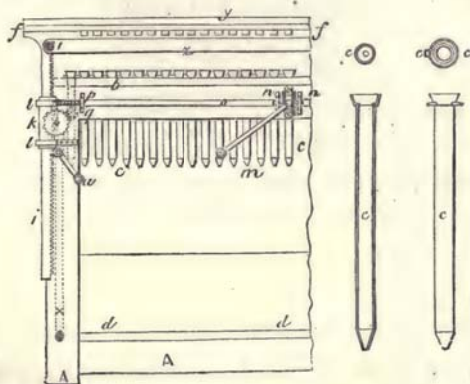
apparatus. We have suppressed, in these figures, about one-half of the breadth of the machine. All the suppressed portion is similar to that part shown by the

figures. The winch *m*, is in the centre of the total breadth of the machine. A is the framework of oak wood. The table or stand *b*, also of oak wood, mounted upon the feet and upper cross-pieces of the frame, is pierced with 396 holes in 12 rows of 33 each, and intended for the reception of the metallic moulds *c*, one of which is represented also by *c*, in elevation, vertical cut, and in detail by the figures.

The platform *d*, is for the support of the copper vessel *e*, containing water for the cooling of the moulds filled with fluid tallow.

The metallic table *f*, is pierced through its face with 396 holes corresponding in size and position with those in the wooden table *b*, as is seen at one of the corners of the stand or frame *f* (Fig. 124). The holes of the metallic

Fig. 124.
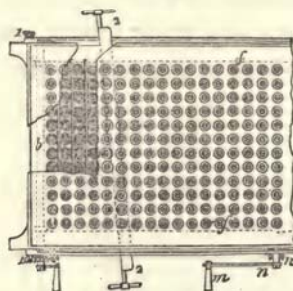
stand are intended to receive the funnel-cups *g*, each of which is fitted as shown at Fig. 126, in the middle, so that it will be immovably retained at its place at the time of the drawing of its candle.

The metallic stand or frame *f*, is mounted upon the upper ends of four racks *i*, gliding in copper boxes *k*, fastened by the iron stays *l*. These racks are made to assume an ascending or descending motion by means of a winch *m*, the axis of which carries a square tip that catches in or works the two cogs *n*. Each of these cogs

is fixed at the end of the two support beams o, which at the other extremities carry screws p, catching in or working an oblique toothed cog-wheel q, at the centre of which is a pinion that governs the wheel r. The axis, s, of this wheel (Fig. 125) has two pinions t, which catch

Fig. 125.
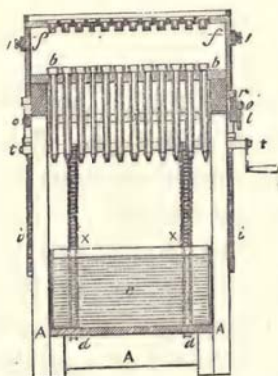
or work in the teeth of the racks i, and thus create an ascending or descending movement of the frame f, accordingly as the winch is turned. When the moulds c, are to be cooled, the vessel e, filled with water, is raised by the aid of two winches u, the axes v, of which carry two pinions that catch in the chains x, the ends of which are fixed to the water-bath.

The iron frame y, forming the ledge of the metallic table f, confines the melted tallow when poured in, and prevents any waste by overrunning. The two iron plates k, retained horizontally by two screws, fastened by eared nuts i, serve as guides to the knife 2, which, when the candles are drawn out of the moulds, cut them all beneath the cups g.

The manner of working this machine is to commence by placing the moulds in the holes of the wooden stand, b, and the funnel-cups in those of the metallic stand, f.

This being done, the upper stand must be lowered by properly turning the winch *m*, until the cups are entirely inclosed by the upper and widened end of the moulds *c*. The wicks *g* (Fig. 126), are to be arranged in the usual

Fig. 126.

manner, and retained in proper position by the hook in the centre of each of the cups. All being ready, the melted suet is then poured in upon the table *f*, whence it runs into each of the moulds.

When the material has cooled and hardened, either in cold weather by the atmosphere, or in warm weather by the ice-water in the bath, the metallic table to which the candles are adherent is lifted up, and the candles detached by a knife which is kept for this purpose, but not attached to the machine. The operation being finished, the cups are removed and cleansed in water before repeating the filling of the moulds. To insure a perfectly successful result, it is important that the metallic stand *f* should always be sufficiently warm to prevent a too rapid congelation of the liquid suet. To this end, the circumference of the upper table exceeds that of the lower stand some three inches, and upon this excess or edge is placed a tin box two inches in height. The admission of a constant current of steam into this box communicates thereto, and from thence to the metal-stand, heat sufficient to maintain the proper fluidity of the tallow. At one corner of this steam-box there should be fitted a stopcock, through which to discharge the condensed steam as it accumulates.

Goursac & Co.'s moulding machine.—Another apparatus, which, with the aid of a single workman, is said to produce 600 candles in 30 minutes, is represented by Figs.

127 and 128. It has the form of a six-footed table, seven feet in height. Its top consists of a hard wooden board *a*,
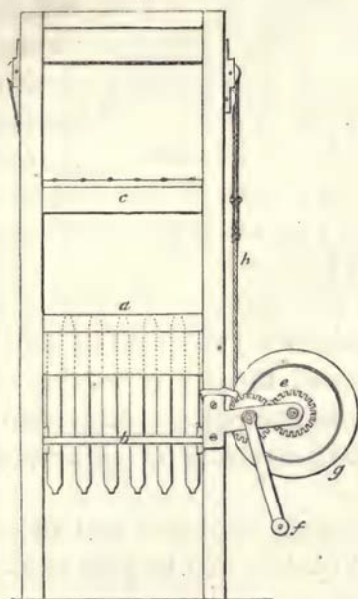
Fig. 127.   Fig. 128.
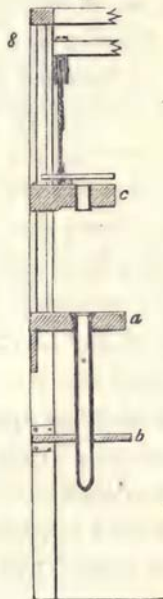
of fifteen lines thickness, and pierced with 600 round holes, in which are placed the candle moulds, fastened by two screws through the small catches which they carry about five lines above their grand opening.

At eight inches below this first board, there is a second, *b*, pierced as is the upper similarly and numerically with holes, in which sets a part of each mould, merely that it may be kept true and in an upright position. Finally, there is a third board *c*, which contains 600 funnel-cups, corresponding with the moulds in the stand beneath. The top surface of this last board is divided off into four equal parts by the iron frames upon which are placed the rods suspending the wicks that are to pass into the moulds. Into these frames, by means of a funnel for that purpose, is poured the quantity of tallow necessary to fill the number of moulds placed thereunder.

To raise and lower this board or plateau, and by these means simultaneously draw all the candles from their moulds, there are fixed upon the upper extremities six iron jacks *e*, eighteen inches in height, and fastened against the six feet of the table. These jacks are put in motion by turning the winch *f*, and in this movement the wheel *g*, revolving upon the axis of one of the wheels of the jack, winds the cord *h*, and lifts the board or plateau. The candles are then drawn from the moulds, and hung in the air from the plateau to which they are suspended, and from which they are now to be cut with a knife.

At the moment that the plateau or board *c*, is being stripped of the candles which it holds, and of superfluous suet, which has been poured thereon in casting the candles, the plateau *a*, must be covered as a protection to the empty moulds from falling particles of tallow and other foreign matters.

The above apparatus, much improved and added to, is shown in front view at Fig. 129, and in plan at Fig. 130.

Fig. 129.
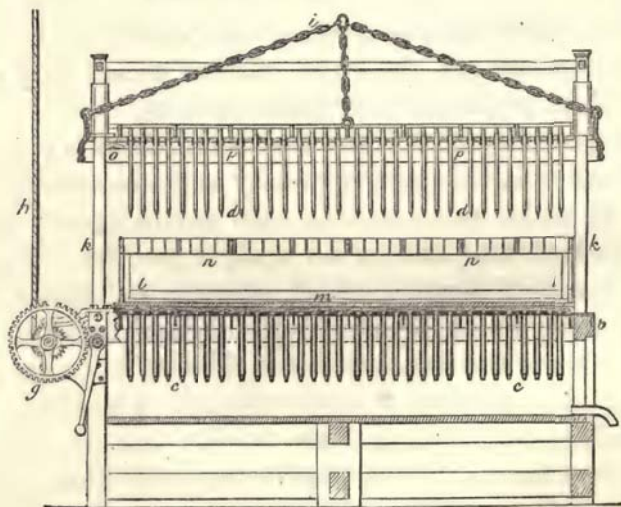
Fig. 130.
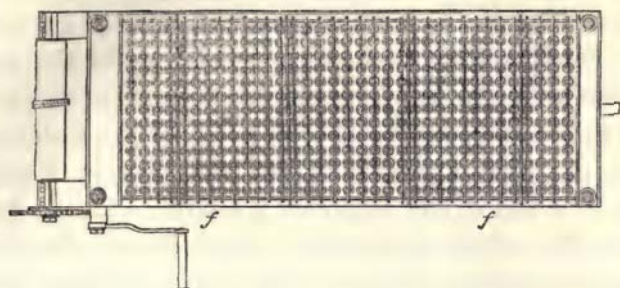
The top or upper table *a*, is seen in plan at Fig. 131, and horizontally and longitudinally at Fig. 132. The lower table *b*, is shown in plan by Fig. 133, and horizon-

Fig. 131.
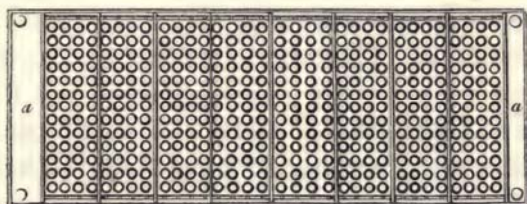
Fig. 132.
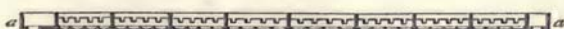
Fig. 133.
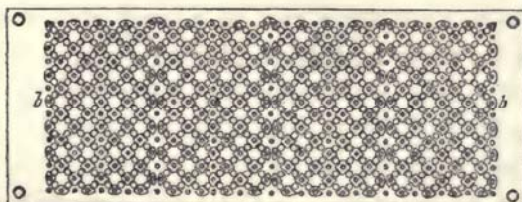
Fig. 134.

tally by Fig. 134. These two tables are pierced with holes, and those of the lower receive the moulds *c*, while

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those of the upper table have the cups d, which, penetrating the orifice of the moulds, prevent, during the casting of the candles, the overflowing or spilling of the tallow upon the under table. The moulds are caught and lodged in the lower table by iron hooks e (Fig. 134), fastened by screws, the cleft heads of which are seen in Fig. 133. There is a space left between the table and the hooks, in order that when the candle is being drawn, the mould, as soon as detached therefrom, may fall by its own weight, and allow the candle to escape without resistance. The wicks are strung upon iron wires or rods f (Fig. 130), laid level upon the upper table, and notched at proper intervals, to indicate the position of the wick. Each wick is furnished with an iron needle, to afford facility of threading as many wicks at a time as there are moulds in the width of the table. The drawing of the candles is effected by means of a windlass or winch g, fastened to the foot of the machine, and upon which runs a cord h, that passes upon pulleys, and is attached to a chain i, fixed to the centre and each of the four corners of the upper table. To avoid the oscillating motion of the lower table, there are adjusted four iron columns k, which pass into or through four copper clamps fixed upon the upper table. The cutting of the candles is accomplished by raising the upper table so that there can be placed under, a wooden frame l, lying upon a wooden plateau m, in order that no particles of tallow or dirt may fall back into the moulds. When this frame is properly set, the upper table is lowered and each candle drops into a square n, formed of tape, so that at the moment the candles are detached with the knife, they shall not, in falling, become bruised or broken.

The knife o (Fig. 129), which is used for this operation, moves upon two iron strips p, placed at a proper height, and is removed after having effected its purpose.

In order that the candles may be drawn with facility,

at all seasons, the moulds are assembled together in a closed chest, framed between the feet of the machine, through one side of which enters a cullendered tube q, and extending the whole length of the chest. A current of hot air or steam expands the moulds, and enables the candle to glide easily out; this application being most requisite in hot and damp weather. With the above apparatus one man can run 416 candles within the space of ten minutes, and draw them all simultaneously in a few seconds.

Morgan's moulding machine.—This apparatus, said to be very effective and rapid, is that used in England for moulding tallow candles. It is so constructed that, with a sufficiently large supply of stands to afford time for cooling, the action of the apparatus may be continued for an indefinite period, and at a saving of both labor and time—the cotton wicks being threaded through the moulds at the same time, and by the same action as that which expels the candle. Fig. 135 represents an end elevation of this improved machine; Fig. 136 a front view, and Fig.

Fig. 135.   Fig. 136.
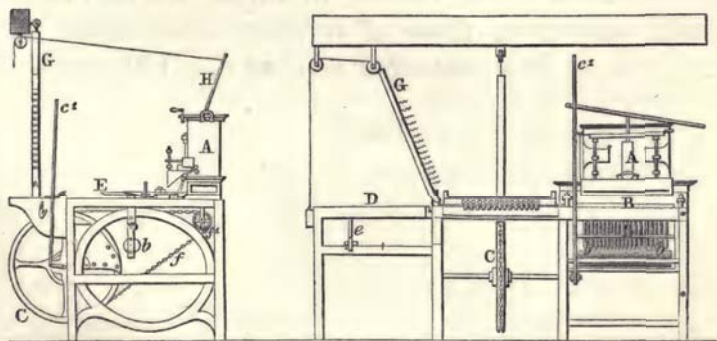
137 a plan of the same; Fig. 138 is an elevation seen from the back of the apparatus in the opposite direction to that represented at Fig. 136. In these figures A re-

presents the vessel or reservoir in which the melted tal-
low or other material for making the candle is contained,

Fig. 137.
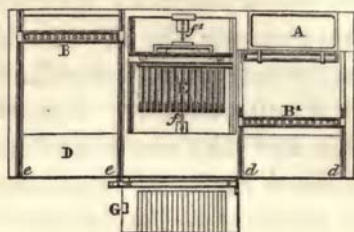
Fig. 138.
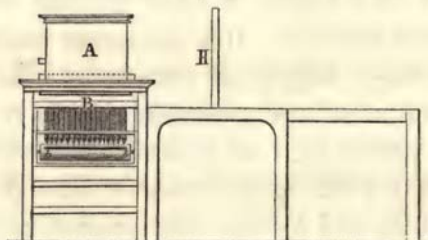
and B exhibits a series of moulds, for giving shape to the
candles in the usual manner; but as the arrangement and
construction of these moulds in which the candles are
formed, vary from those of ordinary construction, this
part is shown on an enlarged scale at Fig. 139, and some

Fig. 139.
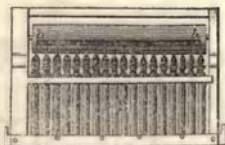
of the detached parts still more in detail at Figs. 140 and
141. In Fig. 139, *b b* represent a hollow cylinder of tin,
opening longitudinally, and provided with a number of
bobbins of cotton or other wick corresponding with the

number of moulds to be supplied. These bobbins revolve freely on a shaft which passes the whole length of the cylindrical case $b\,b$, and gives off the cotton wick as it is required for the formation of the candles, as hereafter explained.

Fig. 140 shows an elevation of the upper end of one of the cylindrical moulds, as given at B, in the other figures; and Fig. 141, a plan view of the same in an inverted position, so that the interior of the mould is there represented. In these two figures, 140 and 141, it will be remarked that the top is not constructed of one piece, as in ordinary moulds, but consists of the part $b\,1$, which is a portion of the cylindrical side of the mould, and the part $b\,2$, the sliding or movable portion. This latter, $b\,2$, is hollow, for the passage of the wick, and fits closely to $b\,1$, when the tallow is poured into the mould to form the candle. 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 the arrangement of this apparatus, forced out by pressure applied to the extremity of the part $b\,2$, through which the wick passes from the cylindrical case $b\,b$; the wick that goes out by a hole in the side of $b\,2$, following the course of the candle as it is forced from the mould, re-cottoning the mould for a successive candle.

Figs. 140, 141.

Fig. 142 exhibits a series of nippers or pincers which

Fig. 142.

Fig. 143.
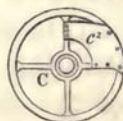
open and shut together by the action of the lever C, and hold the wick in the mould (at the end opposite to that

of its entrance at the hole in *b* 2), in a perpendicular position when the tallow is introduced.

The separate and detached parts of the apparatus being described and represented at Figs. 140, 141, and 142, we proceed to make known the mode of working the whole apparatus. "Supposing a set or frame of moulds, as represented at B, to be regularly wicked, and each wick held accurately in the centre of the mould by means of the series of nippers shown at Fig. 142, the moulds are first taken to the position shown at B 1 (Figs. 136, 137, 138), where they are supported perpendicularly on the small straight edges or railway *d d*, as seen at Fig. 137. In this position they are run forward until they come perpendicularly under the reservoir A, where the tallow is applied in the usual manner. The candles being in this state, the moulds are run along on the railway *d d*, to any convenient position to which the railway may be conducted, where they remain until they are sufficiently hardened to be taken from the moulds, at which period the nippers at Fig. 142 are removed. When the candles have perfectly congealed, the moulds are brought to the position shown at B (Fig. 137), where 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 in the direction indicated by the black arrow, 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 by the operator, carrying along with it the frame of moulds B, in which position it is held by a catch, shown at *c* 1, in Fig. 136; from the horizontal position given at D, in Fig. 137, the moulds B are removed in the direction of the dotted arrow, until they arrive immediately opposite the series of rammers E, as separately represented at Fig. 144, where the cylindrical case *b b* is

removed by binding the jointed frame, as seen at Fig. 145, to be out of the way of the rammer E.

Fig. 144.
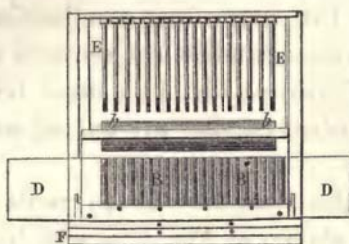
Fig. 145.

"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 represented at Fig. 135, 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 the series of rammers E, so that any vibration of the lever $c\,1$, which is fixed on the axis of the wheel C, is imparted to the rammers E in a horizontal direction. The moulds being in the position shown at Fig. 145, the next duty of the operative is to vibrate the lever $c\,1$, in the direction of the arrow at its extremity (see Fig. 135), and thereby force the series of rammers E into contact with the sliding part, $b\,1$, of each of the moulds, and thereby displacing or pushing out the candles which are received into the grooved table F, raised up in the exact position to receive them 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 thus 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 mould, which are attached to slight springs, as seen

at Fig. 136.   This 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 nippers f, shown at Fig. 142, must be reap-
plied, after which the finished candles are cut off and dis-
posed of."

"The next duty of the operative is to replace the
lever c 1, in the position shown at Fig. 135, which retires
or carries back the rammer E, along with the sliding top
of the moulds 2 b, to their former position, and the moulds
are cottoned or wicked, ready for a fresh supply of tallow.
This series of rammers, shown at E, is formed of sepa-
rate hollow tubes, supported in the cross-piece g g, 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. 140, and
is thereby enabled to bring it back to its former position,
when 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 part 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 de-
scribed.   This second series of rods is fixed in a similar
cross-piece marked h h, in Fig. 137, 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 con-
nection 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 reservoir A

again supplied to them, and the process already described repeated to any number of times."

Tuck's continuous wick machine.—This apparatus is an English invention, patented in 1842. A front elevation of it is shown by Fig. 147; all the parts, severally, being in the positions they would occupy previously to fitting the moulds. An end view is given at Fig. 146, and a transverse section at Fig. 148.

Figs. 146, 147, 148.
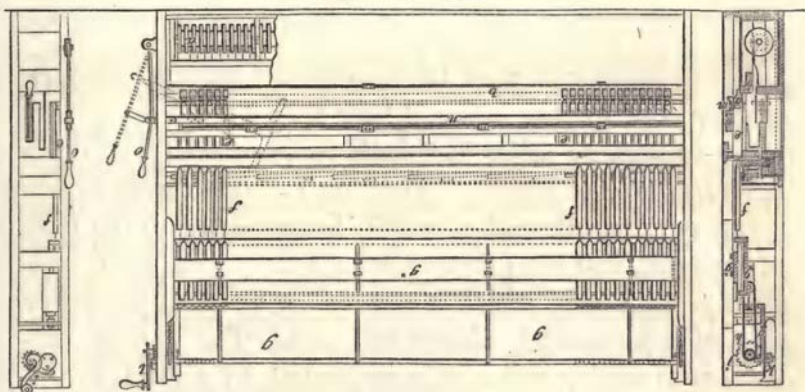
The other figures, in the succeeding pages, exhibit different views of some of the working and internal parts of the machine, drawn to an enlarged scale. *a a a* represent the bobbins or spools, upon which the continuous wick of cotton is wound; or balls of cotton may be used if preferred. These bobbins are mounted loosely upon axles, which hang in suitable bearings, attached to the framework. The continuous wicks from the bobbins *a a a*, pass upwards over a breast beam or board *b b b*, and through small holes *c c c*, made in the lower part of the stopcocks *d d d* (see the detached views of this part of the apparatus, Figs. 149 and 150). The wicks then proceed upwards through the cocks *d d d*, and through the centre of the moulds *e e e*, to the tips of which the cocks

d d d are connected, as seen in the side views, Fig. 151, and in front view, Fig. 152.

Figs. 149, 150, 151.
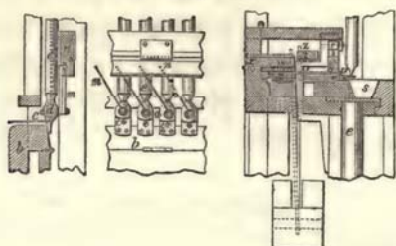
These stopcocks may be constructed in any ordinary manner, but having a small hole through the plug, just large enough to allow the wick to pass easily into the cylindric tube or mould. They are furnished with spring levers *m m m*, one end of which is connected to the plug of the cock, and the other enters a hole or slat, made in a strip of thin iron, which is screwed or fixed on the lower side of a horizontal sliding rail *n n*. The end of this horizontal sliding rail *n n*, is connected, by a joint, to the lower extremity of the hand lever *o o* (see Fig. 146) ; and when this lever *o* is brought from the position represented by dots in Fig. 146, into that shown by lines, the rail *n n* will be moved along, which movement will force the spring levers, *m*, into the diagonal position represented in Figs. 147 and 150, and thereby close the several stopcocks. It then becomes necessary to place the wicks above, in their proper position, in the centre of the cylindric moulds, and hold them up in this position, which is done by tying a knot in each, and attaching it to a hook in the horizontal rail *q*. Then a sliding rail *r* is brought forward, covering about half of the apertures of the moulds, as shown in Fig. 152; and the rail *q*, at the same time receding, draws the wicks, in tension, into the vertical grooves, in the plate, on the face of the rail *r*.

The melted material may now be poured into the trough, extending along the part of the machine as shown at $s\ s\ s$, when the candles will be formed by casting in the moulds. The materials having been allowed to remain in the moulds or cylindric tubes until cold, the surplus matter, occupying the trough above the tubes or moulds, must be removed by a knife or instrument, suitably constructed, previous to "drawing the candles." The first row of candles having become cold and hard, and the positions of the various parts of the machine reversed—that is, the wicks unhooked, and the bar r drawn back—the candles, after being tapped or punched in the usual manner, are to be severally drawn out of the moulds, by the hand of the workman, who takes hold of the knot, and, lifting it perpendicularly, the candle slips readily out of its mould, drawing the length of the cotton wick up through the mould, for the next row of candles. The knot of the wick, before mentioned, is then placed in a conical notch, cut in the rail above, at the bottom of the frame g, and, in that situation, the first row of candles hang, whilst a second row is cast in the moulds.

In order to carry out the manufacture of successive rows of candles in this apparatus, certain motions of the machine are required, which may be now explained, it being remembered that the stopcocks have been opened by the movements of the machine, hereafter described, for the purpose of allowing a sufficient quantity of wick to be drawn up through the moulds, by drawing out the candles previously made, as described.

In order to open or loosen the stopcock, it is necessary to reverse the lever $o\ o$, and bring it into the position shown by dots in Fig. 147; and by this means, the spring levers $m\ m$ will be drawn over into the opposite inclined position, and the wicks allowed to pass freely through the cocks.

, The first row of candles, as at $f f f$, is suspended, in the manner above mentioned, by means of the knots from the lower side of the frame $g g g$, which frame is connected to endless chains $h h$ (see Figs. 146, 147, and 148). These chains pass over toothed pulleys $i i$, and a similar frame, $g g$, is connected to the endless chains $h h$, one frame hanging in front of the machine, and the other a little distance behind. These frames are connected to the chains by swing pivots, so that when the front board is raised, the pivots pass over the pulleys $i i$, and go into the back position, at the same time bringing the hinder board forward. On the same axle as the pulley i, a small cog-wheel j is mounted; this wheel gears into and is turned by a small pinion k, to the axle of which power is applied, by means of the winch l, Figs. 146 and 147. Now, as the winch l is turned, it causes the wheels and pinions i, j, and k, to revolve, and consequently to raise to the highest point the frame g, and at the same time to lower, into its place, the other frame which was behind. This frame, by exchanging positions with the former, and being, as seen, advanced, causes all the conical notches to take hold of the taper ends of the candles of the upper row, and a straight board g^* is then placed against the front of the row of candles, which holds them securely. These frames are furnished with a top and bottom row of notches, as seen in Fig. 147, formed so as to prevent the candles from falling sideways or dropping down.

The knots, by which this first row of candles were suspended from the conical notches of the upper frame g, are then cut off, by passing a sharp knife or other instrument under the lower edge of the top frame g, which is then passed into the back position. This operation having been performed, a fresh supply of wick will be found in the moulds $e e e$; and it now becomes necessary to

tighten or close all the cocks *d d d*, which is effected, as before mentioned, by reversing the position of the lever *o*, and bringing it into the position shown in Fig. 146. The next thing to be done is to place the wicks in the centre of the moulds, and to effect this readily, they are taken hold of, and held by the hooks *p p p*, on the horizontal bar or rail *q*. In order to take hold of the wicks, these hooks have to perform a forward, lateral, and a retrograde motion, at the same time the metal slide *r r r*, which is furnished with vertical grooves, is moved outwards; and when the hook bar *q q* retrogrades, it brings the wicks into the grooves of the metal slide *r r r*, and securely holds them there, the metal slide having, as before mentioned, been moved outwards, until it covers one-half of the aperture of the moulds. These movements are effected in the following manner :—

To the back part of the hook-bar *q*, a flat metal plate *t* is screwed in a horizontal position; which plate is represented detached at Figs. 154 and 155. In this plate there is cut a peculiarly shaped slat *u*. The plate ex-

Figs. 152, 153, 154, 155.
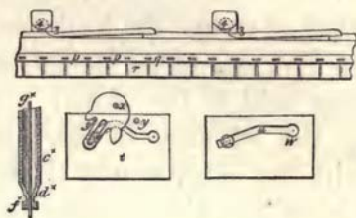
tends backwards through a groove or space cut in the sliding bar *v v*; this bar supports an upright axle, which carries two horizontal brass pulleys *w w*, that work in the slats cut in the plate *t*, and also in the one below it, hereafter to be described. A peculiarly shaped cone *x* is

mounted on a fixed centre, in the back framing of the machine; and the axle of the brass pulley w works in a long slat made in the cam x, as seen in Fig. 154.

The metal plate t is also furnished with pins or stops y y, which, by abutting against the cams, as aforesaid, prevent the plate from having a lateral motion, until the stop y escapes from the ear of the cam. The sliding bar v has a lateral motion, communicated to it by means of the hand lever x. This lateral motion causes the brass pulleys w to advance along the slat u; and as the plate t, and hook-bar q, to which it is attached, are prevented by the pin stops or studs y from moving laterally, the said plate or hook-bar q is forced outwards, until one of the studs y escapes from the ear of the cam x, which it will do the moment the brass pulley has arrived at the apex of the angle of the slat u; then, as there is nothing to prevent it, the plate t, and hook-bar q, move, or slide laterally with the assistance of the other stud y, until the end of the hook-bar abuts against the end framing of the machine, when the continued forward motion of the rod v, and pulley w, pressing against the opposite inclined side of the slat u, causes the hook-bar to retrograde; this motion of the pulley w causes the hooks to traverse three sides of a square, viz: outwards, lateral, and retrograde, and thereby to take hold of the wicks; which movement is completed by the advance of the metal slide r r, simultaneously with the movement of the hook-bars. The metal slide r r is affixed to a wooden bar, to which is also affixed a horizontal plate 1 1, similar in size and shape to the plate t, immediately beneath which it is situated. This plate 1 1 has also a slat of peculiar form, one-half being inclined, and the other half straight. The under brass pulley w works in this slat in a way similar to the other pulley w, in the plate t. The ends of the

metal slide r r fit accurately to the end framing, and thereby form a trough for receiving the melted material; and therefore, when by moving the sliding rod v, laterally, the brass pulley w advances along the inclined slat, the plate 1 1, and the metal slide r r, to which it is connected, are obliged to move outwards, until the pulley w arrives at the end of the inclined slat, when it will advance along the straight part of the slide, without acting upon the plate. The parts of the machine being thus situated, it only remains to make everything tight previous to pouring in the melted material; this is effected by shogging the lever z z to the position shown by dots in Figs. 147 and 151, when it will enter a notch cut in the back part of the slide 2 2; on the front part of which several inclined planes 3 3 are placed, immediately beneath a corresponding number of rollers 4 4, mounted in suitable bearings, as seen in Fig. 152. Having shogged the lever z, it is now to be raised at one end, by which it will move the slide 2 2 laterally, thereby forcing the inclined planes under the rollers 4 4; the bearings of which being fixed, cause the metal slide r r to press tightly against the bed, and prevent any of the melted material from getting under it.

The apparatus is now quite ready for a fresh supply of the melted material, which is, as before mentioned, poured into the trough s s; and, when cold and ready to draw, the cocks d d are loosened by means of the lever o o, and the wicks are disengaged from the hooks at the same time that the metal slide r r, and the inclined planes 3 3, are drawn back. After the candles have been tapped or punched, as before mentioned, the winch handle l is turned, and the empty frame g, above, is brought down to receive the second row of candles, and the full frame is at the same time raised to the highest point, thereby drawing the new candles out of the moulds. A front board or

guard g^* is now put on the hooks in the frame g, as before, to prevent the candles from falling out. The top row is then disengaged from the wick, by simply passing a sharp knife below the frame g, which will thereby leave the candle a sufficient length of wick for lighting. The full frame may then be passed over to the back part of the machine, and the candle removed therefrom at leisure.

In cases where considerable heat is not required to melt the tallow or candle material, the patentee substitutes a peculiarly formed tip to the moulds, in place of the stopcocks before described. This construction is shown at Fig. 153, in which $c\,c$ represent a portion of the candle mould, in vertical section. The tip, constituting the improved form, consists of a narrow tube and flange d, soldered or otherwise attached to the bottom of the mould. At the reverse end of this tube d, is formed a block f, through which the aperture of the tube is continued for the passage of the wick g (as above described with reference to the stopcocks), the aperture being of such a diameter as to compress the wick rather tightly as it passes through it. By this arrangement the melted tallow or candle material will be prevented from passing beyond the tube d; for, on its arrival at the bottom thereof, the enlarged portion f will abstract the heat therefrom, and, consequently, reduce it to a solid state. The improved tip may be made of any suitable material, and the enlarged portion thereof, of any required shape or size, provided the bulk is sufficient to solidify the fluid material as it descends.

The apparatus employed for trimming or finishing the butts or bottoms, and also for forming tops to such candles as may require it, is shown at Figs. 156 and 157. Fig. 156 represents a front elevation of the machine, some of the parts being shown in section, in order that they may be more clearly seen. Fig. 158 exhibits a plan view of

the same. The apparatus, in most parts, resembles a common lathe moved by a treadle *a a*, in the ordinary man-
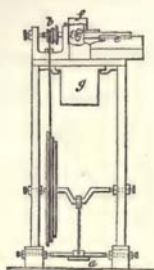
Fig. 156.   Fig. 157.
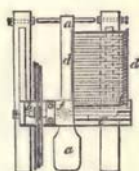
ner. Rotary motion is communicated from the large pulley to the small pulley *b*, above, by means of a band. A knife or cutting instrument *c*, of peculiar construction, hereafter described, is screwed, or otherwise fastened to the axle of the small pulley *b*. The candles to be operated upon are placed in a series upon an inclined board *d d*, attached to the side of the machine, and they are severally brought from thence to a block *e*, having a curved groove at top to receive a candle. The candle is firmly held in this groove, and its end pressed against the edge of the knife *c*, by the hand of the attendant, or in any other convenient manner; and rotary motion being given at the same time to the knife by means of the treadle, the butt or bottom is thereby made perfectly smooth. The cuttings or shavings from the candle are confined to the cover *f f*, and made to fall into a box or receiver *g* below. The peculiarly shaped knife or cutting instrument *c*, is

Figs. 158, 159, 160, 161.

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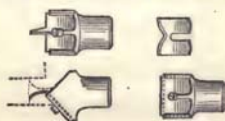
shown in plan at Fig. 158. The knife for forming the tips is shown detached from the holder at Fig. 159. Figs. 160 and 161, are two views of a knife of somewhat different shape from the former, which may also be employed for the same purpose as Fig. 159.

Humiston's moulding machine.—This is a recent American invention, and is shown by Fig. 162. The patentee claims, as its chief advantage, the simple manner in which it clamps the candles at the moment of egress from the moulds, and thus prevents all liability of their being broken or bruised.

Fig. 162.

A A exhibit the candles as held at the top of the stand by the clamps B B. These clamps consist of two sliding parallel slips, of wood or metal, for each row of candles; and have semicircular notches, with India rubber lining to prevent injury to the surface of the candles. They are

supported on posts M M, a few inches above the face of the stand; and, by an arrangement of cams upon one side of the clamp, are made to clasp the candles, and simultaneously hold a whole row suspended with their tips immediately over the centres of the moulds D D, kept in position by the cast-iron bed-plate C. They are then ready to receive the tallow. The tubular pistons for forcing out the candles are shown, as depressed, by F F. A continuous wick is used, and passes from the spools in the lower part of the stand, upwards through the piston-tubes, and centres of the moulds to the top of the candles in the clamp.

The bottom ends of the pistons are all attached to a bar which is connected, at the ends of the stand, to two vertical parallel racks, put in motion by pinions and the crank, so that all the candles in the stand can be forced out at once by a single operation. The bottom bar to which the pistons are attached is made somewhat elastic, so that the candles shall be *successively started* from the ends to the centre of the rows.

In this way, the power required will be less than if all the candles are started at the same instant. A spring is so attached to each piston as to make their tip-moulds descend close to the bottom of the mould, and thus prevent all leakage. L is the leaden chamber, at the sides and bottom, serving as the cooler when the use of ice becomes necessary to chill the candles.

The apparatus being arranged as shown by the drawing, the melted tallow is poured on the bed and into the moulds in the usual manner. When the tallow has "*set*," the candles in the clamps are to be cut loose, and the two removed together from the stand. The stand is next scraped, and the clamps replaced with their jaws so far open as to allow a free passage to the candles. The crank is then turned to expel all the candles, simultaneously,

from the moulds; and the clamps, in closing at that moment, let fall the pistons to the bottom of the moulds. The apparatus is then ready for a second moulding operation.

No special wick-tightener is employed, for the wicks are straightened by the tip-moulds on the pistons, as the latter descend.

Each stand is 3½ feet high, 3 feet long, and 22 inches wide, and contains four rows of 24 candles. The rows are arranged two on a side, so as to leave a space in the centre for a gearing shaft, which extends the whole length. There being ninety-six moulds in one stand, sixteen pounds of candles are made at one casting.

Ashley's machine.—This is a very recent American invention, by which the patentee proposes to impress the trade mark of the manufacturer upon the candles during the process of moulding. To this end, the moulds are arranged in the stand at an angle of fifteen degrees, with the tips uppermost. Openings are made in the sides near the tips for the passage of the melted tallow, which is supplied from a suitably arranged trough. There is also an arrangement for making the wicks continuous, so that the act of drawing one batch of candles, simultaneously wicks the moulds for the next casting. 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 butt end, and, at the same time, receive the impress of the trade mark.

Camp's wheel.—This machine, which is an American invention of recent date, performs its work with expedition—a single workman being able to make, with it, one thousand pounds of 6's and 8's mould candles per day. Its construction, too, is very simple, and it is, moreover, very easily managed. The apparatus has given much

satisfaction, and is in general use throughout the United States.

It consists of a revolving platform, or horizontal wheel B, Fig. 163, suspended by means of iron brace-rods O,
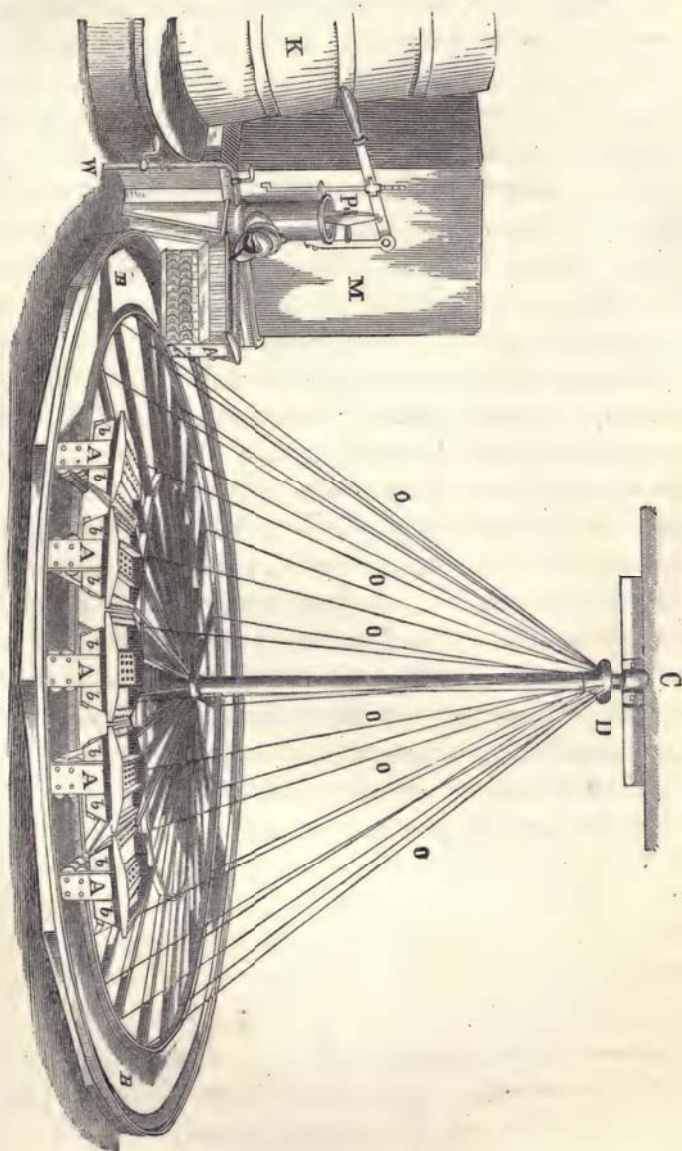
Fig. 163.

which centre at D, in an upright shaft turning upon its pivoted ends in a socket affixed to the floor and ceiling C. This platform serves as a table for the support of the mould-stands A, which are made with lateral recesses b, for the reception of ice, when warm temperatures render necessary artificial aid in the cooling of the candles. In the lower part of the stands, and just below the tips of the moulds, are spools of wick, corresponding in number with that 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 tub M, immediately adjoining the melting tub K, from which it is supplied with fluid tallow, by ladles, or a copper gutter. The first stand being filled, the wheel is then pushed around until the following stand succeeds to its place under the mouth-valve of the feeder. This is filled by opening the valve, as before; and so on, the operation proceeds, until all the stands on the platform are filled. Before, however, the last of the stands are reached, those first filled will have cooled; and this circumstance enables the operator to work in odd moments, by drawing from them the candles, and preparing the emptied mould-stands to regularly maintain their original order during every revolution of the wheel, thus making the process continuous. The drawing is done after the cutting of the wicks and the removal of the excess of tallow on the bed-plate of the moulds, with a trowel-knife, by grasping the wick ends with a pair of smooth-face clamps. The whole row of candles is drawn simultaneously, and are laid over in groove-rests, cut in the ledges of the stand especially for their support. As the wicks move after each candle from off the spools, it follows that the act of drawing a candle threads the

mould for its successor. The previous candle is allowed to rest in the grooves until the succeeding one has cooled, in order to keep the wicks in the centre of the moulds.

Mr. Jno. Curlett, of Baltimore, has added an improvement to this apparatus, which materially enhances its usefulness. It is simply the attachment of an iron cylinder P, to the feeder M. This cylinder has two valve-openings, one connecting with the feeder, and the other a gate or spout for the flow of the fluid tallow into the moulds. The handle moves a plunger which, by means of a gauge-rod attached, may be so adjusted in the cylinder as to prevent the entrance of any larger charge of tallow than is sufficient to fill one stand of moulds. The act of raising the handle brings up the plunger to the adjusted height in the cylinder, whereupon the tallow from the feeder runs in to fill the space vacated. Then, on opening the front valve or gate, the back valve is simultaneously closed, so that no tallow is flowing in from the feeder while the cylinder is being emptied of its charge. This arrangement obviates the necessity of constant attention on the part of the operative. As each stand of moulds reaches its place under the spout, it is steadied by a suitable break or catch. At the bottom of the cylinder is a chamber, into one side of which enters a steam pipe W, and from the opposite a waste pipe, for the escape of condensed steam. This arrangement is for the use of steam in very cold temperatures, which tend to chill the tallow in the feeder.

CHAPTER XXVIII.

THE stearin, of which we are about to treat in this chapter, is not the chemically pure substance considered in Chapter X, as one of the proximate principles of fats; but the commercial article or mixture of the several solid constituents of the fat whence it may have been derived. The processes which we shall describe for its preparation are, therefore, alike applicable to tallow, lard, palm oil, cocoa butter, or any other fat-stock of sufficient consistence to be profitably worked.

In the years 1842 and 1843, when the public attention was being called to the applicability of lard for the manufacture of lard oil, and the conversion of the residual stearin into stearic blocks for candle use, I was requested by Mr. Ellsworth, the able and energetic Commissioner of the Patent Office, at that time, to furnish a paper upon the subject for his annual report to Congress. Being then professionally occupied at my laboratory, I had no time to comply with his wish, further than to forward him a copy of Gay Lussac's process, which he published. A few months following, however, when more leisure ensued, my attention was again called to the matter by a gentleman who desired instruction from me as to a practical method of separating the lard oil from the lard, with a view to commencing the manufacture of that article. The information was furnished and exemplified by an actual performance of the whole process; after which, and some matured reflections, it occurred to me, that as lard con-

sisted of thirty-eight parts of solid constituent in every one hundred, some means might be adopted for its perfect separation without resort to saponification; and in this way be procured a perfectly free stearin, which is, when pure, unalterable in the air, and contracts no bad smell, as tallow does. The object in doing away with the saponification was to obviate its expense, whilst, at the same time, a candle might be made, if not equalling sperm, much better, handsomer, and more durable than the disagreeable greasy tallow candle, and consequently, particularly fitted for the use of workshops, printing-offices, and the poorer classes of the community. The design was to furnish an article of handsome appearance and superior quality at a low price—so low that, without competing with sperm, they would entirely drive the tallow candles from the market.

My experiments were based upon the entire solubility of olein in spirits of turpentine, whilst the solid constituents of the lard, though also possessed of that property, are nevertheless greatly impaired in the exercise of it at *sufficiently low temperatures.* The great disadvantage to be overcome, was in the sale of the large quantity of lard oil, yielded as an incidental product; this, however, no longer exists, as that article has become a standard one in commerce; moreover, for the purpose of making candles, the solid residual cake can now be purchased from those who manufacture the oil exclusively. The results exceeded my anticipation, though not until after much outlay of both time and money; success was, nevertheless, obtained; that was the grand object, and the following report of the Committee on Chemicals of the Franklin Institute—to whom was presented for exhibition, in 1843, a sample of the stearin in every progressive stage of the process, up to the finished candle—afforded me additional pleasure :—

" No. 351, a lot of articles from Mr. Morfit, exhibiting the various processes in the manufacture of stearin from lard; the specimens are highly interesting, and show, in a very clear light, the method of the manufacture. Mr. Morfit claims the discovery of a new method of purification without saponifying, about which claim the committee know nothing, but consider Mr. Morfit (a very young man) as deserving all credit for his unremitting industry in perfecting and extending this important branch of manufacture, and, therefore, recommend for his interesting display, a certificate of honorable mention."

It may be as well to state that my candles were in competition with superior adamantine lights, which, though nearly twice as costly, were not considered worthy of, and did not receive a higher premium.

Tallow produces a white, marble-like stearin, but that from lard is diaphanous, and resembles wax in consistence and appearance. The expense of making either kind is about the same; and the candles need not cost many cents more than pressed tallow candles. The first step in the process is the separation of the oily portion which, from lard, is called:—

Lard oil.—There are frequently in the market lots of lard, quite dark and dirty in appearance, offered for sale at tempting prices; and relative to such article a word or two of advice is necessary, when about to be purchased for conversion into stearin candles. If, upon examination, the darkness of color is occasioned by the lard having been scorched or burned in the course of its preparation, touch it not; it will cost more than it is worth to bleach it, even should the attempt be successful—a doubtful matter in three instances out of five. But if the tinge is only owing to the presence of dirt, then the lard may be used, if it can be had at a price proportionably low, because it regains its whiteness in the process of being worked into

oil and candles. There is a great deal of what is called "stearin" also offered for sale by our merchants. It is the solid residue of the lard after the expression of its oil. This answers every purpose for making candles, except that in working this article, profit that might accrue upon the oil by commencing the process with lard itself, is lost. This stearin is of about the consistence of tallow in summer time, and is more or less contaminated with coloring matter, which must be gotten rid of by one of the usual bleaching processes, in the manner before directed. If the color does not yield to blanching influences, then such stearin is unfit to be converted into candles, and must be rejected. The best way is to select good solid corn-fed lard.

The first step, after the selection of the lard, is to transfer it from the kegs or barrels into a clean wooden tub, of adequate capacity, and therein melt it by the application of steam through a pipe attached to the steam generator. This tub must be iron bound, and in order that there may be no splashing over of its contents, should only be filled three-fourths of its depth. The current of steam must be continued for six or eight hours, at the expiration of which time it is stopped off and the vat of boiled lard allowed to stand for three or four hours; by this repose the water, condensed from the steam thrown into it, by its greater specific gravity subsides, and being unnecessary to the granulation of the lard, is to be drawn off through a spigot, the inner end of which, that its aid may be effectual, it is best to have resting immediately on the bottom of the boiling tub. The water rushing out carries with it all the subsident foreign matter of the lard, which is by this operation purified, whitened, and disposed to granulation. As there is more or less of filth still adjacent to the bottom of the cistern, it is better to draw the steamed lard through a cock placed some two or more

inches from the bottom, so that it may run through clear, white, and uncontaminated. The vessels into which it is racked, are called cooling tubs; they should be of capacity not less than five hundred, nor more than two thousand pounds. In these tubs the boiled lard must remain undisturbed for twenty-four hours, when, through a little gimlet hole at the bottom, fitted with a movable plug, such water as was retained by the warm fat, and has then settled, is drawn off. The hole being closed up, the tubs are left undisturbed for several days, or until the lard has congealed, and exhibits a granular appearance. This granulating room should have a temperature between 40° and 60° F.; if it is higher, the cooling is too slow; if lower, the congelation occurs so rapidly as to endanger the perfect granulation of the mass—that which is necessary for the success of the operation.

In cold temperatures, it becomes necessary, therefore, to keep the tubs covered so as to prevent the dissipation of internal heat. Some of the fats granulate more readily and perfectly than others; for example, palm oil—the solid portion of which settles, as a thick mass, from the olein, leaving the latter as a clear superstratum.

From this thoroughly granulated mass, the oil, portions of which are even now seen floating around the granules, is separated by ladling it into bags to a thickness of almost two inches, the size otherwise not being important, and folding them so as to prevent the expulsion of any of the solid matter. Some factors, instead of bags, use large wrought iron cylinders, cullendered with small holes throughout their whole circumference, and lined interiorly with canvas. This, however, is a wholesale way of operating, very proper where followed for obtaining the oil alone, but not cleanly enough when the residual stearin is intended for candles, and after all does not possess a great advantage over the bags on the score of economy.

Each bag, as it is filled, is put into the press with an iron plate intervening between every two; and, when full, the press is locked by pressure, gradual at first, but increased as the flow of oil begins to lessen. The temperature of the pressing-room should never be higher than that at which the lard was granulated. The oil expelled by the pressure, is caught in suitable vessels, and transferred thence into large covered tin stands.

This oil is the "LARD OIL" of commerce, and when good lard has been used, is very pure and white, but of a brown color when it has been pressed from burned or scorched lard. It is considered much superior to sperm or olive oil for greasing wool, and being more economical in price, is very largely used. But it should not be bleached for these purposes by chemical means, as it will be apt to retain enough of the bleaching agent to injure its quality, and render it inapplicable for many purposes. When the lard from which it is expelled is good and not burned, the steaming produces all the necessary bleaching. Tallow, by similar treatment, yields *tallow oil*.

Winter lard oil is made by subjecting this oil to the influence of a cold temperature, and when it has granulated, re-pressing it in bags as before. The oil running through is able to bear a much lower temperature without congealing, than if it had not undergone this second granulation and pressure. The solid matter in the bags can be mixed with the stearin, which is to be made into candles.

When lard, prepared by Wilson's plan of steaming, is used, then the re-boiling and granulation are unnecessary, for all lard rendered in tanks and by steam is sufficiently granular as it comes to the market, without the necessity of any re-boiling, and is ready to be transferred from the kegs to the bags, and in them to the press. Sometimes ordinary screw presses are used for pressing out the oil,

but the most economical and perhaps best, is the lever press, easily and cheaply made by properly adjusting a long oaken beam over a frame arranged for the reception of the bags. By these means the pressure goes on gradually even during the night, and whilst the attendant is absent.

Previous to passing to the next step which is the beginning of the candle process, it is proper to remark that the use of spirits of turpentine, or camphene, which the author of this work conscientiously believed had originated with him, was, in truth, first proposed by Braconnot, who, as far back as 1821, made some specimens of stearin by his plan, and presented them under the name of *céromimème.**

This fact was not known to the author until after the completion of his experiments; and, though the discovery has caused disappointment, he yet gladly yields the credit of originality to the one who has the best claim. Still, however, the details of the plan have been worked out by himself, and therefore it will not be considered arrogant to style it—

Braconnot and Morfit's process.—When the pressed cakes cease to give any more oil, the press is to be unlocked, and the bags emptied of their contents. This pressed matter is thrown into a clean tub, and steamed again in the same manner as at first, and, after six hours' boiling, allowed to stand for twenty-four hours. The subsident water is then drawn off beneath, and the still fluid fat run into tubs of five hundred pounds capacity each, which tubs are to remain stationary in a uniform temperature ranging between 50° and 70° F., until the whole mass is thoroughly granulated. The centre of the mass being sometimes rather mushy, must be stirred up well with the

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* *Eboline* is another name for stearin, prepared in a manner not very dissimilar from that by which the céromimème is obtained. It is so called, after the name of the manufacturer.

rest, but before this is done, the residual water which has subsided must first be drawn off as before, through the gimlet hole in the bottom. The granulation is known to be perfect when a lump from near the sides of the tub can be handled without softening, and is strictly granular in its appearance. Canvas bags are to be filled and pressed with this grained matter, precisely in the same manner as described for the first pressing of the stearic acid. The bags must be filled to a thickness of only one inch, and the temperature of the room in which they are pressed should be between 60° and 70° F. When all the oil that can be driven out in this way is expelled, then the press is unlocked and emptied. In all instances, where the press is used, the pressure must be applied gradually at first, else the bags will be apt to burst, and the material worm through the meshes of the cloth. The oil which runs out at this pressure, contains a goodly quantity of stearin, and consequently will not remain liquid even at a moderate temperature, and so, upon being congealed at a gradual temperature, is ready to give up another portion of its solid constituent by pressure as before. This oil, however, brings nearly its original price as an ingredient for fine soaps, and perhaps the economy would be as perfect in directing it to that course. In case it is re-granulated and re-pressed, the solid constituent remaining in the bags is saved for the next operation, and the oil sold for greasing wool, or burning in lard lamps, its fluidity not being sufficient to fit it for sperm lamps, or for machinery.

To proceed with our process, we will state that by this first hydraulic pressure of the stearin, it is freed of so much of its more liquid portion, that when taken from the bags, it is in hard cakes, which break with a cracking noise. These cakes, as they are emptied from the bags, are first weighed and then thrown into a very clean jacketed cop-

per kettle, similar to Fig. 9, where it is to be melted
anew by the heat of the steam let in between the sides of
the inner and outer kettle, and kept at the temperature
it is thus raised to, for about four hours, taking care, how-
ever, that the liquid fat at no time gets beyond 200° to
212° F. After the four hours heating, it is allowed to
stand until its temperature has fallen to between 110°
and 140° F., when to every one hundred pounds of the
weighed cake must be thoroughly incorporated by stirring,
eight pints of spirits of turpentine of *recent* distillation.
The liquid fat thus prepared, must now be drawn off into
tubs of about five hundred pounds capacity each, and
placed in a temperature ranging between 45° and 55° F.,
and there allowed to remain for several days, when it will
have hardened into a granular mass. This granulated
mass must then be bagged and pressed in the horizontal
hydraulic press, precisely in the same manner as is effected
the last pressing of the stearic acid, using similar mate-
rials for the bags and envelops.

Fig. 164 gives a longitudinal section of the press. *a* is

Fig. 164.
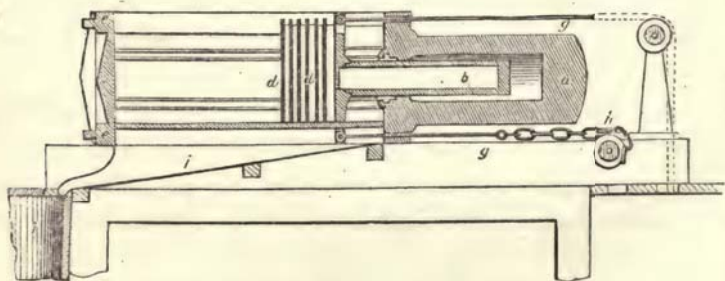
the cylinder of the press; *b*, the ram or piston; *j j j j*, the
hair and flannel bags inclosing the fat under pressure;
d d d d, wrought iron plates, and placed between every
two cakes; *e e*, solid iron end of the press, made to resist
great pressure, and it is strongly bolted to the cylinder *a*,

so as to resist the force of the ram; *g g*, iron rods, for bringing back the ram *b* into its place, after the pressure is over, by means of counterweights suspended to a chain which passes over the pulleys *h h*. The spout and pan *i i*, are to receive the oily fluid as it flows from the bags. The press should carry through twenty courses of bags daily. The pressure must at first be very gentle, but gradually increased until its greatest power is applied. By surrounding the cakes and plates *d d* with a chest, and admitting steam into it through a perforated tube running along the bottom, the apparatus may be converted into an economical hot press.

The thick oil which is expressed must be thrown in an iron kettle with some water, and boiled, until the evaporation of all the turpentine, and the absence of its smell; thus it is made fit for sale to the soap boilers. But in those localities where fuel is plenty, and the price of spirits of turpentine is costly, it is better to have a copper still and heat the oil in it by a current of steam, until all the spirits of turpentine has been driven over and condensed in a cooling worm. The spirits are thus saved for a new operation, and the value of the residue increased as soap stock by the removal, in this manner, of its terebinthine liquid and odor.

When the whole extent of pressure has been applied to the bags, so that no more liquid fat will ooze out, then the press must be unlocked, the bags removed, and their contents immediately emptied into an iron-bound vat, where it is to be steamed until entirely rid of the presence and odor of turpentine; afterwards it is allowed to settle, so that the small quantity of subsident water can be drawn from the bottom through a brass cock. I have said that it should be immediately steamed after pressure, because if the cakes stand too long, the turpentine they contain is prone to change its state by the absorption of oxygen

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from the atmosphere, and render the future operations of cleansing and bleaching difficult. The liquid fat, whilst still warm, is drawn off into a perfectly clean iron pan, and then bleached by digestion with a little water and a very small quantity of alkali.* The scum arising to the surface brings up all impurities, and as soon as the liquid becomes clear and free of milkiness, the operation is finished. The stearin is now strained through linen cloths into tin pans, and when cool forms blocks of wax-like consistence and appearance.

The bags for the turpentined fat must be kept exclusively for that purpose, and steamed out at least once every fortnight.

In winter, the candles into which these blocks are converted, may be readily drawn from the moulds, when cast in the usual way of moulding candles; but in summer the tenacity of their material is such that they adhere to the metal, and will not yield to the usual means of drawing them. Braconnot proposes to obviate this difficulty by mixing five per cent. of white wax with the stearin; but this rather increases the trouble when the stearin is from lard. His suggestion, therefore, must refer to tallow stearin, which differs from the above in physical structure, and is really improved, in many ways, by the addition. My experience proves that the best method of moulding is to allow the stearin to cool to about 125°–130° F., before pouring it into the moulds, which must be heated to nearly the same temperature. This is to be done by means of a chest and steam pipe. In moderate temperatures, the candles will have sufficiently contracted *when thoroughly cooled*, to allow their easy withdrawal in the usual manner. In summer, the cooling must be hastened

* This operation of bleaching is practised as directed in the chapter upon Sperm Candles.

by ice contained in lateral recesses affixed, for the purpose, to the mould stands.

The drawing may also be easily accomplished at the expense of a part of the handsome appearance of the lard stearin, by mixing it with 10 to 20 per cent. of tallow stearin, prepared in the same manner. This mixture leaves the moulds, at even warm temperatures; as also does the tallow stearin itself, without any addition of other fatty matter. The mixed candles, though handsomer than those from tallow stearin, have not the beautiful wax-like appearance of lard stearin candles.

The wick which I have used, is represented by Fig. 165. It consists of seventy fine spun cotton threads, gimped or tied around with thread by a machine similar to that for wrapping bonnet wire. This wick, however, is not wholly satisfactory, for though it gives a fair light, it does not develop the illuminating power of the candle. The essays in the adaptation of a suitable wick were numerous, but not conclusive, and when my attention was called from the subject to other matters, success had become complete only so far as to decide upon this wick in preference to all others that I had tried. It still requires to be materially improved.

Fig. 165.

The candles, by this process, are perfectly dry and inodorous; and, in burning, consume well without guttering. The appearance of the candles, and even the taste, too, of the material so nearly resemble white wax, that it is with difficulty the difference between the two can be distinguished. This wax-like appearance is only peculiar to the candles from lard; when tallow is used, they are equally hard and good, but their appearance is more like that of a very white compact polished marble.

All the different kinds of stearin candles are inferior in illuminating power to those from the fat acids; but this deficit is counterbalanced by their much lower cost.

Plaited wicks, of an eighth of an inch in width, may be used for the candles from tallow stearin, or its mixture with lard stearin; but for the latter, alone, the gimp wick, as far as our knowledge extends, is preferable.

The quantity of solid constituent obtained by the foregoing process, is not the whole amount existing in the original fat. A part has passed off with the olein or fluid portion, for it is impossible, by any known and convenient means, to effect their total separation on a large scale.

If the stearin, during the process, has become dark or dirty by contact with the metallic vessels, it may easily be cleaned and whitened by mixing it with water containing one thousandth of its weight of oil of vitriol, and steaming for an hour, taking care, however, that the ratio of acid to the stearin shall not exceed one per cent.

CHAPTER XXIX.

STEARIC ACID CANDLES.

THE term "*stearic acid candle*" should, strictly, designate only that kind of candle which consists of pure stearic acid; but it has, commercially and technically, a more liberal signification, for it comprises all solid fat-acid candles, without regard to the source or to the manner in which they may have been made. This usage is one of obvious convenience, for, as the solid portion of the different fats is almost universally a mixture of two or more fat acids, it would be very difficult to distinguish the candle product of each, by a title at once popular and expressive; and, to prevent confusion, it has been deemed best to include all under one comprehensive name. Stearic acid being the earliest discovered, and, moreover, the most common of the solid fat acids, is very properly, therefore, taken, for practical purposes, as the exponent of the class of candles to be treated of in this chapter.

The stearic acid candle is the profitable issue of a philosophy which had its inception with the great Chevreul; and, in no path of research, has the science of chemistry left such an impress of its utility, and of the ingenious faculties of man, as in the progress of the study of fats, and the application of the results to the convenience and comfort of society.

The art dawned, in 1811, with the discovery of the compound nature of fats by Chevreul; and though Braconnot, subsequently, added his diligent labors in this field of study, it was not until 1825 that it yielded any re-

munerative results. At that time Gay-Lussac, acting upon
the original suggestions of Chevreul, developed the present
process of saponification by strong bases; to which, by the
simplification of details, Milly, in 1831, contributed a
practical value which brought it into use. Cambaceres,
and others, afterwards added many useful facts to the
then existing stock of information, and gave such consist-
ence to the art, that candles were extensively manufac-
tured by lime saponification to a very recent date, when
that mode was forced to yield to the more advantageous
method of acid saponification, discovered by Fremy, in
1836. This latter will, doubtless, in its turn, sooner or
later become a forfeit to the law of progress; for, already
the simple, ingenious, and economical plans of Bussy,
Lecanu, and Tilghman begin to show evidence of great
superiority.

To convey an idea of the rapid advancement of this
branch of industry, the number of stearic acid candle
establishments in this country were so few, when the first
edition of this work was published, that they could
readily be enumerated. Since that period, the good
qualities and cheapness of stearic acid, or adamantine
candles, as they are frequently called, have given them
such a hold on popular favor, that manufactories now
abound in every section of the country. Nor is it here,
solely, that they constitute an important ramification of
commercial enterprise; for in England, at the Belmont
Factory, which alone covers upwards of three acres, the
weekly product of candles is one hundred tons. The raw
materials there employed, are palm oil and cocoa butter;
and in this country, beef tallow, mutton suet, and lard.
Vegetable tallow and waxes are also used when they are
to be obtained conveniently, and at a remunerative cost.

In proceeding to give the details of the several modes of
treating these substances for their conversion into stearic
acid candles, we will commence with the one styled—

SAPONIFICATION BY LIME.—The first step is to place the raw material, whether it be tallow, pressed lard, palm oil, or any other fat, into No. 1 of a series of large iron-bound, slightly conical cedar cisterns, each of which is to be heated by a direct current of steam, as shown by Fig. 85, introduced by means of branch pipes and a perforated coil at the bottom, connecting with a main feeder of larger size, leading from the steam generator. When melted, it is to be pumped into tub No. 2, and treated with freshly burned caustic lime, in the proportion of 300* pounds to every ton of fat material. The lime must be added in the form of "*milk;*" to which end it must be previously slaked, and mixed with 4 to 500 gallons of water. The steaming must be continued while the lime-milk is being gradually poured in, and for several hours after all has

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* *Saponification by Soap.*—This process is founded upon the fact, recently discovered by Milly, that the neutral fats may be split into glycerin and fatty acids by soap as well as by alkaline bases. Pelouze, who carefully studied out the principle, repeatedly obtained an entire decomposition of olive oil into fatty acids and glycerin by heating it in the proportion of 40 per cent. with a mixture of equal weights of soap and water. The experiments were performed in a Papin's digester, maintained for three hours at 311°—329° F., by the heat of an oil bath. The changes which take place are probably the conversion of the neutral soap, by the water and heat, into an acid and a very basic soap, which latter acts, secondarily, upon the oil in the same way as free alkali.

This principle has already been successfully applied to the manufacture of stearic acid candles by lime, and with great economy of time and material; as it effects a saving of lime, and, consequently, also of the acid required for the subsequent decomposition of the lime soap. The only change necessary to be made in the manipulations above described, is to diminish the proportion of lime to four per cent. of the weight of the fat, and to heat the mixture of fat, lime, and water for several hours in a metallic caldron of three and a half feet diameter and fourteen feet depth. The reaction must be promoted by active mechanical agitation, and by raising the heat to 295° F., under the corresponding pressure of four to five atmospheres. In the reaction which takes place a basic or neutral soap is probably first formed, and afterwards changes into a comparatively acid soap. The glycerin presents all the properties of an uninjured product.

The quantity of lime required will be only 90 pounds per ton of fat; and the proportion of oil of vitriol must be correspondingly reduced to 165 pounds. The decomposition of the lime soap, made as here prescribed, is to be effected in the usual manner, and as above directed, except as to the amount of sulphuric acid. Several tons of fat may be treated at one operation.

been added. To economize heat, and to exclude air by
maintaining an internal atmosphere of steam, the tubs
should be kept closely covered during the boiling. Care
must be observed to select lime as free as possible from
impurities, and such as will wholly slake to powder upon
being drenched with water. The quantity above pre-
scribed is more than the equivalent proportion, but an
excess is necessary to provide against impurities and
other contingencies. To promote the intimate mixture of
the lime and fat, and, consequently, to accelerate the
process, the tub should be fitted with a twirl-shaft, as
shown by Fig. 166; for, by such means, a constant
stirring may be maintained.

Fig. 166.
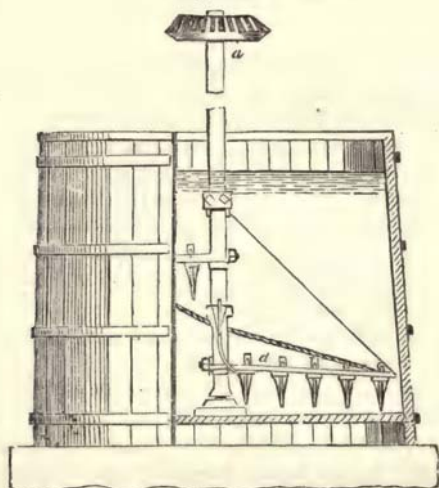
The shaft is seen at a, and its teethed arms, of which
it carries several, are shown by d. Steam is the motive
power generally used, and is applied by means of cog-
wheels and suitable gearing.

This boiling accomplishes what is called the saponifica-
tion of the fat; or, more properly speaking, its chemical
decomposition by the strong base lime, which drives off the

glycerin to be taken up by the water, and then combines, itself, with the fat acids thus set free from their natural base. The result is a true lime soap, technically termed "*rock*," and composed of oleate, stearate, and palmitate of lime, if the fat employed contained the corresponding acids. This preliminary saponification is indispensable, as a disposing influence on the more solid acids of the fat to separate from the oleic or fluid portion ; and the completion of the boiling may be recognized when a test sample of the soap, on being cooled and scratched with the finger nail, appears smooth and glossy. It should, moreover, snap with a cracking sound, and reduce easily to powder, under the pestle. The saponification or boiling generally requires four to eight hours, but the sample, and not time, is the surer guide by which to judge when it is finished.

The upright shaft, and the teethed shaft, must be of wood, for it is absolutely necessary that there should be, as far as possible, an absence of metal from the interior of the vat—all fastenings being made of copper, where metal is positively requisite. After the addition of the milk of lime to the melted oil as before directed, this shaft is made to revolve during the whole term of ebullition, or rather until the saponification has been effected. The operation being finished, the steam is stopped off, and a quantity of cold water added, gradually at first, whilst the stirring shafts are in constant motion. The whole is soon converted into a granular mass, and after being well washed, is ready in the same vat for the next step, and without the necessity of being previously powdered. To facilitate the washing, it is necessary to have a large wooden plug close to the bottom of the saponifying tub; and the form already shown by Fig. 14, will be very suitable and convenient. Covering the plug-hole, in the interior of the tub, must be a piece of copper-wire cloth, so as to arrest the passage of any small particles of soap, when the wash

waters are being drawn off. When one wash water is
drawn off, the hole must be closed during the addition of
fresh water. After three successive treatments with fresh
water and evacuations, alternately, all the glycerin will
have been washed away, and the lime soap will be ready
for the next stage of the process; but before describing
it, we must remark that the stirring is a very important
manipulation. When the shaft is not used, the soap cools
in large lumps, which are difficult to be washed, and
require to be powdered preparatory for succeeding opera-
tions. This involves the expense of a mill, which is a
pair of fluted rollers, over which an axis is placed, carry-
ing tiger-like claws, which revolve between a series of
horizontal prongs. The claws, by passing between the
prongs, tear the lumps into small pieces, which are then
crushed by the fluted rollers.

Decomposition of the lime soap.—This is effected by the
agency of strong sulphuric acid, which, having a stronger
affinity for the lime base of the soap than exists between
it and the fat acids, seizes upon and combines with it to
form sulphate of lime; while the eliminated free acids rise
to the surface as a fluid-oily matter, technically termed
"*yellow matter.*" The vessels used for the operation must
be lined with lead, and of several tons capacity. For every
ton of tallow, two hundred or more gallons of water must
be used; and this latter being poured into the tub con-
taining the granulated soap, the mixture is then heated
to boiling by means of steam introduced through a per-
forated copper coil placed at the bottom. At this point
550 pounds of oil of vitriol of 66° B., previously diluted
with its volume of water, are very gradually added during
constant motion of the stirring-shaft.* The current of

* Cambaceres has proposed to render the manufacture of stearic acid less ex-
pensive, by obtaining, instead of the useless sulphate of lime when the lime soap
is decomposed by sulphuric acid, a more valuable salt of alumina, as an acces-
sory product; but as it is impossible to saponify with alumina, the tallow must

steam, which should be gentle, and always much below the boiling point, must be continued until the granules of soap have disappeared, and the fatty matters form a clear fluid superstratum—signs which indicate that the decomposition is completed. During the heating, it is prudent to shut off the steam occasionally, for a few moments, so as to prevent any tendency of the fats to darken; and the tub must also be uncovered until the end of the process, when the cover is put on in this position ⚋ so as to leave a small opening. The whole is then left to repose until the fatty acids have entirely separated from the water and other ingredients of the lower stratum, and occupy the upper portion of the tub. The plug being then taken out from the evacuating hole, the substratum of water carrying with it the saline matters (sulphate of lime), and excess of lime not acted on during the operation, is drawn off and the hole again closed.

As the fatty acids retain more or less lime salts, they require to be washed several times with fresh waters, in the usual manner, by means of the stirring-shaft and a gentle current of steam. When all impurities have been removed, the cleansed mixture of oleic, margaric, and stearic acids is then to be drawn off into tin pans of sixteen inches length, ten inches breadth, and two inches depth.

Granulation.—These pans, when filled, should be set upon shelved racks, arranged in and around a room specially appropriated for the purpose, and the temperature of which should not exceed 90°, nor descend below 70° F. In this room these filled pans remain for several days, or until their contents become granulated, that is, until the

first be converted into soap by potash. This latter is then decomposed by a solution of alumina in caustic potash, and from the gelatinous aluminated product the fatty acids are to be separated by sulphuric acid. Sulphate of alumina is incidentally formed, and may be very profitably employed in the manufacture of alum.

margaric and stearic acids have undergone a kind of crys-
tallization, which does not occur with the oleic acid except
at a much lower temperature. When the granulation is
complete, or rather when the cakes in the pans have
solidified, and the surfaces appear sweated and dotted
over with drops of oily matter, and yield slightly to the
pressure of the finger, an oiliness being imparted thereto
at the same time, then they are ready to be emptied out
for cold pressure.

The sulphate of lime and excess of lime make excellent
manure, and must be saved and sold for that purpose.

Cold pressing.—Preparatory to being pressed, the cakes
must be enveloped in suitable wrappers, which are gene-
rally square pieces of canvas duck linen, such as is used
for sacking bottoms, but of a better quality, and to be
selected with judgment. The size is such that one of the
cakes in the pan can be entirely enveloped in each cloth.
Additional to these cloths there must be a fellow to
each, corresponding in size, and to act as a jacket or
outer wrapper, and made of twine cloth, similar to that
used in the sperm candle factories. The cloths being
ready at hand, an inner and outer one are taken together,
and placed upon a table, the twine cloth nearest to the
top of the table, and one of the pans emptied thereon.
The workman now closes the canvas cloth carefully
around the cake, and again in turn envelops the cake
already covered with the cloth, in the other twine wrap-
per. And so he proceeds until all are wrapped up,
each cake, as it is covered, being placed in the press,
which should be ready to receive them. This press is
generally an ordinary upright hydraulic press, such as is
made in New Bedford for the sperm candle factors; but a
better form is that of Maudslay, an English engineer. It
is shown in plan at Fig. 167; in side view of pump at
Fig. 168, and in elevation at Fig. 169, where the same

Fig. 167.
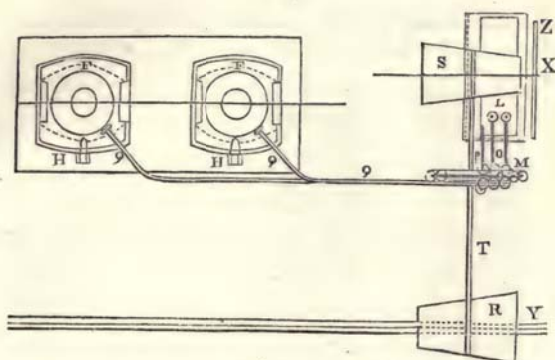
letters refer to like objects. We are indebted for our description to *Ure's Dictionary of Arts and Manufactures.*

Fig. 168.
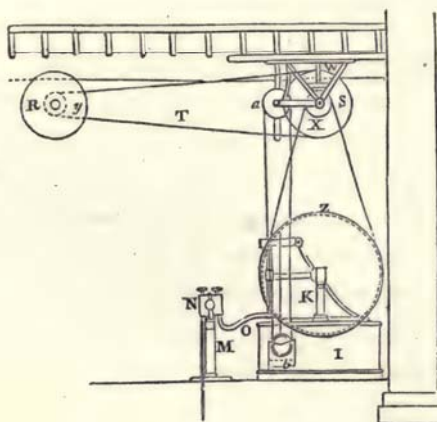
"A A are two hydraulic presses; B, the frame; C, the cylinder; D, the piston or ram; E, the follower; F, the recess in the bottom to receive the oil; G, the cloths with the material to be pressed, having a thin plate of wrought iron between each; H, apertures for the discharge of the oil; I, cistern in which the pumps are fixed; K, framing for machinery to work in; L, two pumps, large and small, to inject the water into the cylinders; M, a frame containing

Fig. 169.
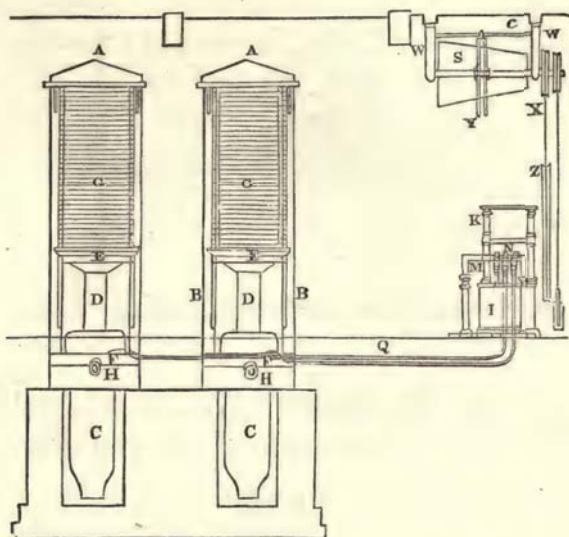
three double branches; N, three branches, each having
two stops or plugs, by which the action of one of the
pumps may be intercepted from, or communicated to, one
or both of the presses; the large pump is worked at the
beginning of the operation, and the small one towards the
end; by these branches, one or both presses may be dis-
charged when the operation is finished; O, two pipes from
the pumps to the branches; P, pipe to return the water
from the cylinders to the cisterns; Q, pipes leading from
the pumps, through the branches, to the cylinders; R,
conical drum, fixed upon the main shaft Y, driven by the
steam engine of the factory; S, a like conical drum to
work the pumps; T, a narrow leather strap to communi-
cate the motion from R to S; U, a long screw, bearing a
nut, which works along the whole length of the drum;
V, the fork or guide for moving the strap T; W W, two
hanging bearings to carry the drum S; X, a pulley on the
spindle of the drum S; Y, the main shaft; Z, fly-wheel
with groove on the edge, driven by the pulley X; on the

axis of S, is a double crank which works the two pumps L; *a* is a pulley on the end of the long screw U; an endless cord passes twice around this pulley, and under a pulley fixed in the weight *b*; by laying hold of both sides of this cord, and raising or loosening it, the forked guide V, and the leather strap T, are moved backwards or forwards, by means of the nut fixed in the guide, so as to accelerate or retard at pleasure the speed of the working of the pumps; *c* is a piece of iron with a long slit, in which a pin attached to the fork V, travels, to keep it in the vertical position."

Hydraulic presses are constructed upon one and the same principle, though they often differ in form. The application of hydrostatic pressure, as a mechanical power, is said to have originated with Bramah, of Piccadilly; but his right is contested by Pascal, who claims to have, first, announced it in 1664.

The term hydrostatic is derived from the two Greek words υδωρ, water, and σταω, I stand; but these apparatusses are not restricted to the use of water, as the application of other dense fluids, for instance oil, creates a pressure of immense power. In the hydraulic or hydrostatic press, the water is forced by a strong pump into an accurately bored, internally smooth iron cylinder, of great strength and thickness, where it acts upon a much larger piston, and pushes it against the matter to be compressed; consequently, the force with which this large piston is propelled, is in power exceeding that acting on the forcing pump rod proportional as its surface is greater. For instance, "if the small pump has only one thousandth of the area of the large barrel, and if a man, by means of its lever handle, presses down its piston with a force of five hundred pounds, the piston of the larger barrel, in virtue of the hydrostatic principle of equal pressure in all directions, will rise with a force of a thousand times five hundred pounds, or more than two hundred tons." Two

pumps generally accompany each press; one rather larger than the other, to expedite the motion of the ram at the beginning of the pressing, when the resistance is slight; and the other, or smaller one, to give a slower but more powerful impulse, when the resistance is augmented. A pressure of five hundred tons may be obtained from a well made hydraulic press, with a ten inch ram, and a two and one inch set of pumps. The fundamental law upon which the action of this press is based, is that which regulates the doctrine of the equilibrium and pressure of fluids, and is as follows: *"When a liquid mass is in equilibrium under the action of forces of any kind, every molecule of mass sustains an equal pressure in all directions."*

Between every two layers of bags in the press, there must be a wrought-iron plate. In some factories, the fat acids are not wrapped in cloths, but the thin, crystalline cakes are taken directly from the cooling pans, and interleaved with cocoa mats and thick zinc slabs, as they are placed in the press. In either case, pressure is at first very gradually applied, and as gently continued, until oily fluid ceases to run from the cakes. In this way nearly all the oleic acid, holding in solution, or suspension, some little solid fat is expelled; the cakes yielding as readily to pressure as spermaceti, and the pressing being conducted in similar manner as for that material. When all the oil that can be removed in this way has been forced out, the press is to be unlocked, and the bag-cloths removed and opened one at a time. The solid cakes, reduced to thinness by the pressure, are very firm and dry, but still retain a portion of oleic acid, which renders necessary additional means for its separation. In cool weather, the oleic acid, or *"red oil,"* as it is called, has a mushy consistence, owing to the solidification of the solid fat which it carries off from the cakes, and which amounts to 10 or 15 per cent.

Second granulation.—As the cloths are unwrapped, the

workman throws the cakes into a clean iron-bound wooden tub, similar to Fig. 9, wherein they are melted by the introduction of steam in a continual current for six hours. After sufficient repose for the water to settle, the superstratum of oleic, stearic, and margaric acids is drawn off into tin pans of about eight to ten gallons capacity, and of form as ordinarily made for domestic purposes. These pans, when filled, are carried into a suitable apartment, the temperature of which must range from 80° to 90° F. After repose for a day or two, the contents of these pans will be solid and granular in the interior, and this is a sign that they are ready for the next operation.

Hot pressing.—The first step is to empty the cold blocks from the pans, one at a time, upon the hopper of the rotary rasping machine described in the chapter on sperm candles. The machine being put in motion, reduces the blocks to a mealy powder, which falls into a capacious wooden box beneath. Twilled woollen bags are then filled with this meal so as not to be more than a half inch thick when folded with their ends under to prevent the escape of any of the powder. Some manufacturers prefer cocoa-

Fig. 170.

29
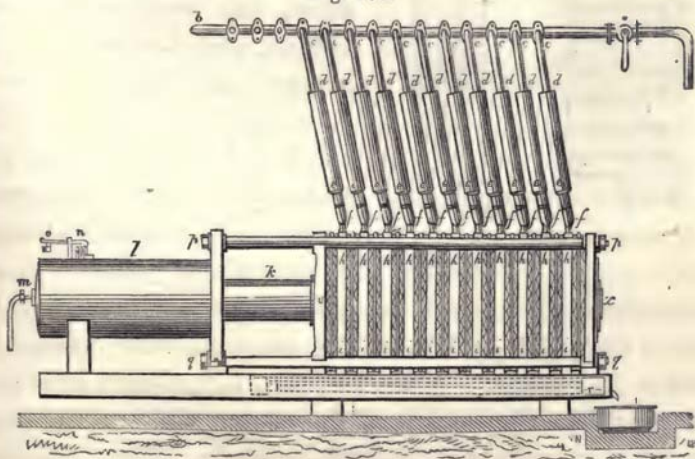
matting, and others hair bags; others, again, use the
woollen bags and interlaid hair-cloth spreads. The hair
web is thick, heavy, and coarse, and resembles the twine
cloth mentioned under STEARIN. They are made in New
Bedford, and also imported from England. As each bag j,
is filled and folded, it is placed in the press in manner as
before directed, with an iron, or, better, zinc slab between
every two layers, as shown by $h\ i$ of drawing 2, Fig. 171.
But the press for this operation differs from that used for
the cold pressing, and is constructed with a view to over-
coming the obstinacy with which the mealy fat retains
the last traces of oleic acid. It is shown by Fig. 170.

For greater convenience, the form of the press is hori-
zontal, and, to insure a uniform distribution of heat, suit-
able arrangements are appended. The press-plates, or
slabs, are also peculiar in one respect, and that is, they
have a winding channel through the middle of their thick-
ness, as shown at $h\ i$, Fig.
171, for the passage of the
steam.

Fig. 171.
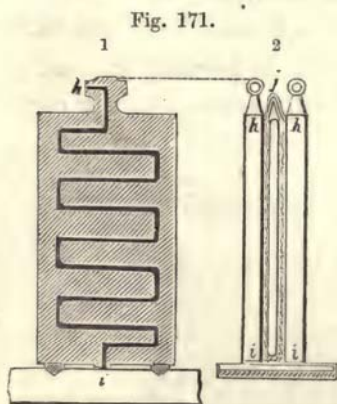
The press being filled with
alternate layers of cloths and
slabs, the cock a is then
opened, and the steam thus
allowed to enter the tube a
b, which in turn feeds the
tubes c, d, e, f, and also the
channels $h\ i$, of the press-
plates. These tubes, by means
of articulated joints c, f, ac-
commodate themselves to changes of position as they
pass to the right or left of the perpendicular when the
press is in motion. A section, Fig. 172, shows how this
is accomplished by means of the piston, which terminates
the tube $c\ d$, entering the large tube $d\ e$. The elevation,

Fig. 173, also explains how the joints *c f* allow the plate *h i* to take a horizontal movement in connection with the telescopic tube *c d*.
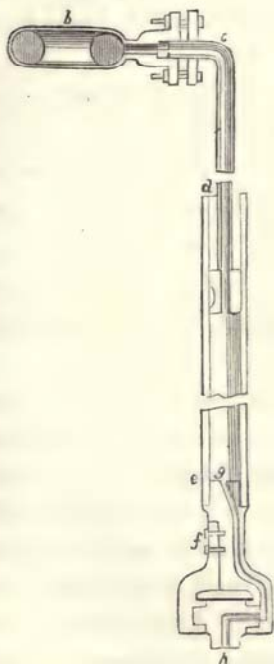
Fig. 172.   Fig. 173.
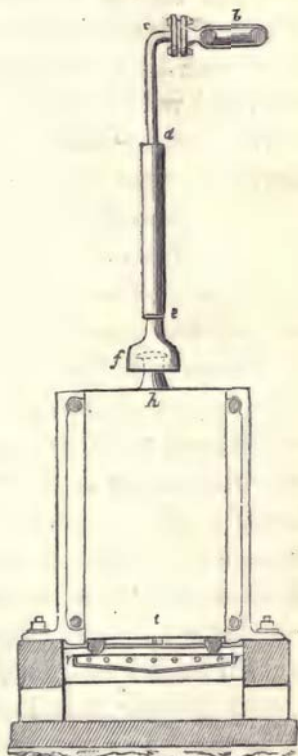
The liquid fat expelled by the pressure escapes through the pipe *r r*, and collects in the vessel *s*, from which it is transferred to a special reservoir, where it is allowed to stand until the small portion of solid fat passing off with it subsides. The upper stratum of oleic acid is then to be drawn off into barrels.

The regranulation and hot pressing combined having expelled all the residual oleic acid, the press, after having remained tight upon the bags for fifteen to twenty

minutes, at its maximum of power, must be unlocked and emptied. To this end, the workman removes each bag and press-plate separately, and laying the latter in a trough arranged near for its reception, he places the former upon an appropriate table, where it is unfolded, relieved of its contents, now in the state of a hard flinty cake of wax-like substance. This cake must be dexterously freed with a knife of its comparatively moist edges, and the parings allowed to fall in the rasping box to undergo another pressure with the next batch. Stearic acid, thus treated, is termed " *hot pressed;*" but the cakes being dirty from traces of lime, oxide of iron, and other impurities incidentally taken up during the different stages of the process, they must, therefore, be subjected to a cleansing operation.

Purification of the block.—The pressed cakes, on being emptied from the bags, are thrown into a very clean lead-lined cedar tub, and the whole batch melted by a current of steam. Five pounds of sulphuric acid, diluted with ten pounds of water, are then gradually added to the melted fat-block, so as to withdraw and precipitate any remaining alkaline or other impurity. After the mixture has stood long enough for the perfect subsidence of the acidulated water, this latter is drawn off by means of a cock in the lower part of the vessel, and the stearic acid washed three several times with hot water, each addition of water, upon settling, being drawn off as was the dilute acid first added. The cleansed stearic acid, now transferred to tin or copper pans, on cooling, takes the form of blocks, corresponding in size with the containing vessels, and, when broken, exhibits a highly crystalline texture. These blocks, amounting to forty-five to fifty per cent. of the original fat or raw material, before being fit for conversion into candles, must be freed of all external dirt with a knife, and then melted down with four to five per cent.

of white wax, in order to counteract the tendency to crystallization ("*break the grain*") which characterizes stearic acid. There are some chandlers who destroy the crystalline texture by fusing a thousandth part of arsenious acid with the stearic acid; but its volatilization during the burning of the candle may seriously affect personal health, as the arsenic is a deadly poison. Wax is much the better material; and even a minute proportion of very fine white marble dust will produce the same result. It can also be accomplished in another and more simple way, as will be described under the head of *Moulding*.

This cleansing does not obviate the necessity of a final bleaching of the candles after they are drawn from the moulds. Therefore some manufacturers adopt the plan of bleaching the stearic block before it is moulded; and for this purpose several processes are in use.

Bleaching.— The cleansed block being melted in a clean, iron-bound, cedar vat, by a current of steam, is then treated with eighty pounds of pure aqua fortis to the ton of fat, and kept in constant agitation for an hour or more by means of the twirl-shaft with arms, and similar to that used for flotant soaps (Fig. 55). The steam must be shut off after or at the time of adding the acid. The vessel and its contents are left to repose, after the operation, and when perfectly cooled, the acidulated water having settled, is to be drawn off through a cock in the lower part of the tub; and the remaining fatty acid subjected to three several washings with warm water, heated by the introduction of a current of steam. The twirl-shaft should be used upon each addition of water, except the last, but not until the mixture has been heated and the steam shut off. Intervals are allowed for the settling of the water after each washing; and it is drawn off, as before, through the cock. The last washing is accomplished merely by the addition of water and steam-

ing; and in this instance, the upper stratum of liquid fat is racked into clean pans, the contents of which, when cold, are blocks of pure stearic acid, brilliantly white and clean. These blocks, afterwards scraped on the outside with a knife, are then ready to be melted and moulded into candles. The twirl-shaft may be geared like that shown by Fig. 51, and driven by the steam-power of the establishment. The drawing above referred to exhibits a hand machine which merely illustrates the principle, for it would not be economical to work in that way. The exit cock in the side of the vat must be arranged at such levels, that, in drawing off the fluid fat or subsident water, either will be clear of particles of the other.

Another method of bleaching stearic acid block is to boil it by steam for half an hour with one-thousandth of its weight of oxalic acid previously dissolved in water. But the stearic acid thus treated becomes colored by exposure, and therefore to remove the oxidized color-matter, and also the oxalic acid, it is necessary to remelt it by steam with dilute sulphuric acid. Five to ten per cent. of wax may then be melted and added, and the whole agitated with the white of forty to fifty eggs for every ton of fat-block. When the melted fat clears, and becomes transparent, it is left to repose; and finally, when cool, drawn off into tin or zinc pans. The cooled blocks, bleached by either method, are then ready to be moulded into candles.

Moulds.—The moulds are made of block-tin, or more generally of an alloy of three parts tin and six parts lead. In form and finish they are very similar to the moulds for tallow candles, except that their tips are more gracefully shaped, and their butt, or funnel portion *m*, in Fig. 174, is a little wider, to promote escape of air as the fluid fat is being cast into candles. Glass moulds have been proposed as superior to those of metal; more particularly for stearic block prepared by distillation, as the latter con-

tracts its volume so inappreciably during cooling that it is very difficult to draw the candle from the metal mould. To protect them against accidental fracture, they may be

Fig. 174.
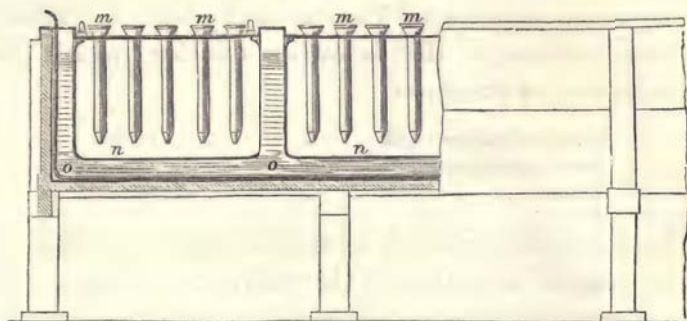
Fig. 175.
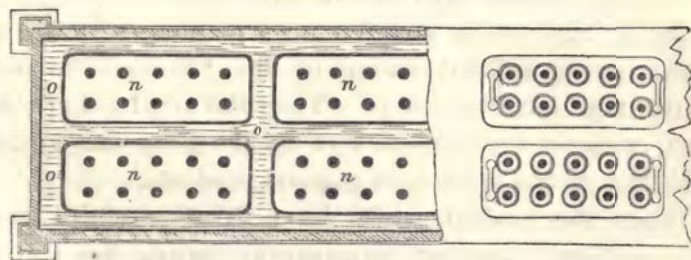
thickly coated with a solution of caoutchouc in Benzole. When the envelop is sufficiently thick, the moulds are to be dried by exposure to air. The frames in which the moulds rest are made to contain, generally, ten to twelve moulds.

Wicks.—The wick most suitable for these candles, is a plaited one of three strands, each of the latter containing twenty-eight finely and uniformly spun cotton threads. This number affords sufficient capillarity to maintain a constant supply of fluid fat, and, at the same time, regulates the consumption so as to prevent guttering during

the burning of the candle. To promote the efficiency of the wick, it is generally subjected to a preparatory treatment, which consists in saturating it with a solution of certain chemical mixtures.

Some chandlers use, for this purpose, an alcoholic or hot aqueous solution of boracic acid; but, a preferable mixture, perhaps, is the following solution, which gives less color to the flame:—

Pure hydrochloric acid	1 pound.
Muriate of ammonia	4 ounces.
Water	12 pounds.

The free acid serves to neutralize any free alkaline or earthy matter adhering to the wick, or remaining in the fat. Moreover, it assists the wick to bend its tip out of the flame during burning. A constant contact with the atmosphere being thus maintained, combustion goes on perfectly, the ash is conglomerated, and gradually consumes away without dropping any "*thieves*," to cause "guttering," or "running." Thus the light is kept brilliant, without the necessity of snuffing, by the uniform oxidation of the wick into gaseous products.

When the soaked wicks have been carefully dried, without much handling, so as not to disturb the arrangement of the threads, they are then ready for use. The threading of the moulds is effected in the usual manner— a little wooden peg being placed in the opening at the tips to centre the wicks and keep them distended, as shown by Fig. 176. As the moulds are wicked, each stand is set aside for the next operation; or—

Moulding.—The first step is to melt the purified stearic block in a steam bath, Fig. 177. This consists of a copper kettle *a*, trimmed exteriorly, and enveloped on its lower exterior with a cast-iron jacket *o*, in such a manner as to leave an intervening steam chamber *c*. This latter is fed by the generator of the establishment; and the

cock *d* serves to regulate the supply. The valve cock *g*, is a vent for any excess of steam, and for condensed steam. This mode of applying the heat prevents any injury to the fat. When the latter is melted, it must be

Fig. 176.   Fig. 177.
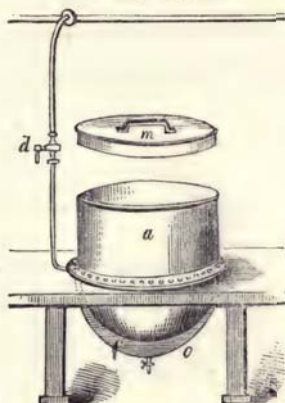
ladled into an adjoining cedar tub, previously well cleansed, and then stirred until it begins to assume a milky appearance. This manipulation destroys any tendency to crystallization, and facilitates the moulding.

In the mean time, the wicked moulds are being gotten ready, by arranging the stands in an iron casing *o o*, Figs. 174 and 175, and introducing a current of steam through a perforated pipe running along the bottom. The condensed and excessive steam escapes through a valve cock attached to the casing.

After the steaming, the temperature of the chest is allowed to fall to 115° to 120° F., when the stands of moulds are taken out and immediately filled with the milky stearic acid. If these precautions are observed, the candles do not assume a crystallized structure; and, moreover, can be drawn, without difficulty, from the moulds, which would not be, if the fat was poured while hot into cold moulds.

Moulding by hand is a tedious operation, rarely practised now except in the smaller factories. In more extensive establishments, where economy of time and labor is an important consideration, the moulding is done rapidly by machinery. We describe, below, a very recent American invention for that purpose.

Kendall's moulding apparatus.—" The process is illustrated by the accompanying drawings, in which Fig. 178

Fig. 178.
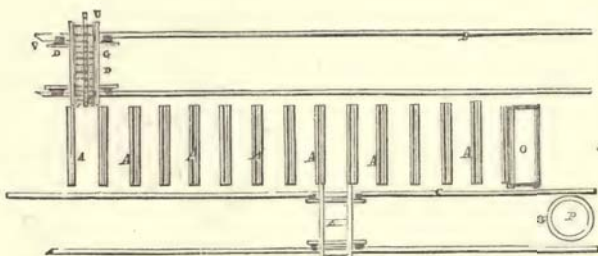
represents a plan of the improved apparatus, including the railways, cars, ovens for melting the fat, the moulds, and apparatus for drawing the candles therefrom.

" Fig. 179 represents a view, in perspective, of an appa-

Fig. 179.
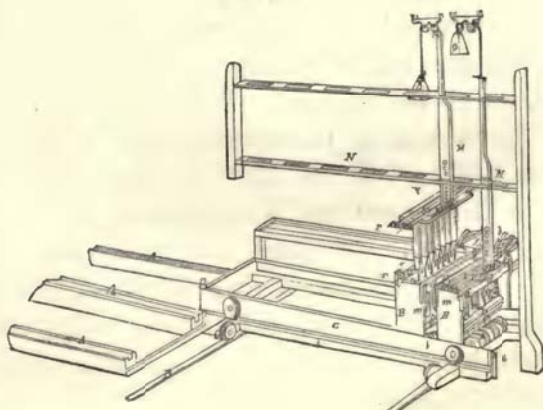
ratus for moulding and drawing the candles, and supplying and centring fresh wick in the moulds.

"Fig. 180 represents a vertical transverse section

Fig. 180.
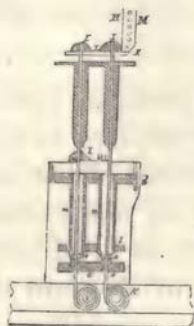
through one of the mould-frames, showing the candles drawn from the moulds.

"Fig. 181 represents a top view of one row of moulds, showing the clamp in place, ready to centre the wicks.

Fig. 181.
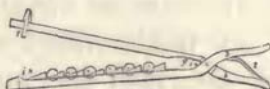
"Fig. 182 represents a view in perspective of a centring gauge and its clamps, turned bottom side uppermost, by

Fig. 182.

means of which the wicks are centred in the moulds, and so firmly griped that the candles, when set in, can be drawn by it.

"Fig. 183 represents a plan of the centring and drawing clamp, inverted and closed.

Fig. 183.

"The moulds are mounted upon cars, by which they are carried from place to place as required. Each of these cars carries several dozens of the moulds, and the latter are heated to about the temperature of the melted fat with which they are to be filled by running the car into an oven. After the moulds are thus heated, they are carried by the cars to a caldron containing the melted fat, and filled therewith. The car is then attached to one of the empty tracks, and permitted to stand until the candles are cooled, when it is moved to an apparatus, by the aid of which the candles are drawn and the moulds re-wicked, ready to be again heated and filled.

"To facilitate the transference of the moulds to different parts of the room, the cars on which they are mounted are carried about on trucks fitted with rails at right angles to the track on which they run, so that the car with the moulds can be carried forward or back by the truck, and run to the right or left on its own wheels upon lateral tracks as may be required. The accompanying drawing represents a series of railways A, of the length of a car, for the purpose of receiving the cars after their moulds are filled, and permitting them to stand until the passage of the fat therein sets, or for the passage of cars to and fro from the tracks B and C, which are at right angles to the tracks A, and at either end of them. The short tracks A are on a higher level than the long tracks B and C, so that the rails on the trucks D and E, which run on the latter tracks, may be on a level with and form

a continuation of any of the tracks A, when placed opposite the same by the movement of the trucks. Upon the truck D, is represented a car A, with two stands, H and H' of moulds *m* thereon, from one of which the candles are drawn; and in one row of the moulds the new wicks are centred by one of the clamps I, the other row of wicks being ready to be centred and clamped by means of another clamp. The remainder of the stands of the car are not shown in the drawing, but they are supposed to have the candles drawn from their moulds, and new wicks centred and clamped in their place. When all the candles are drawn, and the wicks of each row of moulds on a car have been centred and clamped, a knife is passed along the top of each clamp to separate the wicks of the drawn candles from the newly clamped wicks in the moulds below. The whole of the moulds on the car being thus re-wicked, and the centred wicks separated from the drawn candles, the truck is run back until opposite an empty track A, when the car, with its wicked moulds, is run across to the truck E, and the track C. The truck E is then run along until the car G is brought opposite the oven O, when the car is run therein to have its moulds heated to the proper temperature to receive the melted fat. After the moulds are heated, the car is run out of the oven upon the truck E, and carried by the latter to a melting-pot P, containing the fat, which is run from suitable stopcocks into the moulds, or ladled therein, as may be deemed advisable. This being done, the truck is run opposite an empty track A, and the car is run thereon, to rest until the fat is set in its moulds, when it is ready to be run up to the apparatus for drawing its candles, and re-wicking its moulds. While the moulds of one car are being heated and filled, and standing on the track for its candles to cool, the operation of drawing, re-wicking, and re-filling other moulds is going on, so that if

the number of tracks, trucks, and moulds be sufficient, the operation may be continuous, as the cars would have their moulds filled and drawn in endless succession without any greater interruption than is requisite for changing from one car to another. The stands H, for the moulds, are firmly secured to the cars; and the moulds, to the number of (say) twelve, are firmly secured in each stand in an upright position and at equal distances apart, in horizontal boards a, b, placed about two-thirds of the length of the moulds apart in the upper portion of the stand-frame. The uppermost, a, of the horizontal boards is placed an inch, more or less, below the top of the stand, and has a fixed ledge c, fastened on its rear edge, and a sliding ledge d, that can be moved up or down, is fitted to its front edge; when this front ledge is up, the two ledges, and the end of the stand, form a tray into which the upper end of the moulds open, so that, when the fat is poured into it, all the moulds of the stand will be filled at once. Preparatory to withdrawing the candles from the moulds, the cake of fat which fills the tray must be loosened; this is done by pressing down the movable ledge d, and jarring the fat by a knock with the hand, which renders it sufficiently loose. The lower ends or tips n, of the moulds m, rest, in this instance, upon pieces of vulcanized India rubber o, let into the lower cross-bar e, of the stands H; each of these pieces of India rubber is pierced with a hole somewhat smaller than the wick, and as the wick is passed through this hole, the latter compresses it so tightly as to prevent the fat from leaking out; in like manner the leakage is prevented between the bottom or tip of the mould and the rubber by the pressure of the former upon the latter. The spools K hold wick enough to supply the moulds for several months; the end of each wick is passed from the spool up through the India rubber into the mould, and through the latter

to the jaws of a clamp I, above, by which it is firmly grasped. All the wicks of each row of moulds in the stand are secured in one of these clamps. When the moulds are filled, and the fat therein has set or become sufficiently cool, the candles are drawn by lifting their clamps; and as the wicks extend down through the candles to the spools, the act of drawing a candle out of the mould draws a fresh supply of wick therein; and as a gauge or stop is provided for limiting the height to which the candles are raised, precisely the proper quantity of wick to supply the moulds and leave a snuff on the candle will be drawn from the spools; the candles, after being drawn, are moved a little to one side, as seen in Figs. 180, 181, by the movement of the lifter, in order to incline the wicks in the moulds that the notches of the gauge-plate of each clamp may be made certain to catch and centre the wicks, for, if the wicks should happen to incline some one way and some another, there would be no certainty of centring them, and an imperfect candle would of course be the result. When the candles have been withdrawn by raising one clamp, another must be ready to apply the wicks between the tops of the moulds and tips or lower ends of the candles, as seen in Fig. 179. It will be observed that one of the jaws of the clamp I is provided with a plate F, having a series of inclined teeth, or notches in it, corresponding in number to the wicks it is designed to clamp. It will also be observed, that at the inner end of the clamp a narrow slot g, Figs. 181, 182, and 183, is formed between the jaws, and at the outer end a round hole h is formed between the jaws when closed. It will also be observed that two pins i project up from the ends of the stands in a line with the centre of each row of moulds; now, by applying the clamp as seen in Fig. 181, in such manner that the toothed jaws will rest against the pins i, and pushing it as far across the stand as the slot g and

pin i will allow, and then drawing it back, each tooth or notch catches a wick and moves it along, until the hole h, in the front end of the clamp, is brought against the pin i, when every wick will be centred in its mould; the outer jaw of the clamp is now shut upon the toothed jaw without moving the latter, and the two are held together by a spring-catch r, in order that the clamps may hold the wicks with equal firmness throughout its entire length. The adjacent sides of its jaws are made convex in the direction of their length, and one of them has a tongue or rib, and the other a corresponding groove, so that the wick, in being clamped, may be kinked by the groove and rib, and prevented from drawing out, which is highly important, as the pulling of the candles from the moulds requires a considerable amount of force, which would draw the wicks from smooth jaws before the candles would rise; the front extremities of the jaws of the clamp are held together, when closed, by the spring-catch or hook r, and when this catch is unfastened, the jaws are thrown open by a spring s, between the handle t. The jaws of the clamp are pivoted together in the manner of pincers, and the joint should be firm and strong, as the first operation preparatory to drawing the candles from the moulds, is to loosen them by rolling the clamp slightly by its handles, which can only be done by applying considerable force. The jaws of the clamps I prefer to make of cast iron for cheapness and convenience, but they may be made of any other suitable material. The moulds m, are made of metal in the usual manner, and are fixed in the stands in the same way it is common to fix others. The lifting of the clamps to draw the candles from the moulds is effected by means of flat hooks L, affixed to upright bars M, that slide up and down in oblong mortices in a frame N, and which, when raised, are counterbalanced by a weight Q, that preponderates sufficiently over the

weight of the bars, with the clamp and candles hanging upon it, to keep them elevated; the flat hook L, at the bottom of the bar, is introduced beneath the clamps of each stand, so as to draw all the candles of a stand simultaneously; the bar has sufficient play in the guide-mortices to allow it to be swung back far enough to enter the hooks L, beneath the clamps I I. This bar is struck by the hand of the attendant a smart blow upon the bevelled corner X, of its lower end, and at the same time lifted by the other hand for the purpose of starting the candles out of the moulds; this is usually found to be sufficient, but if the candles should still remain in the mould, a repetition of the knocking with one hand on the lower end of the bar, and of the lifting with the other, must prove in every case sufficient. Just as the bar approaches the limit of its upward motion an adjustable inclined plane Y, on one of its edges strikes against the edge of the guide-mortice, which deflects it far enough to throw the wicks to one side of the moulds, to insure the proper action upon them of the centring notches of the clamp, as before mentioned. The upward movement of the lifting bars N is determined by a pin l, which is passed into a higher or lower hole in the bar, as is required to raise the bar more or less. In this way, the same lifted bars are adapted to the drawing of candles of various lengths; and when the candles have been drawn from the moulds of all the stands of a car, and the new wicks have been centred, the drawn candles are separated from the wicks by passing a sharp knife along the top of the lower clamps, the candles are then taken from the hooks L, and laid on a table or shallow tray T, where they are separated from the cake of fat cast with them by means of a knife; the candles thus separated are removed to a suitable receptacle, and the cake of fat, and other trimmings, are thrown into the melting-pot to be again melted and cast. The cars G are

30

all of the same size, and contain an equal number of stands of moulds, which are all of the same size, and arranged in exactly the same relative position on each car, in order that when the cars are run against the stop *u*, on the truck D, and the latter is run against the stop *v*, on the track B, under the frame N, the clamps I may always be exactly in the proper position to be drawn by the hooks L.

Bleaching of the candles.—If the stearic block is previously treated by one of the bleaching processes already given, the candles, on coming from the moulds, will only require a slight exposure to air and light in a damp or shady situation, to perfect their whiteness; and, to this end, they are arranged lengthwise on shallow trays of wood. Whenever it is necessary to present a new surface for action, they may be turned by gently running the palm of the hand over the spread of the trays.

A more rapid method is sometimes resorted to, and though efficient in producing whiteness, is injurious to the fat, and therefore objectionable.

It consists in hanging the candles, by their wicks, upon wooden rods, and suspending them in a tight wooden chest. The candles must be strung, at intervals, wide enough to prevent mutual chafing, and the rods suspended in tiers. When the chest is full, the cover is put on, and the cracks and joints securely luted, or covered with glued muslin. Chlorine is then generated from a leaden retort, and led into the chest through a leaden pipe entering at the base of one of the ends. The requisite materials are, one part of peroxide of manganese and three parts of common hydrochloric acid, of sp. gr. 1.13. The oxide of manganese is placed first in the retort, and drenched with water, after which the acid is gradually added, the whole being kept warm, during the process, by a moderately heated sand bath.

A small window, on the opposite end of the chest, is necessary for observing the progress, and determining the end of the operation without inconvenience of opening the chest. In twenty-four hours, the candles generally acquire a brilliant whiteness; but a longer time is often necessary for the completion of the bleaching. When the candles are being taken from the chest, they must be at once carried to a well-ventilated room, and there left to hang until every trace of chlorine odor has disappeared. The chest may be made of size sufficiently large for the bleaching of 10 to 20,000 candles at a single operation.

Polishing and packing.—The final operation is to dexterously rub the candle with a silk or woollen cloth, moistened by a dilute alcoholic solution of caustic ammonia. This manipulation, generally performed by women or children, cleanses the candle from adhering dust, and imparts a high polish. Davison, of France, has proposed to accomplish the same results by mechanical means. The drawing below (Fig. 184), exhibits an appa-

Fig. 184.
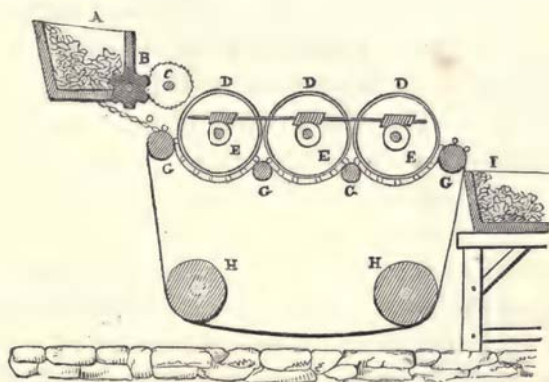
ratus for that purpose, and at the same time for trimming the butt ends of the candles. A is a hopper in which the

candles are arranged, and from which they are taken, one at a time, by the fluted cylinder B. This latter, in revolving, presents them to the circular saw c, which turns and smooths the ends, and then lets them drop upon an endless belt of woollen cloth, supported by the rollers G G G, and passing around the drums H H. Revolving in an opposite direction, by the aid of pinions E E E, are three other rollers, D D D, also covered with cloth. A regular alternating motion is thus maintained; and the candles, passing from the saw to the last roller G, which delivers them into a receptacle I, become perfectly smooth and glossy.

The candles are then packed in boxes for market; and between each row or layer of candles, sheets of thin, highly glazed white pasteboard are interposed. The sides and ends of the boxes are also lined, interiorly, with the same kind of paper. Most of the adamantine or stearic stock is moulded into "sixes;" and the packing boxes are usually of three sizes, viz: 30, 34, and 40 pounds capacity.

SAPONIFICATION BY LIME AND SULPHUROUS ACID.—This mode of saponification is said to yield a greater amount of fatty acids than is obtained by the usual methods. The inventors make it produce as high as 96.8 per cent. Knapp thus describes the mode of operation :—

Moinier and Boutigny's process.—Two tons of tallow, and 900 gallons water are introduced into a large rectangular vat, of about 270 cubic feet capacity. The tallow is melted by means of steam admitted through a pipe coiled round the bottom, and the whole kept at the boiling point for an hour, during which a current of sulphurous acid is forced in. At the end of this period, 6 cwt. of lime, made into a milk with 350 gallons water, are added. The mixture soon acquires some consistence, and becomes frothy and very viscid. The whole is now agitated, in

order to regulate the ebullition, and prevent the sudden swelling up of the soapy materials. The pasty appearance of the lime-soap succeeds, and the agglomeration into small nodular masses. The admission of sulphurous acid is now stopped, but the injection of the steam is continued until the small masses become hard and homogeneous. The whole period occupies eight hours, but the admission of sulphurous acid is discontinued at the end of about three hours.

The water containing the glycerin is run off from below, by a tube to a large underground cistern. The sulphurous acid is generated by the apparatus shown in Fig. 185 (1), sulphuric acid and pieces of wood being introduced by *f f* into retorts *e e*, heated by a single fire *b*, with ash-pit, &c. The sulphurous acid is conveyed to the boiler A (2), by leaden pipes *g g*, where the saponification is effected under the joint influence of the acid and steam.

The lime-soap is then moistened with 12 cwt. of sulphuric acid, at 152° F., diluted with 50 gallons water. The whole is thoroughly agitated, and the steam continuously admitted, so as not to dilute the acid too much until the decomposition is general at all points. This occupies about
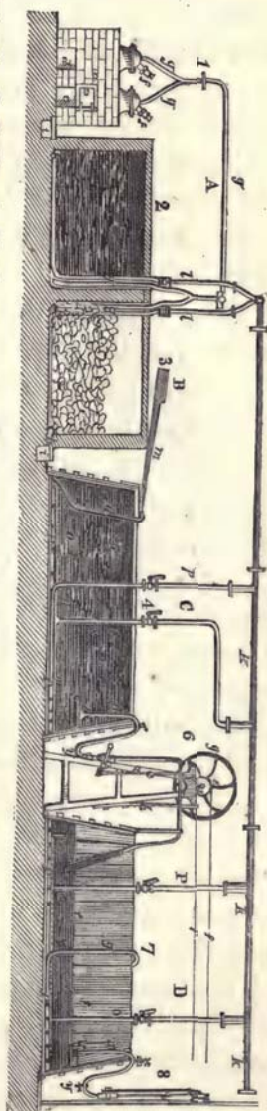
three hours, and in two or three hours more, the sulphate of lime has collected at the bottom, while the fatty acids are floating on the surface of the solution of the bisulphate of lime.

The sulphite of lime, formed in the preliminary step or saponification being decomposed by the sulphuric acids, gives off free sulphurous acid. This latter reacting upon the nitrous compounds generally contained in commercial oil of vitriol, imparts to them a potential influence upon the oleic acid of the fat by which it is partly converted into solid fat.

B (3), represents the vat filled with the masses of the lime-soap; h, the pipe for conveying the liquid into the main drain i; k, main steam pipe; l, open steam pipe; m, wooden spout to carry the fatty acids into the vat (4). Some adhering portions of sulphate of lime are removed to a vat c (4), lined with lead; o, pipe for free steam; p, another pipe for dry steam; r, layer of acidified water; s, position of charred organic matter; t, layer of fatty acids; u, copper siphon, with a perforated copper disk, to prevent the passage of charred matters; x, air-cock; and y, discharge-cock for fatty acids.

After settling, during four hours, the fatty acids are forced through a fixed siphon into a vat D (7), by means of a hydrobalistic pump, where they are washed with water, as in the preceding case. The machinery is supported by a metal framework a', where the handle of the pump is marked b'; intermediate shaft c'; shears e', with two pulleys $f f$, one fixed and another loose; fly-wheel g', and h a lever for putting the whole in or out of gear. The details of the washing, steam pipes, &c., are the same as in the preceding vat (4).

The fatty acids are washed a third time with water, and siphoned at last into the trough D, lined with lead,

on the bottom of which are placed leaden gutters, pierced below by long pegs of wood.

Figs. 186 and 187 represent a wooden framework A, bound by transverse bars of iron B, which support the moulds C C, at the same time. F F are leaden funnels,

Fig. 186.   Fig. 187.
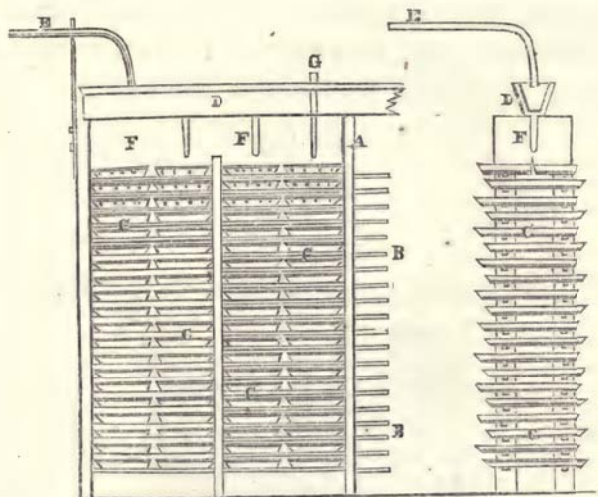
through which the fatty acids are run into the moulds. G is a wooden plug for stopping the funnels F, when the moulds are full.

The cakes of fatty acids are inclosed in bags of flannel H, and submitted to pressure in the cold, in an hydraulic press.

It is important to allow the fatty acids to cool slowly, which prevents too confused a crystallization, and much facilitates the expulsion of the oleic acid. The cakes are now placed between sacks of horse-hair, and submitted to a second pressure at a high temperature. The whole is covered with an oil skin, and the temperature raised to 158.5° F., when the pressure is applied. The heat

slowly falls to 113° F., and ultimately reaches 95° to 86° F.

The oleic acid obtained in this process, contains large quantities of stearic and margaric acids, so that it must be returned to a special cistern, thence to the acidulated water and the subsequent washings from fresh quantities of the original fatty acids.

The cakes of stearic acid are sorted according to color and translucency, and about 20 cwts. are then introduced into a vat, Fig. 188, constructed of wood, lined with

Fig. 188.
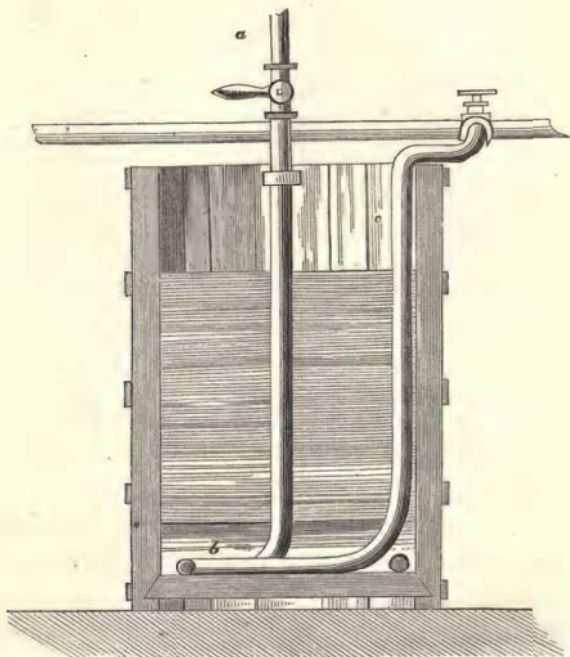
sheet-lead. The materials are boiled by means of steam admitted through a leaden pipe a, which is afterwards employed in heating a stove. Water acidulated with sulphuric acid, is first employed, and afterwards pure water. When the materials are boiling, the white of

twenty-two eggs is introduced, and the albumen is inti-
mately mixed by the violent ebullition. As soon as the
albumen is coagulated, the whole is allowed to cool, and
the stearic acid is removed to another apartment, where
it is kept in a state of agitation, to prevent the formation
of crystals, and allow the cooling to be as gradual as pos-
sible. The moulds for the candles are also heated to a
temperature of 122° F., and are fixed on a carriage, Fig.
189, to the number of one hundred and seventeen. The
wicks are dipped, for twenty-four hours, in a weak solu-
tion of boracic acid, and rapidly dried, when they are
introduced into the moulds. Fig. 189 shows the position
which the moulds occupy before being trimmed with the
wicks.

The moulds are placed three in a row, *e e e*, Fig. 190:
g is the pivot round which the moulds are moved; *i i*,
handles for raising the frames; *j*, hook for placing the
wicks. Fig. 191 represents a frame filled with stearic
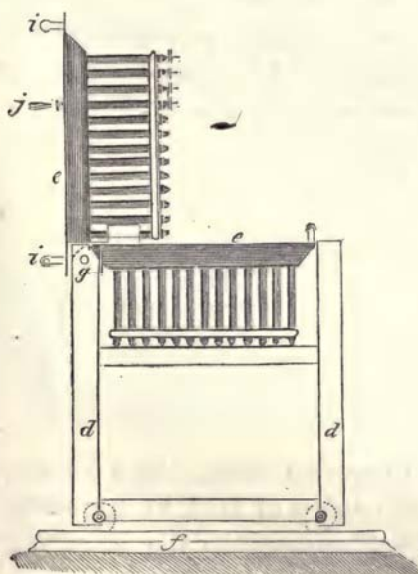
Fig. 189.   Fig. 190.
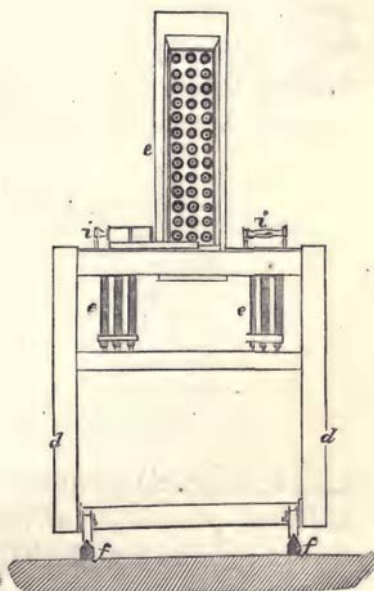
acid, furnished with handles, to facilitate the removal of the candles.

The candles are placed in a case *m*, and afterwards on a table *n*, whence they are thrown on an inclined plane, and carried forward on an endless belt, as shown in Fig.

Fig. 191.
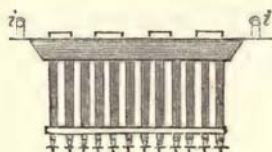
192, which represents the arrangement for raising the candles in a longitudinal and vertical section; *m* is the bin or case to which the candles are carried, previous to their being arranged on the table *n*. The hopper or incline on which they are afterwards laid, is shown at *o*, from whence they pass to an endless belt of cloth *p*, with semicircular hollow rods *q q*, which maintain them in their position; *r r*, wooden rollers for supporting the endless belt; *s t u*, system of rollers and pulleys, connected by the leather straps *o*, which give motion to the endless belt; *f*, a wooden sloping bench, down which the candles slide

Fig. 192.
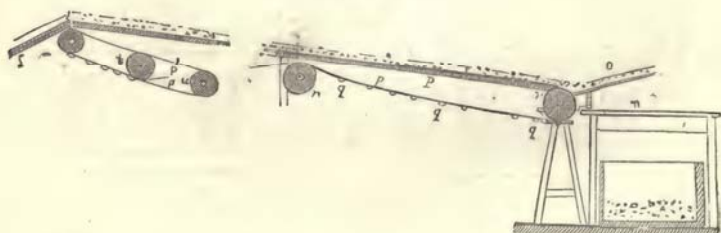
into a receptacle prepared to receive them. The candles are then placed on a wire grating of lead, in a wooden frame, Figs. 193 and 194, and exposed to the bleaching

action of the air. Fig. 193, front view, and Fig. 194, plan of a frame filled with candles. *y*, framework of wood; *z*,

Fig. 193.
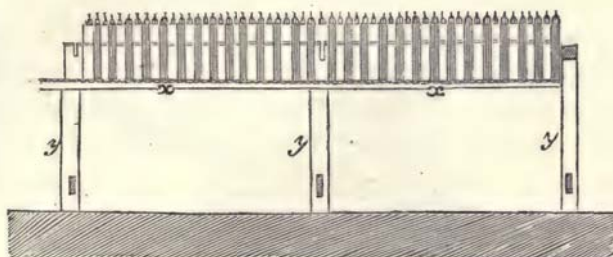
lower gauge of lead, on which the candles rest; *a a*, upper gauge with meshes sufficiently large to admit the candles, which are thus kept in an upright position, and fully exposed to the bleaching action of the air. They are then removed to another department, where the ends are cut square by means of a circular saw, as shown in the Figs. 195 and 196; *b'*, iron framework; *c'*, leather belt which gives motion to the machine; *d'*, movable sheave; *e'*, fixed sheave; *f*, forked lever moving on the fixed point *h'*, for putting the belt in or out of gear by means of the footboard *g*; *i'*, shaft of the multiplying system of toothed

Fig. 194.
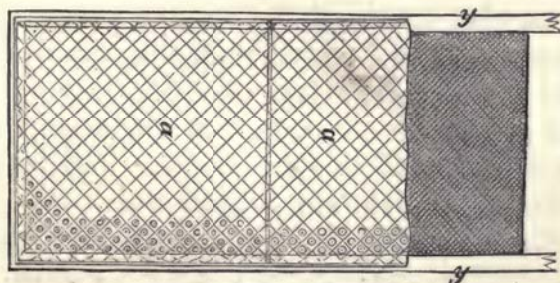
wheels *j' k' l' m' n' o' p'*, which command the small wheel *q'*, which drives the saw *r'*; *s'*, a wheel at right angles,

mounted on a horizontal shaft t', which receives two verti-
cal and parallel wheels u' and v'. The spaces between the

Fig. 195.
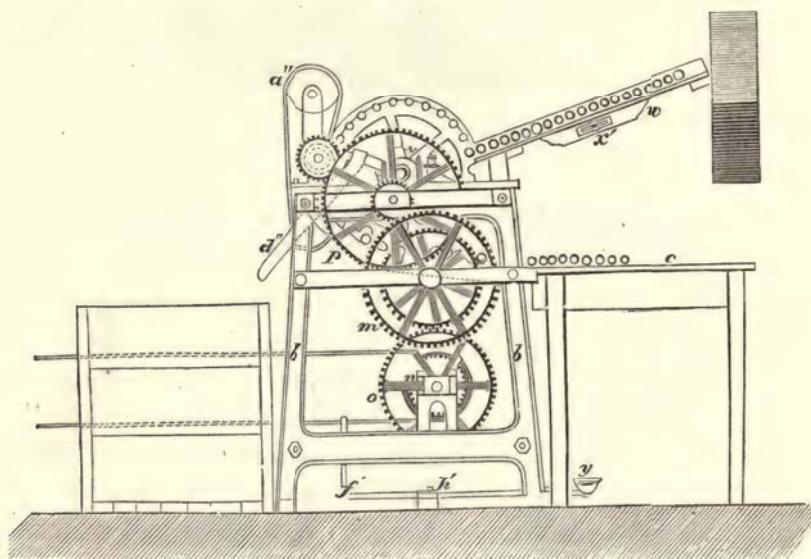
teeth, which are cut in a semicircular form, catch the
candles and draw them forward as they lie parallel with
each other on the incline; x, screw for regulating the
position of the movable and vertical board y, which
determines the length of the candles, according as it
approaches the point z' or not; a'' b'', two wooden sheaves,
connected by an endless belt, crossed for the purpose of
retaining and guiding the candles, which slide down a
board slightly curved to the table c''. The hopper d'',
lined with tin, receives the cuttings which fall into the
box e''; f'', two iron shields for guiding the cuttings. The
candles are afterwards plunged in a weak solution of car-
bonate of potash, cleaned and rubbed smooth with a linen
cloth.

The next process is the polishing, which is a purely

mechanical operation, produced by friction between two surfaces of flannel, which is repeated fourteen times, after slight defects are removed by a workman with a piece of flannel.

Figs. 196 and 197 will explain the polishing process. A A, framework in the form of a kind of cross, and strengthened by the beam B; C, leather belt driving the

Fig. 196.
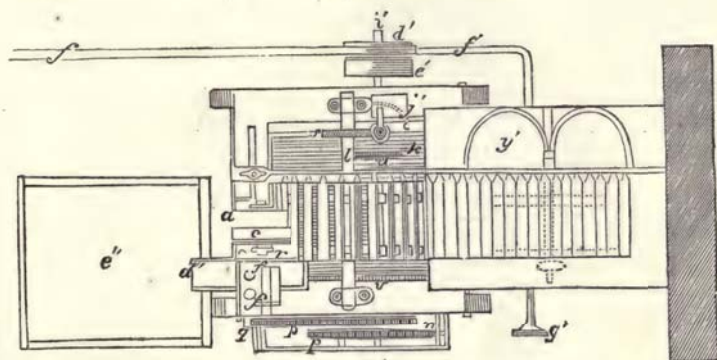
fixed sheave D, or the loose one E; F, lever for putting in or out of gear; G, moving axle, which carries the two fly-wheels H H, which also serve as handles; I I, two shafts attached to the wheels H H, and the rubber J, in the form of a half-cylinder, covered with several folds of woollen cloth and flannel; K L, two toothed wheels, working at right angles, driven by the belt C, and giving motion to the shafts I I, the rubber J, and the rubbing sheave M; N, belt which connects the sheaves M M'. The latter sheave is fixed on a horizontal shaft O, with a pinion-wheel P at the end, working into a large toothed wheel Q. The horizontal shaft O also carries two small wheels with square teeth I I, which give motion to a kind of endless chain 2, composed of rods of iron, and between which the candles 3 are placed. A small table, covered with flannel, is fixed under the endless chain, on which the can-

dles roll as they are drawn forward from an incline, where they are arranged parallel with each other. The candles

Fig. 197.
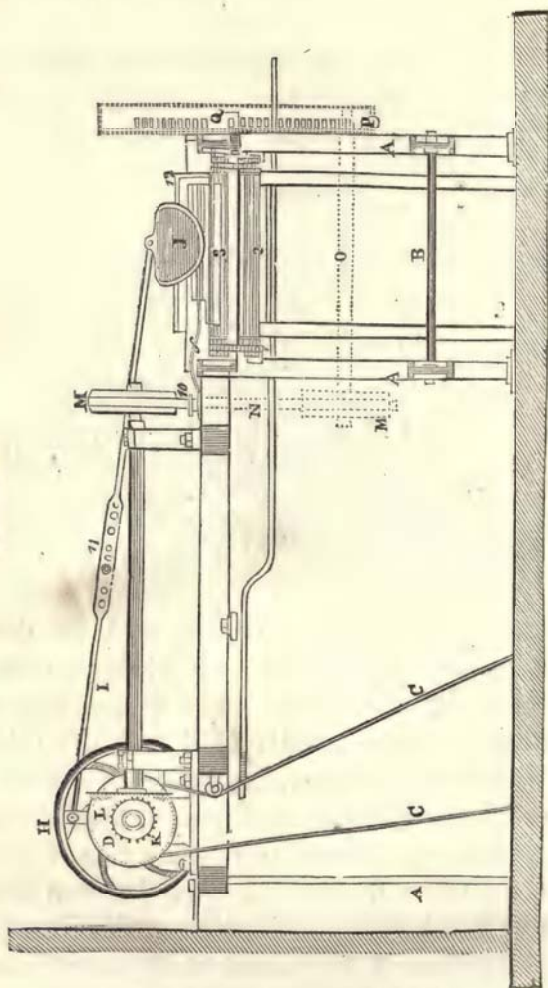
are retained in their position under the rubber by means of a guide 7, regulated by two elastic springs 8 8, and after repeated rubbings are deposited on a table 6, at the other end of the machine. The acidulated water em-

ployed in the process, and which contains some sulphate of lime, is run through a funnel-shaped body, which retains the fatty matters mechanically mixed with it, while the purified acid liquid can be again employed. The in-

Fig. 198.
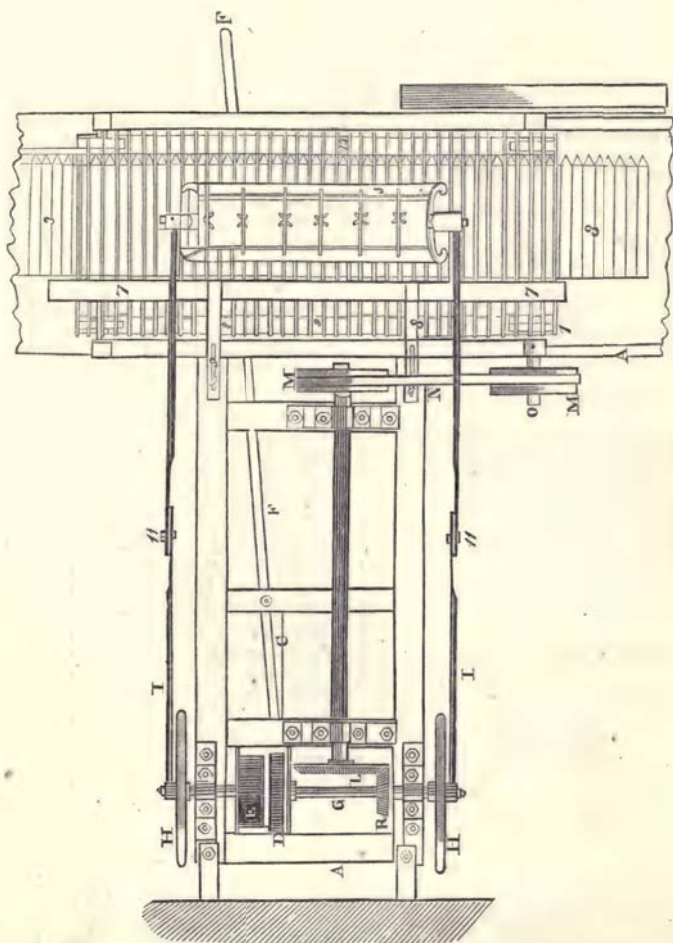
soluble sulphate of lime is repeatedly washed with water to collect every trace of fatty matter.

When any peroxide of iron is accidentally mixed with

the stearic acid, it has been found that a small quantity of oxalic acid assists in purifying the whole.

The following is the monthly expense of Joillon, Moinier & Co.'s manufactory; the product for the same term amounting to 57 tons of stearic acid block, and 47 tons of oleic acid.

			Fr.*	Cent.†
1. Melting of the fat,	{ 10 workmen, at 4¼ fr.		1275	00
	{ 1 general foreman		200	00
2. Saponification,	{ 1 foreman, at 4 fr.		120	00
·Decomposition	{ 4 men, night, at 3 fr.		360	00
Washing, &c.	{ 4 men, day, at 3 fr.		360	00
3. Purification of the acid-sul-	{ 1 chief, at 3¼ fr.		97	50
phate of lime,	{ 3 men, each day and night, 2¾ fr.		495	00
4. Presses,	{ 2 chief, at 4 fr.		240	00
	{ 5 men, each day & night, 2 fr. 90c.		870	00
5. Sorting of the fatty acids,	6 men, for day and night, at			
	1 fr. 40 c.		252	00
	{ 1 foreman, at 4 fr.		120	00
6. Refining, clarifying, &c.,	{ 2 assistants, at 2½ fr.		150	00
	{ 20 workmen, at 1 fr. 65 c.		990	00
	{ 2 children, at 90 c.		54	00
7. Washing, cutting, polishing,	{ 1 foreman, at 3 fr.		90	00
&c.,	{ 60 women, boys and girls, 1¼ fr.		2250	00
8. Preparation, &c. of the wicks,	2 women, at 1 fr. 40 c.		84	00
9. Purification of the stearic-acid	{ 2 women, at 1 fr. 40 c.		84	00
in blocks,	{ 4 women, at 1 fr. 25 c.		150	00
10. Steam engine,	2 men, night and day, 3 fr. 65 c.		438	00
11. Forges, &c. &c.,	6 mechanics, at 4 fr. 20 c.		756	00
12. Joiner's shop,	{ 2 men, at 4 fr.		240	00
	{ 1 apprentice, at 70 c.		21	00
13. Oleic acid warehouse,	{ 1 cooper, at 3 fr.		90	00
	{ 2 laborers, at 3 fr.		180	00
	{ 1 foreman		125	00
14. Candle warehouse,	{ 1 sub-foreman		120	00
	{ 2 children		80	00
15. Laborage,	3 men, at 2 fr. 40 c.		216	00
16. Superintendence,	1 man, at 2 fr. 50 c.		75	00
17. Carriage of goods,	2 porters, at 3 fr. 50 c.		210	00
18. Stable,	{ 1 cartman, at 3 fr.		90	00
	{ 1 groom, at 2 fr.		60	00
19. Clerk,	at 3 fr.		90	00
			11032	50

SAPONIFICATION BY SULPHURIC ACID.—We have already stated, that Fremy originated the principle of the sulphuric acid saponification; but much credit is due to Mas and Tribouillet, Gwynn, Jones, Wilson, and Price,

* A franc is equal to 18.660 cents in American currency.
† A centième is equal to 0.187 cent in American currency.

for their successful efforts in giving it, eminently, a practical and profitable application.

The method is adapted to all kinds and qualities of fats; but bone and common greases, palm oil, cocoa-butter, and other vegetable fats, are more largely treated by it than those of animal origin. This, perhaps, is owing to the fact that, in England, where acid saponification is most generally employed, animal are less abundant than vegetable fats. The different stages of the process are as follows:—

Saponification.—The first step is to melt the fat in a lead-lined wooden tub, with a movable cover, also lined with lead. The heat employed is that of a current of free steam introduced directly into the fat. When the fusion is complete, the heat is maintained at 150° for half an hour or more, and the whole then left to repose until all impurities mechanically suspended in the fluid fat have subsided. The clear fat is then to be pumped or drawn off into the acidifying pan, which is shown by Fig. 199; and is a lead-lined boiler of iron plate A, with an

Fig. 199.
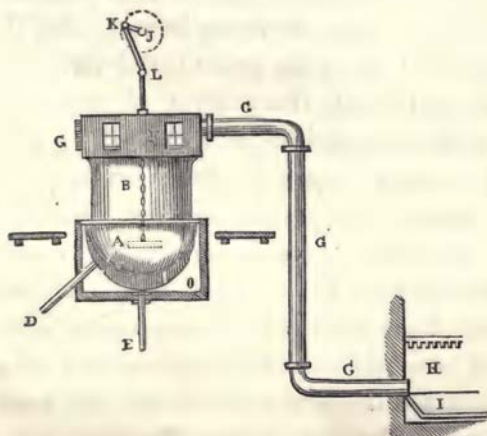
outer casing or steam jacket O. They should be in couples or pairs, so arranged that the steam may be passed

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from one into the other as may be required. As the quantity of tallow generally treated at one operation is six tons, it should be of nine to ten tons capacity. When the acidifying pans have been charged with the melted fat, the temperature is to be raised to 470° by means of a current of steam superheated to 700° F., by passing it through red-hot tubes in its transit from the generator to the pan. The current of steam is then diverted from the first and let into the second acidifying pan, and, during a temporary stoppage, strong oil of vitriol, of sp. grav. 1.80, is very gradually added in the proportion of 125 pounds to every ton of fat. The acid and fat commingle with such violent commotion, that they thus effect their own mixture most intimately, and even before signs of decomposition are manifested. The more consistent fats require a greater quantity of acid than that here prescribed, which is the proportion for palm and cocoa butters. Tallow, for instance, will need thirty to forty per cent. more; but, in all cases, it is safer to determine the exact proportion by a preliminary assay with a small sample of the fat. After the addition of all the acid, the high-steaming is renewed, and the boiling continued for two or more hours. At that period, steam of 250° F. is to be substituted for highly heated steam, and continued from eight to ten hours, when the action will be complete, and the whole must be left at rest for several hours to cool. As the steam and condensed water accumulate in the jacket, they are evacuated, the first through the tube D, and the last by means of the pipe E. A curb B, or cylindrical chamber of thick sheet lead, above the boiler, serves for the collection of sulphurous acid, acrolein, and other volatile matters evolved during the action of the heat and acid upon the fat; and which, being offensive, are drawn off from the top of the chamber through an exit pipe G, leading into the ash-pit H. These vapors, being thus made to traverse the heated fuel, are so destroyed or changed that

they cease to be injurious or inconvenient. In the upper part of the chamber is a man-hole G; and, on another side, are two windows, all of which are necessary for charging and emptying the boiler, and observing the progress of the operation. As the oil and acid must be kept, *continually*, in a state of intimate mixture, a mechanical stirrer A L, working like a churn-stick, is adjusted to the boiler, and kept in motion by the crank K J. When a sample, taken from the boiler, crystallizes readily, and has lost its violet tint, it presents the evidence of complete saponification.

Washing.—The next step is to gradually and cautiously draw off the boiled acidified fat from the black bituminous matter*—amounting to four to ten per cent. of original fat—into a lead-lined wooden tub, containing a volume of water equal to that of the fatty matter, and acidulated with two pounds of oil of vitriol to every hundred gallons of water. The acidulated water must be boiling at the time the melted fat flows into it; and this is effected, as usual, by a current of free steam, which is also continued for an hour after the fat has been added. As the evaporation of the water, during the boiling, may cause the acid to increase gradually in strength, it is necessary to make slight additions, occasionally, of water, to restore the equilibrium. If, on the other hand, the presence of excessive water makes the acid too weak, due evaporation of the former must be promoted by a strong current of steam. As it is important that the original strength of the acidulated water should be maintained throughout the operation, it will be necessary to determine these points, from time to time, with test-samples. When, after sufficient repose, the acidulated water and black dregs have wholly subsided, the clear supernatant fatty matter is to be drawn

* This pitchy residue may serve, after being washed with hot water, as material for making illuminating gas.

off into a large lead-lined wooden cistern A, Fig. 200,* and
boiled with its own bulk of water, slightly acidulated with

Fig. 200.
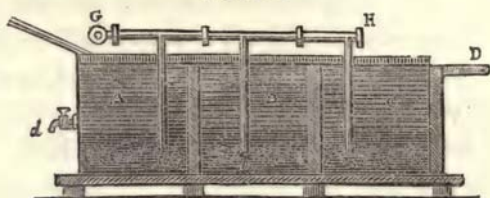
oil of vitriol, for an hour in a current of free steam admit-
ted through the feeder G H, and the open branch-pipe *d*.

In these two operations just described, the object of
which is to wash the fatty matters, the latter pass from
the acidifying boilers into the water as double fatty acids—
sulpholeic, sulpho-stearic, sulpho-palmitic, &c. The gly-
cerin is also an accompaniment in the form of sulpho-
glyceric acid. The water being at 212° F. decomposes
them by sending single fatty acids—oleic, stearic, palmitic,
&c.—to the surface as an oily superstratum, and carrying
down the abstracted sulphuric acid in solution, together
with sulpho-glyceric acid and soluble foreign matters.

The cistern being divided into three or more wells by
means of partitions, as the fatty matter in A is washed by
the water and injected steam, the latter, by their greater
density, form a lower stratum, and flow under the par-
tition into the second well B, carrying along some portion
of the fatty matter. Here the preceding treatment is
repeated; and so on continued in C, and through all of
the wells in the cistern. The wash-waters pass off event-
ually through an overflow-pipe D, into tanks cemented
interiorly with coal-tar pitch, and thus preserved for fur-
ther use. After the fatty acids in A have been sufficiently
purified by four or five washings with steam and water,

* The fat may be drawn directly from the acidifiers into this washing-cistern.

conjointly, they are to be drawn off at d above the level of the lower stratum of wash-water into a cistern arranged for conveniently feeding the still in the next stage of the process. When the cleansed fat has been drawn from A, that in the wells B C is then to be skimmed off into A, and further washed in the same manner.

The cistern or reservoir which feeds the still should be of wood, with a lead lining, and have a tight leaden worm resting on the bottom, or coiled closely around the sides. For convenience, the worm may be connected with a waste-pipe of some of the apparatus, and thus turn to economical use the condensed steam, which will, in circulating through the tube, impart a uniform warmth to the fatty matter of the reservoir, and thus promote the deposition of any foreign matter it may retain in a state of mechanical suspension.

Distillation.—The process of distillation largely increases the fusing point of fats. For example, bone fat and similar fats melting at 75° F., yield a distilled product which requires 105 to 110° F. for its fusion. This latter, on being washed and pressed, has its melting point still further raised a few degrees. It must be remarked, however, that the fusing point of the distillate, or condensed fatty acids, varies at the different periods of the operation. This is shown by the following table of the results of Pohl's experiments with palm oil; the product of distillation having been collected in five separate portions, at different but successive periods of the process:—

Portions and periods.	Percentage of acids compared with entire distillate.	Melting point.
1	1.21	124.5° F.
2	2.28	114.4
3	3.17	113.7
4	4.90	111.9
5	5.25	109.0

The distilling apparatus is illustrated by Fig. 201, and

consists of a flat metal boiler D, with a dome-shape cover
of tinned copper. The fatty acids being drawn into this

Fig. 201.
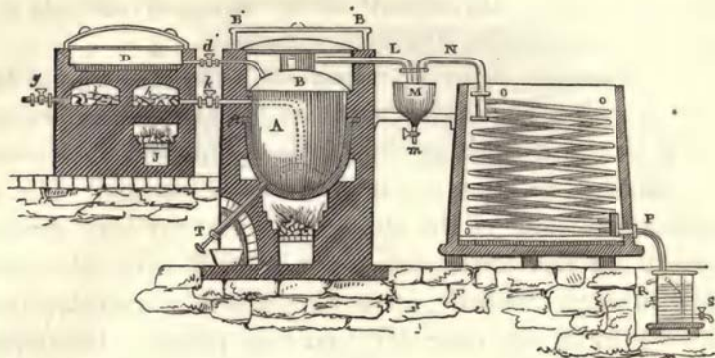
vessel, are then heated by the waste heat escaping into
the flues of the furnace J. The cover being gutter-ledged
at its circumference, the water is condensed on the inte-
rior surfaces as fast as it evaporates, and runs down to the
gutter forming a water lute to the vessel. An overflow-
pipe carries off the water as it accumulates in excess.
When the water has been driven off by sufficient evapora-
tion, the fluid fat is then let into the copper boiler A
through the pipe d—the cock of which serves to regulate
the flow. The dome cover B, of the boiler, is surmounted
with a hollow cap of sheet-iron B B', filled with hot coals
to prevent loss of heat by radiation. On the top of this
cover is a man-hole door.

The contents of the still being gradually heated to
480° F., by means of an open fire beneath, or by a sand-
bath surrounding it, a current of steam is then let into
the metal pipes h and i, through the regulating cock g k.
These pipes are placed in the arched chambers of the
furnace J, where the heat is sufficient to raise the steam,
passing through them, to the required temperature; and

the steam is admitted to the still by opening the cock k. The dotted lines show the tube and the rose at its end, both of them perforated with holes, and by means of which the super-heated steam, as it enters the still, is spread throughout the mass, and thus equalizes its temperature. A thermometer, suitably attached to the pipe, serves to indicate the temperature of the steam, which should range from 480° to 580° F. The action of steam at this high temperature has the effect of changing any remnants of undecomposed fat into fatty acids and glycerin; and the vapors of fatty acids rising with the steam are carried over by the latter through the pipe L into the intermediate vessel M, and thence by the pipe N into the worm O O, where it is condensed into fluid form, and flows into a receiver Q. The intermediate vessel M is designed to intercept acrolein, sulphuric acid, and other products of the earlier stage of distillation, and also any matters that may be driven over mechanically by a too strong heating of the still. In such instances, they are to be drawn off through the cock m. The steam, in this instance, not only acts as the heating agent, but also excludes the air from the interior of the boiler, and thus materially promotes the saponification.

The worm being kept cool, the distillate, as it condenses, passes thence through the tube p into the receiver, where, upon repose, it separates into two strata—the first or upper portion consisting of the fatty acids which are to be drawn off through the cock F, while the lower or aqueous stratum is evacuated by the cock S. A still of five feet diameter and six and a half feet high, will be of sufficient capacity for one ton of fat, and the distillation of this quantity may be accomplished in twelve to fifteen hours. After each distillation, 4 to 7 per cent. of brown, black fluid matter remains in the still, and as it thickens on cooling,

it must always be drawn off, while warm, by means of the syringe T, and reserved as stock for common soap.

Towards the end of the distillation, the proportion of bituminous matter increases and becomes so persistently involved with the last portions of fatty acids, that the latter distil with great difficulty, and then only in an impure, dark state;—thus rendering necessary a second distillation of this residue in a separate vessel, by means of stronger heat and more highly heated steam. To obviate this inconvenience, Bauwen has proposed the use of a stream of air, which is injected, simultaneously with the current of steam, into the still, so constructed as to make the distillation continuous. The color of the distillate, as well as its odor, are said to be improved by this means, which presents other advantages for facilitating the process generally.

The still is a flat vessel, standing upright, and divided into compartments by lateral projections. These projections do not extend all the way across to the opposite side, but leave a small opening, which produces an inter-communication with the several apartments. The current of steam, on entering, rises along the apartments, comes in contact, and mixes with the fatty matters as they run down, and carries off all the volatilizable parts with it, through an opening at the top of the still, into a condenser, while the pitch and non-volatilizable matters fall down into the box. As the steam is admitted in a jet through a pipe lying at the bottom of the box, it will bubble in the pitch as soon as there is a sufficient quantity of that body to cover the pipe, and will then drive off any volatilizable portions that may still remain in it. A gauge-cock, adjusted at a proper height in the side of the box, will indicate when the pitch is to be drawn off, as can be done without stopping the distillation.

The apparatus is heated on the outside by flues, passing

over the exterior of the plates, forming the front and back of the still.

The management of the still becomes easy after short practice; and care must be observed to so regulate the supplies of heat, steam, air, and fatty matters, that the pitch which may rise with the vapors shall be stopped in the still, and not allowed to reach the condenser.

We give a description of the apparatus, as follows :—

Bauwen's continuous distillation.—Fig. 202 is a side elevation of a still constructed according to this part of the invention, and with the brick-work setting removed. Fig. 203 is a sectional elevation of the same; and Fig. 204 a vertical section on the line *a b* of Figs. 202 and 203.

A A is the body of the still, and B B are the projections by which it is divided into compartments communicating with each other, as before mentioned; C is the box or chamber which receives the pitch, and into which the steam is admitted by the open pipe D, which passes through a stuffing-box in the socket E; F is an aperture by which the box C communicates with the body of the

Fig. 202.
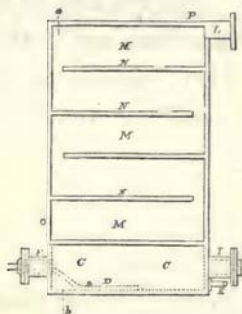
still; G is an aperture at the top of the still for the introduction of the fatty bodies, and H is another aperture for the admission of air, which is supplied by a force-pump, or

other convenient apparatus; I is a socket, in which is inserted a gauge-cock, for enabling the height of the pitch in the box C to be ascertained, and K is a pipe fitted to the box, and furnished with a cock for running out the pitch; L is the outlet through which the matters that distil over are conducted to the condenser, which is of the ordinary construction; M M are flues, formed by building

Fig. 203.
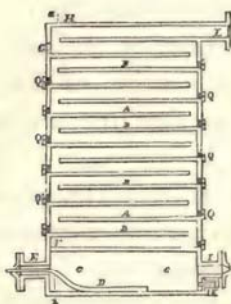
Fig. 204.
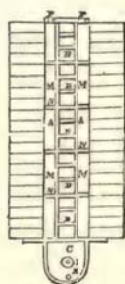
the brick-work up against the projections N N, on the outside of the still, which flues serve for heating the apparatus on the exterior; O O are the inlet, and P P the outlet apertures to the flues M M; Q Q are are apertures in the ends of the still, which are closed by screw plugs, and serve to allow the cleansing of the compartments in the still when required. The steam employed in the still may be either at the ordinary temperature, or it may be super-heated, as may be preferred. The same furnace that raises the steam will serve also to super-heat it, and the products of combustion may also be led into the flues M M, for the purpose of heating the still on the outside. The arrangements by which these objects may be effected, will be readily understood by the practical men, without any further explanation. The details of the arrangement above described may be varied, by admitting the steam along with the fatty bodies at the upper part of the still,

instead of into the box at the lower part, as before described, and by making the outlet to the condenser at the lower part of the still. The admission of steam into the box or chamber is, however, attended with this advantage, that the bubbling of the steam in the pitch will have the effect of disengaging and carrying off any volatilizable matters that may be contained in it, and which would not otherwise be distilled over.

Another mode of making the distillation continuous, is that known as—

Fontainmoreau's process.—Fig. 205, A, shows a longitudinal section of the apparatus; and B presents a transverse

Fig. 205.
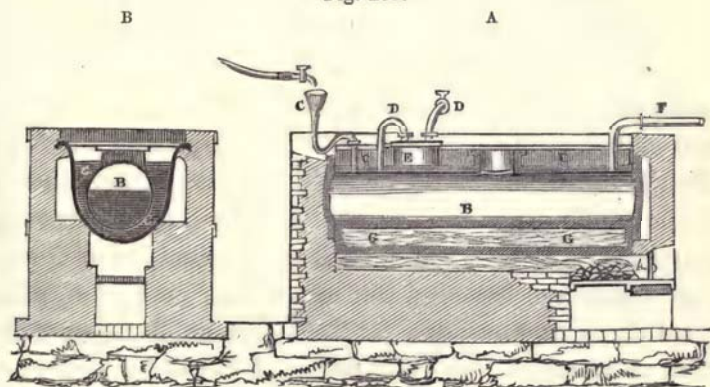
section. It consists of a copper cylinder B, arranged in an outer jacket G G, of cast or sheet iron. The first is the vessel for containing the fatty matters to be distilled, and the last forms the metallic bath by which it is heated to the required temperature. Lead is the metal used as the heating medium, and it must be kept uniformly in a state of low fusion. The boiler is fed with the hot fluid fat, in a thin stream, through the tube C, but should not be filled to more than half of its capacity. To maintain a continuous supply, there is adjusted to the end of the funnel-

tube, in the interior of the copper boiler or still, a counter-poised valve and float ball. This latter rests upon the surface of the fluid fat, and when, as distillation proceeds, the height of the fluid charge becomes lower, the float descends and opens the valve to admit a new portion from the reservoir of washed, acidified fat; and, consequently, also, shuts off the supply when the proper height is attained. The steam is supplied from a generator through the cock-tube D; but, before entering the still, the latter passes through the lead-bath, in order to dry the steam as much as possible. Any aqueous particles that it may still retain, will be vaporized in the intermediate chamber E, as the steam enters the still through the tube D. To promote a speedy action, the steam must be led into the body of the fat; and, to this end, the steam pipe should extend along the bottom of the boiler, and be perforated in that part surrounded by the fat, so that the steam escaping through the holes may urge the products of distillation from the boiler into the head F, and thence into the condensing apparatus. As distillation proceeds, the cylinder-still is supplied with fresh portions of liquid fat at suitable intervals; but when the residuum, after several days, accumulates in the cylinder B to such an extent as to retard the distillation, it must be removed. For this purpose a discharge pipe and cock is arranged on the bottom of the cylinder and in the end nearest the head F. All the volatile matter having been driven over from the charge of fat in the cylinder, the cocks C and F are then closed, and the cock in the discharge-pipe opened. The steam, in rushing through the discharge-pipe, carries along with it all the sediment in the cylinder. This cleaning operation is effected without stopping the fire, and distillation may be renewed, with fresh fats, after a very brief delay.

The cylinder-still has a man-hole in the centre of the upper side, which serves its usual purpose of giving access to the interior, for repairs, &c.

Knabb suggests that the condensing apparatus, or refrigerant, shall consist of a copper tank immersed in an outer vessel filled with cold water. The inner tank is to be fitted with partitions attached alternately to the top and bottom, but not reaching the whole distance, so as to compel the fatty matters to impinge against cold surfaces alternately. The outer vessel should be divided into two chambers, severally supplied with a stream of cold water. When the fatty vapors and steam have been condensed, their different densities will readily enable the workman to separate the oily from the aqueous portion. When tallow or other consistent fat is used, the distillate must be kept fluid by a current of steam.

Melsen's process of saponification.—This method, patented in December, 1854, is a modification of the preceding processes, and consists in decomposing the crude fat in a single operation, by exposing it with water containing only a few per cent. of oil of vitriol, to a temperature of 350° to 400° F. When the saponification is completed, the acids are to be washed and pressed. The pressed cakes, refined in the usual manner, are then ready to be moulded into candles. Below is a description of the apparatus employed by the inventor.

Fig. 206, 1 and 2, represent a section and elevation of one of the arrangements by which fatty bodies may be decomposed, either by means of water alone, or acidulated water, at a temperature of about 400° F.

In this figure, A A is the main boiler, capable of holding about fifty gallons of melted fatty bodies, with about twenty-five gallons of water, leaving empty a space for twenty to thirty gallons. This boiler is made of sheet-iron or brass, of the necessary strength, and is constructed for receiving,

at will, an internal lining of any kind of metal which experience, during the working of the process, may suggest as useful. The front part is closed with a wrought or cast-iron, or brass plate *a a*, secured to the body of the boiler by bolts; a man-hole *o* serves for the introduction of tallow or other fatty body in a solid state. The boiler

Fig. 206.
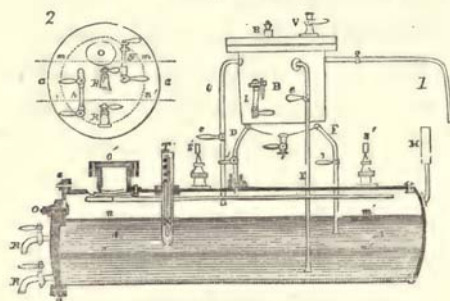
A A must be constructed to support a pressure of ten to twelve atmospheres, and is provided with the following accessories, that is to say, with a safety-valve S S'; one or two tubes T, each disposed to contain a thermometer X, one of which is immersed in the water, the other in the fatty body, for indicating their temperature; a steam gauge M; two levels N N', set so as to indicate, one, the elevation of the water; the other, that of the fatty bath, and two purge-cocks R R'. A second boiler B B, is set above the first, at a distance, and in the situation most convenient for the working of the process, and is provided with similar accessories to the first, namely : a man-hole H, a thermometer, a steam gauge, two levels, and one or two purge-cocks; but the man-hole alone is indispensable for the introduction of the fatty body. This boiler is also provided with two tubes, having the taps Q V, as in feeding steam boilers, which are not provided with feeding pumps.

The boiler B B is represented in the drawing as being only one-fifth of the capacity of the boiler A A. The boilers are united by means of four pipes C D E F, having each of them a tap *c d e f*, serving to produce the result hereinafter described. The working of the taps *c d e f v* and *q*, which are moved by the hand, constitutes the whole mechanism of the apparatus. The tube D is connected squarewise with a horizontal tube *δ δ*, which extends over the whole of the upper part of the boiler; this tube is pierced over the whole of its length, to insure a better division of the substances passing through it.

Having introduced water into the boiler A A, up to the level *n n'*, and tallow up to *m m'*, the whole is gradually heated until the thermometer marks about 400° F., when the reaction of the water on the fatty body begins and continues. After a certain length of time, in order to

Fig. 207.
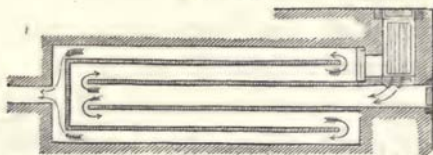
increase that reaction by multiplying and renewing the surfaces of contact, the four pipes C D E F, and tap U, are to be used as follows: The cock *d* being opened, the steam escapes from it into the boiler B B, and by opening the cock V, that steam escapes into the atmosphere at this moment from all the points of the boiler A A; a tumultuous current of steam, charged with water, is formed, which passes through the layer of tallow *m m'*, and produces a first contact between the two liquids; some minutes after, the cocks *d* and *v* are shut, and the boiler B B becomes cool; in case of need, the cooling can be hastened by sprinkling cold water on it, producing a

partial vacuum within the boiler. The taps e and f, being then alternately and simultaneously opened, forces a mixture of melted tallow and water to ascend into the boiler B B, and the taps e and f, being afterwards shut, and the taps e and d opened, the steam introduced through the tube C, acts upon the water and tallow contained in the feeding boiler B B, so as to force them into the main boiler A A, through the pipes D, δ δ; the two liquids fall in showers on the surface of the tallow bath, which is only traversed by the water running to the bottom of the boilers A A; this double current, acting in a contrary direction, forces the water into close contact with the tallow. This double current is reproduced as often as necessary, to disengage the glycerin from the fatty acids, which is dissolved in water as soon as it is separated from the fatty acids. When the water, contained at the bottom of the boiler, becomes too much charged with glycerin, it is partly or wholly drawn off by the tap r, care being taken, however, that the fatty bodies which the water may hold in suspension, should not be lost. The solution of glycerin is used when it is required. The water containing the glycerin, which has been withdrawn, is replaced by pure water; for that purpose, the vacuum is made in the boiler B B, by means of the taps d and v, and the tube Q, is then put in communication with the reservoir of water, and when the water is introduced into the boiler B B, it is forced into the boiler A A, by opening the taps c and d. The same mode of operating serves for introducing into the boiler A A the tallow taken from a vat in which it is maintained in a liquid state; but I prefer operating in a direct manner on the feeding boiler. After first introducing the tallow through the man-hole, it is melted either by heat externally applied, or, what is still better, by means of water and steam supplied from the main boiler; when the tallow is melted, the action of

the taps, hereinbefore described, forces it into the main boiler. The mode of introducing crude tallow into the boiler, necessitates the lining of the entrance of the tubes with metallic cloth or with bored plates, to keep back the parts of tallow not completely decomposed, which, remaining in the liquid, might close the taps.

The operation is carried on with continuous fire; and, in order to give to the process all required surety, the steam gauge is put in communication with an alarum, to warn the stoker in case the pressure should be allowed to go beyond the required degree.

To prevent the temperature rising above the necessary point, the furnace is constructed in such a manner that the heated gases can be withdrawn with rapidity from the body of the boiler, which can also be cooled by means of a current of air.

Fig. 206 represents the arrangement for obtaining such result.

Pressing.—The condensed fatty acids, by the distillation process, as they pass from the worm, have sufficient firmness to make them useful as inferior candle stock, for which purpose much is consumed. But to give maximum hardness and beauty to the stock, and render it suitable for making candles of superior quality, cold and hot pressing must be successively employed, and in the usual manner heretofore described. The oleic acid, running from the press, contains an appreciable quantity of solid fat acids, which may be separated by exposing it, in barrels, to a low temperature, and, when granulation has taken place, filtering it through bags. It is, however, most generally sent to market at once, to be sold as stock for the commoner kinds of washing soap.

Purifying.—After having pared off their greasy edges, the hot pressed cakes are to be thrown into iron-bound wooden tubs (Fig. 85), with water containing a small

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quantity of oil of vitriol, and melted by a direct current of steam. After a half hour's boiling, the whole is left to repose, and the subsident water drawn off. This treatment being repeated with fresh water, the acids may then be considered pure, and are, while still fluid, to be drawn off into pans. When cool, the blocks are ready to be moulded into candles.

SAPONIFICATION, BY THE COMBINED ACTION OF HEAT, PRESSURE, AND STEAM.—This method, first proposed in January, 1854, is a practical application of an older principle, which is destined to work a great change in many branches of chemical art, as it affords the means of simplifying and economizing processes of decomposition. In this instance, it is equally adapted to all kinds of neutral fats, though some yield to its influence more promptly, and at a lower temperature than others—550°–600° F. being the highest degree required for the most persistent of them. The operation consists in subjecting the fats, in suitable apparatus, to the action of water, at a high temperature, under pressure, so as to cause the proximate elements of those bodies to combine with water, and to separate, at the same time, as free fatty acids and solution of glycerin. If the heat is carefully managed and maintained uniformly high, and the admission of steam is continuous, no acrolein is formed; nor is there any decomposition of the elements of the fat. On the contrary, the fatty acids and glycerin separate in a normal condition, though of better color and odor than when obtained by the other methods. The inventor describes the operation as follows:—

Tilghman's process.—"I mix the fatty body to be operated upon with from a third to a half of its bulk of water, and the mixture may be placed in any convenient vessel in which it can be subjected to the action of heat at a temperature about the same as that of melting lead, until the operation is complete; and the vessel must be

closed, so that the requisite amount of pressure may be applied to prevent the conversion of the water into steam.

The process may be performed more rapidly, and also continuously, by causing the mixture of fatty matter and water to pass through a tube or continuous channel, heated to the temperature already mentioned, the requisite pressure for preventing the conversion of the water into steam, being applied during the process; and this, I believe, is the best mode of carrying this part of my invention into effect.

"Fig. 208 is a vertical section of this apparatus; and Fig. 209 shows the various parts of the apparatus in horizontal section. I place the fat or oil, in a fluid state, in the vessel a, with from one-third to one-half its bulk of warm water; the disk, or piston b, perforated with numerous small holes, being kept in rapid motion up and down in the vessel a, causes the fat, or oil and water, to form an emulsion or intimate mechanical mixture. A force-pump c, like those in common use for hydraulic presses, then drives the mixture through a long coil of very strong iron tube d d d d, which being placed in a furnace e e, is heated by a fire f, to about the temperature of melting lead. From the exit end g, of the heating tubes d d, the mixture which has then become converted into free fat acids and solution of glycerin, passes on through another coiled iron tube h h h, immersed in water, by which it is cooled down from its high temperature to below 212° F., after which it makes its escape through the exit valve i, into the receiving vessel. The iron tubes I have employed and found to be convenient for this purpose, are about an inch external diameter, and about half an inch internal diameter, being such as are in common use for Perkins's hot-water apparatus. The ends of the tubes are joined together by welding, to make the requisite length; but where welding is not practicable, I em-

ploy the kind of joints used for Perkins's hot-water
apparatus, which are now well known.   The heating

Fig. 208.
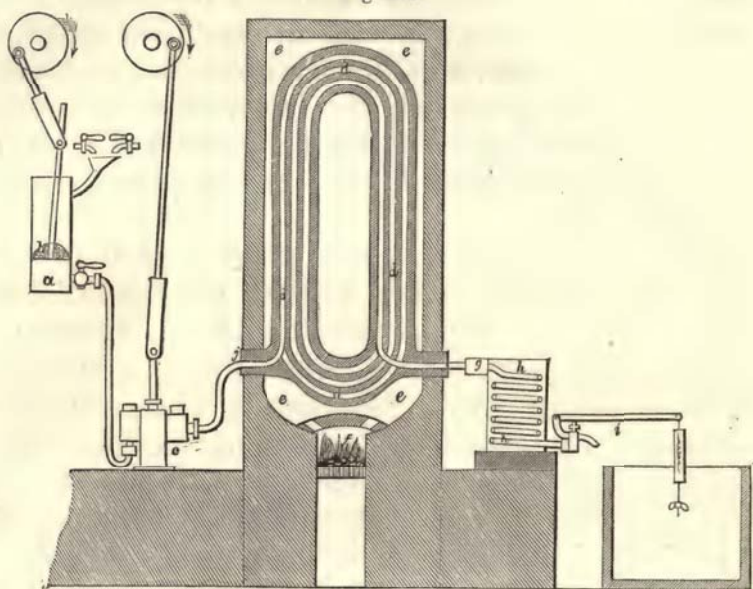
tube *d d d*, is coiled several times backwards and for-
wards so as to arrange a considerable length of tube in a
moderate space.   The different coils of the tube are kept
about one-quarter of an inch apart from each other, and
the interval between them is filled up solid with cast iron,
which also covers the outer coils or rows of tubes, to the
thickness of half to three-quarters of an inch, as shown
in Fig. 209.   This casing of metal insures a considerable
uniformity of temperature in the different parts of the
coil, adding also to its strength, and protecting it from
injury by the fire.

   "The exit valve *i*, is so loaded that when the heating
tubes *d d d*, are at the desired working temperature, and
the pump *c*, is not in action, it will not be opened by the
internal pressure produced by the application of heat to

the mixture; and, therefore, when the pump c, is not in action, nothing escapes from the valve i, if the temperature be not too high. But when the pump forces fresh mixture into one end, j, of the heating tubes $d\ d\ d$, the exit valve i is forced open to allow an equal amount of the mixture which has been operated upon to escape out of the cooling tubes $h\ h$, at the valve i, placed at the other end of the apparatus. No steam or air should be allowed to accumulate in the tubes, which should be kept entirely full of the mixture. For this purpose, whenever it may be required, the speed of the pump should be increased, so that the current through the tubes may be made sufficiently rapid to carry out with it any air remaining in them. Although the decomposition of the neutral fats by water, takes place with great quickness at the proper heat, yet I prefer that the pump c, should be worked at such a rate in proportion to the length or capacity of the heating tubes $d\ d\ d$, that the mixture, while flowing through them, should be maintained at the desired temperature for about ten minutes before it passes into the refrigerator or cooling parts $h\ h$ of the apparatus.

" The melting point of lead has been mentioned as the proper heat to be used in this operation, because it has

Fig. 209.
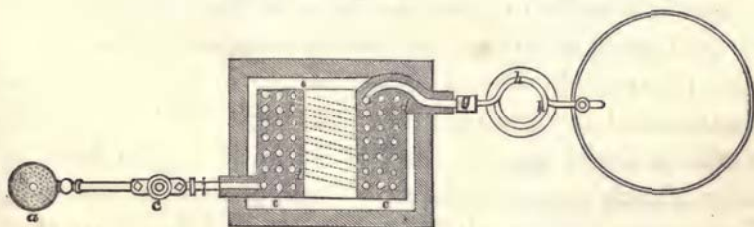
been found to give good results; but the change of fatty matters into fat acids and glycerin, takes place with some materials (such as palm oil) at the melting point of bismuth, yet the heat has been carried considerably above

the melting point of lead, without any apparent injury, and the decomposing action of the water becomes more powerful as the heat is increased. By starting the apparatus at a low heat, and gradually increasing it, the temperature giving products most suitable to the intended application of the fatty body employed, can easily be determined.

" To indicate the temperature of the tubes d d d, I have found the successive melting of metals and other substances of different and well-known degrees of fusibility to be convenient in practice. Several holes, half an inch in diameter and two or three inches deep, are bored into the solid parts of the casting surrounding the tubes, each hole being charged with a different substance. The series I have used, consist of tin, melting at about 440°, bismuth at about 510°, lead at about 612°, and nitrate of potash at about 660° F. A straight piece of iron wire passing through the side of the furnace to the bottom of each of the holes, enables the workman to feel which of the substances are melted, and to regulate the fire accordingly. It is important, for the quickness and perfection of the decomposition, that the oil and water during their entire passage through the heating tubes should remain in the same state of intimate mixture in which they enter them. I therefore prefer to place the series of heating tubes in a vertical position, so that any partial separation which may take place while the liquids pass up one tube, may be counteracted as they pass down the next. I believe that it will be found useful to fix, at intervals in the heating tubes of such apparatus as may admit of such an addition, diaphragms pierced with numerous small holes, so that the liquids, being forced through these obstructions, may be thoroughly mixed together. I deem it prudent to test the strength of the apparatus, by a pressure of 10,000 pounds to the square inch, before taking it into use; but I

believe that the working pressure necessary for producing the heat I have mentioned, will not be found to exceed 2,000 pounds to the square inch. When it is desired to diminish the contact of the liquid with iron, the tube or channels of the apparatus may be lined with copper.

"The hot mixture of fat acids and solution of glycerin which escape from the exit valve of the apparatus, are separated from each other by subsidence. The fat acids may then be washed with water, and the solution of glycerin concentrated and purified by the usual means.

"The fat acids thus produced, are applicable to their various uses, according to quality; but they may be further bleached and purified by distillation.

"To prevent injury to the pipes by the small portion of acetic or other acid generated during the process, from the fatty material, it is necessary to add a little carbonated alkali to the water and oil before pumping them into the tubes.

"This process is equally applicable for the conversion of the fatty matter into soap; and then it is necessary to dissolve the requisite amount of carbonated alkali in the water, and to keep the temperature from 350°–400° F. The carbonic acid eliminated from the carbonated alkali, will pass off with the soap through the exit valve. When the quantity of water used does not exceed that which it is intended the soap shall retain, the warm paste may be received into the frames, as it issues from the valve—it being ready, when cool, for the market."

CHAPTER XXX.

SPERMACETI CANDLES.

In cleanliness, brilliancy of light, and beauty of appearance, the sperm candles are only second to the wax bougies. Their transparent whiteness renders them particularly applicable for parlor use, and though of higher cost than the ordinary kinds of candles, they are, considering their superiority, scarcely more expensive. As met with in the market, however, they are not universally of good quality; some brands are more reliable than others, for the excellence of the candle depends upon the care and skill bestowed in its manufacture. The requisites for a perfect candle are, entire freedom from oil, a proper apportionment of the wick, and a skilful manipulation in moulding, so as to produce a translucency of the stock. Nantucket and New Bedford are the great manufacturing marts, but there are also large quantities made in Philadelphia.

The manner in which they are manufactured, is as follows:—

The crude spermaceti, or, as it is technically called, "*head matter*," is first freed of its loose oil by filtration through long cylindrical bags of linen. For this purpose, the reservoir of sperm must have a high position, so as to allow the fastening of one end of the bag to a feed-pipe projecting from its side near the bottom. The other end of the filter, which is also made open, being then gathered and tied by cords, the sperm may be allowed to enter by opening the cock of the feed-pipe. The superin-

cumbent pressure of the contents of the reservoir materially aids the filtration. As soon as all the oil, that can be removed in this way, has passed through, the bags are loosened at the lower end, and their solid contents allowed to fall into a receiving trough. It is next subjected to the action of a tight press; or, it may be first steamed and granulated.

Without previous granulation the sperm, even after having gone through all the subsequent operations, is greasy, less transparent, and of inferior quality. The process of steaming, therefore, is an advantageous step. The *modus operandi* is the same as directed for stearin, in Chapter XXVIII. The grained mass having been transferred to bags, and folded so as to form thin cakes, is placed between wrought-iron plates in a tight (screw) press, and subjected to pressure until liquid ceases to flow from the pressed cake. This liquid, which passes through, after having gone through the proper rectification, is the " *winter sperm oil*" of commerce.

When the screw press has been carried to its fullest power, and no more oil will ooze from the filled bags, they are to be taken out, and their contents emptied into a clean cast-iron kettle and melted. The kettle, with its charge, should be kept at 125° to 150° F., for some hours, and at the end of that time the liquid sperm must be drawn off into hogsheads and placed aside in a mild temperature to granulate a second time. It is then bagged and pressed as before. The oil obtained in this stage of the process, is " *spring (sperm) oil.*"

After this pressure, the bags are taken out, and their contents again melted as above directed. The liquid fat having remained at a gentle heat for one or more hours is then to be ladled into tin conical pans, each of five or six gallons capacity. When the blocks thus formed have cooled, they are to be placed upon a rack and left, for a

day or more, to "sweat" and "ripen." During this repose, their surfaces become coated with oily exudations, and they are then to be transferred, one at a time, to the sloping hopper D, of the rasping machine, represented by the figure annexed.

Fig. 210.
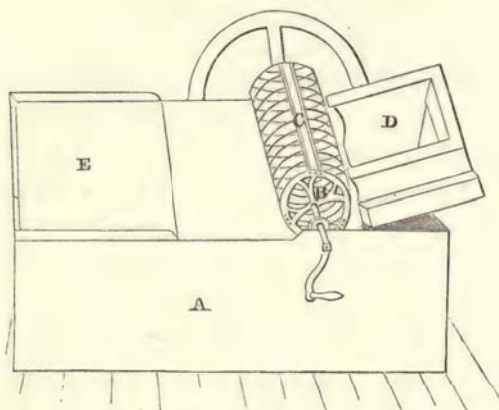
There the blocks come in contact with the knives C, traversing the circumference of the wheel B, kept in constant rotation. In this way they are reduced to a mealy powder, which falls in the chest A beneath. The sperm is now ready for a re-pressing, in order to expel all residual oil, and for this purpose, is filled into cloths with twine wrappers, and folded to a less thickness than in the first pressing. The shelf E is placed on the end of the chest, both for convenience and for facilitating the operation of bagging. The cloths thus filled, are now arranged as before, between iron plates, but in a hydraulic press of greater power. Some factors use an upright, and others an horizontal apparatus. The former is shown at Figs. 167, 168, 169; the latter, which is preferable, is seen at Fig. 164. In cold weather, or when the expulsion of the oil is to be complete, the presses are surrounded, as in the pressing of stearic block, by a steam chest;—the product

obtained in this way, is called *hot pressed sperm*, in contradistinction to that which is *cold pressed*, and procured without artificial heat.

When the compressed cakes cease to yield oil, they are to be taken out of the press, uncovered, and placed aside to be purified. The oil from this last pressing is worked over again, to obtain No. 2, or tight pressed spermaceti. The head matter sperm is never entirely freed from oil by pressure; therefore, when it reaches the refining pan, the small portions which it retains are to be neutralized, as it were, by the addition of about 66 per cent. of pressed "body matter or foots," which is usually pulverulently dry. The cakes from the last pressing are hard, dry, and sonorous. The cleansing and whitening of the sperm are effected by melting it in a perfectly clean iron kettle, at 160° to 180° F., and dosing it with potassa solution of 45° B., as its temperature decreases. Weak lye, while saponifying the oil that may be retained by the sperm, does not act at all, or at most, but feebly upon the sperm itself. The proportion of lye is about one and a half gallons to forty of liquid sperm. The heat must be steady and moderate when the lye is added, because a *rising temperature will "soap" the whole batch*. This is called " physicking" the kettle. After the thorough incorporation of the lye by continued stirring, and sufficient repose to allow a complete deposition, it is dexterously bailed out with a dipper, and thrown aside as material for "*refining kettle soap*." The scum and impurities which rise to the surface, are to be removed as fast as they appear. The physic having been all bailed out, the kettle is heated anew with a *steady fire of oak wood*, to about 230°, or 270° at furthest, and then washed over with water, added pintwise and carefully, throughout the surface. The time required for this operation is about four hours, and the proportion of water, say four gallons; but a much better

criterion by which to judge the completion of the process, is the perfect limpidity and transparency of the melted sperm. The washing must be continued until no more scum arises and the spermaceti is clean and white. In the mean time, the fire must be allowed to gradually decrease, and when the liquid fat has stood for two or more hours after the completion of the washing, it must be gradually dosed with a bucket of cold water, thrown in and over the fat, a cupful at a time. The suspended particles of dirt and the residual impurities are thus carried to the bottom with the water, which also serves the double purpose of protecting the sperm from the heated metal. The supernatant stratum of melted sperm is then to be transvased into clean tin pans (free from rusty spots), where it congeals into perfectly white and pure crystalline blocks.

These blocks are the purified candle stock, but its crystalline structure must first be destroyed, else the candles moulded from it would be brittle. Some chandlers accomplish this by adding three per cent. of virgin white wax; others by casting the candles at a fixed and uniform temperature, for instance 140° F. The cavities which occur as the candles cool and contract, must be filled by fresh additions of melted sperm, or else the excess upon the upper bed of the mould-stand should be sufficient to supply them as they gradually form. The shape of the moulds, and the proper construction of the stand are exhibited by Fig. 211, and described at pages 388, 389, and 390.

The temperature at which the candles are moulded has an important influence upon their beauty of appearance; for example, in the winter when there is less difficulty to detach them from the moulds, the spermaceti can be run whilst very hot, and yet the candle, instead

of being brittle and imperfect, will be beautifully diaphanous and wax-like in appearance.

Fig. 211.
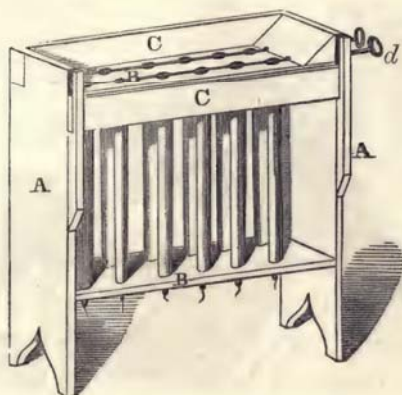
Sperm block may also be moulded into candles by any of the moulding machines already described in preceding chapters. The annexed drawing will call to mind the mode of operation, which we will, however, describe again for the convenience of the reader. The apparatus here referred to, is not very different from one of those we have before noted, and is shown by Fig. 212. Each frame contains a row of eighteen moulds; and in a chamber at the bottom, there is a corresponding number of reels, severally holding sixty yards of wick, and connecting with the moulds. In threading the moulds, the wick is left to protrude at the top; and when the fat has been poured in, and the candles have set and cooled, the frame is drawn forward, by means of a lever, directly in front of a series of horizontal plungers, which are made to press against the conical caps of the moulds, and, by forcing them into the moulds, thus expel the candles. The candles, in passing from the moulds, draw after them sufficient wick from the reels to re-thread the latter for the next casting. The

candles, as drawn, are shown at *a*; and, in that position,
they are held firmly by a hinged press-board, suitably in-

Fig. 212.
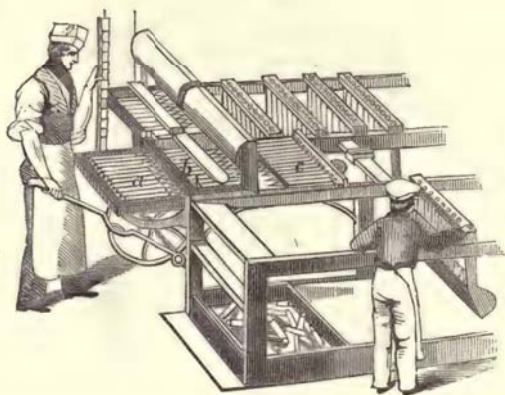
dented, and covered with flannel; while a circular knife,
moving between *a* and *b*, clips the wicks, and thus frees
the candles from the mould-stands. The ends of the
wicks are then caught by clasps arranged on a rod, and
tightened by drawing back the plungers, which bring
with them, at the same time, the conical caps of the
moulds. The whole frame is then placed, conical ends
downwards, on a pair of rails at the side, whence it is
pushed forwards, by a boy, into a hot chamber, to be
warmed to the proper temperature. The frames, on com-
ing from this chamber, are brought immediately under
the reservoir of sperm placed above the rails, and the
contents of which is maintained in a state of fusion by
steam pipes. Having been then filled, through a suitable
cock, they are pushed on to the extreme end of the rail-
way, which should have considerable length. When the
candles have set and cooled, the excess of sperm and the
clasps are removed from the top, the frames are transferred,
on a movable truck, to a parallel railway opposite, and

thereon moved up to the plungers, and acted upon as before mentioned. Great care must be observed to keep the clasps in their proper position, so as to maintain the wicks, exactly, in the centre of the candle.

The wick used in this country for pure sperm candles, consists of a doubled strand of eighteen very fine threads; but for the "*patent sperm*" candles (which are composed of sperm and wax, or stearic acid) the braided wicks are used.

For ornamental purposes, the sperm candles are sometimes colored. This is readily done by triturating a very minute quantity of the pigment with oil, and incorporating it thoroughly with the melted sperm. Carmine is used to impart a red or pink shade; chrome yellow, or gamboge, gives a lemon tint, and Prussian blue furnishes an azure color.

CHAPTER XXXI.

WAX CANDLES.

The great beauty and high illuminating power of wax candles, render them superior to all other kinds; but, as candles from spermaceti and stearic acid closely approximate them in many qualities, with the great advantage on their side of being much less costly, these latter have almost wholly taken the place of the former. Wax candles, however, are still used in churches, and by a few of the more wealthy people.

A large amount of wax is produced in the Western States, and other parts of this country. It is also extensively imported from British Gambia, in Western Africa; from Cuba and the East Indies. The wax from Gambia and Cuba is bleached with much more difficulty than that from the other sources.

There are two kinds of candles: the dipped or basted, and the moulded; and as the natural yellow color of wax would detract from the beauty of the candles, the first step in their manufacture is the washing and bleaching process. Preliminary to that, however, is the

Examination of the wax.—Before commencing the operation, care must be taken to determine whether the wax contains any one or more of the adulterations with which it is occasionally, and fraudulently mixed, viz: rosin, stearic acid and starch, white-lead, and other insoluble matters. By melting the wax in hot water, the three latter will subside, while the wax collects at the top of the water. Starch, moreover, will give a gelatinous consistence to the

aqueous solution, and its presence may be further confirmed by adding a drop or two of solution of iodine, which will strike a blue color. Rosin may be detected by its peculiar odor, during the burning of the wax, and by the smokiness of the flame. If the wax, on being boiled, for a few minutes, with a solution of carbonate of soda of 1.50, gives effervescence and froth, and a mucous solution on cooling, it contains stearic acid, for pure wax is not acted upon under the same circumstances. The soda solution is made by dissolving two drachms of carbonate of soda in twelve and a half ounces of distilled water.

The addition of rosin causes the wax to stick to the teeth when chewed, and imparts a peculiar taste. It also destroys its granular structure; and it is to restore the latter that potato starch is sometimes used.

Washing and bleaching.—The bleaching-yard always forms a main portion of the wax foundry and refinery, and for the sake of being as intelligible as possible, we will describe the different apartments of the atelier, or laboratory, and the tools and apparatus required for the operations:—*

The laboratory consists of two distinct and separate apartments: the foundry and bleaching-yard. The former is a large room, or hall, in which are arranged the furnaces, caldrons, and all such utensils as are indispensable to the process of melting and casting the wax. Fig. 212 represents, in perspective, an interior view of a foundry. The larger pieces of apparatus are apparent in this figure; the smaller ones will be described in detail. Against one of the walls of the building, back of which there is a free passage for the workmen, are erected in the brick-work

* We acknowledge an indebtedness to the French of Séb Le Normand, for much of the information, and all the drawings in this chapter.

C C, the furnaces A A A, over which rest the caldrons
B B B. These caldrons are formed of an half-egg shape,
and tinned throughout. The middle one has double the
capacity of either of the other two, as it serves to feed

Fig. 213.
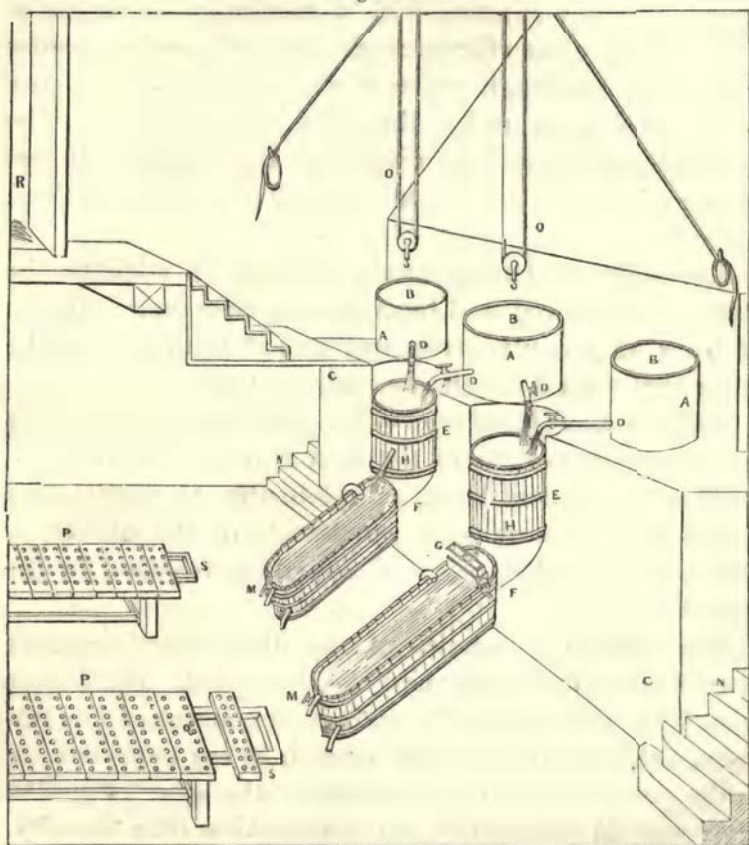
both of them with melted wax. At four inches from the
bottom of each caldron is soldered a copper tube, carrying
at its end a strong brass cock D; and the centre kettle
has two. The top edges of these kettles incline inwardly,
that the wax which spatters against the sides may fall
back again. Between the caldrons, and under the fur-
naces, are placed the iron-bound tubs E E, supported by

the brick platform F, of such a height that the melted
wax can readily flow into the *greloir* G, which is beneath.
These tubs have each two gully-holes, with movable
wooden stops; one placed almost even with the bottom,
the other a little above the third of its height. It is
through this latter, H, that the fluid wax flows ·to be
grained. The lower hole serves as an evacuating outlet
for the cleansing of the tub. The greloir G, Fig. 214,

Fig. 214.
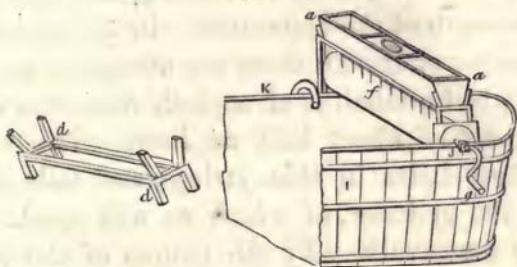
which will be described separately, is placed upon the
bath I, and serves, by means of the cylinder J, to ribbon
the wax. Through the tube K, a continual stream of
cold water is conveyed to the bath. The cold water
being specifically heavier, goes to the bottom, displaces
the hot water, and drives it to the top, where it escapes
through the tube M. A similar greloir is placed upon
the other bath. Two ladders, or stair-cases N N, are
affixed to the two extremities of the furnaces, and lead to
the magazine or store-room R, in which is placed the
ribboned wax. The tackle and pulleys O O, serve, with
the assistance of three cords properly adjusted, to lift off
the tubs E E, which frequently require to be cleansed,
and would otherwise be difficult to remove. In other
parts of the atelier are arranged the tables P P, upon
which are ranged the planks Q, indented throughout
their surfaces with cavities, intended as moulds for the

wax, as is seen at Fig. 215. Fig. 214 represents the greloir, which is a tinned copper vessel *a a*, as long as

Fig. 215.
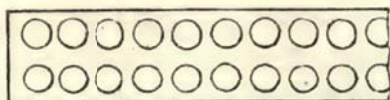
the width of the bath, at a place where it rests. Its bottom has the form of a reversed gutter, and extends the whole length of the apparatus. In the bottom of this reversed gutter or trough there are numerous small holes of about eight hundredths of an inch diameter, and at a distance apart of about half an inch. The wax runs through these holes in thin strings, and falls upon the surface of the cylinder, of which we will speak directly. It is easily conceivable why the bottom of the greloir is in the form of a reversed gutter, and that the holes are made in the more elevated part; for, if any dirt should fall in the wax whilst running from the upper gully-hole of the tub E, to spread upon the cylinder, these dirty particles remain below, and do not ascend to stop the holes, and thus prevent the running out of the wax. For a like reason there is placed above the greloir a square

Fig. 216.
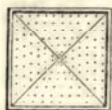
cullender, Fig. 216, upon which the wax first falls, and thence, through the meshes, into the greloir. This cullender or strainer is adjusted in a groove in the centre of the length of the greloir, which is entirely covered by two lids opening on hinges. At each end of this greloir is a cavity, of a similar form, in which are placed the hot coals for maintaining the fusion of the wax at the ends of the greloir, where it cools much sooner than in the middle. The greloir is supported by an iron framework, or trestle *d d*. In some factories they do not use the

square cullender or the hinged covers of which we have just written. The entire opening is covered by a tinned copper plate, about fifteen inches long, and of breadth equal with that of the greloir. Three of its sides are ledged with a rim of $1\frac{1}{4}$ inches height, and the fourth is jagged like a saw. This plate rests upon a sloping rabbet, and upon it is placed an oval copper sieve, with a high rim, and tinned exteriorly and interiorly.

This construction allows the liquid wax to fall in the cullender, and from thence upon the plate of copper, where it spreads, and is conducted, by the inclination or decliviy of the plate, into the greloir, in thin layers. It would, otherwise, drop in flakes, and, by closing the holes of the greloir, stop its passage-way. At Fig. 217 is seen the arrangement—the oval cullender *b*, the plate *c*.

Fig. 217.
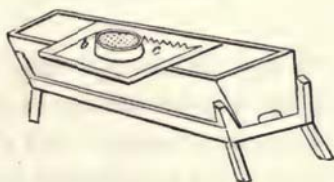
Supposing the greloir to be placed upon the edges of the tub, there must be arranged beneath a wooden cylinder *f*, the iron axis of which has, at each end, a pivot resting in two notches upon the edges of the bath. The winch *g*, which fits to one of these pivots, serves to put the cylinder in motion. The larger the cylinders are, the better; they may be even a foot in diameter. The wax, in falling through the holes of the greloir upon the cylinder, immersed about one-half in water, immediately congeals.

The cylinder is generally made of walnut wood, well

jointed and fastened together. Fig 215 represents one of
the boards in which are hollowed out the holes for mould-
ing the wax. These holes are cónical, five to six lines in
depth, thirty lines in their upper or greater, and twenty-
seven lines in their lower or lesser diameter. There are
two rows in each plank, and so far distant from each
other, that the two beaks of the feeder, Fig. 218, shall
fall simultaneously in the centres of the two moulds when
they are being filled. Fig. 219 exhibits the *coffre à eculer*.

Fig. 218.

Fig. 219.
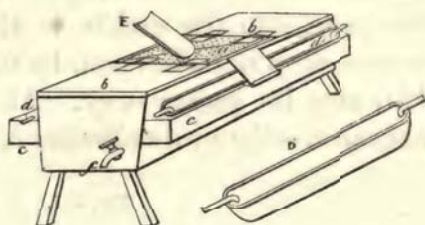
It is of copper, tinned interiorly and exteriorly, and
thirty inches long by fifteen inches broad, and formed
something like a kneading-trough. Its cover consists of
three pieces; the centre *a* is a cullender exactly similar to
that already described—the end pieces being two hinged
gates serving to hermetically close the chest, and to pre-
vent the admission of dirt or dust. At one of the corners
of the trough and near the bottom is a cock *f*; and their
two larger sides, throughout the whole outer length, have
casings *c c*, in which are placed the sheet-iron warming-
pans *d d* (the form of which is seen at D), used, when
filled with coals, for preventing the congelation of the
wax. The coffre sets upon a trestle, and is movable, in
order that it can be substituted for the greloir, when
necessary.

When about to melt the wax, the coffre is substituted
for the greloir under the cock of the tub, so that it may

be filled with liquid wax, which runs at first upon a gutter E, thence into the strainer *a*, upon which is arrested all the particles of dirt contained in the wax. This coffre is a reservoir from which the workman draws a supply of wax for filling the moulds. It is for this reason that one or more of them are arranged near to the mould tables, so that it may be convenient for the workman to fill the feeder when it becomes empty.

Fig. 218 represents the feeder. When closed up, it has the form of two clogs joined together. At *a a* are seen the two beaks or spouts; *b b* are the two handles, which can also be placed at *c.* The coverlet *d* is always kept closed whilst running the wax into the moulds, in order to prevent the entrance of dust. The mould tables, before spoken of, and represented at P P, by Fig. 213, are strongly built, and from ten to twelve feet long. They have no top, but in its place a movable frame, five or six feet longer than the table itself, and overspreading equally on all sides. This frame is seen at S S. It is not to be entirely covered with mould boards, as there should be a foot at each end unoccupied.

Fig. 220 is a wheelbarrow carrying a wicker basket

Fig. 220.
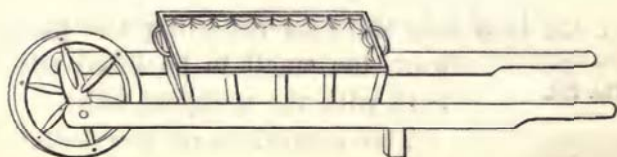
lined with linen duck. It is in this basket that the ribboned wax is placed as soon as it is formed in the bath; and when filled the workman wheels it into the bleaching yard.

Fig. 221. A three-forked shovel, of white pine wood, and wrapped around with willow osiers, as is seen in the

figure. This is used for shoveling or lifting out the ribbons of wax when they are too delicate and fragile to be

Fig. 221.

otherwise handled. A lighter one, modified, is shown by Fig. 222.

Fig. 222.
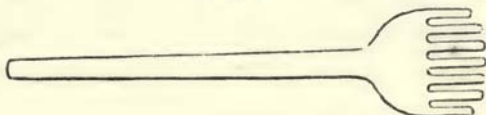
Fig. 223 is a wooden spatula, or paddle, called, by the workmen, *palon*, and used for stirring the wax whilst it is in fusion.

Fig. 223.
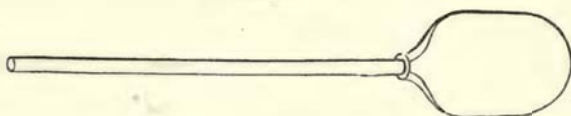
Fig. 224 is a hair sieve for collecting the particles of wax, too small to be lifted out of the bath with the wickered forks.

Fig. 224.
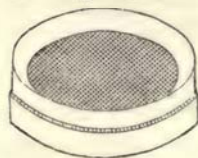
The operations of the foundry and bleachery are connected so closely together that it would create confusion in the numerous details to attempt a separate description of the two ateliers. Different operations are being successively and some simultaneously performed in both apartments, so we continue our description, passing on to the bleachery or

bleaching-yard, and proceed to explain the different stages of the process consecutively, as conducted in either division of the factory.

For this part of the establishment, an extensive, open field should be selected, for it is important that the sun's rays should have full play upon the exposed wax, which, when ribboned, is spread upon cloths arranged as follows: The framework which sustains the cloths is of eighty feet length, by ten feet breadth. The supports *a a a* (Fig. 225),

Fig. 225.
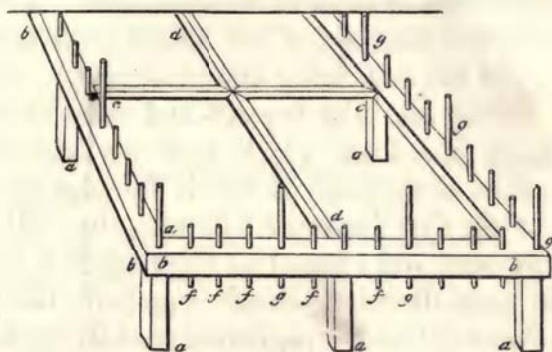
on which rest the squares two feet from the ground, are strong stakes, pointed at the end, and well driven into the earth. The tops of all these pieces must be uniformly and exactly two feet from the ground; and there must be three ten feet rows of nine stakes to each row, the distance between each being five feet, so that these twenty-seven stakes shall inclose a rectangular area of eighty by ten feet. Upon the ends of the three stakes is affixed a strong beam of three inches width and eighteen lines thickness; and parallel to the other stakes are fastened strong beams of similar dimensions.

The stakes or posts of the middle row are covered throughout their breadth by strips of the same height as those of the circumference, but only one inch wide.

They are jointed in the centre, and supported by the posts and side-pieces, and are beveled on the edges. Seven strips, similar to these last, are placed upon the three posts along the breadth. All being thus arranged, the strips which form the circumference of the frame are bored through with vertical holes of about an inch diameter. The holes are about nine inches apart: each of the side strips contain one hundred and three, and the end pieces thirteen, so that the whole number of holes is two hundred and thirty-two. In each hole is fitted a peg, tightly hammered in so as to be immovable. These pegs vary in length; some are of six inches projection above the strip, and the rest, being the lesser part of the whole number, extend two feet beyond, and carry at their top ends a small iron hook, which faces the interior of the square. Here is the order in which the pegs are placed: At each of the four corners a long one, then following it three short ones, and succeeding these again a long peg; and so on until the whole circuit is properly filled. Care must be observed that the pegs are of good strong wood, and by preference of oak. Fig. 225 gives an end-view of the frame, and will serve to illustrate our explanation. The strips or scantlings are seen at bb; the pieces cc and dd forming the union stretch which connects the posts. The short pegs are shown at f, and the long ones with their hook-nails attached, at g. The cloths that cover the frames are eighty by ten feet, and edged around with a hem or border of two feet height. Fig. 226 represents the manner in which it is stretched over by means of a cord and the pegs. Some strong iron rings are generally sewed to the edge of the cloth, and in position, so that they may be directly opposite the pegs. This bag-cloth is stretched over the frames in the same manner as a sacking-bottom is stretched over a bedstead, care being taken to fasten the ends of the cords to the posts in a manner to prevent

loosening by the wind. In these two preceding figures we have only shown one-half of the frames, because the

Fig. 226.
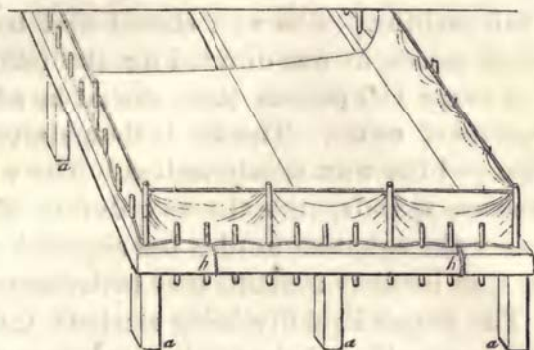
other portion being exactly similar, it is unnecessary to give the whole.

The other apparatus used in the bleachery, consists of a small, very light fork (Fig. 227) for spreading out the

Fig. 227.
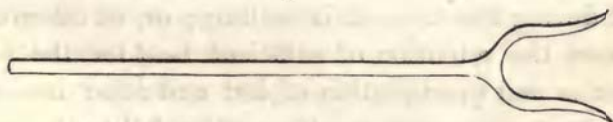
wax ribbons upon the cloths; a scoop and thin paddle for removing the wax when it is bleached, and duck linen sacks in which to collect it.

The first process* is that of melting the wax; but, before commencing to describe it, we will remark that the operations of bleaching can only be carried on during a portion of the year, from April to October, as it is but

* In some places, the first operation is to melt and boil the wax, by the direct action of steam, with oil of vitriol, in the proportion of one pint to the ton of wax. On cooling, the condensed steam subsides, holding in solution a large quantity of the impurities of the wax.

slowly and indifferently effected in the remaining and colder months. The workman puts into one of the caldrons A (Fig. 213), a quantity of wax sufficient to cover one of the cloths destined to receive the ribbons proceeding from this melting. The wax should first be hashed up into small pieces, as was directed for the tallow, at p. 309, and to every 100 pounds there should be added two or three quarts of water. The fire is then started under the caldron, and the wax slowly melted. The workman, with a wooden spatula, stirs the wax during its fusion, and continues the agitation until it has acquired sufficient fluidity, so that its dirty contents may better separate and deposit. The proper liquidity being attained, the cock of the caldron is opened, and the melted wax drawn off into the tub, partially filled with water. This tub is fitted with a plug, the management of which will be explained directly.

As soon as the wax has entirely run off, the tub is covered over, and the whole enveloped with woollen blankets, so that the liquidity of the wax may be maintained during the time it is settling; or, in other words, to insure the retention of sufficient heat for the perfect separation and precipitation of dirt and other impurities, which, by their greater specific weight, fall to the bottom, together with the water added to facilitate the fusion. This is called refining the wax. The tub is left in repose for two or three hours or more, according to its amount of contents.

Having finished this operation, the tub should be made ready for the reception of the pure fluid wax. In the subsequent stages the tubs are arranged as the wax commences to melt. Each time that the wax is emptied out to be ribboned, the tub should be cleaned, and in the mean time another substituted in its stead. It is well, whilst the wax is settling, to supply the bath, which is

below it, with fresh water, by opening the cock K, Figs. 213 and 214. The warm water is to be drawn off through the plug-cock near the bottom.

Fig. 228 shows the two pieces used in this instrument. A, the gully-hole, properly speaking, is a tube of hard wood, solidly fastened to an iron plate *a a*. The tube fits and enters the gully-hole, and the iron plate is screwed to the tub. The channel is stoppered with a cock internally, for in this position it resists much better the pressure of the liquid wax; and for the purpose of drawing it off, there is used a cylinder B, of hard, solid wood. It has a large, strong handle C, by the aid of which it can be strongly driven or pushed in, accordingly as the wax is wanted to run out in a thick or thin stream, upon the greloir beneath.

Fig. 228.
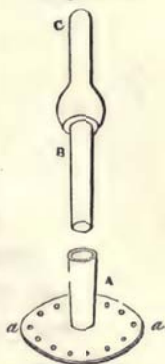
The wax falls upon the cullender, from that upon the plate, and finally, into the greloir, where it occupies at first the two furrows or trenches at the bottom, and thence runs through the holes of the gutter in small threads, upon the wet cylinder beneath, kept continually in motion. The thread of wax falling upon the cylinder, becomes flattened, and on entering the water congeals, and forms a thin ribbon. The more rapid the motion of the cylinder, the thinner are the ribbons of wax. During this operation, the cock K, through which is furnished the cold water, is left open, and the heated water pushed out by the greater specific weight of the cold water through the escape pipe M. It is very necessary that the water of the bath shall be kept as cool as possible, for otherwise the wax, not being sufficiently cold, will ribbon badly, or perhaps adhere to the cylinder, and cake together.

The workman takes the fork and pushes the ribbons,

as they accumulate near the cylinder, towards the end of the bath opposite to the tub, and then lifts them out into a basket. When this basket is full of ribbons, it is put upon the wheelbarrow, and conveyed to the cloth on which they are to be spread. They are now carefully taken out by a woman, and spread equally over the whole surface of the cloth, so that all the particles may have a uniform exposure.

This operation is continued until the wax is all emptied out, and it requires about an hour and a half for every 1,000 pounds of wax. The tub is then raised up behind by the aid of a lever, so that all its contents of wax may drain out through the exit hole.

That the steps may succeed each other rapidly, and without loss of time, a melting should be made every three hours. The length of time for its exposure depends altogether upon how it is set out, and on the brightness of the weather. Sometimes the ribbons require to be left on the cloths for ten, twelve, fifteen, twenty, and even thirty days and more, before they are ready to be turned over. This is done with a paddle, which is pushed under and made to turn them topsy turvy. A few days after the ribbons have been turned, they are stirred about upon the cloths with small forks, so that they may present as much surface as possible. An experienced workman well knows the circumstances under which it is necessary to stir the ribbons more than once or twice.

When, by this operation, the wax has acquired its first degree of whiteness, it is removed from the cloths with a scoop and thrown into linen sacks; and these, when full, are carried into the magazine, piled up, and there left undisturbed for thirty or forty days. In this time it settles and becomes a matted, rather compact, mass, which, by a second fusion and treatment, acquires additional whiteness.

The second fusion.—The fire being made under the caldron, there are then placed in it 40 to 50 pounds of the ribboned wax treated as above directed, and one quart of water. The wax should be thrown in gradually, and in small quantities at a time, by one workman, while another keeps the mixture of water and wax in constant agitation by continual stirring. The fire should be moderate, and the addition of wax discontinued as soon as the kettle is sufficiently full. This is a tedious operation, because wax forms a kind of thick paste, which it is difficult to stir. The kettle being full, the fire is then increased, to give perfect fluidity to the wax, so that it will run easily through the cock. The stirring must be continued until the fusion is complete, and all granules have disappeared; for, otherwise, there is a liability of scorching the wax. It is now drawn off and put through the same process of ribboning and exposure as before, and as soon as it has acquired whiteness it must be transferred to linen bags and carried to the magazine.

Third and last fusion.—Some bleachers add, to every 1,000 pounds of fused wax, three or four quarts of milk; but it is acknowledged that this addition occasions a loss by the considerable deposit that falls to the bottom of the tub. It is preferable to add cream of tartar or powdered alum, as has been directed for the suets. The fusion is made as before directed, but this time the wax is moulded and not ribboned. While the wax is reposing in the tub and depositing its impurities, the number of mould planks requisite to receive the whole of it, must be put to soak in the bath. The greloir and cylinder are lifted from their places; the *coffre*, Fig. 219, is substituted for them, and the casings are then filled with hot coal. When the wax has entirely deposited its impurities, it is then drawn off into feeders through the exit cock of the *coffre*, and from thence served, by women, into the mould holes of

the planks, on the tables P P, Fig. 213, until all the cavities have been filled.

As fast as the wax becomes thoroughly congealed, the small cakes are thrown into a tub of clean water, and, that they may be easily detached, the moulds must always be moistened previous to the casting. These cakes are dipped out of the bath upon a pack-thread sieve, which lets the water run through and retains the pieces of wax, that are then placed in the baskets and from thence transferred to the cloths, and there arranged side by side, for several days' exposure to the air and sun. Thus they become very white and dry, and when packed in clean boxes are ready for the market or conversion into candles.

The waste, which deposits at the bottom of the tub, is thrown into a cullendered vessel; and, after the water has drained off, it is stored until enough has accumulated to be treated for the separation of the residual wax. To every 100 pounds of waste are added twelve pints of water, and the whole heated together until liquefied, and this state retained for six hours, to give sufficient time for the thorough deposition of the water and the impurities with it. The fire being then extinguished, the wax which swims on the surface is to be ladled into suitable pans. The lumps of wax thus obtained, are to be re-melted and bleached in the manner aforesaid.

It must not be forgotten that the action of the wax upon copper may impart a green tinge to the former, and, therefore, prevents the use of vessels made from that material, unless they are thoroughly tinned inwardly and exteriorly.

When it is windy, it is necessary always to have an eye upon the cloths, lest there be a loss of ribbons through negligence; as they are apt to be whisked off into the air far beyond recovery. To provide against this contingency, the cloth must be detached from that side of the frame

facing the wind, and doubled over the other half. The wax is then protected between the folds. There often results another inconvenience from the intensity of the sun's rays, which is at times so great that, concentrating upon certain portions of the wax, the latter becomes softened, and mats together with the neighboring ribbons. When the wind has ceased blowing, the cloth folded over, as above directed, must then be restored to its original position, and the ribbons of wax spread over the surface.

In moulding the wax, there is a certain experience required, in order that it may have a pleasing smooth appearance. It should not be poured in whilst either too cold or too hot, for the surface of the cakes will be wrinkled and full of holes.

The foregoing method is very effectual, but tedious; and, therefore, it is proposed to shorten it, as follows :—

Cassgrand's process.—"This process consists in melting the wax, by means of steam, until it becomes very liquid, and then passing it, along with the steam, through a kind of serpentine or worm, by which a large surface becomes exposed to the action of the steam. After traversing the worm, it is received into a pan with a double bottom, heated by steam where water is added, in order to wash it; from this it is elevated by a pump, kept hot by steam, into another pan similarly heated, and where it is also treated with water, and is again passed through the serpentine. This operation is repeated twice, thrice, or four times, according to the quality of the wax. During the passage with the steam through the worm, it becomes denser by, it is said, absorbing water (perhaps mechanically?), and deposits in the upper pan. It is allowed to repose in this for about four or five minutes after each passage; and after the last one, about one or two hours, according to quantity, in order to allow any impurities to subside. The wax is then granulated in the ordinary way,

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by means of cold water, is allowed to dry during two or three days, and the action of light and air does the rest. The aid of one workman suffices; for the whole of the operations require only a few days, and are certain, as well as free from danger. Independent of the advantage which such an apparatus presents for bleaching wax, it has also that of enabling its qualities, according to relative whiteness, to be distinguished; for this purpose, it is only necessary to present the wax in mass to the end of the worm, and in a second or two the vapor determines the relative color which it will yield."

In some places, the bleaching is more rapidly accomplished by means of chemical substances; but the use of these latter involves the necessity of great care to prevent an injurious action upon the wax. Chlorine, the usual bleaching agent, is wholly inadmissible, on account of the great difficulty of removing the last traces of it from the wax, for should the smallest portion remain, it will, by reacting upon the hydrogen of the wax, generate hydrochloric acid during combustion, and thus impair both its burning and illuminating qualities. The only chemical process which we consider worthy of description, is

Solly's process.—This method is more applicable to vegetable waxes than to beeswax, and acts both promptly and economically. It consists in melting the virgin wax with water containing one-half its weight of oil of vitriol, and adding to the mixture, during constant stirring and the continuance of a gentle heat, powdered nitrate of soda (*cubic nitre*), in small portions at a time. Decomposition of the latter takes place, and the sulphuric acid, uniting with its base soda, eliminates nitric acid, which, in its nascent state, penetrates the fluid mass, and, by oxidizing and destroying the coloring matter, bleaches the wax.

Wicks for wax candles.—We have already considered the general principles by which the wicking of candles

should be regulated, so that it is now only necessary to add a few notes in reference particularly to those for wax candles.

The material should be pure, unbleached cotton thread, free from any admixture with linen; for this latter, though used by some manufacturers to stiffen the wick, injures its burning qualities. Platted wicks are also unsuitable, as they diminish capillary action, curl in the flame, and collect soot. The proper kind for the best candles, or parlor bougies, as they are called, is formed of two strands of sixteen uniformly spun cotton threads, making the whole number of threads thirty-two. The greater power and brilliancy of the light from wax, render unnecessary so large a wick as is required by other kinds of candles.

In describing the flambeaux, &c., we shall always take care to mention when the wicks are to be of hemp threads, and the absence of any remark as to this, will indicate the employment of pure cotton threads. The chandlers, who use hemp wicks, purchase the threads from the rope-makers, twist them slightly, and cut them six feet in length for the larger flambeaux. Each cut consists of eight threads, which, when doubled over and slightly twisted, forms the wick. A few white threads of cotton shaped into a loop and passed through the bend of each wick, forms the tip.

Some chandlers soak the wicks in alcohol before using them, but this is useless, for the volatility of that body is such that it all escapes by evaporation, and leaves the wick as it was before being impregnated. Spirits of turpentine, too, is not unfrequently employed for the same purpose, yet with no better effect. The only benefit that might accrue from the use of it is the facility acquired in igniting the wicks from the ready inflammability of the turpentine; but this advantage is defeated, first, by the volatility of the essential oil, which causes its rapid eva-

poration; and secondly, by the disagreeable smoke and smell its application would occasion. Hence, also, the spirits of turpentine is a useless, and would be a deleterious mixture for the wicks. Fine, uniformly spun, cotton thread, perfectly dried, answers every purpose without any previous preparation. The size of the wick must be proportional to that of the candle, so that during the burning of the bougie the melted wax at the top may be entirely absorbed by the wick, and leave the cup which forms around nearly clean and empty. Well-made bougies should not require to be snuffed, except where a "thief" occasionally forms upon the wick, and must be removed to prevent the candle from running. It is better to put out the candle, when necessary, by the breath than with an extinguisher, because the ashes or cinders are then blown away, whereas, in the latter case, they fall into the cup, and when the bougie is again relit, cause it to run.

Dipped bougies.—This kind of wax bougie is made very much in the same manner as the tallow "dips." The ends of the wicks are covered with small tin tubes, or tags, to protect them from the fluid wax during the process of basting. This operation is performed by a woman, who, setting herself at a table on which is a box containing the tags, takes in her right hand a brass wire catch, and threads each tag with a wick from a packet placed on her knee for the purpose.

Care must be observed in arranging the threads, that the tag shall protect that part of the wick which it covers, during the process of soaking and dipping the wicks; which, when thus prepared, are handed over to the workman whose duty it is to form the bougies.

The prepared wicks are next suspended on hooks around the circumference of an iron or wooden hoop, as shown by Fig. 229. The hoop G should have sufficient size to hold fifty candles, which must be placed about two inches apart

from each other. It is hung by means of the ring and cords H to the ceiling; and the upper cord, passing over a pulley, allows the apparatus to be raised or lowered, as

Fig. 229.
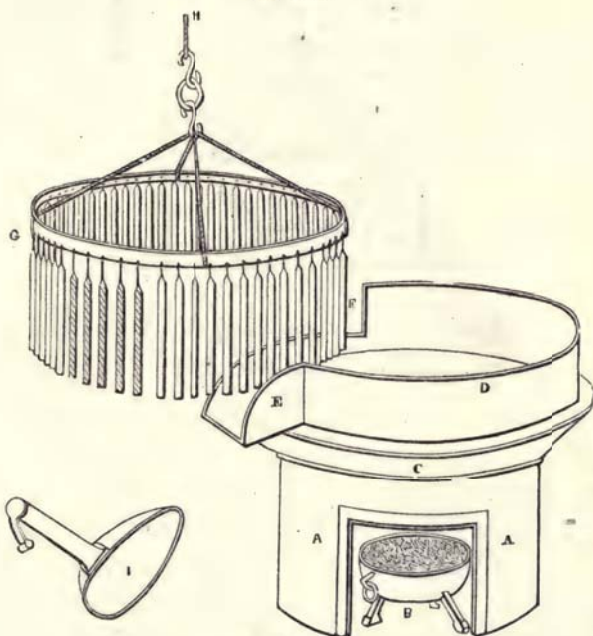
may be requisite. Beneath the hoop is a small portable furnace A, for burning charcoal; and upon this furnace is a heavy copper basin C, well tinned, and with a rim D, around its top. This basin serves as the dripping-pan during the operation of basting the candles, and is also the reservoir for the melted wax; and, therefore, an opening, F, is left in the rim for the easy passage of the candles as the hoop revolves. Fig. 230 gives a view, in section, of the four pieces of apparatus united, as shown in perspective by the preceding drawing.

The cullendered disc K, Fig. 231, is intended to be placed over the top of the furnace, as may be necessary to moderate the heat.

All the necessary preliminaries being adjusted, the workman commences to baste the wicks. This is done by

Fig. 230.
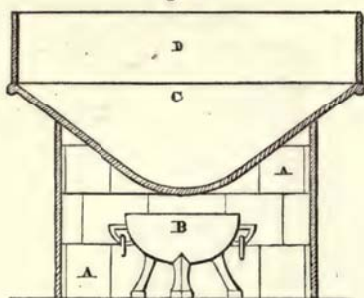
drawing the hoop into the opening F of the basin C, and pouring the fluid tallow from the ladle I upon the lower

Fig. 231.
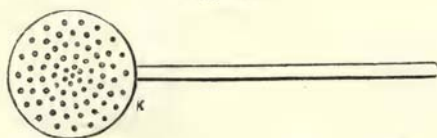
half of the wicks, until they have acquired a sufficient thickness of wax covering. Then reversing the position of the candles thus treated, by suspending their opposite ends to the hoop, the basting operation is continued as before, upon the residual half of the wick. Any wax that may drip from the candles during the basting, will fall back into the basin C.

During the pouring of the fluid wax upon the wicks, the latter must be kept in a continuous twirl by dexterously fingering them just below the point of suspension, in order to insure a uniform distribution of the wax throughout the length and circumference of the candle. It requires ten or twelve successive bastings to complete a hoop full of candles; but, by basting each wick in regular

order, the operation may be made continuous and without loss of time; for when the hoop has made one entire revolution, the wicks which were first in being basted, will have dried sufficiently to receive a second treatment, and so on a third and fourth, until the last.

When the bougies, or candles, have acquired the requisite size and weight, they are removed from the hoop, placed upon a damp table with walnut top, and rolled under a guaiacum-wood planisher, shown in perspective and profile, by Figs. 232 and 233.

Fig. 232.
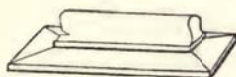
Fig. 233.

An occasional dampening of the table is necessary, as the wax becomes heated by the friction, and might otherwise adhere to the wood. A little practice in this manipulation of rolling, enables the operator to give smoothness, polish, and uniformity to the wax.

Towards the completion of the rolling, the lower ends of the candles are smoothed with a sharp knife, so as to give them a uniformity of length. The metallic tags are removed from the upper ends in the same way, the cutting of several candles being accomplished at one operation, and merely by pressing the edge of the knife upon the proper part while the candles are in motion under the roller. The wax, being then trimmed from around the tip of the wick, the candles are finished.

Cierges.—This is a larger size of dipped candle, used in the observance of religious ceremonies, and more particularly those of the Roman Catholic Church. They are conical in shape, and the process for making them is the same as just described, with the following modifications in the details:—

The three first bastings must be given to the whole length of the wick; and the fourth commenced a little below the top, and the descent continued gradually at each basting, so that the candle may acquire the form of a cone, as desired. There is no change to be made in the position in the wick, but when the candles are half finished they should be removed from the hoop, strung upon rods, and left, for some time, to cool, before proceeding with the bastings. This precaution is especially necessary in summer, for if in warm weather the basting is finished at a single operation, the wax is liable to separate from the wicks. Whilst one operative is removing the half finished cierges from the hoops, another replaces them with new wicks, or with half-made cierges that have entirely cooled, and are ready for the remaining dips. A little experience enables the workman to make the cierge of any weight that may be desired, without unhooking it to test it by the scales. In order that the finished cierges may cool gradually, they should be put between cloths and covered with blankets, otherwise on rolling them they are apt to peel, and become so hard as to be manageable with difficulty.

The rolling is done upon a walnut table with a wooden planisher, the cierges being made to revolve between it and the top of the table, until they acquire smoothness and polish. Thus finished, they are reduced to the proper and uniform length, with a knife, in manner as directed for the ordinary bougies. After being bored at their base with a hole sufficiently large to fit upon the spike of the stand on which they are to be burned, the cierges are then ready to be packed for market. These holes should be exactly in the centre, otherwise when the cierge is placed in the candelabra, it will not stand steady; and in order to counteract a tendency to crack, the lower end should be bound around with a ribbon previously imbued

with melted wax. These cierges are embellished, and sometimes gilded; the ribbon binding, particularly, is generally red. Cierges are made in France, beautifully ornamented with designs in relief.

Flambeaux.—These differ from the preceding only in form, and consist of an assemblage of dipped bougies. They are made of two pairs of bougies, of uniform length and size, united together with melted wax, and trimmed at the lower end to a smooth, round base.

Moulded bougies.—The tenacity with which wax adheres to the moulds, renders it difficult to make it into mould candles. The manipulations are very similar, in most particulars, to those required in moulding other kinds of candles. The exceptions are with regard to the mould and the manner of drawing the candle.

The moulds must be made of glass, but of the usual shape, and, on account of their fragility, should have an outer covering of India rubber. There is no need of any caution as regards the temperature of either the fluid wax or the moulds at the time of casting. When the moulds have been wicked and filled with melted wax, and their contents have set and thoroughly cooled, they are to be taken one at a time, and plunged quickly into hot water. The expansion of the glass allows the easy exit of the candle, which must be dexterously drawn whilst the mould is being lifted from the water, otherwise the heat of the glass will extend to the candle and injure its appearance.

A little practice will render the operative, generally a woman, very expert in this manipulation.

A portion of Chinese wax, or Pela, may be advantageously used with beeswax. Spermaceti is also frequently mixed with it to form candle stock.

Wax tapers.—These are made by winding the wick upon a drum, and leading it under a guide-roller, placed

in a trough of melted wax; from this it passes through a series of holes on to a second drum, the operation resembling, somewhat, that of wire drawing. A little turpentine is added to render the wax pliable.

Coloring.—A *blue* tint may be given with artificial ultramarine, or Prussian blue, by rubbing it to an impalpable powder, and thoroughly incorporating it with the melted wax. Verdigris, in the same manner, will impart a *green* color; bichromate of potassa an *orange*; neutral chromate of potassa a *lemon;* vermilion a *red;* and carmine a *crimson.* By digesting alkanet root in hot wax, and straining, a coloring body is obtained which, when added to the hot wax in limited proportion, will color it, delicately, pink.

CHAPTER XXXII.

COMPOSITE CANDLES.

THE term "composite candle" was originally given to those made from a mixture of wax and spermaceti; but the term has acquired a more extended signification, and is now indiscriminately applied to all candles made of more than one kind of block. At the same time, the several kinds of composite candles are distinguished by some specific title, according to the whim and taste of the manufacturer; and thus it is we find, in commerce, " *German wax*," "*pearl wax*," *Venetian*," and "*Belmont sperm*" candles, all being made up of two or more of the fat materials usually employed as candle stock.

Parlor bougies, similar to Judd's "patent candles."—The handsome appearance of these candles, and their similarity in that respect to those of wax, has induced the title for them of bougies, which, properly speaking, is only applicable to candles exclusively of wax. Their mode of manufacture is as follows:—

Melt slowly over a moderate fire, in a well-tinned copper kettle, seventy pounds of pure spermaceti, and to it add piecemeal, and during constant stirring, thirty pounds of best white wax. By increasing the proportion of wax to fifty pounds, the resulting compound is much more diaphanous. The bougies moulded of this mixture are not as durable as candles made from wax alone. These bougies are often tinted rose, yellow, light-blue, or green, &c. For the red shade, carmine or Brazil wood, and alum are used. The yellow is made with gamboge, the blue

with indigo, and the green with a mixture of yellow and blue. The bougies are sometimes perfumed with essences, so that in being burned, they may diffuse an agreeable aroma.

Experience has shown that a more transparent and elegant bougie is made by adding only six and a half pounds of wax to one hundred pounds of pure, dry sperm, and the candles made of the block formed in these proportions closely resemble the "patent candles" of Judd. These latter have a plaited wick of three strands, each containing twenty-one fine threads.

By still further reducing the proportion of wax to 3 per cent., a compact structure only is given to the sperm, without any very great improvement in its appearance.

Transparent bastard bougie, by Debitte, of Paris.—To compose one hundred pounds of stock, take ninety pounds of spermaceti, five pounds purified mutton suet, and five pounds wax; melt each separately over a water-bath, and to the whole, when mixed together, add two ounces cream of tartar, and two ounces of alum in very fine powder, and whilst stirring constantly, raise the heat to 176° F., then withdraw the fire, and allow the mixture to rest until it has fallen in temperature to 140° F. When the impurities subside, the clear liquid composition must be drawn off into clean pans. Of this cooled block, candles are made which not only look well, but burn well. The suet is in just such proportion as will be a benefit rather than an injury.

The product of these admixed ingredients is not equal in beauty to that by the preceding process, but its quality and good appearance are more than proportional to its cost, which is much less than the aforementioned composition.

The wicks generally used for the foregoing composite candles, are the same as employed for wax and spermaceti

alone; but it has recently been proposed to substitute plaited wicks, which are to be previously prepared by soaking them in a solution of four ounces borax, one ounce chlorate of potassa, one ounce nitrate of potassa, and one ounce sal ammoniac in three quarts of water. After being thoroughly dried, they are ready for the moulds.

Belmont sperm and wax.—These candles are made from a mixed stock of hot-pressed stearic acid from palm and cocoa butters. Palmitic acid tinted by gamboge is called *Belmont wax.*

Cérophane.—This block, the invention of Boilot, is made by fusing together, over a water-bath, one hundred parts of stearic acid, and ten to eleven parts of bleached beeswax. These proportions give a product of beautiful waxy appearance and consistence. But to insure success, the mixture must remain over the bath for twenty to thirty minutes, and without being stirred or agitated. At the end of that time, the fire is to be extinguished, and the fluid fat allowed to cool, until a slight pellicle begins to form on the surface, when it is ready to be cast directly into the moulds, previously heated to the same temperature, in the usual manner, but with the precaution to avoid stirring the mixture throughout. A disregard of this latter precaution will cause the mixture to be opaque instead of transparent.

Diaphane.—This block is also the invention of Boilot. It is a handsome material, made by melting together, in a steam jacket, from two and a half to seventeen and a half pounds of vegetable wax, one and a half to ten and a half of pressed mutton tallow, and forty-six to twenty-two pounds of stearic acid. The proportions are to be varied between the above limits, as may be desired, to augment or decrease the consistence of the mixture—the

vegetable wax and stearic acid being the hardening ingredients.

The moulding of the candles is accomplished in the manner employed for stearic acid candles.

"*Composite candles.*"—The block for these candles is made by adding a portion of hot-pressed cocoa-stearin to stearic acid of tallow. This is an excellent and economical mixture, in which the red, carbonaceous flame of the acid is improved in illuminating power by the white and more hydrogenated flame of the stearin.

CHAPTER XXXIII.

PARAFFIN CANDLES.

PARAFFIN, though of comparatively recent discovery, has already taken a first rank as candle material—its beautiful appearance and admirable burning qualities giving it a peculiar adaptation to that purpose. It was first known as an artificial product, having been originally isolated, from beech-wood tar, in 1830, by Reichenbach. Since then native specimens have been found in Moldavia, Gallicia, Lower Austria, France, England, and other localities, and are known among mineralogists as *ozokerite* and *mineral wax.*

Pure paraffin is brilliantly white, inodorous, and tasteless. It resembles spermaceti in its silky feeling and physical structure, but at the same time presents a waxy appearance. It derives its name from two Latin words, *parum*, little or none, and *affinis*, affinity, because of its complete neutrality and great stability—neither the alkalies nor concentrated acids having any action upon it, even at high temperatures. It gives a powerful, clear flame, without soot. Its sp. gr. is 0.87. At 112° F., it melts into a colorless oil, but the heat may be *gradually* raised to 698° F., its boiling point, without producing any very appreciable decomposition. Spirits of turpentine and naphtha dissolve it readily. Boiling ether also takes up a large proportion, but on cooling sets into a thick mass. Boiling absolute alcohol dissolves 3 to 4 per cent., but drops it on cooling.

The percentage composition of paraffin is—

Carbon	.	.	.	.	.	.	85.22
Hydrogen	.	.	.	.	.	.	14.78

The two components existing, therefore, in the same equivalent proportions as the elements of olefiant gas, the former is isomeric with the latter. Olefiant gas being the chief illuminating principle of oil, rosin, and coal gas, it follows that paraffin may be, properly, considered as solid, portable illuminating gas.

Paraffin is obtained by the destructive distillation of wood, oils, pit coal, bituminous shale, peat, and such matters—care being taken, in the case of coal and shale, to keep the heat at a low redness, and below that degree at which they would be converted into illuminating gas. Coals, which are rich as sources of illuminating gas, make the best raw material for paraffin. The price of it, as made from shale, in England, is fifty cents per pound, and even at this high cost, it holds a successful competition with wax and sperm, on account of the great uniformity of its combustion, high illuminating power, and beautiful appearance.

Paraffin candles generally consist, in part, of wax, spermaceti, or the solid fat acids; and their manufacture is destined to become an important branch of industry.

The processes for making pure paraffin are numerous, but we shall confine our descriptions to those only which seem to be the most practical and economical, remarking, incidentally, that the oily products obtained simultaneously, are applicable to many useful purposes, and therefore assist in reducing the cost of the paraffin.

Reichenbach's process.—This method consists in the destructive distillation of wood, and the subsequent treatment of the tar thus obtained. The latter, in being distilled, yields, among other products, a heavy, oily portion, forming the substratum of the distillate. By the action

of intense cold, the paraffin, in an impure state, is made to crystallize out, and may be separated by pressure.

It is next added to three times its weight of concentrated hot sulphuric acid, and distilled over a sand-bath, by a gradually elevated heat. In this operation, the empyreumatic foreign matters are carbonized and destroyed by the acid, and the paraffin passes over pure and white.

The necessary apparatus consists of a basin-shaped cast-iron vessel, with a broad, flat rim, upon which is fitted a flat lid, with a copper dome in the centre capable of being kept cool by a stream of water. The iron lid may be removed, when necessary, for the purpose of stirring the contents, in case of any interruption of the process.

Young's process.—This method is applicable to Cannel, Parrot, and all kinds of bituminous coals and shale, but more particularly to those which yield a large amount of illuminating gas, and without regard to the amount of ash in the raw material.

The first step is to reduce the coal to egg-size, and to distil it in an ordinary gas retort, to which is attached a condensing-worm, kept continuously at 53° to 55° F., by a stream of cold water. At this degree the distillate passes over freely, and without clogging the pipes, as would happen at a lower temperature from its partial congelation. In commencing the distillation, the heat must be gentle, and gradually raised to low redness only, for beyond this degree much of the desired product would be changed into permanent gases. It is indispensable, therefore, to keep the temperature always within bounds, and at the lowest point possible to accomplish the distillation, so as to prevent any undue loss of paraffin. As soon as volatile products cease to come over, the process is to be stopped, the retort emptied of its coke, and after being cooled, again charged as before with fresh coal or material, and heated anew for another portion of volatile product.

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This latter, as it falls from the condensing-worm, is to be received in a suitable vessel, and is a brown, oily matter, holding paraffin in solution, and often dropping it in dark crystals, when cooled to 40° F. The permanent gas, coming over at the same time, may either be collected or allowed to escape.

The crude, oily matter is to be next purified by warming it to 131°–133° F., and leaving it to repose for a day under cover. This treatment promotes the subsidence of water and undissolved foreign matters, and allows the clear superstratum of oil to be drawn off by means of a siphon or cock, for distillation. For this purpose an iron still is to be used, and the condensing worm, which is to deliver the distillate in leaden receivers, must be kept at 53° to 55° F., by a stream of cold water. The heat is continued until all the oil has passed over and nothing remains in the retort but a dry carbonaceous residuum, which is to be removed before the still is re-charged with a fresh quantity of oil.

To every 100 gallons of the distillate, 10 gallons of oil of vitriol, of 66° B., are to be gradually added, and the mixture kept constantly stirred for an hour; after which it is left to repose for twelve hours, to promote the precipitation of acid and impurities. The supernatant oil is then to be drawn off into an iron vessel, and thoroughly agitated with caustic soda lye, of sp. gr. 1.300, in the proportion of four gallons to the hundred of oil. After an hour's treatment, in this manner, all the acid retained by the oil will have been neutralized; and, at the same time, certain impurities will have been taken up in solution by the alkali. Another repose of twelve hours, or less, is now necessary for the settling of the soda lye; and then the supernatant oil is to be drawn off and distilled as in the previous operation. The distillate obtained, consists of volatile oil and paraffin in solution, and must be mixed

with half its volume of water, and boiled, for twelve hours, in an iron still, to which a condensing worm is adjusted, as before. Care must be observed to add water occasionally, so as to supply the loss by volatilization. In this way most of the volatile oil is separated from the paraffin, and passes over, with vaporized water, into the condensing worm, and thence into the receiver. It is clear and transparent, and of much less density than water, and may be drawn off from the latter. The distillation having been sufficiently prolonged to drive off all of the volatile oil that can be separated in that way—the liquid remaining in the still is left to repose, and the oil drawn off from the water into a leaden tub. Sulphuric acid, of 66° B., is then added in the proportion of two gallons to every one hundred gallons of oil, and the mixture stirred for six or eight hours; after which it is left to repose for a day, in order that the sulphuric acid and impurities may subside to the bottom. The clear oil being decanted, as before, is mixed, for every one hundred gallons, with twenty-eight pounds of chalk, made into a thin aqueous paste, and thoroughly stirred until all traces of sulphurous acid (generated by the action of the sulphuric acid) are neutralized, as may be known when the vapors of a sample heated in a test tube, no longer redden blue litmus paper. In case of remaining acid, more chalk must be added. The whole is then left to repose for a week, at a temperature of 98° to 100° F., at the end of which the clear oil may be decanted from the subsident impurities. Being finally cooled to 30° F., it drops its paraffin component in crystals, which may be separated by straining through woollen bags and subsequent pressure.

To render the pressed paraffin sufficiently pure for candle material, it requires to be treated at 158° to 162° F., several times, *alternately*, with its volume of

sulphuric acid, and a similar quantity of caustic soda lye, of sp. gr. 1.300, until the paraffin ceases to blacken the sulphuric acid. It is then to be washed with weak soda lye, and finally with boiling water, until the wash water no longer acts upon red litmus paper.

The foregoing process, which is an elaboration and simplification of Reichenbach's original method, gave to the inventor, Mr. Young, thirteen pounds of paraffin and thirty gallons of oil, from one ton of Cannel coal.

Brown's process.—The first operation consists in distilling the coal, or other bituminous matter, in conjunction with steam, at a dull-red heat; and, for this purpose, the coal or other bituminous matter, is introduced into a retort fitted with a steam-pipe, so situated as to become red-hot by passing through the furnace. This steam-pipe terminates in the closed end of the retort; so that when the retort is charged with coal or other bituminous matter, and the furnace is in action, the steam-pipe becomes red-hot—and steam being then passed along it, this also becomes super-heated—and in this state enters the end of the retort, and rapidly unites with, and expels the volatile matters arising from the coal or other bituminous matter; by which means their decomposition into gas is wholly, or in great measure, prevented, and the amount of oily or condensable product greatly increased.

The steam-pipe may, if preferred, be passed through a furnace, distinct and separate from that which heats the retort; which arrangement admits of the withdrawal of the fire from the retort, or the diminishing of its intensity at pleasure, without altering the temperature of the steam-pipe. By this means the distillation of the coal or bituminous matter can either be continued altogether, or in part, with the retort at a temperature below that of a dull red heat. The steam-pipe may be of cast-iron, or of cast or wrought iron, glazed or enamelled, as it is termed, or it

may be of clay or earthenware. In distilling, a condenser is employed as usual, the temperature of which should not be lower than 50° F.

A quantity of volatile products having been thus obtained from coal or other bituminous matter, these are again subjected to distillation, in a still or other convenient vessel, with or without the employment of a steam-pipe, though the use of steam is preferred when a large amount of paraffin is required; but where the production of oil is the chief object, steam may be dispensed with. When steam is used, it is to be brought into the still, in a super-heated state, by passing it through a red-hot steam-pipe, disposed in the furnace, or flue of the furnace, which heats the still. The steam enters through the upper part of the side of the still, and promotes, as before, the distillation of the volatile matters, whilst it retards their destruction, or conversion into gaseous or other worthless compounds. By this means the paraffin and heavy and hydrocarbonaceous oils are preserved.

" During the progress of the second distillation, it will be observed that the products vary at the different periods of the distillation; and these are, therefore, to be kept separate, or received in different vessels. At first a thin oil, or impure eupione oil comes over to the extent of about one-eighth of the total fluid employed; after this a thicker and heavier oil, containing paraffin, makes its appearance, to the extent of from 40 to 50 per cent. of the fluid employed; and lastly, a thick, butyraceous matter is evolved, consisting chiefly of paraffin, but mixed with heavy oil; and this continues to the end of the operation, and constitutes about one-fourth of the bulk of the fluid originally used.

" These three products are treated as follows : The impure eupione oil is mixed with from 5 to 10 per cent. of its weight of oil of vitriol, or sulphuric acid, to which an

equal bulk of water is added; bichromate of potash is next thrown in, equal in weight to one-half of the sulphuric acid employed; the whole is then heated in any convenient vessel of wood, lead, or earthenware, and during the heating the materials are diligently stirred together. As soon as the temperature has reached 212° F., the heating means may be withdrawn, and the whole permitted to cool and settle.

" The eupione oil is next to be decanted from the acid fluid, and treated with a warm solution of caustic soda; the whole being well mixed, and afterwards left at rest for some time to settle. Lastly, the eupione oil is decanted from the alkaline fluid, and distilled, either alone or with water, or steam, as is practised with respect to volatile oils generally. The heavy oil, containing paraffin, is next treated, either with strong sulphuric acid and peroxide of manganese, in the proportion of 10 per cent. of acid and 5 per cent. of peroxide of manganese; or, it is subjected, like the eupione oil, to the action of the sulphuric acid and bichromate of potash, in the same manner and proportion as indicated for the eupione oil; after which it is treated with soda lye, and allowed to settle. The heavy oil is then decanted and distilled in the usual way; the first portions being added to the eupione oil, as consisting chiefly of that substance; the second, and by far the larger portion of the whole, is received apart under the name 'lubricating oil;' whilst the last portions, being thick, and of the consistence of butter, are mixed with the impure paraffin, which results from the third stage of the second distillation of the crude products, and which are next treated as follows. Having allowed the impure paraffin to remain for twenty-four hours, or longer, in a cool place, to crystallize, the oily mixture is placed in a bag or filter, similar to those in use for the separation of spermaceti from sperm oil. When the oily fluid has

drained away, the paraffin is removed to a press, and sub-
jected to severe pressure, as is practised with respect to
stearic acid by the makers of that substance. It must
then be melted, and when cold, again pressed—the oil
being, in both cases, added to the drainings, which are to
be treated as explained under the head of 'heavy or lubri-
cating oil.' The paraffin must now be melted, and the
heat raised to about 400° F., when strong sulphuric acid
is to be carefully stirred into it in the proportion of from
one-twentieth to one-tenth of the weight of paraffin ope-
rated upon. After boiling for a few minutes, the fire
must be withdrawn, and the charred oil of the paraffin
allowed to settle in the form of a black powder from the
melted paraffin. This being separated, the paraffin must
be boiled in water, or in a weak solution of soda; after
which it may be cooled, and is fit for the market."

Wagenmann's process.—This method applies to the
bituminous coals and shales, which must be reduced to
nut-size; and sprinkled with milk of lime, when they con-
tain sulphur. They are then to be dried on the bed of
a furnace about one hundred and fifty feet long and eigh-
teen feet wide, and supported at intervals of three or four
feet by walls two feet high. This furnace may be heated
by the coke residues, emptied from the retorts during the
process. The dried material is then distilled after the
manner followed in gas-works, except that the distillate
or products of distillation are led off from the farther end
of the retort through discharge-pipes of five to six inches
diameter. There are two retorts over each fire or furnace,
and the flame plays only upon the bottom of the retorts,
and thence passes immediately into the chimney.

The author uses a circular furnace, with the chimney
in the centre, and eight furnaces and sixteen retorts
arranged around it, so that the flame can circulate from
furnace to furnace, and thus impart a gradual increase of

the heat. The products of distillation from this series of retorts are received in a condensing tube of seventy feet length, kept constantly cool by a stream of water. As soon as the gases leave this tube, they pass into a large iron cylinder, filled with coke, which removes the last traces of tar, and thence into a chimney thirty-five to forty feet high, the draft of which is regulated by a damper. The liquid products fall into a capacious receiver, kept constantly heated to 100° F., so that the tar may separate from the ammoniacal waters.

The tar is then pumped into an iron tub, where it is mixed and well stirred, for an hour, with solution of sulphate of iron at 100° F., in the proportion of 10 gallons to 200 gallons of tar. The tar thus freed of sulphohydrate of ammonia, is transferred to a still of 350 gallons capacity, and distilled by the introduction of highly heated steam. The distillate is condensed in a leaden worm attached, of one hundred feet length and four inches diameter. The first part of the distillate is a volatile liquid, of sp. gr. .700 to .865; the second an oil, of sp. gr. .865 to .900; and lastly, crude paraffin, of .900 to .930. These products are separately treated in leaden vessels, at 140° F., with 4, 6, and 8 per cent., respectively, of concentrated sulphuric acid; 1, 1½, and 2 per cent. of hydrochloric acid; and ½, ¾, and 1 per cent. of bichromate of potassa, and thoroughly stirred for thirty minutes. After three hours' repose, they are decanted from subsident matters, and mixed in an iron pan, respectively, with 2, 3, and 4 per cent. of caustic potassa lye, of 50° B. Finally, each of the purified products is redistilled, as before directed, with superheated steam. The distillate of No. 1, mixed with a part of the distillate of No. 2, furnishes *photogene*, of sp. gr. .820—a burning fluid. A part of the distillate of No. 2, of sp. gr. .860 to .700, forms *solar oil*, for burning in Argand lamps. The re-

mainder of No. 2, mixed with a part of the product of No. 3, furnishes lubricating oil.

The residue of No. 3 is placed in a tub, and cooled down to the lowest possible temperature, so as to effect the separation of the paraffin in crystals. At the end of three or four weeks, the paraffin is to be separated from its mother liquor, by means of the centrifugal mill (Fig. 74), driven at the rate of 2,000 revolutions per minute. The paraffin is to be melted, cast into blocks, and subjected to cold pressure. It is next melted, and treated at 350° F., with 50 per cent. of sulphuric acid, and, after two hours' repose, decanted, and thoroughly washed with water. It is then cast into cakes, hot-pressed in hair-bags, melted anew with 5 per cent. of stearic acid, then agitated, for two hours, in a leaden vessel, with 70 per cent. of sulphuric acid at 300° F. After several hours' repose, the acid is drawn off, the residue washed with water, mixed with another 5 per cent. of stearic acid, and finally agitated with 1 per cent. of caustic potassa lye of 40° B. After two hours, all the impurities will have subsided, and the clear, supernatant paraffin must be drawn off into cooling pans.

Bellford's process.—This system of distillation is applicable to the bituminous coals, shales, and analogous materials; and the inventor claims, for it, greater economy than can be attained by other methods.

The operation requires a cupola furnace, similar in many respects, to that used in iron foundries. It must have an outer casing A A, Fig. 234, of strong iron plates, and a lining B B of fire-brick. It should have a height of five times its diameter, and capacity sufficient for three tons of material. The bottom is open, but immediately below are grate bars C, arranged so as to leave wide enough intervals for the free passage of the ash. The ash door is seen at D, and the ash chamber at E E E.

There are three openings in the wall of the furnace, fitted with dampers which can be opened for the admission of

Fig. 234.
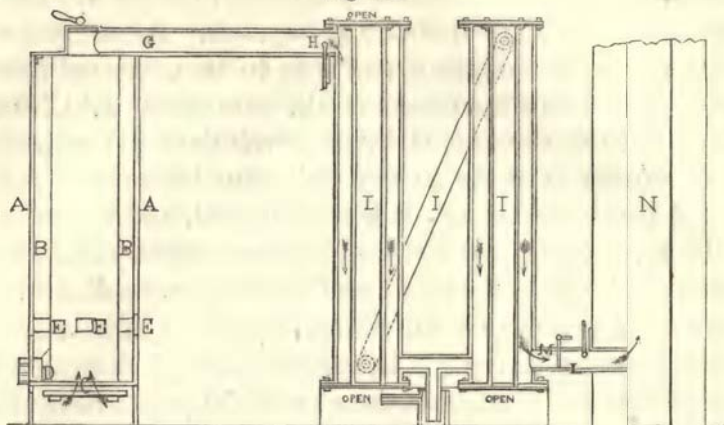
air when the draught of the furnace does not keep up the fire to the proper heat. At the top of the furnace is a movable cover F, which can be opened and tightly closed, as may be necessary for, and after the introduction of the material into the furnace. Near the top of the furnace is an exit tube G, for conducting off the volatile and gaseous products of the distillation into a refrigerant I I I, kept at 55° F., by a constant stream of cool water, care being taken, however, that the temperature does not descend many degrees below that point. By this arrangement, the liquid products are condensed while the gases are led into a chimney sufficiently high to give a good draught to the furnace. Upon the exit tube is a thermometer H, for determining the temperature of the furnace, and also that of the volatile products, which should never exceed 600° F. A siphon K serves to draw off the brown oil from the receiver into which the refrigerant empties the condensed distillate. A second thermometer L, is a guide

for determining the heat of the gases passing into the chimney, and, consequently, for the regulation of the temperature. The register M, allows the regulation of the draft of the furnace. The chimney N, is the final outlet for the gases into the air.

The process is commenced by heating the furnace with a coke fire, and then pouring in its charge of material, previously broken into small lumps, through the opening at the top, which is then closed with the lid, and tightly luted at the joints. The distillation is then continued until volatile matters cease to be given off, the top is opened, and after the removal of about one-third of the ashes, the furnace is charged, as before, with fresh material. If there should be much coke remaining with the ashes, then it is necessary to remove nearly all of the latter from the furnace, previous to the introduction of a fresh charge of material. If there should be only a little coke, a large proportion of ash may remain in the furnace. During the distillation it will be necessary to promote the passage of the ash through the grating, by the occasional use of a poker. The coke remaining in the retort, and accumulating from oft-repeated distillations, is valuable as fuel for the furnace.

The distillate of brown oil is now ready for re-distillation and conversion into eupione, lubricating oil, and paraffin, by any of the processes already described.

Kilgour's process.—This method is designed for the use of the petroleum or earth oil, of the Burman empire.

The "earth oil," in its natural state, being of a viscid consistency, varying from that of treacle to that of soft butter, according to the atmospheric temperature, and containing, in this state, certain impurities mechanically mixed or suspended in it, is to be put in a tank, cistern, or other suitable vessel, constructed of iron, wood, or stone, called a "settler," and then heated by steam, to

from 100° to 200° F., according to circumstances, until the oil becomes sufficiently fluid to allow the water and mechanically suspended substances to subside with facility.

The "earth oil" having its impurities thus separated from it, is now to be run into a general receptacle or tank, similar to the "settler" from which it has been transferred preparatory to the next operation. It is then run into a series of stills, or retorts, constructed of iron or other suitable material, and built in brick-work with fire-place and flues in the ordinary way, having the usual appendages of charging doors, pipes or worms, for the conveyance of the products of the stills to the receiver; discharging taps, or plugs, &c., all which mechanical arrangements are well known and understood by distillers of oils, resins, &c. Having charged the stills with the "earth oil," the heat is now to be gradually raised by means of the fire, till the naphtha begins to rise in vapor from the "earth oil." The vapor thus evolved, is conducted from the stills by the usual worm or pipe, and is condensed into liquid as it approaches the cooler or receiver—which is a common cistern or other receptacle.

When the naphtha ceases to flow, the temperature of the stills or retorts is to be further increased, to effect the separation of an oily liquid, which the inventor calls "paraffin oil," and which is condensed and collected in a cooler or cistern, and this higher temperature is to be maintained or increased until the oil is all or nearly all driven off. What now remains in the stills or retorts is paraffin, with a portion of the paraffin oil. By increasing the temperature of the apparatus still further, these substances may be distilled over in the same manner as in the former operations, and may be conducted in like manner, by the pipe or worm, to a separate recipient or cooler, there to become sufficiently congealed and stiff, so as to

be fit to be put into bags and subjected to pressure after the manner of the stearic acid process.

It is well to state that the "earth oil," in the first stage of the distillatory process, as hereinbefore described, may be distilled, only so far as to separate the naphtha, which is the first product of distillation, and then the paraffin oil and paraffin which remain in the stills as before mentioned, may be transferred to a separate vessel, and left to cool down. When cool, the whole may be transferred to bags, and subjected to pressure, in order to separate the oil from the paraffin.

If it becomes desirable or necessary to refine or purify the products of these operations herein described, they are to be placed in a sufficiently large vessel, lined with lead, and to every thousand pounds of naphtha or paraffin oil, eighty to a hundred pounds of concentrated sulphuric acid (of sp. gr. 1.845) are to be added and well mixed by thorough agitation. The whole is then allowed to remain undisturbed, at a temperature of about 150° F., till all the floating impurities completely subside. The naphtha or oil, thus purified, is now to be transferred to another vessel (also lined with lead), and as much caustic potash, soda or lime added to it as will neutralize any sulphuric acid which may remain in the products under treatment; and this state of neutralization may be easily ascertained by the application of one drop of the liquid to common test or litmus paper.

The purification of the paraffin is best accomplished by mixing it thoroughly with its own weight of concentrated sulphuric acid (of sp. gr. 1.845), in a vessel lined with lead, and then transferring it to a still or retort, well protected in all its parts from the cooling influence of the atmosphere. The paraffin is then distilled off from the sulphuric acid by the agency of the fire in the usual manner, and conducted by a pipe or worm into a proper

receptacle, by which means the paraffin is rendered pure and colorless in one operation.

Reece's process.—This method, recorded in the *Technologiste*, vol. ii. p. 74, applies to the distillation of peat; but as the latter material yields only two and a half pounds of paraffin (?) to the ton, it is not an economical source of that product, and we, therefore, shall omit any further notice of the process.

CHAPTER XXXIV.

WE devote a chapter to " patent candles," for the pur-
pose of presenting such processes of recent and patented
inventions as may be intrinsically good, or else suggestive
of new ideas, and more perfect methods.

Candles with movable wicks.—Some years since, Mr.
Bolts, an Englishman, invented a new mode of making
candles and bougies, the products of which, it was said,
equalled the best French candles in all the requisite pro-
perties. Mr. Bolts' candles are of particular forms, and
are as represented by the figures annexed. They can be
varied at will, but the shapes most generally given, are
those which we exhibit. The first is the most simple,
Fig. 235, a solid cylinder or truncated cone, closely ap-

Figs. 235, 236, 237, 238, 239.
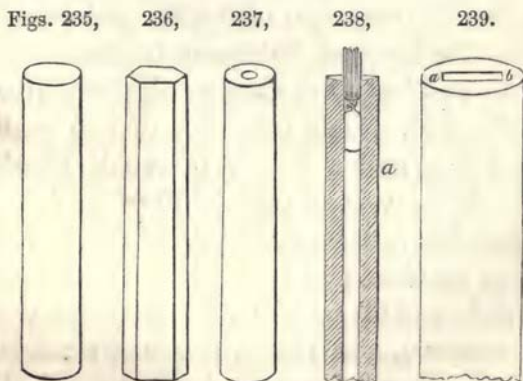
proximating the cylindric form. The body of the candle
should consist entirely of combustible material, the wick

not being introduced until it is about to be lit. Another form given to the candle (Fig. 236), is a truncated pyra-

Figs. 240, 241, 242, 243.
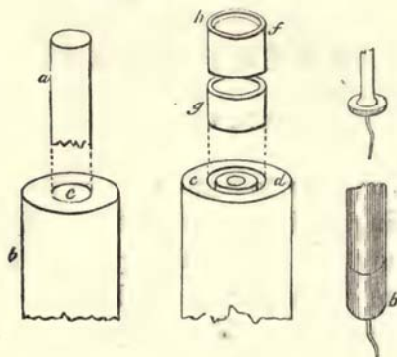
mid with hexagonal base. This exterior angular shape is independent of the internal form of the candle. The third form is a perfect cylinder (Fig. 237), perforated in its centre, as seen at Fig. 238, the diameter of this hole being regulated by the size of the wick. For general use a round hole is preferable, but the elliptic candles (Fig. 239), have great advantages. The opening $a\ b$, should be oblong, for the reception of a wide and slender wick, in order that the flame of light may be larger.

The fourth and last form that we shall describe, is that shown by Fig. 240. It is composed of two parts, an interior cylinder a, and a hollow external cylinder b, the opening of which, c, is of one-eighth of an inch greater diameter than the interior cylinder. This last is enclosed by a ring or moulding around its base, of about three inches breadth, and of sufficient thickness to exactly fill the hollow centre a, and thus preserve a concentric position when it is placed there, as shown by d, in Fig. 241. This concentric position, however, is only applicable to the lower part; indeed, the remaining length of the cylinder,

the internal c, should be filled by the wick f, the annular form of which produces a slender circular flame, fed simultaneously both by the interior and exterior cylinders. The weight g is suspended by the wick f. This arrangement of the wick produces much more light than if it was imbedded as usual in the centre of the candle. This last form possesses the advantage of facilitating the excess of a double current of air to the circular flame; and if the interior cylinder a, Fig. 240, is made with an opening in its centre, as at h, Fig. 241, there will evidently be produced a current of air at each side of the flame, and the candles thus possess all the illuminating advantages of an Argand lamp. Fig. 242 shows a very profitable form for the wicks. It can be used either by hooking on a small weight beneath, as at a, Fig. 238, the size of which should nearly fill the circular hole in the centre of the candle, or by the use of an elastic spring placed in the bottom of the candlestick. The better and most usual form of movable wick is that shown at Fig. 243. Its whole length is from one to three inches, according to that of the candle which it is to consume. It is previously impregnated with the same material of which the candle is made, in order to facilitate the first ignition. There is suspended beneath, a small weight a, Fig. 238, sufficiently heavy to cause the descent of the wick as the combustion proceeds. This wick is retained, without friction, by its tip b, Fig. 243, in the hollow centre of the candle or bougie. In every case, the wick, by a little attention and care, is so thoroughly fed by the liquid fat as to require no snuffing, it being only necessary to remove the small quantity of carbon which occasionally collects, after a long burning, at the top of the wick. It has been said above, that the wicks should be previously saturated with the fat of which the candle is made; the better way is to impregnate but one inch of its length,

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leaving the rest dry, so that it may more' readily suck up the liquefied fat in the surrounding basin, and which, in ordinary candles, is difficult of absorption by reason of the wick being already surcharged; and hence an overflow of the excess causes the candle to run. Another defect in the manufacture of ordinary candles, is the too great torsion of the wick, by which the easy penetration of the fluid fat is hindered. In those above recommended, the threads are placed longitudinally, and thus, independent of the capillary tube, which each thread is in fact, are formed, by the interstices between the threads, numerous other capillary tubes, which facilitate the ascension of the fluid fat towards the point of combustion, as well as the access of the air by the perforated centre ; that which considerably augments the brilliancy of the flame. The application of these wicks to the candles after they have been formed, presents two other advantages, first the ability of properly proportioning the wick to the candle, so that during its combustion only so much of the tallow or wax is melted as is requisite for the nourishment of the wick. A few essays with wicks of different sizes speedily determine this important point, and the manufacture of the candles on a large scale can be regulated accordingly. Secondly, the convenience of preparing the wicks previous to their introduction into the candles, in such manner as will tend to an increased brilliancy of flame, or an emission of agreeable aroma.

There is a variety of methods for making candles upon this new principle; they can be formed, as usual, in the ordinary moulds, with some additional apparatus for the perforation of their centre. It is much better, however, to cast them in an assemblage of moulds, Fig. 244, without intervals, and arranged with the least possible loss of space. These moulds are open at each end, and when the candles are being moulded, in order that their centres

may be hollow, there is introduced an iron piercer a, Fig. 245, equal sized with the hole, and having screwed at

Fig. 244.
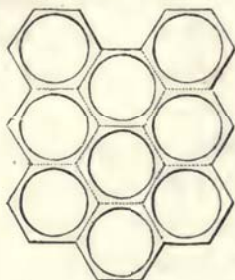
Fig. 245.
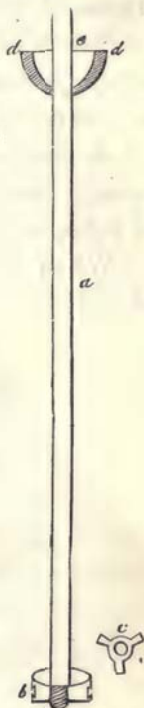
its end a piston or plug b. This piston is not round, but triangular, as is seen at c, and exactly fills the end of the mould, the three notches allowing a facility to the liquid fat of making its way into the mould, as will be seen. The other end of the piercer has a regulator d d, which is lowered until it reaches the top of the mould, in order to insure to the piercer a truly central position. The moulds, regulated and prepared as directed and shown by Fig. 244, are introduced into a chest just large enough for their admission, and but one inch higher. The melted tallow, at the proper degree of temperature, is then poured in until the moulds are completely submerged. If the candles are to be of ordinary quality, when cool, draw them by grasping the piercer by the handle part e, and lifting it upwards. The excess of tallow resting in the interstice between the moulds and sides of the box is left undisturbed; it serves to hold them steady for a subsequent operation.

When it is desired to subject the fluid matter to the action of a strong pressure, and by means of a vacuum, the trough, as soon as filled, must be slipped into a cast-

iron chest, to which is adapted a pneumatic apparatus, with a gauge and safety valve.

This, however, is an impracticable arrangement for manufacturing on a large scale, for, otherwise, if the pressure is so useful, it will be much more simple to employ that of a column of water aided by a suitably constructed apparatus.

A more expeditious manner of making these candles, would be to inject the melted fat with a syringe, through a tube, in the following manner:—

When the wax or tallow is melted, it is poured into a double-bottomed vessel, Figs. 246, 247, at the base of

Fig. 246.
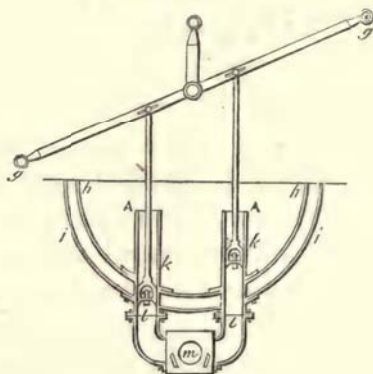
which is fixed a double acting force pump A A A, and adapted to which is a hollow tube B, Fig. 247, of the shape of an ordinary mould. This mould tube is secured at the point *b*, that it may be easily taken off and cleansed or changed; and when it is operated with for the fracture of the hollow candles, it carries in its centre a well-polished steel spike *e e*, of size corresponding with that of the hollow. This spike or pin is fixed to *b*, and by the open circular piece *d*, it is fastened by means of cross-pieces, and a screw which insures its central position without

disturbing the circulation of the melted substances. This spike or pin extends twelve inches beyond the end of the mould tube to the point *e*.

Fig. 247.
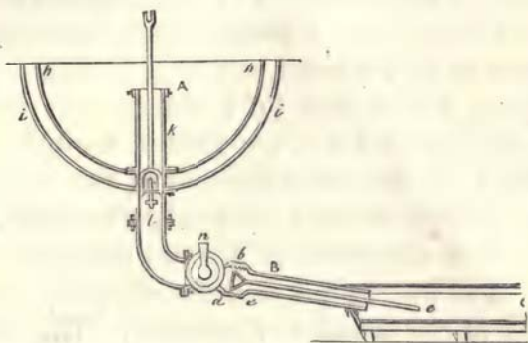
The temperature of the fused material should, for this operation, be regulated by the thermometer, and should be held midway between the points of congelation and fusion, by means of hot water placed in the double bottom before mentioned. The tubes leading from the base are also enveloped with an outer jacket communicating with the preceding, and consequently equally heated by hot water.

In this position the melted matter is driven by the pistons of the pump into a tube which forms a continual thread of tallow or stearin, traversing the mould tube B, under the form of a candle, perforated by the end of the rod *e*, extending into a tub of water, the heat of which is kept at about 10° F., lower than that requisite to produce a prompt cooling. The candle breaks off, and falls into this tub.

The resistance of the water is counterbalanced and the straightness of the candles maintained, by a semi-cylindrical tube placed under the elongated rod *e*, upon the breadth of the tub, and which receives and conducts the

ejected tube. As soon as the full length of a candle is out, a workman cuts it at the point *e*, and lifts it up successively, to make place for the consecutive candle, and so in this manner the process is continued until all the melted tallow is consumed. The tube candles, after having cooled, are cut off at a proper length, and the wicks, either simple or impregnated, are then applied.

The pumps are worked by a double lever *g g*. The bodies of the pumps *k k k*, are pierced throughout their length with holes for the admission of the melted suet; the pistons or suckers carry their valves reversed.

In the box *m*, the valves of the two pumps are united.

Finally, at *n*, Fig. 247, is seen the safety-cock, which is opened only at the moment of injection. The interior of the chest is designated by the letters *h h*; the exterior or jacket, by the letters *i i*. This manipulation also enables the manufacture of a tube or casing of wax, which can afterwards be filled with tallow so as to form a low-priced candle of handsome bougie-like appearance.

Goddard's candles.—In 1845, Mr. Samuel Goddard, of the city of London, proposed an improvement preventive of the guttering, or running of candles, whilst burning; consisting, first, in the peculiar modes of constructing the moulds in which the candles are to be cast; secondly, in the novel forms or shapes for the shafts of candles, which may be hollow for the introduction of dry wicks, or cast solid without wicks, or with wicks in the ordinary way; thirdly, in crystallizing the materials of which the candles are made; fourthly, in a novel method of covering or coating the surfaces of candles, if required, with a material for ornamental purposes; and, fifthly, in peculiar constructions of metallic caps to be applied to candles, in order to prevent their guttering whilst burning, or to conduct a descending wick.

In reference to the construction of moulds for the cast-

ing of candles, the inventor makes them of thin malleable metal, by first bending a suitable strip of the metal into a tubular shape, then soldering the edges together, so as to produce the perfect tube, and afterwards drawing the same to the required figure by the ordinary drawing process, upon a polished steel mandril. For the purpose of more readily discharging the cast candle from the moulds, the mandril may be made slightly tapering. These moulds may be made of a round, elliptical, or any other desired form, the main feature being to construct them of very thin malleable metal, drawn upon a mandril, for the purpose of operating upon the candle in the mould in the way hereafter described. In the construction of these moulds, zinc plates, tinned on their surfaces, and of about from the thirtieth to the fiftieth part of an inch in thickness, before drawing, have been found to answer the purpose. These moulds may be arranged in boxes, and made with tips or ribs, in the ordinary way; or they may be made with sliding tips or ribs, which will be necessary for discharging such candles as are made without wicks, from the moulds as above mentioned.

Fig. 248 represents, in longitudinal section, one of the improved moulds. *a a* is the tube or shaft of the mould; *b*, the box or trough, into which the melted material is poured for casting the candle. The lower part of the tube is compressed at *c c*, to form a ledge or resting-place for the sliding tip or rib *d*; which tip has a button at the outer end, by which it may be forced up, in order to relieve the candle previously to its being discharged from the mould, and to replace the rib again in its proper situation.

Fig. 248.
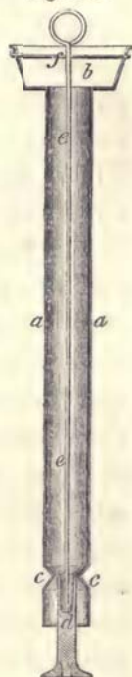
This rib *d*, slides through an aperture in the end of the mould, which aperture forms a guide. The mould here represented, is designed for casting hollow candles, through which a dry wick is to be drawn after the candle is made; and for this purpose, a long rod *e*, is inserted, its lower end resting in the centre of the rib, and the upper end being held by an adjustable guide *f*. By another form of rib, the end of which may be flat, or of any other required shape, solid shafts for candles, without wicks, may be cast in these moulds.

The novel forms or shapes for the shafts of candles, the inventor proposes to be, in some cases, elliptical, with flat wicks inserted, and manufactured in the ordinary way. In other cases, he proposes to make these elliptical shafts and also cylindrical as well as other shaped candles with an aperture through the centre (for the reception of a dry wick to be hereafter inserted), which aperture is formed by means of the central rod *e*, before mentioned. The patentee also makes elliptical and other shaped shafts for candles, solid, and without wicks or apertures for wicks. These candles are to be burned by wicks mounted in apparatus hereafter described.

The mode of crystallizing the material, such as spermaceti or other crystallizable substance, of which candles may be made, consists in employing, by preference, the thin metallic moulds, such as have been above described, and immersing the moulds in hot water, immediately on their being filled with the melted fatty material; the moulds must be left immersed in the hot water, and allowed to cool as the temperature of the water becomes naturally reduced. By this means the material, at a uniform temperature throughout its mass, forms itself into crystals, which will produce upon the surfaces of the candles so operated upon, beautifully variegated appearances, and by the introduction of coloring matters in small

quantities, in the way well known, into the material, whilst melting, the variegated and beautiful appearance of the candle will be improved.

The novel mode of covering or coating the surfaces of candles with a material for ornamental purposes, is effected by the use of the above described thin metallic moulds. The moulds being filled with the melted material of which the coating of the candle is to be formed, are, immediately on being filled, to be immersed in cold water for one or two minutes, in order that a thin stratum of the material may become chilled, and incrusted on the internal surface of the mould. The thickness of this interior crustation will, of course, depend upon the length of time that the mould is immersed, and will be regulated according to the judgment of the workman. When the incrustation has been thus formed, the fluid part of the material must be poured out of the mould, and the mould then filled with such fatty matter to form the substance of the candle as may be desired; the moulds must then be immediately immersed in cold water again, in order to prevent the incrustation from melting and running into the other material; and having remained immersed in this cooling liquid for two or three minutes, according to the temperature of the water, the moulds are to be withdrawn, and placed in a cooling medium, surrounded by an atmosphere not lower than 70° F. This mode of treating the candles will prevent their cracking, and produce, particularly in spermaceti candles, a smooth face without the aid of wax. It is scarcely necessary to say, that the covering material may be colored in any way to suit the desire of the manufacturer. The correct performance of this process of covering candles with a very thin coating, depends upon the thinness of the metal of which the mould is constituted, and the sudden action of the cooling medium on the immersion of the mould; whereas it must be obvi-

ous that the same cannot be so delicately and rapidly effected by the employment of thick moulds, made in the ordinary way.

The peculiar constructions of metallic caps to be applied to candles for the purpose of preventing them from guttering whilst burning, and also for conducting a detached wick, will be seen by reference to Fig. 249, which

Figs. 249, 250, 251.

represents, in several views, a simple cap of thin metal, to be placed on the top of any candle, which as it burns, will be prevented from guttering by the cap descending, the lip or rim around its edge guiding it and preserving it in its proper position. This cap may be of any form suitable for the candle to which it is to be applied. In some cases the inventor proposes to attach to this cap a circular or elliptical tube of glass or mica to act as a chimney, which may be supported by small arms, for the purpose of holding a short piece of wick, which is to be saturated with some oleaginous material. The cap with its wick being placed upon the top of a candle, formed with a hollow channel down in its centre, as above described, or upon a solid candle, as shown at Fig. 251 will, on being lighted, heat the fatty material below, and gradually descend as the candle burns; the tube and wick continuously conducting up the fatty matter, which will support

the combustion as long as the candle lasts, and it will not require snuffing. The wick is also capable of being elevated or depressed in the tube, for the purpose of increasing or diminishing the light at pleasure.

Bougies which burn in water.—These are for the chambers of the sick and nursery, or other purposes requiring a light throughout the night. They are made of wax, after the manner of dipped bougies; and, to give them an upright position in the water, they are fitted with a guide, which is a tin tube C, Fig. 252, of diameter slightly

Fig. 252.

larger than the bougie, to give a free motion, and soldered to a tinned iron plate A, pierced in its centre with a hole B. This plate being placed upon a glassful of water, the bougie burns at the surface and always rises or mounts in proportion as it consumes. A slight improvement upon this arrangement renders the apparatus a time-teller, and, as such, a very convenient assistant to the nurse in cases of sickness, and as a substitute for a clock where medicine is to be administered at certain hours.

The modified candle burner is seen at Fig. 253. In place of the entire tube there are two rings, A and B; the first, soldered upon the plate C, within it, being fastened, by one of their ends, four iron wires D D, equi-distant apart; the other ends are fastened on the other side of

the ring B, so as to form, by this means, an open tube.
After having ascertained the amount of wax consumed in

Fig. 253.
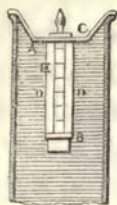
a bougie of determined and uniform size, a scale E is then
made, the divisions of which are equal, and extended
throughout a length pre-ascertained by experiment, and
are each represented by figures 1, 2, 3, &c., commencing
at the base.   This scale must be managed so that it can
slide easily upon the length of one of the iron wires that
form the tube.   When the bougie is lit, let it be at a mo-
ment simultaneous with the commencement of an hour
marked by the time-keeper, the division 0 being coincident
with the lower edge of the bougie.   Proportionally as the
candle rises, the scale indicates how much has been its
consumption since it was first lit; it being only necessary
to remember the hour at which you inflamed it to know
nearly the hour at the time of examining it during the
night.

These kinds of bougies can be made of length propor-
tional to that of the night at different seasons of the year;
and so that twenty to a pound shall last for ten or twelve
hours; the thirty-two's nine hours; the forties eight
hours; the sixties four to five hours.

Perfumed candles.—These are of the ordinary candle
material, aromatized by the addition of any essential oil
that is grateful to the smell.   When made of the pressed
tallow, then, in order that they may not be greasy to the
touch, a coating of varnish is applied to each.   In this

way an appearance is imparted equal to wax, whilst the candle is not necessarily of price exceeding that of the ordinary vaxeme light. The following are the ingredients, in proper proportions, for the varnish: Three parts, by weight, of gum damar (*pinus dammara*), a colorless resin, and two parts of white wax, thoroughly melted and mixed together.

The temperature requisite for the fusion of these ingredients forming the varnish being higher than that sufficient to melt the material of which the candle is made, they consequently burn without impediment, and, while equal in gloss, feeling, and apparent hardness, to those of wax, have the advantage of costing but one-third their price.

Patent candlestick.— This new and simple invention fully answers its purpose of promoting economy in the burning of a candle. By its means, the candle is made to

Fig. 254.
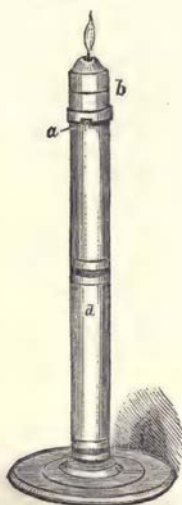
Fig. 255.
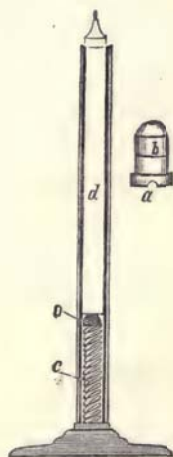
give a uniform light, and consume away without guttering or leaving a stump.

It is shown by Figs. 254 and 255, and consists of a

cylindrical tube *d*, of tin-plate or sheet-brass, corresponding with the size of the candle to be used, and mounted upon a foot or base, in the ordinary manner of candlesticks. In the interior is an elastic wire spring *c*, surmounted by a solid, tapering head *o*, with a flat top, for the support of the candle *d*. The candle being set upon this head, and sufficient pressure applied by the hand to compress the spring, is thus forced entirely down the tube, where it is held by the cap *b*, which is there fastened to the cylinder by a notch *a*. The wick, protruding through the opening at the top of the cap, on being lighted, melts the surrounding portion of the candle. A clean cup is formed around the wick, and, as the fluid fat offers no resistance to the confining edges of the cap, the spring gradually relaxes as the candle burns away, and thus forces it up by degrees, and effects a great regularity of consumption.

The price of these candlesticks varies from thirty-eight cents to one dollar, according to quality and finish, and may be purchased at any of the lamp stores.

CHAPTER XXXV.

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 the 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, and which is easily seen by reference to the following table from Ure, arranged for the convenience of operatives. But, for those liquids lighter or rarer than water, viz: alcohol, ethers, &c., 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. 256 and 257; 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. 256.
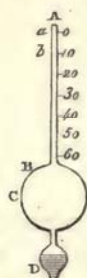
Fig. 257.

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 part 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 little different from the preceding, in form, and necessarily has a modified scale, which is graduated as is shown by Fig. 257. 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 tall glass cylinder, Fig. 258, 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 has, as will be seen by reference to the following table, a specific gravity of 1.2063. The tables, pages 50 and 53, will next show that a liquid of that specific gravity contains 18.71 per cent. of caustic soda, or 21.25 of potassa. The presence of foreign 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

Fig. 258.

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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.

Specific Gravity Numbers Corresponding with Baumé's Areometric degrees.

LIQUIDS DENSER THAN WATER.						LESS DENSE THAN WATER.			
Degrees.	Specific gravity.	Degrees.	Specific gravity.	Degrees.	Specific gravity.	Degrees.	Specific gravity.	Degrees.	Specific gravity.
0	1.0000	26	1.2063	52	1.5200	10	1.0000	36	0.8488
1	1.0066	27	1.2160	53	1.5353	11	0.9932	37	0.8439
2	1.0133	28	1.2258	54	1.5510	12	0.9865	38	0.8391
3	1.0201	29	1.2358	55	1.5671	13	0.9799	39	0.8343
4	1.0270	30	1.2459	56	1.5833	14	0.9733	40	0.8295
5	1.0340	31	1.2562	57	1.6000	15	0.9669	41	0.8249
6	1.0411	32	1.2667	58	1.6170	16	0.9605	42	0.8202
7	1.0483	33	1.2773	59	1.6344	17	0.9542	43	0.8156
8	1.0556	34	1.2881	60	1.6522	18	0.9480	44	0.8111
9	1.0630	35	1.2992	61	1.6705	19	0.9420	45	0.8066
10	1.0704	36	1.3103	62	1.6889	20	0.9359	46	0.8022
11	1.0780	37	1.3217	63	1.7079	21	0.9300	47	0.7978
12	1.0857	38	1.3333	64	1.7273	22	0.9241	48	0.7935
13	1.0935	39	1.3451	65	1.7471	23	0.9183	49	0.7892
14	1.1014	40	1.3571	66	1.7674	24	0.9125	50	0.7840
15	1.1095	41	1.3694	67	1.7882	25	0.9068	51	0.7807
16	1.1176	42	1.3818	68	1.8095	26	0.9012	52	0.7766
17	1.1259	43	1.3945	69	1.8313	27	0.8957	53	0.7725
18	1.1343	44	1.4074	70	1.8537	28	0.8902	54	0.7684
19	1.1428	45	1.4206	71	1.8765	29	0.8848	55	0.7643
20	1.1515	46	1.4339	72	1.9000	30	0.8795	56	0.7604
21	1.1603	47	1.4476	73	1.9241	31	0.8742	57	0.7656
22	1.1692	48	1.4615	74	1.9487	32	0.8690	58	0.7526
23	1.1783	49	1.4758	75	1.9740	33	0.8639	59	0.7487
24	1.1875	50	1.4902	76	2.0000	34	0.8588	60	0.7449
25	1.1968	51	1.4951			35	0.8538	61	0.7411

Thermometers.—The thermometer is an instrument made of glass exclusively, when intended for practical purposes. Fig. 259 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. 260. In the Fahrenheit thermometer, the interval between the freezing and boiling points of water, is divided into 180 degrees. The freezing point is placed at 32°, and hence the boiling point at $32+180=212$. Reaumur divides the distance between the two extreme points of water into 80°, and Celsius spaces his thermometer (the Centigrade), into 100 equal intervals, the zero point, as in Reaumur's, being placed at freezing. The Fahrenheit scale is most convenient, because of the lesser value of its divisions; but, as it frequently happens that the manufacturer has no choice in the kind, but is compelled to take such as can be conveniently obtained, we annex a table showing the comparative value of each.

Fig. 259.

In the graduation of the scale, it is only necessary to have two fixed determinate temperatures, and for these

Fig. 260.
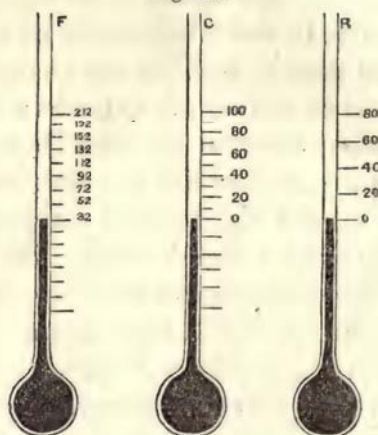
the boiling and freezing points of water are universally chosen. The scales can be extended beyond either of these points, by continuing the graduation. Those degrees below zero or 0° have the minus (—) prefixed, to distinguish them from those above; thus, 55° F., means fifty-five degrees above zero, 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°. The figure represents one ranging as high as 240°.

The following table shows at a glance, the corresponding value of each scale.

Table of the Corresponding Degrees of Fahrenheit's, Reaumur's, and the Centigrade Thermometers.

Fahr.	Reau.	Centig	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.
600	252.4	315.5	565.2	237	296.2	531	221.7	277.2	496.4	206.4	258
599	252	315	565	236.9	296.1	530.6	221.6	277	496	206.2	257.7
598	251.5	314.4	564.8	236.8	296	530	221.3	276.6	495.5	206	257.5
597.2	251.2	314	564	236.4	295.5	529.2	221	276.2	495	205.7	257.2
597	251.1	313.8	563	236	295	529	220.9	276.1	494.6	205.6	257
596.7	251	313.7	562	235.5	294.4	528.8	220.8	276	494	205.3	256.6
596	250.3	313.3	561.2	235.2	294	528	220.4	275.5	493.2	205	256.2
595.4	250.4	313	561	235.1	293.8	527	220	275	493	204.9	256.1
595	250.2	312.7	560.6	235	293.7	526	219.5	274.4	492.8	204.8	256
594.5	250	312.5	560	234.6	293.3	525.2	219.2	274	492	204.4	255.5
594	249.7	312.2	559.4	234.4	293	525	219.1	273.8	491	204	255
593.6	249.6	312	559	234.2	292.7	524.7	219	273.7	490	203.5	254.4
593	249.3	311.6	558.5	234	292.5	524	218.6	273.3	489.2	203.2	254
592.2	249.	311.2	558	233.7	292.2	523.4	218.4	273	489	203.1	253.8
592	248.9	311.1	557.6	233.6	292	523	218.2	272.7	488.7	203	253.7
591.8	248.8	311	557	233.3	291.6	522.5	218	272.5	488	202.6	253.3
591	248.4	310.5	556.2	233	291.2	522	217.7	272.2	487.4	202.4	253
590	248	310	556	232.9	291.1	521.6	217.6	272	487	202.2	252.7
589	247.5	309.4	555.8	232.8	291	521	217.3	271.6	486.5	202	252.5
588.2	247.2	309	555	232.4	290.5	520.2	217	271.2	486	201.7	252.2
588	247.1	308.8	554	232	290	520	216.9	271.1	485.6	201.6	252
587.7	247	308.7	553	231.5	289.4	519.8	216.8	271	485	201.3	251.6
587	246.6	308.3	552.2	231.2	289	519	216.4	270.5	484.2	201	251.2
586.4	246.4	308	552	231.1	288.8	518	216	270	484	200.9	251.1
586	246.2	307.7	551.7	231	288.7	517	215.5	269.4	483.8	200.8	251
585.5	246	307.5	551	230.6	288.3	516.2	215.2	269	483	200.4	250.5
585	245.7	307.2	550.4	230.4	288	516	215.1	268.8	482	200	250
584.6	245.6	307	550	230.2	287.7	515.7	215	268.7	481	199.5	249.4
584	245.3	306.6	549.5	230	287.5	515	214.6	268.3	480.2	199.2	249
583.2	245	306.2	549	229.7	287.2	514.4	214.4	268	480	199.1	248.8
583	244.9	306.1	548.6	229.6	287	514	214.2	267.7	479.7	199	248.7
582.8	244.8	306	548	229.3	286.6	513.5	214	267.5	479	198.6	248.3
582	244.4	305.5	547.2	229	286.2	513	213.7	267.2	478.4	198.4	248
581	244	305	547	228.9	286.1	512.6	213.6	267	478	198.2	247.7
580	243.5	304.4	546.8	228.8	286	512	213.3	266.6	477.5	198	247.5
579.2	243.2	304	546	228.4	285.5	511.2	213	266.2	477	197.7	247.2
579	243.1	303.8	545	228	285	511	212.9	266.1	476.6	197.6	247
578.7	243	303.7	544	227.5	284.4	510.8	212.8	266	476	197.3	246.6
578	242.6	303.3	543.2	227.2	284	510	212.4	265.5	475.2	197	246.2
577.4	242.4	303	543	227.1	283.8	509	212	265	475	196.9	246.1
577	242.2	302.7	542.7	227	283.7	508	211.5	264.4	474.8	196.8	246
576.5	242	302.5	542	226.6	283.3	507.2	211.2	264	474	196.4	245.5
576	241.7	302.2	541.4	226.4	283	507	211.1	263.8	473	196	245
575.6	241.6	302	541	226.2	282.7	506.7	211	263.7	472	195.5	244.4
575	241.3	301.6	540.5	226	282.5	506	210.6	263.3	471.2	195.2	244
574.2	241	301.2	540	225.7	282.2	505.4	210.4	263	471	195.1	243.8
574	240.9	301.1	539.6	225.6	282	505	210.2	262.7	470.7	195	243.7
573.8	240.8	301	539	225.3	281.6	504.5	210	262.5	470	194.6	243.3
573	240.4	300.5	538.2	225	281.2	504	209.7	262.2	469.4	194.4	243
572	240	300	538	224.9	281.1	503.6	209.6	262	469	194.2	242.7
571	239.5	299.4	537.8	224.8	281	503	209.3	261.6	468.5	194	242.5
570.2	239.2	299	537	224.4	280.5	502.2	209	261.2	468	193.7	242.2
570	239.1	298.8	536	224	280	502	208.9	261.1	467.6	193.6	242
569.7	239	298.7	535	223.5	279.4	501.8	208.8	261	467	193.3	241.6
569	238.6	298.3	534.2	223.2	279	501	208.4	260.5	466.2	193	241.2
568.4	238.4	298	534	223.1	278.8	500	208	260	466	192.9	241.1
568	238.2	297.7	533.7	223	278.7	499	207.5	259.4	465.8	192.8	241
567.5	238	297.5	533	222.6	278.3	498.2	207.2	259	465	192.4	240.5
567	237.7	297.2	532.4	222.4	278	498	207.1	258.8	464	192	240
566.6	237.6	297	532	222.2	277.7	497.7	207	258.7	463	191.5	239.4
566	237.3	296.6	531.5	222	277.5	497	206.6	258.3	462.2	191.2	239

Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.
462	191.1	238.8	425.7	175	218.7	389	158.6	198.3	352.4	142.4	178
461.7	191	238.7	425	174.6	218.3	388.4	158.4	198	352	142.2	177.7
461	190.6	238.3	424.4	174.4	218	388	158.2	197.7	351.5	142	177.5
460.4	190.4	238	424	174.2	217.7	387.5	158	197.5	351	141.8	177.2
460	190.2	237.7	423.5	174	217.5	387	157.7	197.2	350.6	141.6	177
459.5	190	237.5	423	173.7	217.2	386.6	157.6	197	350	141.3	176.6
459	189.7	237.2	422.6	173.6	217	386	157.3	196.6	349.2	141	176.2
458.6	189.6	237	422	173.3	216.6	385.2	157	196.2	349	140.9	176.1
458	189.3	236.6	421.2	173	216.2	385	156.9	196.1	348.8	140.8	176
457.2	189	236.2	421	172.9	216.1	384.8	156.8	196	348	140.4	175.5
457	188.9	236.1	420.8	172.8	216	384	156.4	195.5	347	140	175
456.8	188.8	236	420	172.4	215.5	383	156	195	346	139.5	174.4
456	188.4	235.5	419	172	215	382	155.5	194.4	345.2	139.2	174
455	188	235	418	171.5	214.4	381.2	155.2	194	345	139.1	173.8
454	187.5	234.4	417.2	171.2	214	381	155.1	193.8	344.7	139	173.7
453.2	187.2	234	417	171.1	213.8	380.7	155	193.7	344	138.6	173.3
453	187.1	233.8	416.7	171	213.7	380	154.6	193.3	343.4	138.4	173
452.7	187	233.7	416	170.6	213.3	379.4	154.4	193	343	138.2	172.7
452	186.6	233.3	415.4	170.4	213	379	154.2	192.7	342.5	138	172.5
451.4	186.4	233	415	170.2	212.7	378.5	154	192.5	342	137.7	172.2
451	186.2	232.7	414.5	170	212.5	378	153.7	192.2	341.6	137.6	172
450.5	186	232.5	414	169.7	212.2	377.6	153.6	192	341	137.3	171.6
450	185.7	232.2	413.6	169.6	212	377	153.3	191.6	340.2	137	171.2
449.6	185.6	232	413	169.3	211.6	376.2	153	191.2	340	136.9	171.1
449	185.3	231.6	412.2	169	211.2	376	152.9	191.1	339.8	136.8	171
448.2	185	231.2	412	168.9	211.1	375.8	152.8	191	339	136.4	170.5
448	184.9	231.1	411.8	168.8	211	375	152.4	190.5	338	136	170
447.8	184.8	231	411	168.4	210.5	374	152	190	337	135.5	169.4
447	184.4	230.5	410	168	210	373	151.5	189.4	336.2	135.2	169
446	184	230	409	167.5	209.4	372.2	151.2	189	336	135.1	168.8
445	183.5	229.4	408.2	167.2	209	372	151.1	188.8	335.7	135	168.7
444.2	183.2	229	408	167.1	208.8	371.7	151	188.7	335	134.6	168.3
444	183.1	228.8	407.7	167	208.7	371	150.6	188.3	334.4	134.4	168
443.7	183	228.7	407	166.6	208.3	370.4	150.4	188	334	134.2	167.7
443	182.6	228.3	406.4	166.4	208	370	150.2	187.7	333.5	134	167.5
442.4	182.4	228	406	166.2	207.7	369.5	150	187.5	333	133.7	167.2
442	182.2	227.7	405.5	166	207.5	369	149.7	187.2	332.6	133.6	167
441.5	182	227.5	405	165.7	207.2	368.6	149.6	187	332	133.3	166.6
441	181.7	227.2	404.6	165.6	207	368	149.3	186.6	331.2	133	166.2
440.6	181.6	227	404	165.3	206.6	367.2	149	186.2	331	132.9	166.1
440	181.3	226.6	403.2	165	206.2	367	148.9	186.1	330.8	132.8	166
439.2	181	226.2	403	164.9	206.1	366.8	148.8	186	330	132.4	165.5
439	180.9	226.1	402.8	164.8	206	366	148.4	185.5	329	132	165
438.8	180.8	226	402	164.4	205.5	365	148	185	328	131.5	164.4
438	180.4	225.5	401	164	205	364	147.5	184.4	327.2	131.2	164
437	180	225	400	163.5	204.4	363.2	147.2	184	327	131.1	163.9
436	179.5	224.4	399.2	163.2	204	363	147.1	183.8	326.7	131	163.7
435.2	179.2	224	399	163.1	203.8	362.7	147	183.7	326	130.6	163.3
435	179.1	223.8	398.7	163	203.7	362	146.6	183.3	325.4	130.4	163
434.7	179	223.7	398	162.6	203.3	361.4	146.4	183	325	130.2	162.7
434	178.6	223.3	397.4	162.4	203	361	146.2	182.7	324.5	130	162.5
433.4	178.4	223	397	162.2	202.7	360.5	146	182.5	324	129.7	162.2
433	178.2	222.7	396.5	162	202.5	360	145.7	182.2	323.6	129.6	162
432.5	178	222.5	396	161.7	202.2	359.6	145.6	182	323	129.3	161.6
432	177.7	222.2	395.6	161.6	202	359	145.3	181.6	322.2	129	161.2
431.6	177.6	222	395	161.3	201.6	358.2	145	181.2	322	128.8	161.1
431	177.3	221.6	394.2	161	201.2	358	144.9	181.1	321.8	128.8	161
430.2	177	221.2	394	160.9	201.1	357.8	144.8	181	321	128.4	160.5
430	176.9	221.1	393.8	160.8	201	357	144.4	180.5	320	128	160
429.8	176.8	221	393	160.4	200.5	356	144	180	319	127.5	159.4
429	176.4	220.5	392	160	200	355	143.5	179.4	318.2	127.2	159
428	176	220	391	159.5	199.4	354.2	143.2	179	318	127.1	158.8
427	175.5	219.4	390.2	159.2	199	354	143.1	178.8	317.7	127	158.7
426.2	175.2	219	390	159.1	198.8	353.7	143	178.7	317	126.6	158.3
426	175.1	218.8	389.7	159	198.7	353	142.6	178.3	316.4	126.4	158

Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.
316	126.2	157.7	279.5	110	137.5	243	93.8	117.2	206.6	77.6	97
315.5	126	157.5	279	109.7	137.2	242.6	93.6	117	206	77.3	96.6
315	125.7	157.2	278.6	109.6	137	242	93.3	116.6	205.2	77	96.2
314.6	125.6	157	278	109.3	136.6	241.2	93	116.2	205	76.9	96.1
314	125.3	156.6	277.2	109	136.2	241	92.9	116.1	204.8	76.8	96
313.2	125	156.2	277	108.8	136.1	240.8	92.8	116	204	76.4	95.5
313	124.8	156.1	276.8	108.8	136	240	92.4	115.5	203	76	95
312.8	124.8	156	276	108.4	135.5	239	92	115	202	75.5	94.4
312	124.5	155.5	275	108	135	238	91.5	114.4	201.2	75.2	94
311	124	155	274	107.5	134.4	237.2	91.2	114	201	75.1	93.9
310	123.5	154.4	273.2	107.2	134	237	91.1	113.9	200.7	75	93.7
309.2	123.2	154	273	107.1	133.8	236.7	91	113.7	200	74.6	93.3
309	123.1	153.8	272.7	107	133.7	236	90.3	113.3	199.4	74.4	93
308.7	123	153.7	272	106.6	133.3	235.4	90.4	113	199	74.2	92.7
308	122.6	153.3	271.4	106.4	133	235	90.2	112.7	198.5	74	92.5
307.4	122.4	153	271	106.2	132.7	234.5	90	112.5	198	73.7	92.2
307	122.2	152.7	270.5	106	132.5	234	89.7	112.2	197.6	73.6	92
306.5	122	152.5	270	105.7	132.2	233.6	89.6	112	197	73.3	91.6
306	121.7	152.2	269.6	105.6	132	233	89.3	111.6	196.2	73	91.2
305.6	121.6	152	269	105.3	131.6	232.2	89	111.2	196	72.8	91.1
305	121.3	151.6	268.2	105	131.2	232	88.9	111.1	195.8	72.8	91
304.2	121	151.2	268	104.8	131.1	231.8	88.8	111	195	72.4	90.5
304	120.9	151.1	267.8	104.8	131	231	88.4	110.5	194	72	90
303.8	120.8	151	267	104.4	130.5	230	88	110	193	71.5	89.4
303	120.4	150.5	266	104	130	229	87.5	109.4	192.2	71.2	89
302	120	150	265	103.5	129.4	228.2	87.2	109	192	71.1	88.8
301	119.5	149.4	264.2	103.2	129	228	87.1	108.9	191.7	71	88.7
300.2	119.2	149	264	103.1	128.9	227.7	87	108.7	191	70.6	88.3
300	119.1	148.9	263.7	103	128.7	227	86.6	108.3	190.4	70.4	88
299.7	119	148.7	263	102.6	128.3	226.4	86.4	108	190	70.2	87.8
299	118.6	148.3	262.4	102.4	128	226	86.2	107.8	189.5	70	87.5
298.4	118.4	148	262	102.2	127.7	225.5	86	107.5	189	69.7	87.2
298	118.2	147.7	261.5	102	127.5	225	85.7	107.2	188.6	69.6	87
297.5	118	147.5	261	101.7	127.2	224.6	85.6	107	188	69.3	86.6
297	117.7	147.2	260.6	101.6	127	224	85.3	106.6	187.2	69	86.2
296.6	117.6	147	260	101.3	126.6	223.2	85	106.2	187	68.9	86.1
296	117.3	146.6	259.2	101	126.2	223	84.9	106.1	186.8	68.8	86
295.2	117	146.2	259	100.8	126.1	222.8	84.8	106	186	68.4	85.5
295	116.9	146.1	258.8	100.8	126	222	84.4	105.5	185	68	85
294.8	116.8	146	258	100.4	125.5	221	84	105	184	67.5	84.4
294	116.4	145.5	257	100	125	220	83.5	104.4	183.2	67.2	84
293	116	145	256	99.5	124.4	219.2	83.2	104	183	67.1	83.9
292	115.5	144.4	255.2	99.2	124	219	83.1	103.9	182.7	67	83.7
291.2	115.2	144	255	99.1	123.8	218.7	83	103.7	182	66.6	83.3
291	115.1	143.8	254.7	99	123.7	218	82.6	103.3	181.4	66.4	83
290.7	115	143.7	254	98.6	123.3	217.4	82.4	103	181	66.2	82.7
290	114.6	143.3	253.4	98.4	123	217	82.2	102.7	180.5	66	82.5
289.4	114.4	143	253	98.2	122.7	216.5	82	102.5	180	65.7	82.2
289	114.2	142.7	252.5	98	122.5	216	81.7	102.2	179.6	65.6	82
288.5	114	142.5	252	97.9	122.2	215.6	81.6	102	179	65.3	81.6
288	113.7	142.2	251.6	97.6	122	215	81.3	101.6	178.2	65	81.2
287.6	113.6	142	251	97.3	121.6	214.2	81	101.2	178	64.9	81.1
287	113.3	141.6	250.2	97	121.2	214	80.9	101.1	177.8	64.8	81
286.2	113	141.2	250	96.9	121.1	213.8	80.8	101	177	64.4	80.5
286	112.8	141.1	249.8	96.8	121	213	80.4	100.5	176	64	80
285.8	112.8	141	249	96.4	120.5	212	80	100	175	63.5	79.4
285	112.4	140.5	248	96	120	211	79.5	99.4	174.2	63.2	79
284	112	140	247	95.5	119.4	210.2	79.2	99	174	63.1	78.8
283	111.5	139.4	246.2	95.2	119	210	79.1	98.9	173.7	63	78.7
282.2	111.2	139	246	95.1	118.9	209.7	79	98.7	173	62.6	78.3
282	111.1	138.9	245.7	95	118.7	209	78.6	98.3	172.4	62.4	78
281.7	111	138.7	245	94.6	118.3	208.4	78.4	98.0	172	62.2	77.7
281	110.6	138.3	244.4	94.4	118	208	78.2	97.8	171.5	62	77.5
280.4	110.4	138	244	94.2	117.8	207.5	78	97.5	171	61.7	77.2
280	110.2	137.7	243.5	94	117.5	207	77.7	97.2	170.6	61.6	77

Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.
170	61.3	76.6	133.2	45	66.2	97	28.9	36.1	60.8	12.8	16
169.2	61	76.2	133	44.9	56.1	96.8	28.8	36	60	12.4	15.5
169	60.8	76.1	132.8	44.8	56	96	28.4	35.5	59	12	15
168.8	60.8	76	132	44.5	55.5	95	28	35	58	11.5	14.4
168	60.4	75.5	131	44	56	94	27.5	34.4	57.2	11.2	14
167	60	75	130	43.5	54.4	93.2	27.2	34	57	11.1	13.8
166	59.5	74.4	129.2	43.2	54	93	27.1	33.9	56.7	11	13.7
165.2	59.2	74	129	43.1	53.9	92.7	27	33.7	56	10.6	13.3
165	59.1	73.9	128.7	43	53.7	92	26.6	33.3	55.4	10.4	13
164.7	59	73.7	128	42.6	53.3	91.4	26.4	33	55	10.2	12.7
164	58.6	73.3	127.4	42.4	53	91	26.2	32.7	54.5	10	12.5
163.4	58.4	73	127	42.2	52.7	90.5	26	32.5	54	9.7	12.2
163	58.2	72.7	126.5	42	52.5	90	25.7	32.2	53.6	9.6	12
162.5	58	72.5	126	41.8	52.2	89.6	25.6	32	53	9.3	11.6
162	57.7	72.2	125.6	41.6	52	89	25.3	31.6	52.2	9	11.2
161.6	57.6	72	125	41.3	51.6	88.2	25	31.2	52	8.9	11.1
161	57.3	71.6	124.2	41	51.2	88	24.9	31.1	51.8	8.8	11
160.2	57	71.2	124	40.9	51.1	87.8	24.8	31	51	8.4	10.5
160	56.8	71.1	123.8	40.8	51	87	24.4	30.5	50	8	10
159.8	56.8	71	123	40.4	50.5	86	24	30	49	7.5	9.4
159	56.4	70.5	122	40	50	85	23.5	29.4	48.2	7.2	9
158	56	70	121	39.5	49.4	84.2	23.2	29	48	7.1	8.9
157	55.5	69.4	120.2	39.2	49	84	23.1	28.9	47.7	7	8.7
156.2	55.2	69	120	39.1	48.9	83.7	23	28.7	47	6.6	8.3
156	55.1	68.9	119.7	39	48.7	83	22.6	28.3	46.4	6.4	8
155.7	55	68.7	119	38.6	48.3	82.4	22.4	28	46	6.2	7.7
155	54.6	68.3	118.4	38.4	48	82	22.2	27.7	45.5	6	7.5
154.4	54.4	68	118	38.2	47.7	81.5	22	27.5	45	5.7	7.2
154	54.2	67.7	117.5	38	47.5	81	21.7	27.2	44.6	5.6	7
153.5	54	67.5	117	37.7	47.2	80.6	21.6	27	44	5.3	6.6
153	53.7	67.2	116.6	37.6	47	80	21.3	26.6	43.2	5	6.2
152.6	53.6	67	116	37.3	46.6	79.2	21	26.2	43	4.9	6.1
152	53.3	66.6	115.2	37	46.2	79	20.9	26.1	42.8	4.8	6
151.2	53	66.2	115	36.9	46.1	78.8	20.8	26	42	4.4	5.5
151	52.9	66.1	114.8	36.8	46	78	20.4	25.5	41	4	5
150.8	52.8	66	114	36.4	45.5	*77	20	25	40	3.5	4.4
150	52.4	65.5	113	36	45	76	19.5	24.4	39.2	3.2	4
149	52	65	112	35.5	44.4	75.2	19.2	24	39	3.1	3.9
148	51.5	64.4	111.2	35.2	44	75	19.1	23.8	38.7	3	3.7
147.2	51.2	64	111	35.1	43.9	74.7	19	23.7	38	2.6	3.3
147	51.1	63.9	110.7	35	43.7	74	18.6	23.3	37.4	2.4	3
146.7	51	63.7	110	34.6	43.3	73.4	18.4	23	37	2.2	2.7
146	50.6	63.3	109.4	34.4	43	73	18.2	22.7	36.5	2	2.5
145.4	50.4	63	109	34.2	42.7	72.5	18	22.5	36	1.7	2.2
145	50.2	62.7	108.5	34	42.5	72	17.7	22.2	35.6	1.6	2
144.5	50	62.5	108	33.8	42.2	71.6	17.6	22	35	1.3	1.6
144	49.7	62.2	107.6	33.6	42	71	17.3	21.6	34.2	1	1.2
143.6	49.6	62	107	33.3	41.6	70.2	17	21.2	34	0.9	1.1
143	49.3	61.6	106.2	33	41.2	70	16.9	21.1	33.8	0.8	1
142.2	49	61.2	106	32.9	41.1	69.8	16.8	21	33	0.4	0.5
142	48.9	61.1	105.8	32.8	41	69	16.4	20.5	32	0	0
141.8	48.8	61	105	32.4	40.5	68	16	20	31	—0.4	—0.5
141	48.4	60.5	104	32	40	67	15.5	19.4	30.2	—0.8	—1
140	48	60	103	31.5	39.4	66.2	15.2	19	30	—0.9	—1.1
139	47.5	59.4	102.2	31.2	39	66	15.1	18.8	29.7	—1	—1.2
138.2	47.2	59	102	31.1	38.9	65.7	15	18.7	29	—1.3	—1.6
138	47.1	58.8	101.7	31	38.7	65	14.6	18.3	28.4	—1.6	—2
137.7	47	58.7	101	30.6	38.3	64.4	14.4	18	28	—1.7	—2.2
137	46.6	58.3	100.4	30.4	38	64	14.2	17.7	27.5	—2	—2.5
136.4	46.4	58	100	30.2	37.7	63.5	14	17.5	27	—2.2	—2.7
136	46.2	57.7	99.5	30	37.5	63	13.7	17.2	26.6	—2.4	—3
135.5	46	57.5	99	29.7	37.2	62.6	13.6	17	26	—2.6	—3.3
135	45.8	57.2	98.6	29.6	37	62	13.3	16.6	25.2	—3	—3.7
134.6	45.6	57	98	29.3	36.6	61.2	13	16.2	25	—3.1	—3.8
134	45.3	56.6	97.2	29	36.2	61	12.9	16.1	24.8	—3.2	—4

Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.	Fahr.	Reau.	Centig.
24	−3.5	− 4.4	12.2	− 8.8	−11	2	−13.3	−16.6	− 8.5	−18	−22.5
23	−4	− 5	12	− 8.9	−11.1	1.4	−13.6	−17	− 9	−18.2	−22.7
22	−4.4	− 5.5	11.7	− 9	−11.2	1	−13.7	−17.2	− 9.4	−18 4	−23
21.2	−4.8	− 6	11	− 9.3	−11.6	0.5	−14	−17.5	−10	−18.6	−23.3
21	−4.9	− 6.1	10.4	− 9.6	−12	0	−14.2	−17.7	−10.7	−19	−23.7
20.7	−5	− 6.2	10	− 9.7	−12.2	−0.4	−14.4	−18	−11	−19.1	−23.8
20	−5.3	− 6.6	9.5	−10	−12.5	−1	−14.6	−18.3	−11.2	−19.2	−24
19.4	−5.6	− 7	9	−10.2	−12.7	−1.7	−15	−18.7	−12	−19.5	−24.4
19	−5.7	− 7.2	8.6	−10.4	−13	−2	−15.1	−18.9	−13	−20	−25
18.5	−6	− 7.5	8	−10.6	−13.3	−2.2	−15.2	−19	−14	−20.4	−25.5
18	−6.2	− 7.7	7.2	−11	−13.7	−3	−15.5	−19.4	−14.8	−20.8	−26
17.6	−6.4	− 8	7	−11.1	−13.9	−4	−16	−20	−15	−20.9	−26.1
17	−6.6	− 8.3	6.8	−11.2	−14	−5	−16.4	−20.5	−15.2	−21	−26.2
16.2	−7	− 8.7	6	−11.5	−14.4	−5.8	−16.8	−21	−16	−21.3	−26.6
16	−7.1	− 8.9	5	−12	−15	−6	−16.8	−21.1	−16.6	−21.6	−27
15.8	−7.2	− 9	4	−12.4	−15.5	−6.2	−17	−21.2	−17	−21.7	−27.2
15	−7.5	− 9.4	3.2	−12.8	−16	−7	−17.3	−21.6	−17.5	−22	−27.5
14	−8	−10	3	−12.9	−16.1	−7.6	−17.6	−22	−18	−22.2	−27.7
13	−8.4	−10.5	2.7	−13	−16.2	−8	−17.7	−22.2	−18.4	−22.4	−28

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