A

GENERAL TREATISE

ON THE

MANUFACTURE OF SOAP,

THEORETICAL AND PRACTICAL:

COMPRISING THE

CHEMISTRY OF THE ART, A DESCRIPTION OF ALL THE RAW MATERIALS AND THEIR USES,

DIRECTIONS FOR THE ESTABLISHMENT OF A SOAP FACTORY, WITH THE NECESSARY APPARATUS, INSTRUCTIONS IN THE MANUFACTURE OF EVERY VARIETY OF SOAP, THE ASSAY AND DETERMINATION OF THE VALUE OF ALKALIES, FATTY SUBSTANCES, SOAPS, ETC. ETC.

BY

PROFESSOR H. DUSSAUCE,

LATELY OF THE LABORATORIES OF THE FRENCH GOVERNMENT.

AUTHOR OF "A PRACTICAL GUIDE FOR THE PERFUMER;" "A COMPLETE TREATISE ON TANNING, CURRYING, AND LEATHER DRESSING, ETC. ETC.

WITH

AN APPENDIX,

CONTAINING EXTRACTS FROM THE REPORTS OF THE INTERNATIONAL JURY ON SOAPS, AS EXHIBITED IN THE PARIS UNIVERSAL EXPOSITION, 1867, NUMEROUS TABLES, ETC. ETC.

PHILADELPHIA:
HENRY CAREY BAIRD,
INDUSTRIAL PUBLISHER,
406 Walnut Street.

LONDON:
TRÜBNER & CO.,
60 Paternoster Row.

1869.

PHILADELPHIA:
COLLINS, PRINTER, 705 JAYNE STREET.

PREFACE.

AMONG industrial pursuits the art of soap-making is one of the most important and useful, as well in its bearings on domestic economy as on many branches of manufactures. To every class of society, from the highest to the lowest, soap has become an absolute necessity. Some one has indicated the consumption of soap as a measure and test of the advancement of any people in civilization.

The art of manufacturing soap has for ages attracted the attention of chemists, who have aimed to perfect an operation which had long remained without explanation upon a rational theory. Notwithstanding this, and with all the researches, and the real services which their predecessors had rendered toward the advancement of this branch of industry, it is only since the appearance of the important works of MM. Chevreul, and Braconnot, that the theory of the reaction of the alkalies upon oils and greases has been well understood, and consequently the art of saponification reduced to sound principles.

The present work has over all others on this subject which have preceded it, the advantage not only of the improvements which have of late been generally applied

to the art, but also of the results of numerous experiments which we have ourselves made, and which have enabled us to describe with exactness the different operations which elucidate the principles involved.

We have much pleasure in acknowledging our indebtedness to the works of MM. Marcel de Serres, D'Arcet, Pelletier, Lelievre, Collin, Chaptal, Berthollet, Boutet, Lormé, Morfit, Chateau, Ure, Braconnot, and especially to that of M. Chevreul. The work of Professor Morfit, "Chemistry applied to the Manufacture of Soap and Candles," as well as that of M. Lormé, we have freely used, but for what we have said on the composition of fatty bodies, we are mainly indebted to our illustrious master M. Chevreul, whose great work on that subject we have without hesitation laid under contribution.

The materials which compose this treatise we have arranged in a systematic manner, and we believe that nothing has been omitted which is indispensable or could be useful. Especially have we endeavored to describe the most important improvements which have recently been applied to the art.

We have aimed to avoid the use of scientific terms in the description of the practical operations of the art, but in the theoretical parts which are connected with the chemistry of the subject we have been under the necessity of retaining the language of science.

In conclusion, we beg with some confidence to hope that the work which is now presented to the public will be found useful, valuable, and worthy of the great im-

portance of the subject of which it treats, and that it will be received with favor. We have devoted much time and care to its preparation, and have had these aims and objects constantly in view.

H. D.

New Lebanon, N. Y.
June 15, 1869.

It now becomes my sad duty to announce the death of my esteemed friend and efficient co-worker in the cause of industrial knowledge, Professor Henry Dussauce, who had corrected and returned to me the final proofs of this volume on Saturday last, when, on the following day, Sunday, June 20th, he was suddenly cut off, in the midst of eminent usefulness.

A Frenchman, thoroughly educated in the science and practice of chemistry, under the great Chevreul, he had, prior to coming to the United States, filled several important scientific positions under the government of his native country. He had resided in this country for a number of years prior to his death, and at that time held a responsible place in the laboratory of Messrs. Tilden and Co., manufacturing chemists, New Lebanon, N. Y.

My own acquaintance with him commenced early in the year 1863, since which time we had been on terms of intimacy and friendship, and I had always found him courteous, kind, and gentlemanly in a high degree. He

was a man of ability and intelligence, and had acquired a vast fund of knowledge, and I have never known any one who had less fear of hard and constant work than my departed friend. To me his death is a severe blow, as well, inasmuch as it rudely sunders ties of friendship and high regard, as because it breaks up important literary and business relations. To his family the loss is irreparable.

H. C. B.

PHILADELPHIA, June 22, 1869.

CONTENTS.

CHAPTER III.

Equivalents.

CHAPTER IV.

Chemical Reactions.

CHAPTER V.

Special Characteristics of the Different Classes of Bodies.

SECTION II.

RAW MATERIALS USED IN THE MANUFACTURE OF SOAPS.

CHAPTER VI.

LIME.

CHAPTER VII.

POTASH.

CHAPTER VIII.

SODA.

CHAPTER IX.

Ammonia.

CHAPTER X.

Alkalimetry.

CHAPTER XI.

Acids.

SECTION III.

FATTY SUBSTANCES USED IN THE FABRICATION OF SOAPS.

CHAPTER XII.

General Observations on Fatty Substances.

CHAPTER XIII.

Immediate Principles of Fatty Bodies.

CHAPTER XIV.

Fatty Acids.

CHAPTER XV.

Action of Acids on Fatty Bodies.

CHAPTER XVI.

General Considerations on Fixed Oils.

CHAPTER XVII.

Fixed Oils.

CHAPTER XVIII.

Animal Greases.

CHAPTER XIX.

Waxes—Resins—Turpentines.

CHAPTER XX.

Falsifications and Assays of Fatty Matters.

CHAPTER XXI.

Volatile Oils—Resin.

SECTION IV.

ESTABLISHMENT OF A SOAP FACTORY.

CHAPTER XXII.

Kettles.

CHAPTER XXIII.

Lye Vats.

CHAPTER XXIV.

Soap Frames.

CHAPTER XXV.

Drying Rooms.

CHAPTER XXVI.

Divider—Moulding Machine, and Minor Implements.

CHAPTER XXVII.

Plan and Description of a Soap Factory.

SECTION V.

FABRICATION OF SOAPS.

CHAPTER XXVIII.

The Theory of Saponification.

CHAPTER XXIX.

The Preparatory Manipulations in the Process of Making Soap.

CHAPTER XXX.

Fabrication of Marbled Soaps.

CHAPTER XXXI.

White Soap from Olive Oil.

CHAPTER XXXII.

Soap Made with Bone Tallow.

CHAPTER XXXIII.

Soaps Made with Oleic Acid.

CHAPTER XXXIV.

Resinous Soaps.

CHAPTER XXXV.

Soaps of Coco Oil.

CHAPTER XXXVI.

Soft Soaps.

CHAPTER XXXVII.

Silicated Soaps.

CHAPTER XXXVIII.

New Processes.

SECTION VI.

TOILET SOAPS.

CHAPTER XXXIX.

White Toilet Soap made with Lard.

CHAPTER XL.

Soap Made of Tallow.

CHAPTER XLI.

Palm Oil Soap.

CHAPTER XLII.

Half Palm Soap.

CHAPTER XLIII.

Coco Oil Soap.

CHAPTER XLIV.

Soaps Made by the Cold Process.

CHAPTER XLV.

FLOATING SOAPS.

CHAPTER XLVI.

POWDERED SOAPS.

CHAPTER XLVII.

ESSENCE OF SOAP.

CHAPTER XLVIII.

TRANSPARENT SOAPS.

CHAPTER XLIX.

SOFT TOILET SOAPS, OR ALMOND CREAM AND WINDSOR SOAP.

CHAPTER L.

SAVONNETTES.

CHAPTER LI.

DIFFERENT PREPARATIONS OF TOILET SOAPS.

SECTION VII.

DIFFERENT MANIPULATIONS TO WHICH THE PASTES OF CRUDE SOAPS ARE SUBJECTED TO BE TRANSFORMED INTO TOILET SOAPS.

CHAPTER LII.

The Cutting Machine.

CHAPTER LIII.

Grinding Machine.

CHAPTER LIV.

Mortars in which to Pound the Soap.

CHAPTER LV.

Moulds and Presses.

CHAPTER LVI.

Fabrication of Toilet Soaps.

CHAPTER LVII.

Formulæ for Perfuming and Coloring Toilet Soaps.

SECTION VIII.

FORMULÆ FOR PREPARING DIFFERENT KINDS OF SOAP AND IMPROVEMENTS IN THE FABRICATION.

CHAPTER LVIII.

PREPARATION OF DIFFERENT KINDS OF SOAP.

CHAPTER LIX.

IMPROVEMENTS IN THE FABRICATION OF SOAPS.

CHAPTER LX.

SUBSTITUTES FOR SOAP.

CHAPTER LXI.

ON THE CHANGES TO BE MADE IN THE ACTUAL PROCESSES OF SAPONIFICATION BY M. D'ARCET.

SECTION IX.

ANALYSIS AND ASSAYS OF SOAPS.

CHAPTER LXII.

DETERMINATION OF THE PROPORTIONS OF WATER.

CHAPTER LXIII.

DETERMINATION OF THE PROPORTIONS OF FATTY ACIDS.

CHAPTER LXIV.

DETERMINATION OF THE PROPORTION OF ALKALI.

CHAPTER LXV.

DETERMINATION OF THE PROPORTIONS OF FOREIGN SUBSTANCES INTRODUCED INTO SOAP.

CHAPTER LXVI.

SPECIAL METHODS OF ANALYZING SOAPS.

CHAPTER LXVII.

DIFFERENT METHODS OF DETERMINING THE COMMERCIAL VALUE OF SOAP.

APPENDIX.

TREATISE

ON THE

MANUFACTURE OF SOAPS.

GLANCE AT THE HISTORY OF THE ART.

The art of manufacturing soaps occupies a place as distinguished as important in our national industry.

Pliny affirms that the discovery of soap is due to the Gauls, who manufactured it with tallow, and lye made from ashes. (*Pliny*, book xviii. c. 51.) They also seem to have been acquainted with both hard and soft soaps. From the Gauls that industry passed to the Romans, through whom it spread with their conquests throughout Europe.

Whatever is the origin of soap, it seems to have been known by the ancient Romans. Galen mentions it in his works, and what confirms the testimony of that historian is the discovery of a soap-works, with all its apparatus, and some of its products, among the ruins and ashes of Pompeii, destroyed by an eruption of Vesuvius A. D. 79. Amongst the Romans soap was often used as a cosmetic to color the hair red, in imitation of the fashion prevalent at that time in Germany, from whence that kind of soap was imported.

From these statements it is evident that the manu-

facture of soap is of a very ancient origin; indeed, Jeremiah figuratively mentions it, "For though thou wash thee with nitre, and take thee much sope, yet thine iniquity is marked before me" (*Jer.* ii. 22), as does also Malachi: "He is like a refiner's fire, and like fuller's sope." (*Mal.* iii. 2.)

The etymology of the term *soap* appears to be derived from the Latin word *sapo*, itself corrupted from the old German word *sepe*, now written *seife*.

The French word *savon* is most likely derived from Savona, an Italian city on the Mediterranean shore, where the industry of soap-making was flourishing.

Without going further back, authentic documents establish in an incontestable manner, that soap manufactures existed in Italy and Spain in the eighth century; but it was only towards the end of the twelfth or the beginning of the thirteenth century that this industry was introduced into France. The first manufactories were established at Marseilles.

Marseilles, that old colony of the Phoceans, half Gaul, half Greek, energetic, active, intelligent, friend of industry, of arts, and commerce, was indeed specially favored for being the cradle of this industry. There, all the crude materials were abundant. Its soil, of an admirable fecundity, produced at the same time the olive-tree of the East, and the vegetable soda; its port on the Mediterranean, and its immense trade with all Europe, were all so many elements of fortune and prosperity for its soap manufactures.

The future justified, and even went beyond all the expectations which had been conceived; by slow degrees this industry increased and developed itself, and soon soap became an object of the first and indispensable necessity for domestic uses, and even for some kinds of

manufactures. But, what considerably increased its consumption, was the use made of it in the bleaching of linen in the beginning of the sixteenth century, the epoch at which this new branch of industry was imported from India to Europe, and consequently before the happy application of chlorine to the bleaching of textile fabrics.

Notwithstanding the richness of its soil and its natural resources, Marseilles could not produce in sufficient quantities the raw materials necessary to support its soap manufactories, which increased every year, both in number and importance; it thus became tributary to Spain and Italy—to the first for the sodas and oils, and to the latter for the oils alone.

However, it would be unjust to attribute the prosperity of the soap manufacture of Marseilles, during so long a period, alone to local circumstances resulting from its position and its commerce. What has principally contributed to establish the superiority of its products is the integrity of its fabrication. Indeed, since it has been in possession of that industry, it has been its faithful guardian. During a period of several centuries the soap manufacture of Marseilles has never given the lie to its origin. It has preserved, nearly intact, all its processes, combinations, and even its mixtures. Persistent and wise, its ameliorations and improvements have been progressive; faithful to its origin and traditions, its fabrication has generally been loyal and regular, that is, without alteration and without fraud. Besides, it was not easy to do it, especially for the marbled soaps, the constant composition of which cannot be modified with impunity; indeed, 60 to 62 per cent. of fatty matters, 6 to 7 per cent. of alkali, and 30 to 35 per cent. of water, are the normal proportions which constitute the marbled soap.

At the beginning of this century, the soap factories of Marseilles had to pass through a dreadful crisis. The supply of natural soda, an essential element of the manufacture, failed in consequence of the war with Spain; then the genius of science intervened, and saved this industry thus shaken to its foundations. One of the most ingenious, most learned, and most modest *savants* of the period, LEBLANC, discovered artificial soda. That discovery, one of the most beautiful and most important that we owe to modern chemistry, saved the soap manufacture from irremediable ruin. From this time the manufacture revived; it was a period of transformation. Until that time, pure olive oil alone was admitted into the manufacture of Marseilles soaps, but the constantly increasing importance of this manufacture, and the high price of olive oil, which had become scarce, determined some manufacturers to try other oils. At first, they tried a mixture of olive and poppy oils, and the results obtained did not sensibly affect the quality of the soap. Encouraged by this first experiment, they tried successively different seed oils, and after more or less happy results, it was ascertained that sesame and earthnut oils, the latter especially, could be used with as much benefit as success.

To-day, the Marseilles soaps are a mixture of olive oil with the oils named above, but the quality of the soap is better in proportion as the quantity of olive oil is increased.

It is thus that the soap makers of Marseilles, always prudent, owe nothing to chance; it is only progressively, and after a long and careful examination, that they have introduced into their manufacture new fatty matters, and after ascertaining that these substances could not in

any degree diminish the well-deserved superiority of their products.

The annual consumption of the different kinds of Marseilles soap reaches the enormous quantity of 135 millions of pounds, for the production of which they employ 81 millions of pounds of fatty matters, and from 90 to 102 millions of pounds of artificial soda.

Of these 135 millions of pounds of soap, almost 112 millions are used in France. The balance is exported to all parts of the world. Until the beginning of this century, Marseilles was in possession of a kind of monopoly of the manufacture of hard soap, and that right was justly acquired. Now, thanks to the general progress that chemistry has given to industrial arts, it is no longer so. The manufacturers of that rich and industrious city have found numerous rivals in the soap manufacturers of several other localities.

The importance of that new manufacture, the beauty of its products, and their origin, deserve a particular mention.

From respect to the art, we may say that we do not consider as soaps those mixtures of common tallow, greases, etc., combined with an excess of alkali and surcharged with common salt, earthy matters, and water. These brown, caustic, efflorescent products improperly called soaps, are completely outside of the dominion of the art, and are appreciated for what they are worth.

What really constitutes an art, is the application of the principles on which it rests. More than any other, the art of manufacturing soap is submitted to fixed and constant rules. Thus, when we speak of soaps, we understand a product resulting from the chemical union of fatty matter with a pure alkali; we understand a loyal and regular manufacture resting on a sure basis, and the

processes of which are in harmony with the chemical and practical principles of the art; and it is from this point of view, the only true one, that we shall consider the other soap factories.

Let us commence with the Parisian. The Parisian manufacture has only constituted a real industry for about fifty years. Truly, soaps were made there before, but the establishments anterior to the period of which we speak were few and of little importance; and their products generally badly prepared, with an odor often disagreeable, were not of a nature to sustain a competition with the fine and rich soaps of Marseilles. It is not so any longer, when men as respectable for their character, as for their practical knowledge in the art of soap making, have formed in Paris establishments similar to those of Marseilles. The Parisian manufacturers furnish also to the trade, family and industrial soaps—white, gray, yellow, and various colored soaps made with tallow, olive oil, palm oil, etc., of fine appearance and of the first quality.

But the most important success of the Parisian factories incontestably dates from the manufacture of oleic acid soaps. For some years the manufacture of these soaps has assumed a considerable and always progressive development.

We should be happy to praise in the same manner the soaps of coco oil manufactured in Paris, but we cannot. If to a fine appearance, to a brilliant whiteness, these soaps united the essential qualities which constitute a good soap, we would signalize them to the attention and confidence of the public. Nearly all of these kinds of soap found in commerce are loaded with a considerable quantity of lye, salt, and water, in such a way that some manufacturers make from 7 to 800 pounds of soap with

100 pounds of coco oil, while the amount obtained for a good soap varies from 150 to 175 per cent. of the fatty matter.

Without doubt it will be objected that the exceptional nature of coco oil does not permit us to treat it like other fatty substances. This is true, but what is true, also, is that this considerable amount can be obtained only to the detriment of the essential qualities of the soap. Thus, notwithstanding their low price, these soaps are sold with difficulty, and are rarely used in the arts.

We shall not speak here of the different toilet soaps manufactured in Paris. We shall only say that in that rich and important branch, Paris occupies the first rank.

We have endeavored in this rapid sketch to indicate the principal origin of the manufactures of soaps. We have rendered to the manufacturers of Marseilles the justice due to them, and with the same justice have paid a tribute to Paris. They are true sisters who ought to live in harmony, but do not.

By a feeling of rivalry which unhappily exists amongst many industries, Marseilles accuses Paris of adulterating its products, and of bringing discredit on the manufacture. It is possible that many abuses have existed, and do yet exist, in the Parisian manufacture. It is also possible that some manufacturers have given ground for complaints. Considered in this restricted view, the manufacture of Marseilles has not always been without reproach. There are frauds everywhere, but this may be affirmed on either side, that these facts are isolated and rare, and do not implicate the generality of the trade.

Nothing can surpass the regular manufacture; it alone conducts to respectability, and often to fortune, while fraud has rarely been a source of profit to those

who practise it; and whatever may be said, Parisian soap-makers have not brought discredit on the trade, nor lowered the standard of the art. Less favored than those of Marseilles in regard to the raw material, they could never produce soaps of that sweet odor which the oils from the South only can give; but they manufacture with great success purified tallow, palm oil, and oleic acid soaps. These products are pure, well made, and without fraud or adulteration. Besides, the fraud is not an easy thing to conceal, and men of skill know very well that such soaps are easily detected; furthermore, the rapid development of the Parisian fabrication is the best proof of the purity of its products.

The reader will pardon us this digression, on account of the sentiment of justice which has inspired us. We had thought it our duty to oppose an opinion sanctioned by the Marseilles trade, and which has taken deep root in the minds of many persons, viz: that good soap can only be made at Marseilles. Reduced to its true principles, the manufacture of soap is the same everywhere.

Previous to the discovery of Leblanc, hard soap was made with potash and salt, as is yet the case with the itinerant soap-makers in various parts of Germany. Next, kelp and barilla were largely employed, which are a sort of crude soda, resulting from the burning of sea-weeds.

The application of rosin to making soap is of English origin. When the art of soap-making was introduced into that country, it is difficult to ascertain, the oldest records on the subject dating back to 1710, during the reign of Queen Anne; but it is certain that the great impulse which the art received originated in 1804, from the genius of Leblanc, by whom soda was extracted from

salt, the process being introduced to the English market by J. Muspratt.

The investigations of Chevreul, in 1811, on the exact composition and nature of oils and fats, have created the manufacture of candles, and have been of great profit to the soap-maker; so much so, that, at the present day, there is nothing empirical in the manufacture of soap. It is entirely based on scientific principles.

Large soap factories are now to be found all over the world; and although the people of the United States labor under the disadvantage of having to pay high rates for the soda, the industry of soap and candle making is represented in this country by many respectable houses, and involves a large capital.

That much remains to be done before all the kinds of soap found in the trade reach the desired standard of superiority, is not to be doubted. A more thorough knowledge of the principles of the art, coupled with honesty, and a desire not to make *cheap* soaps only, will do much to arrive at the desired end.

The following figures, taken from the United States census of 1860, show the importance of the soap and candle manufactures of the country:—

	Number of factories.	Capital invested.	Value of raw materials.	Value of manufactured products.
United States . .	614	6,347,138	12,562,179	18,464,575
New York . . .	134	1,456,400	2,885,856	4,182,683
Pennsylvania . .	98	1,036,258	1,577,372	2,355,402
Massachusetts . .	75	612,650	1,284,381	1,839,206
Ohio	62*	1,081,570	2,716,993	3,828,564

* Including lard oil.

SECTION I.

ELEMENTARY NOTIONS OF CHEMISTRY.

CHAPTER I.

GENERAL PRINCIPLES.

I. It is difficult to define chemistry by one of those precise phrases used in mathematics; it is rather by examples that we can be made to understand its objects and its meaning. We shall choose the following: There is a variety of brass which resembles gold so closely that it has been called *similor*, and is used to manufacture false jewelry; but this similitude is only apparent, and if we compare a bar of each, we can readily distinguish one from the other. If we heat in a crucible, without the contact of the air, the two substances in the same furnace, the brass will melt much sooner than the gold, and the temperature must be raised higher to produce the fusion of the latter metal. When these metals conveniently cooled, have become solid, we find them in their original state, without any modification in their color, brightness, solidity, weight, etc.

The greater specific gravity of gold can be used also to mark their difference; indeed, if we place on the two plates of a scale, sheets of these two metals, as equal as possible in volume, we perceive the gold to be much heavier, and we arrive at the conclusion that these substances which appear to be similar are really very

different. It is superfluous to add, that neither of these experiments produces the slightest alteration in the characteristics of these two metals.

The different facility with which these substances are reduced to laminæ or wires, and their very varying hardness, lead us to the same conclusions. We shall see, besides, after all these trials, that the metals have not experienced any modification in their essential properties, and have kept their general characteristics. But let us change the test, let us take these same metallic laminæ and dip them into a mixture of nitric and hydrochloric acids, known as *aqua regia;* the brass is violently attacked, red vapors escape from the liquor, and the metal disappears, communicating to it a fine emerald-green color. With gold the action is slow, red vapors are produced, but they are light, and when the gold is dissolved, the liquid instead of being green is a dark yellow.

We arrive once more at the conclusion that these metals are far from being alike. However, these phenomena cannot be confounded with the preceding illustrations.

In the first case, after melting and weighing the metals, reducing them into laminæ and wires, their properties are not changed; in the last case they have ceased to exist, and there is no similarity between the two solutions.

Hitherto, our tests have not changed the weights of the metals; now these substances appear to be annihilated, the *aqua regia* in which we have placed them being perfectly limpid. Lastly, these new phenomena are not momentary like the first, for gold and brass do not deposit in the bottom of the liquid in which they are assimilated, and we cannot extract them. If we evaporate the liquor we shall find, it is true, a solid residuum, not metallic, but soluble in water, brown with gold, green with the brass. These residues do not resemble

the metals which have produced them, and their weights have no analogy with the primitive weights of the metals.

II. *Phenomena of Chemical Combination.*—It is to the examination of these last phenomena that the chemist gives his attention. It is to these that he gives the name of *chemical phenomena*, and when they are realized he says that a *chemical combination* is formed.

Those, the study of which engaged us at first, have for him less interest, and as they belong to natural philosophy, they are called *physical phenomena.*

It is impossible to make confusion between them, for the first are transitory, they never cause radical changes in the properties and weights of bodies; while the second give birth to particular substances, having a durable and proper existence, and which, by their weights and characteristics, are different from those which have produced them.

Every day we see chemical combinations produced under our eyes. Nature at every moment shows us some in the process of execution. The iron which becomes rusty, the copper which is covered with verdigris, the coal which burns, are examples among thousands. Each of these operations is accompanied by variation in the weight, which is the essential characteristic of the combination, for rust and verdigris weigh more than iron and copper, and coal never completely disappears, but is simply transformed.

Is matter created, or not, by the fact of the combination? Certainly not, and the appearances are deceptive. As Lavoisier has said: "*Nothing is lost, nothing is created in nature.*"

The rust is iron in which air and water have fixed

themselves, and if we succeed in determining the quantities of iron, air, and water which constitute it, we find that the sum of their weights is exactly equal to the weight of the rust. The verdigris offers us the same results; and if coal seems to disappear by burning, it is that its substance unites with an active principle contained in the air, and gives birth to carbonic acid gas, and to other gaseous products that the draft of the chimney carries into the atmosphere. Here there is, as before, a perfect equation between the coal and the oxygen combined with it, and the gas resulting from that union.

III. *Definition of Chemistry.*—It is now easy for us to give a definition of chemistry. This science treats of the phenomena which occur by the contact of bodies, the result of this contact, and the changes in their condition and weight, when they react one upon the other to produce what we have called chemical combinations.

Its study is devoted to these combinations, and it does not examine those mixtures in which bodies maintain their proper individuality.

An example will make clearer the difference between mixture and combination. If we take gold dust, and agitate it as thoroughly as possible with sand, we can always distinguish the particles of gold in the midst of the sand. It is easy to separate the gold by imitating the process made use of in the countries where sands contain gold, by washing the mixture with water. The sand is carried off, and the pure metal is left. The result is different if we attempt to extract gold from the solid product which we have obtained by dissolving it through the action of *aqua regia;* even the microscope has not the power to detect the metal in this state. The examination of this substance with that instrument

will prove that there is not a particle of the metal left; it has been taken up by the acids. A combination has been formed, while the gold and sand only constitute a mixture.

When we have mixed gold and sand, no increase of temperature has been manifested in the mass. On the contrary, where aqua regia has touched the metal a considerable quantity of heat has been developed, and there has been an increase of temperature during all the combination. This production of heat is a characteristic demonstration of the chemical combination, and is never manifested in the mixture. The presence of this caloric proves the presence of electricity, for if we put the vessel in which the combination is effected, in contact with an apparatus called a *galvanometer*, we perceive an abundant disengagement of electric fluid, while the mixing of substances does not show a sign of this agent.

We understand then that it is easy, in the majority of cases, to decide if the bodies we unite are simply mixed, or if they have combined to form a chemical compound.

The quantities of heat and electricity which result from the chemical action are very considerable, and often the temperature rises sufficiently to produce luminous phenomena of great intensity. These phenomena are the origin of the heat as generally produced, and to name an example, we shall say that when a combustible disengages heat, it is due to the combination of the carbon, or other combustible principle, with the active principle of the air which surrounds us.

It is to chemical reactions that we address ourselves when we desire electricity; and the batteries, those instruments now so advantageous to industry, produce galvanic currents, only on account of chemical reactions

which are developed between the substances that constitute them.

IV. *Affinity.*—Many scientific men have tried to ascertain the cause which produces combination; it remains unknown in its true nature. However, to render more easy the interpretation of the facts, a name is given to it, that of *affinity*, and when two bodies combine, we say that it is on account of the force of affinity, simply because they have affinity one for the other.

V. *Simple and Compound Bodies.*—It appears from what we have before said, that all chemical action is necessarily accompanied by a profound alteration of the reacting substances, and the production of a new body. Must we conclude from this, that when the combination is once effected the substance has disappeared, and that it is impossible to extract it from the compound into which it has passed? By no means; and if we go back to our first example, we shall see that it is very easy to extract gold from the combination into which it has entered. If, indeed, we dissolve in water the dry residuum produced by the action of *aqua regia* on gold, and if we introduce into the solution a bar of iron, we see very soon a brown powder deposited in it, and if we carefully collect and melt it, we find the gold with all its characteristics and its primitive weight.

The same assay, tried on the residuum left by the solution of brass in *aqua regia*, will furnish us a powder which, melted, will reproduce a metal, but this metal has neither the color nor the weight of the brass used. It is red, and is formed only of pure copper, and represents only a part of the brass dissolved.

Has the matter been transformed? Have we experi-

enced a loss in weight, contrary to the opinion of Lavoisier? Nothing of the kind, for a more attentive examination will show us that the liquor still contains a quantity of zinc, which has not been precipitated by the action of the iron; and if, by a particular process, we extract and melt this zinc with the copper, we obtain a metal, the weight and characteristics of which are similar to the brass used at first.

This fact is a proof that brass is a substance very different from gold, that the latter is a pure metal, unmixed with any other metallic body, while, on the contrary, brass is a compound of copper and zinc. This distinction, very important to establish, justifies the term "*simple body*," given to gold and other substances from which we can extract only one individual property, and that of "*compound body*" to those like brass, in which several simple bodies are united.

In the preceding experiments we have used certain substances, such as nitric acid, hydrochloric acid, etc., which have been made to react on the metals that we have had an object in transforming; these agents, in the same manner, have experienced an alteration, for a part of them have combined with gold and brass; that is the reason why we call them *reagents*. The chemist gives the name of *analysis* to the operation we have just described, by which we separate the copper from the zinc; he can collect and weigh the elements which enter into the combination, and then he performs a *quantitative analysis;* or he ascertains only the mixture of these substances, he then makes a *qualitative analysis*. If he makes the contrary operation, and melts the copper and zinc together to reproduce the brass, he executes a *synthesis*.

VI. *Cohesion.*—Since the principal object of chemistry is to study the combinations which bodies form, it is very important to determine the causes which have an influence on affinity. All these causes may be reduced to a single one known as *cohesion*, or the force which determines the more or less energetic aggregation of the molecules of bodies. This cohesion, by its variable energy, produces the different conditions of the matter. Bodies are solid, liquid, or gaseous, and the force which unites these molecules is very great in solids, weaker in liquids, and negative in gases, as in the latter case they are in a state of continual repulsion.

While the cohesion is very great in solids, it, however, presents different degrees. It is sufficient to remember how easily we can break a piece of chalk, how difficult to break a piece of wood, and the impossibility of dividing with the hands a bar of iron.

A substance is not always confined to a single condition; sometimes it may take upon it either of them. Water, for example, which freezes in winter, runs liquid at the surface of the earth during the greater part of the year, and is well known in the state of steam or vapor. We shall say, then, in general, that all bodies may, when placed in favorable conditions, assume in turn the three states.

Caloric is the agent which causes variation in the cohesion of bodies. Ice melts when the temperature rises, and to convert water into vapor it is sufficient to heat it. But if we can, by adding caloric to a solid, successively bring it to the liquid or gaseous state, we naturally incline to the opinion that the cooling of a liquid, or of a vapor, will produce a solid; and such is the case. The production of ice during winter, and the water which con-

denses from the vapor or steam of the engine, are every day proofs.

This being well established, we say, as a general rule:—the greater the cohesion, the less strength has the affinity; and *vice versa*, the less energetic the first, the greater intensity has the second.

Whilst heat opposes adhesion, and is apt to destroy it, it must increase the affinity, and we must expect to find in this agent a valuable help to produce chemical combinations, and experience proves it. Thus at the ordinary temperature, water attacks iron, but very slowly; while it is sufficient to direct steam, or water, upon iron heated to redness, to decompose the water and oxidize the iron. Sulphur and lead may remain in contact for any length of time, at the ordinary temperature, without any alteration; but if we heat the mixture, a combination immediately takes place.

This influence of heat is general, and we shall always see that solidity is the state which has the most cohesion, resisting to the greatest degree chemical combination. There are very few examples of solids reacting one upon the other.

The liquid state is eminently favorable to combination; and generally, when we want to unite two substances, we always try to bring one or both of them into the liquid condition. There are two ways of liquefying them. First, by fusion. Sulphur and copper mixed together cannot unite at the ordinary temperature; but if we heat them, the action is produced as soon as the sulphur is melted; at that moment, the temperature rises sufficiently to produce a very remarkable phenomenon of light, and a few seconds are sufficient for the disappearance of the copper and sulphur, and to witness also the formation of a new compound containing the two sub-

stances in a state of perfect combination. Second, by solution. The dry bicarbonate of soda and tartaric acid will remain together without any alteration, but it is sufficient to add a few drops of water, to produce a disengagement of gas, which is known as carbonic acid gas.

What has occurred here is very simple; the two substances, when mixed with water, have the property of penetrating the interior of its molecules, without changing their transparency, or, to employ the usual term, to dissolve in it. By this solution in water cohesion has lessened, and the affinity has increased sufficiently to permit their uniting and forming a combination.

We have seen that gold disappears in *aqua regia* in the same manner as tartaric acid in water; but these two actions must not be confounded. The first is a combination, and the second a mixture, as we shall prove.

If we take a solution of tartaric acid and evaporate it to dryness, the solid residuum is tartaric acid. This operation may be repeated several times with the same results. It is then necessary to avoid the confounding of this operation with combination, for the concentration of the product obtained by dissolving gold in *aqua regia* is not gold, but a combination of this metal with chlorine. In the first place, we have a mixture; in the second, a combination.

A very important characteristic prevents the confounding of a solution with a combination, as they present different calorific phenomena. Not only where one substance dissolves in another is there no increase of temperature, as is the case in a combination, but an absolute absorption of caloric takes place, and this property is utilized to prepare certain freezing mixtures.

CHAPTER II.

NOMENCLATURE.

"PHYSICAL science is formed of three things: the series of facts which constitute the science, the ideas which recall them, and the words which express them. The word ought to give birth to the idea, the idea ought to show the fact; they are marks of the same seal, and as the words keep the ideas and transmit them, the result is, that the language cannot be perfected without perfecting the science, nor the science perfected without perfecting the language."—*Lavoisier, Tr. of Chem.*, p. 6, 2*d edition.*

It is according to these principles, that the chemical nomenclature was created by a commission of the Academy of Sciences, of France, at the end of the last century, after the discoveries which established modern chemistry.

Its object is to represent with a small number of signs, all the combinations which result from the union of the simple bodies known to the present day.

The following are the uses and conventional rules, adopted in the nomenclature of simple bodies, and their compounds.

I. *Simple Bodies.*—The names of the simple bodies are the starting point of all the others. They are not systematic. They are taken either from tradition, or from some of their properties, or their origin. Several have been given in an arbitrary manner.

Thus, the names of the metals and other common

bodies, such as iron, copper, sulphur, etc., have been preserved. Chlorine, bromine, and iodine are named from their color and odor—*greenish*, *disagreeable odor*, *violet*; oxygen from its property of forming nearly all the acids; hydrogen from its property of generating water; potassium, sodium, etc., from their origin (metals of potash, soda, etc). The name of selenium is derived from *Sélené, the moon;* that of tellurium from *Tellus, the earth;* those of niobium and tantalium have a mythological origin.

Under the name of *metalloids* we rank the following:—

Oxygen,	Bromine,	Selenium,	Boron,
Hydrogen,	Iodine,	Tellurium,	Silicium,
Nitrogen,	Fluorine,	Phosphorus,	Carbon.
Chlorine,	Sulphur,	Arsenic,	

These bodies, by uniting with oxygen and hydrogen, constitute the majority of acids. These oxides do not act like bases. All gases but one are formed by the metalloids, free or combined together.

The other bodies are the *metals*. We count forty-six which are well known. They are the following:—[1]

Potassium,	Didymium,	Tantalium,	Bismuth,
Sodium,	Yttrium,	Niobium,	Lead,
Lithium,	Erbium,	Titanium,	Mercury,
Calcium,	Terbium,	Antimony,	Silver,
Barium,	Zirconium,	Tin,	Gold,
Strontium,	Norium,	Uranium,	Platinum,
Magnesium,	Iron,	Cobalt,	Palladium,
Glucinum,	Chromium,	Nickel,	Iridium,
Aluminum,	Manganese,	Zinc,	Rhodium,
Thorium,	Vanadium,	Cadmium,	Osmium,
Cerium,	Tungsten,	Copper,	Ruthenium.
Lanthanium,	Molybdenum,		

[1] During the last ten years, several new metals have been discovered; but on account of their rarity, and their study not being completed yet, we omit them.

Metals are distinguished by their physical characteristics, and by their property of forming basic combinations with oxygen. Besides, several of them form acids. In general they do not combine with hydrogen.

II. *Compound Bodies.*—The names of compound bodies are derived from the names of the simple bodies which constitute them, with the help of certain conventional rules. These rules relate first, to the binary combinations that metalloids and metals form with oxygen, and to the ternary combinations formed by the union of two binary compounds with a common element, oxygen; second, to the binary combinations which a metalloid forms with hydrogen; third, to the binary combinations which a metalloid forms with a metal or another metalloid, and to the ternary combinations formed by the union of two binary compounds having a common element other than oxygen; fourth, to the binary combinations which metals form one with the other.

Binary Oxygenated Compounds.—The binary combinations which simple bodies form with oxygen, are the best known and the most important. A simple body united with oxygen may form an *oxacid*, a compound body capable of uniting with bases or oxides. An acid combined with an oxide produces a *salt.*

The names of these compounds are thus formed:—

1. Acids.—These are designated by preceding the word acid with the name of the simple body which unites with oxygen, substituting for the last syllable the termination *ic;* thus, sulphur and oxygen form *sulphuric* acid, etc.

If a simple body with oxygen forms two acids, they are designated by preceding the word acid with the

name of the body terminating in *ous* for the less oxygenated, and in *ic* for the more highly oxygenated; *arsenious* acid and *arsenic* acid are thus formed from arsenic and oxygen.

If a simple body forms with oxygen three, four, or even five acid combinations, they are designated by grouping the syllables *per*, *hypo*, *ic*, *ous*, as in the following: *Perchloric* acid, *chloric* acid, *hypochloric* acid, *chlorous* acid, *hypochlorous* acid; they are all formed of chlorine and oxygen.

2. Oxides.—We designate by the name of *oxides* the combinations of simple bodies with oxygen, which unite with acids. The oxides are of three kinds: Basic oxides, or oxybasic, which combine with acids; indifferent oxides; saline oxides, which may be considered as formed by the union of an acid and a basic oxide, both produced by the same metal. There is no difference in their nomenclature. To designate one of them, it is sufficient to follow the word oxide with the name of the simple body united to oxygen. Some add to the name of the simple body the syllable *ic*, and have the word oxide follow it: *oxide of zinc* or *zincic oxide.*

If the simple body forms two oxides, the most oxygenated is followed by the syllable *ic*, the less oxygenated by the syllable *ous;* thus, *ferric oxide* and *ferrous oxide* are both formed with iron and oxygen.

If there are three oxides formed by the same simple body, the principal is called oxide, the less oxygenated suboxide, the most oxygenated peroxide: *suboxide of lead, oxide of lead, peroxide of lead.*

In certain cases, the names of protoxide, sesquioxide (sesqui = 1½), binoxide, etc., have been adopted, which not only designate the degrees of oxidation, but the ponderal relations between the quantities of

oxygen combined to a like weight of the other simple body. *Protoxide of manganese*, *sesquioxide*, and *binoxide* are formed of manganese and oxygen; *protoxide of nitrogen* and *oxide of nitrogen* are formed of oxygen and nitrogen.

We must remark here that the same simple body may unite with oxygen in many proportions, and give birth at the same time to oxides and acids. The latter are most oxygenated. The nomenclature of all these combinations follows the preceding rules, as one can see in the example of nitrogen and manganese.

Nitrogen united with oxygen forms two indifferent oxides, the *protoxide* and *binoxide*, and three acids, the *nitrous*, *hyponitric*, and *nitric*.

Manganese united with oxygen forms two basic oxides, the *protoxide* and *sesquioxide;* one indifferent oxide, the *binoxide;* and two acids, the *manganic* and *permanganic*.

To these rules there are a few exceptions. We shall name only those which concern an acid and several oxides, which retain the same names they had before the invention of the chemical nomenclature. We say

Silica,	instead of	Silicic acid,	
Water,	"	Protoxide of	Hydrogen,
Potassa,	"	"	Potassium,
Soda,	"	"	Sodium,
Lithia,	"	"	Lithium,
Lime,	"	"	Calcium,
Strontia,	"	"	Strontium,
Baryta,	"	"	Barium,
Magnesia,	"	"	Magnesium,
Alumina,	"	"	Aluminum,
Glucina,	"	"	Glucinium.

Ternary Oxygenated Compounds.—*Salts.*—An acid combined with an oxide constitutes a salt, a ternary

compound, formed by the union of two binary compounds having a common element, the oxygen.

The name of a salt is formed by suppressing the word acid, substituting the termination *ic* by *ate*, or *ous* by *ite*, and following by the name of the oxide. Thus, sulphuric acid and the oxide of zinc form the *sulphate of oxide of zinc;* sulphurous acid combined with the oxide of zinc forms the *sulphite of oxide of zinc.*

Instead of designating the base in the salt by the name of the oxide, followed by the name of the metal, it has been found shorter to suppress the word oxide, and we say

Sulphate of Zinc, instead of Sulphate of Oxide of Zinc,
" Copper, " " " Copper,
" Silver, " " " Silver.

We may also, and more logically, precede the word sulphate by an adjective formed by the name of the metal—*zincic sulphate*, *cupric sulphate*, etc. If a metal possesses two basic oxides, the name of each is employed in the nomenclature—*ferrous sulphate*, *ferric sulphate.*

If an acid unites to a base in several proportions, we indicate the proportion before the name of the salt with the prefixes *bi*, *tri*, *sesqui*, etc. Sulphates—*sulphate of potash*, *bisulphate of potash;* carbonates—*carbonate of soda*, *bicarbonate*, *sesquicarbonate*, *etc.*

If a salt combines with a new proportion of the base it contains, the compound is called *basic salt.* Thus, the mercurous nitrate, united to a new proportion of mercurous oxide, produces the *basic mercurous nitrate.*

Two salts, formed by the same acid and two different oxides, may unite and form a double salt; the name is formed by uniting the names of the two oxides of this compound, following the name of the acid: *double sulphate of oxide of iron* and *oxide of copper.*

Hydrogenated Binary Compounds.—The binary combinations which simple bodies form with hydrogen may be *acid*, *neutral*, or *basic*.

1. *Acids*.—They are called hydracids. Their names are formed by the word acid, preceded by a word composed of the names of the two elements: *Hydrochloric* or *chlorhydric* acid, formed of chlorine and hydrogen.

2. *Neutral*.—The other compounds of hydrogen are designated by the names of their elements. Sometimes an adjective precedes the word hydrogen, and sometimes it is preceded by the name of the other simple body, the last syllable of which is substituted by the termination *ide*. Thus we say, *phosphureted hydrogen* or *hydride of phosphorus*. If there are several combinations between hydrogen and a simple body, the same rule is adopted as for oxygenated combinations: *protocarburet of hydrogen*, *bicarburet of hydrogen*.

3. *Basic*.—If two hydrogenated binary compounds combine and give rise to a ternary compound, the first compound is designated as above; thus, the combination of hydrochloric acid with ammonia is called *chlorhydrate of ammonia*.

Hydrates.—Water, or oxide of hydrogen, forms with many simple or compound bodies particular combinations, which are called *hydrates*: *Hydrate of chlorine*, a combination of chlorine with water; *mono-hydrated*, *bihydrated*, *trihydrated sulphuric acid*, combinations of sulphuric acid with one, two, and three proportions of water.

Binary Compounds Formed of two Simple Bodies.—The binary combinations which metalloids form with metals, and metalloids other than oxygen and hydrogen, are named according to the same principles, with the names of their elements, only we terminate in *ide*

the name of one of them; it is generally the name of the body which manifests itself as electro-negative, if the compound be decomposed by electricity: *chloride of potassium, sulphide of sodium, bromide of silver, iodide of iron*, etc.

If a simple body forms with another, two compounds, we use the terminations *ic* and *ous* as for the oxides; thus, phosphoric chloride, phosphorous chloride. The binary compounds which such metalloids as chlorine, bromine, and iodine form with metals, are very similar to the salts, and are called haloid salts. Thus, the chloride, iodide, etc., of potassium are haloid salts.

Sulphureted Ternary Compounds.—The binary compounds of sulphur may unite one with the other, in the same manner as oxygenated compounds. They act the part of *sulphacids* and *sulphobases*, the union of which forms a *sulphosalt.* Thus, the sulphide of carbon, or sulphocarbonic acid, unites with sulphide of potassium and forms the *sulphocarbonate of sulphide of potassium, etc.*

Binary Combinations of Metals.—The combinations which metals form with each other are called *alloys;* the names of the metals follow the word alloy. Thus, alloy of copper and zinc. If mercury enters into the combination, the alloy is called an amalgam. Thus, we say amalgam of silver for the alloy of mercury and silver.

III. *Symbols.*—To the above language, another entirely symbolic, has been added, and its signification is more precise. This *symbolism* consists in representing each simple body by a capital letter, sometimes followed by a small one to specify it. These symbols are the following:—

Metalloids.

Oxygen,	O.	Nitrogen,	N.	Iodine,	I.
Hydrogen,	H.	Phosphorus,	Ph.	Fluorine,	Fl.
Selenium,	Se.	Arsenic,	As.	Boron,	B.
Tellurium,	Te.	Chlorine,	Cl.	Carbon,	C.
Sulphur,	S.	Bromine,	Br.	Silicium,	Si.

Metals.

Potassium,	K.	Zirconium,	Zr.	Nickel,	Ni.
Sodium,	Na.	Norium,	No.	Zinc,	Zn.
Lithium,	Li.	Iron,	Fe.	Cadmium,	Cd.
Calcium,	Ca.	Chromium,	Cr.	Copper,	Cu.
Barium,	Ba.	Manganese,	Mn.	Bismuth,	Bi.
Strontium,	Sr.	Vanadium,	V.	Lead,	Pb.
Magnesium,	Mg.	Tungsten,	W.	Mercury,	Hg.
Glucinium,	Gl.	Molybdenum,	Mo.	Silver,	Ag.
Aluminium,	Al.	Tantalium,	Ta.	Gold,	Au.
Thorium,	Th.	Niobium,	Nb.	Platinum,	Pt.
Cerium,	Ce.	Titanium,	Ti.	Palladium,	Pd.
Lanthanum,	La.	Antimony,	Sb.	Iridium,	Ir.
Didymium,	Di.	Tin,	St.	Rhodium,	R.
Yttrium,	Y.	Uranium,	U.	Osmium,	Os.
Erbium,	Er.	Cobalt,	Co.	Rhuthenium,	Rh.
Terbium,	Tb.				

A binary compound is represented by a formula having the symbols of its elements at the right of the above symbols. Small figures indicate in what proportion of weight the simple bodies are combined :—

HCl, hydrochloric acid; Cu^2O, suboxide of copper; NO, protoxide of nitrogen; Fe^2O^3, sesquioxide of iron.

A ternary compound is represented by the symbols of the binary elements, separated by a comma; the electro-positive element is written first :—

KO,SO^3, sulphate of potash; AgO,NO^5, nitrate of silver; KS,CS^2, sulphocarbonate of sulphide of potassium.

If we write a number to the left of the symbol, it multiplies the whole as far as the comma: $2KO,3CO^2$,

sesquicarbonate of potash, represents the same as K^2O^2, C^3O^6.

If we express a chemical reaction, write one after the other the symbols of the bodies which react, separating them by the sign +; write afterwards the sign of equality =, and then indicate the formed bodies in the second member of the equation, as in the following example. The sulphate of oxide of copper, decomposed by the nitrate of oxide of barium, produces sulphate of oxide of barium and nitrate of oxide of copper:

$$CuO,SO^3 + BaO,NO^5 = BaO,SO^3 + CuO,NO^5.$$

We see how easily the chemical phenomena are expressed by these symbols; they show at first sight which are the primitive compounds and the bodies resulting from their action; they indicate the binary or ternary compounds which do not change, or which are decomposed. We shall see that they represent not only bodies which react, but their equivalents, that is, the relation of weights which exists between these different bodies, simple or compound.

CHAPTER III.

EQUIVALENTS.

I.—Law of Weights.

In a chemical phenomenon, the *initial* weight of the bodies reacting on each other is constant.

"*Nothing is lost; nothing is created!*" It is comparatively easy to verify this fundamental law in all cases where only fixed compounds at the ordinary temperature are involved. Mercury, acting upon silver, will

dissolve the latter, and the weight of the amalgam thus formed will represent the united weights of the mercury and silver; if we distill the amalgam, the mercury is volatilized, the silver remains in the retort, and we obtain the primitive weights of the silver and mercury.

It is not always, however, that the truth of the foregoing proposition is so easily demonstrated. We give two examples in which the proof is obtained only by a very attentive analysis of the phenomena. Heat to redness, in a crucible, some copper; the metal, little by little, changes its nature, and is transformed into a black powder, the weight of which is greater by one-fourth than that of the copper put into the crucible. Again, burn a piece of wood; it entirely disappears, leaving only a few ashes, the weight of which represents a very small fraction of the weight of the combustible body. In these two cases, the weight of the substance, far from remaining the same, is in the one instance increased, and in the other diminished.

The explanation of these phenomena, on true principles, remained a mystery for a long time, for it was only at the end of the last century that the discovery of the gases, and the subsequent study of their properties, gave to science some of its fundamental principles. Thus, the above examples are easily understood by one acquainted with the properties of gaseous bodies.

In the first example, the copper heated in a crucible is transformed into a black substance, and increased in weight by absorbing the oxygen of the air; and the weight of the body thus formed (oxide of copper), is equal to the united weights of the copper and oxygen which have combined. Indeed, we can heat copper in a vessel, with the air excluded, and in this case its nature and weight are not changed; but if heated in a

convenient apparatus with air, the weight and composition of which are known, it will be found at the end of the experiment, that the air has lost a weight of oxygen equal to the increased weight of the copper itself. In the second example, the wood which burns and disappears, combines with the oxygen of the air; it gives birth to water and gaseous products. The total weight of this water and the gases, united with that of the ashes, is equal to the total weight of the wood and of the oxygen which has disappeared during the combustion.

This law leads immediately to another, of which it is a consequence. If we study the chemical transformations which the different bodies in nature undergo, we ascertain that all these transformations are effected between a certain number of substances which have not as yet been themselves decomposed, or resolved into different constituents. They are *simple bodies*, and represent the extreme limits of all our analyses. All compound bodies result from the combinations of these simple bodies. If these bodies cannot be decomposed, or annihilated, or transformed, it is evident that the *weight of each of the simple bodies entering into the formation of a compound body, must remain invariable.*

Upon the truth of this proposition rests the law referred to above. Indeed, to give an example, if the weight of the black substance formed by heating the copper, exposed to the air, is equal to the united weight of the transformed copper and the absorbed oxygen, it is because copper and oxygen, being simple bodies, cannot be decomposed.

"It is from this principle that we have the bases on which to make chemical experiments. We are obliged to suppose in all cases a true equality or equation be-

tween the elements of the body examined, and those which are obtained by analysis."—*Lavoisier, Tr. de Chim*, I. 141, 2*d edition.*

The discovery of the preceding laws and their experimental demonstration, pursued through the more general as well as the most important chemical phenomena, involving careful investigation into the constitution and nature of the simple bodies, secured at last defined bases for chemical science—such was the work of Lavoisier. In consequence of his labors in this field, he has remained the true founder of modern chemistry.

II.—Law of Definite Proportions.

When two bodies combine, the compound to which they give birth is formed by these two bodies in definite proportions.

Thus, nine parts of water consist of eight parts of oxygen and one of hydrogen, whatever the circumstances under which water is formed. If we burn a mixture of eight parts of oxygen and one of hydrogen, the entire mixture combines and forms nine parts of water; but if we burn a mixture of one part of hydrogen and nine parts of oxygen, eight parts of oxygen only unite with the one part of hydrogen. Nine parts of water are formed, all the hydrogen is burned, but one part of oxygen remains free without entering into the combination. In the same manner, if we burn a mixture of eight parts of oxygen with two of hydrogen, one part of hydrogen unites with eight parts of oxygen to form nine parts of water, and one part of hydrogen is left free.

This law applies not only to the combinations of simple bodies, as between each other, but also to the combinations of compound bodies. It is thus that fifty four parts of nitric acid exactly combine with twenty-

eight parts of lime, and form eighty-two parts of nitrate of lime. If more than fifty-four parts of the acid are used, the lime combines only with fifty-four parts of the acid, and the excess remains free. The result is similar if more than twenty-eight parts of lime are used for fifty four parts of acid.

The law of definite proportions has been generally accepted among chemists only since the beginning of the present century. It was for a long time opposed, on account of the possibility of combining two simple and compound bodies according to several proportions. It was thought that the combination was thus possible in all proportions, but only between two definite limits. Thus, forty-seven parts of potash combine with forty parts of sulphuric acid to form the sulphate of potash, and forty-seven parts of potash combine with eighty parts of sulphuric acid to form the bisulphate. Some chemists contended that the forty-seven parts of potash would unite indifferently with all proportions of acid between forty and eighty, forming in each case a definite compound. But this theory was confuted by careful attention to the phenomena. The combinations formed by the proportions included between the two extreme limits were not definite compounds, but were generally mixtures of the two definite combinations corresponding with the true limits. Thus, forty-seven parts of potash with forty parts of sulphuric acid form a definite compound (sulphate of potash). Another definite compound is formed by the union of forty-seven parts of potash and eighty of sulphuric acid (bisulphate of potash), but the compounds formed by the union of forty-seven parts of potash with more than forty parts, and less than eighty parts of sulphuric acid, are mixtures of two definite compounds, the sulphate and bisulphate of potash.

The proportions which exist between the weights forty and eighty of sulphuric acid which unite with forty-seven parts of potash, are to be noticed. The highest limit is just double that of the smallest. This proportion is not accidental; it results from a general law which explains the preceding considerations.

III.—Law of the Multiple Proportions.

When two bodies combine in several proportions, if an invariable weight of one of the bodies is taken, the weight of the other body, which enters into the combination to form definite compounds, is in the proportion of simple numbers.

Thus mercury and oxygen unite in two definite proportions: 100 parts of mercury combined with 4 parts of oxygen, form the protoxide of mercury; 100 parts of mercury combined with 8 (2×4) parts of oxygen form the binoxide; the proportions of oxygen combined with the same weight of mercury in these two compounds are as one to two.

In the same manner nitrogen and oxygen combine in five definite proportions: 14 parts of nitrogen combined with 8 parts of oxygen form the protoxide of nitrogen; 14 parts of nitrogen combined with 16 (2×8) parts of oxygen form the binoxide of nitrogen; 14 parts of nitrogen combined with 24 (3×8) parts of oxygen form nitrous acid; 14 parts of nitrogen combined with 32 (4×8) parts of oxygen form hyponitric acid; 14 parts of nitrogen combined with 40 (5×8) parts of oxygen form nitric acid. The weights of the oxygen combined with a constant weight of the nitrogen, are to each other as 1, 2, 3, 4, 5.

In the same manner (and this example is one of the most complicated in mineral chemistry), manganese and oxygen combine in five definite proportions: 27.6 parts

of manganese combined with 8 parts of oxygen form the protoxide of manganese; 27.6 parts of manganese combined with 10.67 ($8\times1\frac{1}{3}$) parts of oxygen form the mangano-manganese oxide; 27.6 parts of manganese combined with 12 ($8\times1\frac{1}{2}$) parts of oxygen form the sesquioxide of manganese; 27.6 parts of manganese combined with 16 (8×2) parts of manganese form the binoxide of manganese; 27.6 parts of manganese combined with 24 (8×3) parts of oxygen form the manganic acid; 27.6 parts of manganese combined with 28 ($8\times3\frac{1}{2}$) parts of oxygen form the permanganic acid. The weights of the oxygen combined with the constant weight of manganese are to each other as 1, 2, 3, $\frac{3}{2}$, $\frac{4}{3}$, $\frac{7}{2}$.

These proportions are not approximate, but are the results of rigorous experiments. They apply not only to the combinations of simple bodies, but also to the combinations of compound bodies.

IV.—Law of Chemical Equivalents.

The proportions, in weight, according to which two simple or compound bodies unite to form a third body, are often identical with the proportions in which they combine between themselves and all other bodies.

1 part of hydrogen united with 8 parts of oxygen forms water; 1 part of hydrogen united with 35.5 parts of chlorine forms hydrochloric acid. Then, on the one side, 35.5 parts of chlorine united with 8 parts of oxygen form hypochlorous acid; on the other side, if we determine what are the weights of potassium, zinc, copper, silver, &c., to which 8 parts of oxygen unite in the oxides, we find that it is to precisely the same weights of potassium, zinc, copper, silver, &c., that 35.5 parts of chlorine will be united in the chlorides. Thus the weights of chlorine and oxygen, which separately unite

with one part of hydrogen, are the same as those which unite with the same weights of different metals.

If all cases were similar to the one here mentioned, the law could be simplified; it would be sufficient to say that the weights of the simple bodies, uniting with the same weights of other bodies, are as between them, in constant proportion; but here arises a difficulty—chlorine and oxygen form several combinations. Which is the one to be taken for a term of comparison? These combinations necessarily obey the law of multiple proportions, and consequently, the weights of oxygen united with 35.5 parts of chlorine in any of these combinations, will be in a simple proportion with the weight of the oxygen united to one part of hydrogen, which is the enunciation of the above law. It is easy to verify it, for 35.5 parts of chlorine united with 8 parts of oxygen, form hypochlorous acid; 35.5 parts of chlorine united with 24 parts of oxygen form chlorous acid; with 32 parts of oxygen it forms hypochloric acid; with 40 parts of oxygen it forms chloric acid; with 56 parts of oxygen it forms perchloric acid.

We give a second example which explains the subject more fully. 8 parts of oxygen unite, on one side, with 1 part of hydrogen to form water; on the other side, the same quantity of oxygen unites with 14 parts of nitrogen to form the protoxide of nitrogen, and 14 parts of nitrogen unite with 3 parts of hydrogen to form ammonia; in this case the simple relation is that of 1 to 3. But as oxygen and nitrogen form several combinations, we take one of them as a starting-point. The weight according to which hydrogen and nitrogen unite with 8 parts of oxygen is necessarily in another proportion than the preceding, with the weights according to which nitrogen and hydrogen combine between each other, but

this proportion is always expressed by simple numbers. Thus, if we take water (8 parts of oxygen and 1 of hydrogen), for a term of comparison, and the binoxide of nitrogen in which 8 parts of oxygen unite with 7 parts of nitrogen; as 7 parts of nitrogen are united with $1\frac{1}{2}$ part of hydrogen to form ammonia, we shall have the relation $1 : 1\frac{1}{2}$. If we depart from water and from nitric acid (formed of 8 parts of oxygen and $\frac{1}{5}^4$ of nitrogen), $\frac{3}{5}$ part of hydrogen unites with $\frac{1}{5}^4$ of nitrogen in ammonia, and the relation will be $\frac{3}{5}$. These different relations, 3, $1\frac{1}{2}$, $\frac{3}{5}$, are between them as simple numbers.

We give a third example, more simple than the above. 1 part of hydrogen unites with 8 parts of oxygen to form water; 1 part of hydrogen unites with 16 parts of sulphur to form hydro-sulphuric acid; these 16 parts of sulphur combined with 16 parts of oxygen form sulphurous acid; combined with 24 parts of oxygen they form sulphuric acid.

The preceding law is the basis of the theory of chemical equivalents, that is, of the constant proportions of weights according to which bodies combine one with the other. It is applied as well to compound as to simple bodies, for the equivalent of a compound body is necessarily the sum of the equivalents of the simple bodies which form it, or a multiple of that sum.

The importance of this law is so great, that we give its applications to compound substances in the chronological order by which chemists were conducted to its verification, giving the different forms in which the preceding ideas were developed.

Law of Wenzel.

If we combine an acid with a base, according to the laws of definite proportions, there are certain proportions

according to which the acid and base unite without residue, and give birth to a single compound which is generally crystallizable. If the acid and base unite in a single proportion, the compound thus formed is ordinarily called a *neutral salt.* If they form several compounds, they follow the law of multiple proportions. To a constant weight of a base, weights of acid will unite in different proportions, and they will be to each other as simple numbers. One of these compounds will receive the name of *neutral salt.*

For more simplicity we shall reason as if acids and bases united two by two in a simple proportion.

It has been determined by experiment according to what proportions, acids and bases combine. It has thus been ascertained:—

First, that 40 parts of sulphuric acid unite essentially and form a definite neutral salt with

47.1	parts of	potash,
31.0	"	soda,
28.0	"	lime,
76.6	"	baryta,
20.6	"	magnesia.
40.5	"	oxide of zinc,
111.6	"	lead,
115.9	"	silver.

Second. It was then determined by actual experiment that 54 parts of nitric acid were necessary to form a neutral salt with 47.1 parts of potash; this was followed by further experiments to determine the quantity of soda, lime, etc., necessary to combine with 54 parts of nitric acid to form a definite neutral salt. It was ascertained that 54 parts of nitric acid unite exactly, and form a neutral definite salt with the same quantities of the different bases named in the above table. That is, that the

weights of the different bases which saturate and neutralize 40 parts of sulphuric acid, are the same as those which saturate 54 parts of nitric acid.

Third. Experiments were next made to determine how much chloric acid was necessary to form a neutral salt with 47.1 parts of potash, when it was found that 75.5 parts of chloric acid fulfill this condition. The weights of soda, lime, etc., which would combine with 75.5 of chloric acid to form a definite neutral salt were next sought, and it was found that 75.5 parts of chloric acid exactly unite with the same quantities of the above bases. That is, that the weights of the different bases which saturate 40 parts of sulphuric acid are the same as those necessary to saturate 75.5 parts of chloric acid.

These experiments made with different acids have constantly given the same results, from which we have the following rule: The weights of the different bases which saturate a fixed weight of a determined acid, are proportioned to the weights of the same base which saturate the same weight of any acid; and reciprocally, the weights of the different acids which saturate a determined base are proportioned to the weights of the same acid which saturate any base.

This is the law of Wenzel, or of the *proportional numbers.* By it, the weights of the bases which stand as *equivalents* towards the acids, and the weights of the acids which bear the same relation to the bases, are thus represented:—

47.1 parts of potash,
31.0 " soda,
111.6 " oxide of lead,
115.9 " " silver,

are as equivalent to

40 parts of sulphuric acid,
54 " nitric acid,
75.5 " chloric acid.

Such is the origin of the term *chemical equivalents:* the definition given above expresses a more general sense.

Wenzel was a contemporary of Lavoisier. He was led to this law by reflecting on the phenomena of the double decomposition of salts. In the action of two salts dissolved in water, a double decomposition is often produced, by which two new salts take birth—one insoluble, which is precipitated; the other soluble, which remains in solution. Thus, if we treat a solution of nitrate of baryta by a solution of sulphate of soda, sulphate of baryta is formed; this salt is insoluble, and is precipitated, and the nitrate of soda being soluble, remains in solution. Consequently, in this reaction neither acid nor alkali is set free; the two salts used are exactly substituted by two other salts.

A characteristic purely empirical, enables us to ascertain very easily, the above facts. Neutral salts, formed by the union of an energetic acid with a powerful base ordinarily present this characteristic—they have no sensible action on litmus paper. This peculiarity is frequently used in determining neutral salts, but it is important to remark that it does not present any theoretical signification. The neutral salt may be characterized as a preparation between the base and the acid which concur to form it, so proportioned that a definite and single compound is formed. Consequently, the nitrate of baryta, the sulphate of soda, and the nitrate of soda, salts chemically neutral, are at the same time without any sensible action on litmus paper. Also, the original solutions have no action on this coloring matter. They do not change it after their reunion, and the precipitation of the sulphate of baryta, which shows that neither acid nor base has been set free. This fundamen-

tal fact is expressed by saying that the two neutral salts have reacted one on the other, and produced a double decomposition preserving the neutrality. This shows us that nitric acid, which exactly saturates the baryta, exactly saturates the soda which was before neutralized by sulphuric acid, that is, that the two bases and the two acids are, respectively, equivalents.

Law of Richter.

From the law of Wenzel we have the equivalents of acids and bases, but not those of the simple bodies. A law discovered by Richter about the same time, carries us further. It indicates in what proportion metals are precipitated.

If, in a solution of sulphate of oxide of silver, we introduce a piece of copper, we soon see the silver precipitated in bright and crystalline flocks, while the copper is dissolved. After a certain time all the silver is precipitated, and the liquid contains only sulphate of oxide of copper, without excess of acid or oxide. For 107.9 parts of silver precipitated, 31.6 parts of copper have entered in solution. The same experiment made with a diluted solution of any salt of silver will give the same results. The chemical neutrality of the liquor was not changed, and for 107.9 parts of silver precipitated, 31.6 parts of copper were dissolved.

Instead of precipitating silver by copper, we can use zinc; the phenomena are the same, only the weight of the zinc dissolved is more considerable. For 107.9 parts of silver precipitated, 32.5 parts of zinc are dissolved. Silver may be precipitated by iron with the same results; 28 parts of iron are dissolved for 107.9 parts of silver precipitated. Many other metals will precipitate silver with the same results; but for the

same weight of silver precipitated, the weight of each precipitating metal will be different.

The same series of experiments may be made with the sulphate of copper. If, into a solution of sulphate of copper, we introduce a plate of zinc, the copper is precipitated and the zinc is dissolved, and we see that for 31.6 parts of copper precipitated, 32.5 parts of zinc are dissolved. If we precipitate by iron, we find that for 31.6 parts of copper precipitated, 28 parts of iron are dissolved. The phenomena are the same with several other metals.

Experiment has also shown, that the weights of the different metals which will precipitate 107.9 parts of silver, will also precipitate 31.6 parts of copper; the weights 32.5 of zinc and 28 of iron, which precipitate 107.9 of silver, precipitate also 31.6 of copper. Generally, the weights of the different metals which precipitate the same weight of one of them, are proportional to the weights which precipitate the same weight of a second metal. It is from the weights, according to which the same metals precipitate each other, that a table of their equivalents can be made.

If we remark that some metalloids—chlorine, bromine, iodine, for example—displace each other according to the same principles, a table of their equivalents can also be made.

These two tables of the equivalents of metals and metalloids are not distinct from the tables of the equivalents of bases and acids, as is shown by the following consideration: When metals precipitate each other, it always occurs, if the operation is carefully performed, that the chemical neutrality is not modified. There are neither bases nor acids set free, and there is no disengagement of gas. It results then:—

First, That the quantities of sulphate of oxide of silver, of sulphate of oxide of copper, of sulphate of oxide of zinc, etc., which respectively contain 107.9 parts of silver, 31.6 parts of copper, and 32.5 parts of zinc, contain the same quantities of sulphuric acid, since the chemical neutrality has not changed.

Second, That the quantity of oxygen combined with 107.9 parts of silver, is the same as that combined with 31.6 of copper, with 32.5 of zinc, and with 28 of iron, in the sulphates of these oxides. We conclude from this, that the weights of the different metals which are equivalents, combined with the same proportion of oxygen, form equivalent bases with sulphuric and other acids. Then it is sufficient to determine the equivalents of the bases and the quantity of oxygen contained in the equivalents, to deduce the equivalents of the metals. If a metal forms two oxides capable of uniting with the acids, each of these oxides has its equivalent, which leads to two distinct weights for the equivalent of the metal, but these two weights will be between each other as simple numbers. Then it is sufficient to choose the most convenient to conform to the analogies.

Thus 40 parts of sulphuric acid form a neutral definite salt with 36 parts of protoxide of iron and with 26.7 parts of sesquioxide of iron. These two numbers express the equivalents of these two oxides, which contain the same weight (8) of oxygen. Then the equivalent of iron may be designated by 28 or 18.7. These two numbers are between them as 3 : 2. The first has been preferred as more conformable to the analogies.

The equivalents of the metalloids are determined in the same manner. We may compare, for example, the composition of the oxides, sulphides, selenides, chlorides, etc., formed by one or several metals, and we will thus

find the proportions according to which oxygen, sulphur, selenium, etc., are equivalents. Two parallel tables are thus obtained, one containing the equivalents of the metalloids, the other the equivalents of the metals.

Nearly all metalloids unite, sometimes with oxygen, sometimes with metals; then they form a common tie between these two parallel series.

Law of Berzelius.

If the acid is oxygenated, there must of necessity be a simple proportion between the oxygen of the acid and the oxygen of the base, necessary to neutralize it. This simple proportion is of great importance in chemistry and mineralogy, being frequently used to define neutral salts. For the sulphates the proportion is as 3 : 1 ; for the nitrate as 5 : 1, etc.

The different laws which we have given—the law of Wenzel, the law of Richter, the law of Berzelius—afford peculiar illustrations of the general laws given at the commencement, as well as throw much light on the real nature of the equivalent; for, to the idea of simple numerical proportions, they add the idea of a similar chemical function. But it is important to remark, that this last idea has something arbitrary and hypothetical; while the chemical equivalents, considered as simple proportions of weights, take a characteristic nearly absolute, and at once present a degree of peculiarity as elevated as the best established natural laws.

Determination of the Equivalents.

From the foregoing statements it is easy to understand how the equivalent of a simple body can be determined; it is sufficient to engage that body in a definite combination with another body, the equivalent of which

is known—with oxygen in nearly every case—and to determine the true proportion of weight existing between the two elements of that combination. The equivalent sought is obtained, or at least a multiple or a submultiple of that equivalent.

To decide this last point, and to fix the real equivalent, try to unite the binary compound with another binary compound, the equivalent of which is known; if the first body is an acid, combine it with a base; if it is a base, unite it with an acid; and then determine what weight of the base in the first case is united to the equivalent of the acid, and what weight of the acid in the second case, is united to the equivalent of the base, from which the equivalent of the simple body is easily deduced. The ponderal proportion between zinc and oxygen is equal to $\frac{100}{24.6}$ $\frac{106.5}{100}$.

To one equivalent of sulphuric acid (500) unite 506.5 parts of oxide of zinc: the number 506.5 expresses the equivalent of the oxide of zinc, and it follows that the number 406.5 expresses the equivalent of the zinc comparatively to that of oxygen=100.

In some cases, the determination of the precise numbers is more difficult, especially in finding the equivalents of the metalloids, which form with oxygen a single combination of an acid nature. If this acid unites with the bases in several proportions, as, for example, silicic and boracic acids, we can determine what is, in such definite salt, the proportion between the acid and the base, and more, we could also determine it from the acid, and the proportion between the oxygen and the metalloids; but there is some uncertainty between several equivalents of the metalloids and their acids, all being multiples one of the other, and all equally probable. It is thus that some chemists adopt for the equivalent of

boron the number 21.8, and others the number 10.9. In the same manner, the equivalent of silicium adopted by nearly all chemists is equal to 21.4, but others prefer 7.13 or even 14.27.

Isomorphism.

Some compounds, very similar in their composition and in their properties, present the same crystalline form, either in a free state, or in the combinations they form with some other substances. Thus, the three corresponding compounds formed by chlorine, bromine, iodine, with the same metal, present generally the same crystalline form. The sulphates and seleniates of the same bases have generally the same crystalline form; they ordinarily unite with the same quantities of water, and present the same phenomena of solubility and insolubility. When the bodies thus present the same crystalline form, they are called *isomorphous.*

Isomorphous bodies, if mixed, crystallize together in indefinite proportions, each crystal containing a variable and not a definite proportion of the different isomorphous compounds. The phenomenon of isomorphism was discovered by Mitscherlich. It affords the means of making more precise the ideas of the chemical analysis cited above, and is a great help in the definitive fixation of the equivalents.

In the following table we give a list of the equivalents. In the first column are the names of the simple bodies; in the second their equivalents compared to hydrogen as unit. This remark is necessary, as the equivalents are not absolute weights, but proportions of weights, so that a unit must be chosen. In the third column the equivalents are calculated from oxygen=100 for a unit. In the fourth column is the symbol of each

simple body. Each of these symbols represents not only the body, but also its equivalent. In the fifth column we have indicated the formula of the fundamental combination, from which analysis has determined the equivalent indicated in the table.

Table of the Equivalents of the Simple Bodies.

Simple Bodies.	Equivalent brought to		Symbol.	Formula of fundamental compound.
	Hydrogen = 1.	Oxygen = 100.		
Aluminum or Aluminium	13.7	170.9	Al	Al^2O^3
Antimony (Stibium)	129	1613	Sb	SbO^3
Arsenic	75	937.5	As	AsO^3
Barium	68.6	858	Ba	BaO
Bismuth	208	2600	Bi	BiO^3
Boron	21.8	272.4	B	BO^6
Bromine	80	1000	Br	HBr
Cadmium	55.7	696.7	Cd	CdO
Calcium	20	250	Ca	CaO
Carbon	6	75	C	CO^2
Cerium	47	587.5	Ce	CeO
Chlorine	35.5	443.2	Cl	HCl
Chromium	26.3	828.5	Cr	Cr^2O^3
Cobalt	29.5	368.6	Co	CoO
Copper	31.6	395.6	Cu	CuO
Didymium	48	600	Di	DiO
Erbium	.....	.....	E	
Fluorine	18.8	235.4	Fl	HFl
Glucinium or Beryllium	4.6	58	Gl or Be	GlO
Gold (Aurum)	196.4	2455.6	Au	AuO^3
Hydrogen	1	12.5	H	HO
Iodine	126.9	1586	I	HI
Iridium	98.6	1232.1	Ir	Ir^2O^3
Iron (Ferrum)	28	350	Fe	FeO
Lanthanium	47	587.5	La	LaO
Lead (Plumbum)	103.6	1294.6	Pb	PbO
Lithium	6.5	81.6	Li	LiO
Magnesium	12.6	158.1	Mg	MgO
Manganese	27.6	344.6	Mn	MnO
Mercury (Hydrargyrum)	100	1250	Hg	HgO
Molybdenum	46	575	Mo	MoO^3
Nickel	29.6	369.4	Ni	NiO
Niobium	.....	.....	Nb	
Nitrogen (Azote)	14	175	N or Az	NO^5
Norium	.....	.....	No	
Osmium	99.4	1242.6	Os	OsO^4
Oxygen	8	100	O	HO
Palladium	53.2	665.5	Pd	PdCl
Phosphorus	32	287.5	Ph	PhO^5
Platinum	98.6	1232.1	Pt	$PtCl^3$
Potassium (Kalium)	39.1	489.2	K	KO
Rhodium	52.2	652	R	R^2Cl^3
Ruthenium	51.7	646	Ru	Ru^2Cl^3

Simple Bodies.	Equivalent brought to		Symbol.	Formula of fundamental compound.
	Hydrogen = 1.	Oxygen = 100.		
Selenium	39.6	495.2	Se	HSe
Silicon or Silicium	21.4	266.9	Si	SiO^1
Silver (Argentum)	107.9	1349	Ag	AgO
Sodium (Natrium)	23	287.1	Na	NaO
Sulphur	16	200	S	SO^3
Strontium	43.8	548	Sr	SrO
Tantalium	183.8	2296.8	Ta	TaO^3
Tellurium	64.1	801.7	Te	HTe
Terbium	.....	.....	Tb	
Thorium	59.5	743.9	Th	ThO
Tin (Stannum)	58.8	735.2	St	StO^2
Titanium	25.2	314.7	Ti	TiO^2
Tungsten (Wolfram)	95.1	1188.4	W	WO^3
Uranium	60	750	U	U^2O^3
Vanadium	68.5	855.9	V	VO^3
Yttrium	32.2	402.3	Y	YO
Zinc	32.5	406.5	Zn	ZnO
Zirconium	22.4	280	Zr	ZrO

A few examples will demonstrate the use of the above table.

1st. Alumina is represented by the formula Al^2O^3. How many grains of aluminium and oxygen are respectively contained in 10 grains?

$$Al^2 = 13.7 \times 2 = 27.4$$
$$O^3 = 8 \times 3 = 24.0$$
$$Al^2O^3 = 51.4$$
$$Al^2O^3 : O^3 :: 51.4 : 24 :: 10 : x.$$

The weight of the oxygen $x = \frac{24 \times 10}{51.4} = 4.67$ grains.

consequently that of the aluminium

$$= 10 - 4.67 = 5.33 \text{ grains.}$$

2d. Alum is represented by the formula

$$KO,SO^3 + Al^2O^3,3SO^3 + 24HO.$$

Which is the quantity of each contained in 25 parts?

KO	=	47.1
SO^3	=	40.0
Al^2O^3	=	51.4
$3SO^3$	=	120.0
24HO	=	216.0
		474.5

474.5 : 47.1 (potash) :: 25 : x = 2.48 potash;
474.5 : 51.4 (alumina) :: 25 : x = 2.71 alumina;
474.5 : 160 (sulphuric acid) :: 25 : x = 8.43 sulphuric acid;
474.5 : 216 (water) :: 25 : x = 11.38 water.

3d. The analysis of peroxide of iron has shown that 100 parts of that substance contain 70 parts of iron, and 30 of oxygen. The question is to find the most simple formula by which these results can be represented. Let us see what will be the weight of the oxygen combined in the peroxide, to one equivalent (28) of iron. We have the proportion

70 : 30 :: 28 : x = 12; Therefore,

to one equivalent of iron (28), 12 parts of oxygen are combined, that is $8 \times 1\frac{1}{2}$ or $1\frac{1}{2}$ equivalent; or in full numbers, 2 equivalents of iron are combined to 3 equivalents of oxygen. The formula is then Fe^2O^3.

4th. In the analysis of two parts of a metallic sulphide, the sulphur has been changed to sulphuric acid, which has been precipitated in the form of sulphate of baryta. Three parts of this sulphate have been obtained; the question is to find how much sulphur is in the two parts of the sulphide.

S has given BaO, SO^3, consequently we have:—

BaO	76.6
S	16.0
O^3	24.0
	116.6 parts sulphate of baryta.

Then 116.6 : 16 :: 3 : x = 0.411.

5th. What is the quantity of chlorate of potash necessary to obtain 20 grains of oxygen?

KO, ClO^5 gives $O^6=48$.

K	39.1
O	8.0
Cl	35.5
O^5	40
	122.6

Then 48 : 122.6 :: 20 : x=51.83.

6th. What quantities of bicarbonate of soda and bisulphate of potash are necessary to obtain one quart of gaseous water, containing 12 parts of carbonic acid?

One equivalent of bicarbonate of soda ($NaO,HO,2CO^2$) is exactly decomposed by one equivalent of bisulphate of potash ($KO,HO,2SO^3$), and furnishes 2 equivalents of carbonic acid ($2CO^2$).

Na	23	KO	39.1	2C	12
O	8	O	8.0	4O	32
HO	9	HO	9.0		44
2C	12	2S	32.0		
4O	32	6O	48		
	84		136.1		

44 : 84 :: 12 : x=29.91 weight of bicarbonate.
44 : 136.1 :: 12 : x=27.12 " bisulphate.

The equivalents not only represent all the chemical transformations of the simple or compound substances, but they play a fundamental part in the decomposition of compound bodies by electricity; and they are connected with the different physical properties of the simple or compound substances, principally those dependent upon their specific gravity, their specific heat, and their solid or gaseous form.

CHAPTER IV.

CHEMICAL REACTIONS.

I.—Different Cases of Reactions.

Bodies react one upon the other, according to invariable and precise laws, the discovery of which is due to Berthollet. These laws govern all the combinations and decompositions which can be produced between two bodies. Let us examine the cases which may occur.

1st. Two metalloids or two metals, a metal and a metalloid in contact, may or may not combine, or remain without action; in such case they only obey the law of affinity, and it is upon this law that depends the chemical phenomenon which occurs between them.

2d. A metal or a metalloid in contact with a binary body may or may not give a reaction, according to its affinity; for one of the two elements of the binary body must be too strong or too weak for one or the other of the two first-named bodies. It is also the ordinary law of affinity which alone governs these phenomena.

3d. An acid may react on a salt.

4th. A base may react on a salt.

5th. A salt may react on another salt.

In the last three cases it is not only the law of affinity that these bodies obey, but the reactions which are produced are governed by new laws which we shall examine in turn.

II.—Action of Acids on Salts.

A salt and an acid being in presence, we ought to consider the two principal cases, the one in which the acid added is not the same as the one already combined with the salt; and the other in which the acid is the same.

Let us consider the first case: In four different circumstances there will be a decomposition of the salt, the acid it contains will be set free, and the acid added will take its place in an equivalent quantity. This important decomposition takes place as follows:—

1st. *When the acid added can give, with the base of the salt, an insoluble compound or one less soluble than the pre-existing salt.*

Example.—The nitrate of baryta is soluble, the sulphate is not. If we add sulphuric acid to nitrate of baryta there will be a decomposition, precipitation of sulphate of baryta, and nitric acid is set free.

$$\underbrace{SO^3HO}_{\text{Sulphuric acid.}} + \underbrace{BaO,NO^5}_{\text{Nitrate baryta.}} = \underbrace{BaO,SO^3}_{\text{Sulphate baryta.}} + \underbrace{NO^5HO}_{\text{Nitric acid.}}$$

2d. *The acid existing in the salt is insoluble or less soluble than the acid added.*

Example.—Silicic acid is insoluble, sulphuric acid is very soluble; if we add the latter to a solution of silicate of soda there is a decomposition, formation of sulphate of soda, and precipitation of silicic acid.

$$\underbrace{NaO,SiO^3}_{\text{Silicate soda.}} + \underbrace{SO^3HO}_{\text{Sulphuric acid.}} = \underbrace{NaO,SO^3}_{\text{Sulphate soda.}} + \underbrace{SiO^3,HO}_{\text{Silicic acid.}}$$

3d. *The acid existing in the salt is more volatile than the acid added.*

Example.—Carbonic acid is more volatile than sulphuric acid; if we pour the latter on carbonate of soda there is a decomposition, formation of sulphate of soda, and carbonic acid is set free.

$$\underbrace{NaO,CO^2}_{\text{Carbonate Soda.}} + \underbrace{SO^3HO}_{\text{Sulphuric Acid.}} = \underbrace{NaO,SO^3}_{\text{Sulphate Soda.}} + \underbrace{HO}_{\text{Water.}} + \underbrace{CO^2}_{\text{Carbonic Acid.}}$$

4th. *The differences we have noted between the two acids, in regard to solubility and fixity, being small or even null, one of the acids happens to be employed in great excess in relation to the other.*

EXAMPLE.—Hydrosulphuric and carbonic acids have very little chemical difference; it seems, then, that by treating a carbonate with hydrosulphuric acid, or a hydrosulphate with carbonic acid, no reaction ought to take place. However, there will be a decomposition when a certain quantity of carbonate is treated by an excess of hydrosulphuric acid, or when a certain quantity of hydrosulphate is treated by a great excess of carbonic acid.

$$\underbrace{NaO,CO^2}_{\text{Carbonate Soda.}} + \underbrace{HS}_{\text{Hydrosulphuric Acid.}} = \underbrace{NaS}_{\text{Sulphide Sodium.}} + \underbrace{HO}_{\text{Water.}} + \underbrace{CO^2}_{\text{Carbonic Acid.}}$$

$$\underbrace{NaS}_{\text{Sulphide Sodium.}} + \underbrace{CO^2}_{\text{Carbonic Acid.}} + \underbrace{HO}_{\text{Water.}} = \underbrace{NaO,CO^2}_{\text{Carbonate Soda.}} + \underbrace{HS}_{\text{Hydrosulphuric Acid.}}$$

Let us now examine the second case, that in which the acid added is the same as the one existing in the salt. It will act in either of the following modes: that the acid mixes with the salt without producing any effect, or it accelerates its solution in water, or it adds itself to the neutral salt and forms an acid salt, as, for example:—

$$\underbrace{KO,SO^3}_{\text{Sulphate Potash.}} + \underbrace{SO^3HO}_{\text{Sulphuric Acid.}} = \underbrace{KO,(SO^3)^2}_{\text{Bisulphate Potash.}} + \underbrace{HO}_{\text{Water.}}$$

III.—ACTION OF BASES ON SALTS.

The greatest analogy exists between the laws governing this order of phenomena and those we have described. If we add a new base to a salt, there is a

decomposition, *i. e.*, union of the acid with the new base, and the first one is set free, thus:—

1st. *When the new base can form with the acid an insoluble salt, or one less soluble than the original one.*

2d. *When the new base being soluble, that which is combined with the acid is insoluble, or less soluble than the other.*

3d. *When the base of the original salt is more volatile than the one added.*

4th. *When lastly, the base added being insoluble, like that of the original salt, the decomposition can nevertheless take place.*

If the base added were the same as the one contained in the salt, we should observe the same phenomena we have alluded to in the case of the addition of an acid to a salt containing the same acid.

IV.—Action of Salts on each other.

We consider here three cases: one in which both salts are dissolved; another in which they are mixed by the dry process; and a third in which one only is dissolved, the other being insoluble. The first is governed by a simple law of a remarkable generality:—

When two salts are put together, if, by the exchange of their bases and their acids, they can form two other salts, of which one is insoluble or less soluble than the first two, or unable to dissolve in the quantity of solvent used, a double decomposition takes place, and the less soluble salt is precipitated.

Example.—Sulphate of soda and nitrate of baryta are both soluble, while sulphate of baryta is not: if we mix the first two, a double decomposition takes place. Sulphuric acid, substituting itself for the nitric acid, united

to baryta, will form an insoluble sulphate; while nitric acid, uniting with soda, will form soluble nitrate of soda.

$$\underbrace{NaO,SO^3}_{\text{Sulphate Soda.}} + \underbrace{BaO,NO^5}_{\text{Nitrate Baryta.}} = \underbrace{BaO,SO^3}_{\text{Sulphate Baryta.}} + \underbrace{NaO,NO^5}_{\text{Nitrate Soda.}}$$

The second case is when the salts are mixed by the dry process. The double decomposition takes place *when, by the exchange of the acids and bases, a salt is formed which is more volatile than the first two salts.* We see that the law is the same under these two circumstances, only in the second the volatility takes the place of the solubility.

EXAMPLE.—The sulphate of ammonia is less volatile than the chlorhydrate of the same base; it is the same with chloride of sodium. If we heat a mixture of sulphate of ammonia and chloride of sodium, a double decomposition takes place, and we see the chlorhydrate of ammonia volatilize, while there remains in the apparatus used for this purpose, sulphate of soda, which is fixed.

$$\underbrace{NH^3,SO^3,HO}_{\text{Sulphate of Ammonia.}} + \underbrace{NaCl}_{\text{Chloride Sodium.}} = \underbrace{NaO,SO^3}_{\text{Sulphate Soda.}} + \underbrace{NH^3,HCl}_{\text{Chlorhydrate Ammonia.}}$$

The third case has been examined by Dulong; it concerns the reactions which occur in a liquid when a soluble salt is mixed with an insoluble one. This law may be stated thus:—

There is a double decomposition when the base of the insoluble salt can form, with the acid of the soluble salt, an insoluble compound having a powerful cohesion.

EXAMPLE.—The insoluble sulphate of baryta boiled with a solution of carbonate of soda, gives carbonate of baryta, which is insoluble, and sulphate of soda; but to effect this reaction a great excess of carbonate of soda must be used. On the contrary, when a small quantity

of carbonate of baryta is boiled with a large excess of sulphate of soda the reverse reaction takes place, so that we can have

$$\underbrace{BaO,SO^3}_{\text{Sulphate Baryta.}} + \underbrace{NaO,CO^2}_{\text{Carbonate Soda.}} = \underbrace{NaO,SO^3}_{\text{Sulphate Soda.}} + \underbrace{BaO,CO^2}_{\text{Carbonate Baryta.}}$$

$$\underbrace{BaO,CO^2}_{\text{Carbonate Baryta.}} + \underbrace{NaO,SO^3}_{\text{Sulphate Soda.}} = \underbrace{NaO,CO^2}_{\text{Carbonate Soda.}} + \underbrace{BaO,SO^3}_{\text{Sulphate Baryta.}}$$

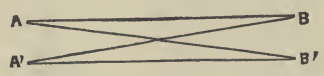
V.—General Formulæ.

Such are the laws which govern the reactions of different chemical compounds; at first they look complex, but all can be easily brought back to the same principle, the *double decomposition.*

As for the question relating to the action of the salts on each other, nothing is more easy of solution, and that is the real type of the double decomposition, of which a kind of general formula can be given in the following manner: A and A′ are two acids, B and B′ two bases, forming two salts that we shall write

$$A + B \text{ and } A' + B'$$

Let us put these salts in contact, and make between the two an exchange by a displacement, thus:—

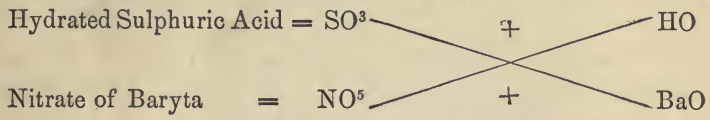


Let us suppose A goes to B′, and A′ to B; when A B′ or A′B is insoluble, or less soluble than A B and A′B′, there is a double decomposition. The result would be the same by the dry process if A B′ should be more volatile than A B and A′ B′.

The laws governing the action of the bases or acids on the salts, may be ranked in the same general formulæ, for bases and acids are always hydrated or mixed with water, and then it intervenes, so as to make from the

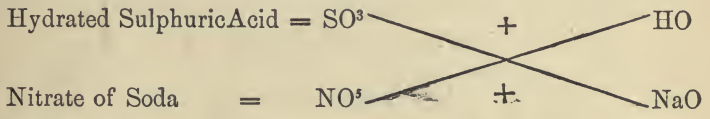
base or the acid a hydrate—that is, a true salt—which is then submitted to the laws governing the action of the salts on each other. A few examples will illustrate the principle, and render more easy of comprehension this important matter of the double decomposition.

1st. *Action of the Acids on Salt.*—Let us take, for example, hydrated sulphuric acid and nitrate of baryta:—



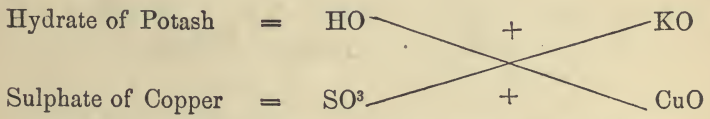
Let us examine what is the result of this exchange; hydrated nitric acid and sulphate of baryta. Then we know by experience that the latter is insoluble, consequently there will be a double decomposition.

Let us treat nitrate of soda by this same sulphuric acid.



The nitric acid is more volatile than the sulphuric acid; consequently, there will be a double decomposition, etc.

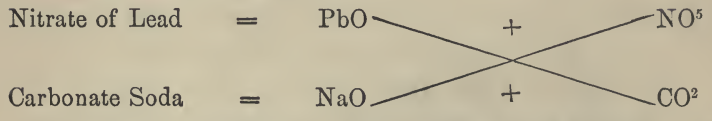
2d. *Action of Bases on Salts.*—It is the same. Let us take hydrate of potash, and mix it with sulphate of copper.



The hydrated oxide of copper which is formed is insoluble, consequently there is a double decomposition.

3d. *Mutual Action of the Salts.*—The generality of the

formulæ is more striking in this case than in the first two. Let us take, for example, the nitrate of lead and carbonate of soda. We have



Experience teaches us that carbonate of lead is insoluble, while the two other salts dissolve easily, consequently there is a double decomposition.

It is useless to insist further on this point; a few exercises will teach rapidly the use of the simple and valuable mechanism of double decomposition.

CHAPTER V.

SPECIAL CHARACTERISTICS OF THE DIFFERENT CLASSES OF BODIES.

I.—Metalloids.

Metalloids have no similar physical properties, and differ entirely from each other. Some are gaseous and may often be liquefied under pressure, some are entirely refractory to that action; others are liquid, others solid. They have no common physical properties. It was an error when it was asserted, that metalloids differ from metals by the absence of metallic lustre. Recent works have shown that it is otherwise. As for the chemical properties, they are similar in the activity they exhibit in combining with oxygen to form acid compounds. While metals by combining with oxygen generally furnish bases, metalloids under the same circumstances form energetic acids, having great stability. Besides (and it

is a characteristic property), the oxides they form have no basic element.

Besides this general property of the metalloids, experiment has made known others which are common, and which have permitted a classification of the metalloids by groups, which groups seem to constitute natural families, the members of which play in the combinations the same part, and can be substituted one for the other. There are four:—

1st group.	2d group.	3d group.	4th group.
Hydrogen,	Oxygen,	Nitrogen,	Carbon,
Chlorine,	Sulphur,	Phosphorus,	Boron,
Bromine,	Selenium,	Arsenic.	Silicium.
Iodine.	Tellurium.		

It will be difficult just now to establish in what respects the bodies of each group are similar, but we can show how they approach each other.

II.—Metals.

Metals are opaque bodies, good conductors of heat and electricity, and have a peculiar lustre which has been called *metallic*, and which disappears when the metal is in a state of division.

The opacity of metals is maintained only under a certain thickness; reduced to very thin laminæ, they become translucent, and allow a certain quantity of colored light to pass through them; gold, for example, permits the passage of a light which is then colored green. There are forty-six metals well studied, but leaving out the unimportant, the number of useful ones is reduced to twenty-nine.

The principal characteristic properties of metals are density, *conductibility* for caloric and electricity, fusibility, ductility, malleability, tenacity, hardness, etc. Metals

are all solid at the ordinary temperature except mercury. All melt at variable temperatures; some can be reduced to vapor. They all unite with oxygen; sometimes the combination is effected with a disengagement of heat and light; the resulting body generally has a tarnished aspect, and is entirely different from the metal which has produced it.

There are several kinds of oxides, corresponding to different degrees of oxidation of the metal. The principal ones are those which unite with acids and form salts; they are the oxides called *basic*. Besides, there exist four classes of oxides: the *indifferent oxides*, the *acid oxides*, the *singular oxides*, and the *saline oxides*.

All metals unite directly or indirectly with chlorine, bromine, iodine, and fluorine, and form perfectly definite compounds. Sulphur combines with metals and gives a sulphide when the metal forms weak oxides, and a sulphate when it forms a powerful base.

Hydrogen, nitrogen, phosphorus, arsenic, boron, silicium, and carbon, with difficulty, and rarely, form with metals, definite combinations.

Metals by uniting together form *alloys*, compounds which play a great part in industry. Indeed, it is rare that a single metal possesses all the properties that its uses in the arts demand.

The greater or less affinity of the metals for oxygen, makes their decomposing action on water very variable. It is upon this property that is based the classification made by THENARD, and which is exhibited in the following table.

CLASSIFICATION OF METALS.

1st Section.	Absorb oxygen and decompose water at all temperatures.	*Potassium*, *Sodium*, *Lithium*, *Calcium*, *Barium*, *Strontium*.
2d Section.	Absorb oxygen at the most elevated temperature, decompose water above 122° F. Their oxides are not decomposed by heat alone.	*Magnesium*, *Manganese*, *Aluminium*, *Glucinum*, *Zirconium*, *Yttrium*, *Thorium*, *Cerium*, *Lanthanium*, *Didymium*, *Erbium*, *Terbium*.
3d Section.	Absorb oxygen at a red heat; decompose water above 212°, but below red heat. Their oxides are undecomposed by heat alone; they decompose water in presence of acids.	*Iron*, *Nickel*, *Cobalt*, *Chromium*, *Vanadium*, *Zinc*, *Cadmium*, *Uranium*.
4th Section.	Absorb oxygen at a red heat; decompose water at a dark red heat. Their oxides are undecomposed by heat alone; they decompose water in presence of alkalies.	*Tungsten*, *Molybdenum*, *Osmium*, *Tantalium*, *Tin*, *Antimony*, *Niobium*, *Ilmenium*, *Pelopium*.
5th Section.	Absorb oxygen at a red heat; decompose water at a high temperature. Their oxides are undecomposable by heat alone; they do not decompose water in presence of acids or alkalies.	*Copper*, *Lead*, *Bismuth*,
6th Section.	Their oxides are easily reduced by heat alone; they do not decompose water, whatever is the temperature, even in presence of acids or alkalies.	*Mercury*, *Silver*, *Rhodium*, *Iridium*, *Palladium*, *Ruthenium*, *Platinum*, *Gold*.

III.—Acids.

If the oxides or bases are easy to distinguish by certain general properties, it is not so with acids, for the latter present a great diversity of characteristics. They may be divided into two distinct classes: the acids formed by the metalloids, and those produced by the metals.

Acids generally possess great stability; they will resist the action of heat; nearly all of them may be volatilized. Some are gaseous; nearly all possess the sour taste to which they owe their name. All are more or less soluble in water; some are solid and crystallizable.

On the contrary, metallic acids have no stability; they decompose very easily, by giving products of oxidization of an inferior degree, demonstrating thus the tendency of metals to form bases rather than acids.

Their energy of saturation varies much, and cannot be used to classify them; it would determine only a general and essential character to group them together.

IV.—Oxides.

The compounds formed by the union of a metal with oxygen have received the name of *oxides*. They are divided into five classes.

1st. The *basic oxides*, capable of uniting with acids to form definite salts; the most important are the oxides of the alkaline metals.

2d. The *acid oxides*, which combine with bases to form definite salts, and which unite very rarely with acids; such are the tungstic, antimonic acids, etc.

3d. The *indifferent oxides*, which do, as their name indicates, unite sometimes with bases, and sometimes

with acids to form salts; such is the oxide of aluminium (alumina).

4th. The *singular oxides*, which never unite with bases or acids; some of them, in contact with hydracids, decompose them, abandon their oxygen which combines with the hydrogen of the acid to form water, while the metal unites to the radical which the acid sets free. With ox-acids, they lose a part of their oxygen, which disengages, or unites with water to form binoxide of hydrogen. Such are the binoxides of barium and manganese. Others, as the suboxide of lead, in contact with acids, are decomposed into metals and protoxides, which unite with the acid.

5th. The *saline oxides*, which are in reality nothing but combinations of protoxide with a more oxygenated oxide of the same metal; such is the red oxide of manganese, Mn^3O^4, which may be represented by the formula, $2MnO + MnO^2$.

Many oxides are reduced by hydrogen gas under the influence of heat; the metal is set free at the same time that water is formed. We must except the metals of the first two sections.

Charcoal reduces to the metallic state the oxides reducible by hydrogen, and those of some metals of the first two sections, especially potash and soda.

Sulphur acts on nearly all the oxides, under the influence of heat. When the base is strong, a sulphate is formed; in the contrary case a sulphide is obtained.

Among the oxides, we particularly designate under the name of *alkalies*, potash, soda, lithia, and ammonia. The first three result from the union of oxygen with a metal; they are called fixed alkalies. Ammonia, or volatile alkali, is a nitride of hydrogen. All these bodies dissolve in water, possess the property of turning

blue, litmus paper reddened by an acid; they neutralize the most powerful acids.

We designate under the name of *alkaline earths*, several other oxides, slightly soluble or insoluble in water, such as lime, strontia, baryta, and magnesia, bodies which have the same action on litmus paper, and neutralize powerful acids.

The so-called alkalies generally produce salts soluble in water, while the greater number of salts formed by the alkaline earths are insoluble in this liquid.

V.—Hydrates.

Water unites with nearly all known compound bodies, to give rise to combinations having the condition of *hydrates*. It plays in this case an important part, for it exalts the properties of the bodies with which it combines.

We know hydrated acids, hydrated bases, and hydrated salts. Hydrates are prepared by treating with water the body in an anhydrous state. Often a disengagement of heat is manifested, indicating the production of a combination.

The same body may form several hydrates, all perfectly distinct from each other.

The presence of water in some compounds increases the solubility, or even gives them a solubility that they do not possess while in an anhydrous state. Some oxides lose, when their hydratation water is taken off, the property of dissolving into acids and forming salts.

When it combines with saline compounds so as to constitute hydrated salts, water gives them a tendency to crystallize, and they lose this crystalline form when their water of constitution is subtracted. However,

there are a few salts which crystallize in an anhydrous state.

The presence of water in salts sometimes changes their aspect. Thus, the hydrated sulphate of copper is of a fine blue color, while it is white when anhydrous. Caloric is the agent most generally employed to *dishydrate* a compound, whatever it may be, but there are cases in which it is not sufficient; such is the case in potash, sulphuric acid, etc.

Some reagents, having a great affinity for water, as sulphuric acid, have in some cases the property of dishydrating substances containing water.

VI.—Chlorides.

These salts, in an anhydrous state, are formed of chlorine and a simple body. Often they contain water, and then assume different crystalline forms.

Chlorides are sometimes fluid and volatile (chloride of tin); sometimes fusible and easily volatilized (chloride of zinc); sometimes solid and volatile at a high temperature (chloride of silver); some, when submitted to a high temperature, are decomposed (chloride of platinum), and the metal is set free.

In contact with water, their action varies. Alkaline chlorides are all very soluble in that liquid. Metallic chlorides are partially soluble in water; others are decomposed by this liquid into an oxide corresponding with the chloride, and hydrochloric acid; others are very slightly soluble; the chloride of silver is entirely insoluble.

Several chemists admit that an anhydrous chloride in contact with water, is transformed into a saline compound, which is the chlorhydrate of the oxide of the metal. To demonstrate this fact they show the differ-

ence existing in the physical properties, color, solubility, etc., of anhydrous chlorides, and the same when hydrated. These compounds when dissolved play the part of real salts, and act alike in all their reactions.

Chlorides can, by uniting, give birth to compounds named double chlorides; they can also combine with oxides to form oxychlorides. Chlorides are not decomposed by charcoal; but they are reduced by hydrogen, except the chlorides of the metals of the first two sections.

VII.—Bromides.

Bromides are compounds formed by the union of bromine with a simple body. They have the same principal characteristics as the chlorides, and are isomorphous with them; they are less volatile, but like them are generally soluble; bromide of silver is an exception. Metals, the chlorides of which are decomposed by water, have also their bromides decomposed by that liquid.

VIII.—Iodides.

Iodine forms compounds similar to the chlorides and bromides; however, they are distinguished from the first by this property—that nearly all of them are insoluble in water, and are less volatile. Alkaline iodides are easily soluble, and are apt to dissolve the other insoluble iodides, forming thus double iodides. Alkaline iodides are not decomposed by heat, even in contact with the air; the others are in great part decomposed, in the same conditions, into free iodine and an oxide. Chlorine decomposes them by forming a chloride, and disengaging iodine; bromine acts in the same manner.

IX.—Fluorides.

By treating alkalies with hydrofluoric acid, we obtain bodies similar to chlorides, bromides, and iodides. They are all soluble in water, and have a great tendency to combine with new quantities of hydrofluoric acid to form true salts, the hydrofluorates of fluorides, in which the fluorides play the part of bases.

Earthy fluorides are all insoluble, or rather very slightly soluble in water. It is the same with the compounds of fluorine and the metals; however, the fluoride of silver is an exception. Fluorides are very slightly volatile; generally, they are undecomposed by heat.

X.—Cyanides.

Cyanogen, *compound radical* (nitride of carbon C^2N), like the above, unites with metals, and forms compounds which have received the name of *cyanides*. Alkaline and earthy alkaline cyanides are soluble in water. Nearly all the others are insoluble in this liquid, but soluble in cyanide of potassium. They have a reaction strongly alkaline; nearly all of them, especially the alkaline cyanides, resist the action of a high temperature without being decomposed.

Cyanides are destroyed by a long ebullition in water; they give birth to formiates, and disengage ammonia. Acids, even the weakest, set cyanhydric acid free from the cyanides.

XI.—Sulphides.

Nearly all metals are directly attacked by sulphur, under the influence of a low temperature. Sometimes, as is the case with iron, they combine at the ordinary temperature with this metalloid, provided they are in a

damp place. Sulphur may also act on metallic oxides, expel the oxygen, and take its place, so as to form sulphides similar in their composition to the oxides from which they are derived.

Generally, metallic sulphides have a tarnished aspect; the only exceptions are those of the metals of the third and fifth sections, which possess a very unmistakable metallic lustre. They are brittle, except the sulphide of silver, which can be worked with the hammer.

Sulphides are attacked by oxygen; from the sulphides of the first section sulphates are obtained; from those of the third and fifth sections, and the sulphide of manganese, there are formed oxides, or sulphates, or a mixture of the two, according to the temperature. From the sulphides of the metals of the fourth section we obtain, by the action of oxygen, an oxide and sulphurous acid. The sulphides of the metals of the sixth section, treated with oxygen, are reduced to the metallic state; they are even decomposed by the action of heat alone. Others, in the same condition, are sublimed without decomposition, such as the sulphide of cadmium. When a highly sulphuretted sulphide is submitted to the action of heat, it loses a part of the sulphur it contains, while a sulphide less highly sulphuretted is formed. This is the case with the iron pyrites—

$$2FeS^2 = Fe^2S^3 + S.$$

Metallic sulphides are all, except those of the metals of the first section, insoluble in water, or undecomposable by it. The sulphides decomposed by water are those of aluminium, zirconium, and magnesium. Among the metallic sulphides there are some which have the property of dissolving in alkaline sulphides, and which then form true saline compounds called *sulpho-salts*, in

which one of the sulphides, that of the alkaline metal, plays the part of a base, while the other plays the part of an acid. This is the case with the sulphides of gold and platinum, which are easily dissolved by the sulphide of potassium.

Sulphides are decomposed by acids; the alkaline monosulphides are decomposed by the weakest acids. This decomposition is accompanied by a disengagement of hydrosulphuric acid gas. Alkaline polysulphides, in the same condition, disengage hydrosulphuric acid, but at the same time a deposit of sulphur is produced.

XII.—Chlorates.

Chloric acid unites with bases, and forms saline compounds called *chlorates*, in which the proportion of the oxygen of the base to that of the acid is $\frac{1}{5}$. From all these compounds, the most common and the most employed is the chlorate of potash. Chlorates fuse as nitrates when projected on red hot coals; calcined, they disengage oxygen, and leave a residuum of chloride. Chlorates are generally slightly soluble.

XIII.—Hypochlorites.

Hypochlorites are all soluble in water, and possess a characteristic odor, which is due to the hypochloric acid. They destroy vegetable colors, which is the cause of their use in the art of bleaching.

XIV.—Sulphates.

Sulphuric acid, by combining with bases, gives rise to perfectly definite saline compounds, sometimes soluble, as the salts of the alkaline oxides; sometimes insoluble, or very slightly soluble, such as those formed by the earthy alkaline oxides.

In neutral sulphates, the relation between the oxygen of the base and that of the acid is $\frac{1}{3}$; where this relation is $\frac{1}{6}$, we have the bisulphates, salts which possess a very acid reaction, and the symbol of which is $MO,2(SO^3)$. (M. designates the metal.)

Neutral sulphates, except those of the first section and those of silver and manganese, have an acid reaction on litmus.

All the sulphates are decomposed by charcoal; sometimes the metal is set free, but in nearly every case there is formed a monosulphide or polysulphide, which may be mixed with a certain quantity of oxide. All sulphates are decomposed at a high temperature, except the sulphates of the metals of the first section, and those of magnesia and lead.

XV.—Sulphites.

Sulphurous acid unites with the different bases to form salts, in which the relation of the oxygen of the base to that of the acid is $\frac{1}{2}$. Alkaline sulphites are all soluble in water; the earthy alkaline sulphites are nearly all insoluble, but are decomposed by acids even very diluted. Sulphites have a great tendency to absorb oxygen and to pass to the state of sulphates at a high temperature, even in close vessels they are all decomposed into sulphates and sulphides.

XVI.—Hyposulphites.

These salts are all soluble in water, and decomposable by heat. Treated with acids, they disengage sulphurous acid at the same time that a deposit of sulphur is produced. When treated by iodine they are transformed into iodides and tetrathionates. This reaction is characteristic.

XVII.—Salts of the Thionic Series.

Sulphur, in combining with oxygen, produces, besides sulphuric acid and sulphurous acid, five acid bodies, which have been reunited in one series to which the name of *thionic series* has been given. The salts formed by these acids are very unstable, except the hyposulphates, which are not easy to decompose. All the others, the pentathionates, tetrathionates, etc., are decomposed when in contact with water; they deposit sulphur, and are transformed into sulphites and sulphates.

XVIII.—Nitrates.

Nitrates are all soluble in water. In neutral nitrates, the relation of the oxygen of the base to that of the acid is $\frac{1}{5}$. There exist basic nitrates, in which we find 2, 3, and 6 times more base than in neutral nitrates. There is not an acid nitrate known.

All nitrates may be decomposed at a temperature sufficiently elevated. Some are transformed first into hyponitrates or nitrites, and into oxygen, binoxide of nitrogen and nitrogen.

Some are decomposed directly into their elements, without the formation of nitrous acid. Nitrates are also decomposed by concentrated sulphuric acid, which sets the nitric acid free.

XIX.—Phosphates.

Phosphoric acid has a great affinity for bases, and completely neutralizes them. In phosphates the relation of the oxygen of the base to that of the acid is $\frac{3}{5}$. Phosphates are fixed salts; they will melt, but rarely volatilize and decompose, even at a high temperature. In cooling they generally take a vitreous aspect.

Phosphoric acid is tribasic; that is, to form a salt, it always requires three equivalents of base or water of combination.

Alkaline phosphates are soluble in water, and all have alkaline reactions on litmus paper. All the others are insoluble, or very slightly soluble, but all are soluble in hydrochloric, nitric, and many even in acetic acid.

The action of heat on the phosphates presents remarkable results; indeed, those which contain three equivalents of fixed base are undecomposed under these circumstances, but those which contain two equivalents of fixed base and one of basic water, abandon the latter at a high temperature, and give birth to new salts, to which the name of pyrophosphates has been given, and in which the relation of the oxygen of the base to that of the acid is $\frac{2}{5}$. When, in the same manner, we heat phosphates containing only one equivalent of fixed base and two of basic water, we obtain a new series of salts, called metaphosphates, and in which the relation of the oxygen of the base to that of the acid is $\frac{1}{5}$. Heated with three times their weight of potassium and sodium, the phosphates are transformed into phosphides, which in contact with water, give phosphuretted hydrogen, known by its garlic odor.

Alkaline pyro-phosphates are soluble in water, and have an alkaline reaction on litmus paper. The other pyro-phosphates are insoluble in this liquid, but soluble in acids, and nearly all of them in an excess of a phosphate.

XX.—Arseniates.

In neutral arseniates the relation of the oxygen of the base to that of the acid is $\frac{3}{5}$. These salts have a great similarity to the phosphates. Neutral arseniates are all insoluble in water, except those of potash, soda, lithia,

and ammonia; but they are all soluble in acid solutions, or in solutions of ammoniacal salts, and especially the hydrochlorate of ammonia. There is one exception, it is with the arseniate of ammonia and magnesia, which is, as the corresponding phosphate, entirely insoluble.

Treated by nascent hydrogen, arseniates give arseniuretted hydrogen gas, easily recognized by the property that its flame deposits arsenical spots on a cold body.

XXI.—Arsenites.

Arsenious acid combines with all metallic oxides and forms salts, in which, when they are neutral, the relation between the oxygen of the base to that of the acid is $\frac{3}{3}$.

Alkaline arsenites are soluble in water, the others are very slightly soluble or insoluble. Nearly all the salts formed by arsenious acid are decomposed by the action of heat, with disengagement of arsenic, and formation of an arseniate.

Arsenites are all reduced by charcoal, when their base is easily reduced; in this case metallic arsenides are formed; when their bases are powerful, they are transformed into carbonates and the arsenic is volatilized. As the temperature at which we operate is generally elevated, there is very often decomposition of the formed carbonates, and an oxide is left as residuum.

XXII.—Carbonates.

Carbonic acid, by uniting with bases, forms perfectly definite saline compounds. It may form protocarbonates, sesquicarbonates, and bicarbonates. In the first case, the relation of the oxygen of the base to that of the acid is $\frac{1}{2}$; in the second $\frac{1}{3}$; in the third $\frac{1}{4}$.

With the exception of the alkaline carbonates, all are insoluble in water. Some, and especially that of lime,

are soluble in small quantities in carbonic acid water. The soluble carbonates have an alkaline reaction on litmus paper. At a high temperature they are all decomposed, with the exception of the carbonates of potash, soda, and lithia.

These compounds are liable to effervesce when treated by acids. The disengaged gas is colorless, and causes a precipitate in lime-water.

XXIII.—Borates.

Boracic acid, by combining with bases, forms salts, in which, when neutral, the relation between the oxygen of the base and that of the acid is $\frac{1}{3}$. Alkaline borates are soluble in water, and always have an alkaline reaction on litmus paper. Borates formed by the other oxides are insoluble, or very slightly soluble in this agent.

Borates resist a very elevated temperature. However, if the heat is very strong, and kept up for a long time, they may be decomposed and the acid volatilized. Borates, when melted, assume, in cooling, an aspect similar to that of glass, and according to the nature of the base, the vitreous substance, thus obtained, may be transparent, colored, or colorless.

XXIV.—Silicates.

Silicic acid combines with bases in several proportions, especially by the dry method. We regard as neutral those in which the relation of the oxygen of the base and that of the acid is $\frac{1}{3}$. They are all insoluble, except alkaline silicates containing an excess of base. The insoluble silicates are transformed into soluble salts by melting them with an excess of potash or soda. Silicates are undecomposable by heat. At a high temperature they experience the vitreous fusion.

SECTION II.

RAW MATERIALS USED IN THE MANUFACTURE OF SOAPS.

These substances form two very distinct classes: 1st, the alkaline oxides; 2d, the fatty acids, oily substances of animal and vegetable origin. In this section we shall study only the inorganic substances, reserving for another section the study of the fatty matters most generally used in the fabrication of soaps.

Alkalies are real metallic oxides, having for their bases alkaline metals combined with oxygen. Those metals are called alkaline, because they present in their chemical properties a great many reactions which are common to each other, and because long since their oxides secured the name of alkalies.

In combination with oxygen, alkaline metals form bases, the energy of which corresponds to their greater solubility in water. For a long time, alkalies were considered as simple bodies, but it is now well demonstrated that they are real metallic oxides. It was an English chemist, Sir Humphry Davy, who first obtained the alkaline metals in a pure state, by decomposing their oxides by electricity. That precious and important discovery gave a new impetus to inorganic chemistry. In France, Gay-Lussac and Thénard undertook at the beginning of this century a series of experiments on the decomposition of alkalies and alkaline earths, which enabled them to obtain potassium and sodium by processes

more simple and less costly than electricity, employed by the learned English chemist already named.

In speaking of potash and soda, we shall indicate the process in use to extract potassium and sodium. For the present we shall specify only the distinctive characteristics used to distinguish the alkalies:—

1. They are more or less soluble in water.

2. They have an acrid and caustic taste; this last property is considerably developed by lime.

3. They turn green nearly all blue vegetable colors, and restore the blue of litmus paper reddened by an acid.

4. They neutralize the acids and form salts, which differ entirely in their physical and chemical properties from the bases and acids, which have produced them.

Amongst the alkalies, lime, potash, and soda are the only ones used in the fabrication of soaps. We shall examine them particularly, but before studying them, we must present some observations on the characteristics and properties which distinguish potash from soda.

These two oxides, having a certain analogy in several of their chemical properties, have been confounded together under the same denomination of alkali. Indeed, both are completely soluble in water, have a very energetic acrid and caustic taste. They possess the property of combining with fatty bodies and forming soaps soluble in water. This last properly belongs only to potash and soda, all the other alkalies forming soaps entirely insoluble.

But besides their common properties, these two alkalies have some others very distinct and peculiar to each. Potash exposed to the air attracts its moisture and becomes deliquescent; soda, on the contrary, dries and becomes efflorescent by its exposure to the air. Combined with sulphuric, nitric, and hydrochloric acids, potash forms very dry salts, distinguished by a very strong

bitter taste, while with the same acids, soda forms hygrometric salts, with a saline taste.

These differences are not the only ones which distinguish the two alkalies. Considered in their connection with the art of soap-making, they present properties more characteristic than those we have indicated. Potash combined with certain fatty or oily substances, always forms soaps of a soft and pasty consistency; while soda always produces hard and solid soaps, which completely separate from the excess of alkaline lye, in which they have been formed.

CHAPTER VI.

LIME.

Lime is the oxide of the metal calcium, which was isolated for the first time by Sir Humphry Davy, by decomposing by electricity the hydrate of oxide of calcium. This metal in combination with oxygen, forms the oxide of calcium, or quicklime.

Quicklime has the following composition :—

		Per cent.
1 equivalent calcium, . .	20	71.43
1 " oxygen. . .	8	28.57
1 " lime, . . .	28	100.00

It is represented by the formula CaO.

Lime does not exist in nature in a pure state. In combination with sulphuric acid, it forms the sulphate of lime, or plaster of Paris ; combined with silicic acid, it forms the silicates of lime; this salt exists in abundance

in primitive rocks, mixed with metallic oxides. Lastly, combined with carbonic acid, it constitutes the numerous and various classes of carbonates of lime (marbles, limestone, &c.).

Industrially, lime is prepared by calcining natural carbonate of lime in kilns. During the burning the carbonic acid is disengaged, and quicklime is the product of the calcination.

The qualities of lime essentially depend on the purity of the carbonate used to prepare it. When the calcareous stone (carbonate of lime) is mixed with large proportions of quartz, magnesia, or alumina, a lime of an inferior quality is obtained, which slacks with difficulty, and forms, with water, a paste without homogeneity; it is then called *poor*, and is rarely used in soap-making.

Lime prepared with a carbonate sensibly pure, that is, which contains only traces of foreign matters, is of a superior quality, and is called *fat*. It rapidly combines with water, and grows very warm. If very little water is added, it slacks and forms a white and light powder, with a burning and caustic taste, and turning green the blue vegetable colors. Lime thus prepared is known by two different names. For the chemist it is *hydrated lime*, for the manufacturer it is *slacked lime*.

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

Lime recently burned is white, or slightly colored, if the limestone used to prepare it contains oxide of iron. To ascertain if it is completely caustic, treat a few

drachms by nitric acid; if the lime is entirely caustic, it ought to dissolve in the acid without disengaging carbonic acid; if there is any effervescence during the solution, it is a proof that it still contains carbonate of lime, which has not been transformed into caustic lime. Entirely caustic lime is more advantageous; it better decomposes the carbonates of potash and soda.

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

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

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

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

Lime plays an important part in the preparation of lyes. It is the essential and indispensable agent of their causticity. When we examine the preparation of lyes, we shall indicate the special conditions of this operation, one of the most important in the manufacture. We may here state that lime is not an integral part of soap—its

action being chemical. It combines with the carbonic acid of the alkaline carbonate with which it is in contact, and forms an insoluble carbonate of lime. The pure alkali, or hydrated alkali, remains in solution in the water, and constitutes the caustic lye used in the fabrication of soaps.

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

CHAPTER VII.

POTASH.

Potassium—Potash—Extraction.

Potassium.

Potassium is the metallic element of potash. It was isolated, as we have already said, for the first time by Sir Humphry Davy, in 1807, by decomposing potash by means of electricity. Since then, Gay-Lussac and Thénard have made known the chemical properties of this metal, and have even succeeded in obtaining it by a more economical process, by passing potash, in vapor, through well-cleaned iron filings, brought to a white heat in an iron pipe, in a reverberatory furnace. In this operation, the

iron combines with the oxygen of the potash, and is transformed into the oxide of iron; the potassium set free is disengaged in the form of vapor, and collected in a receiver. Lastly, by a third process discovered by Brunner, potassium is prepared by decomposing pure carbonate of potash by means of charcoal, at a high temperature. This process gives more potassium than the two above mentioned.

Potassium is much employed in laboratories; it is one of the most valuable and energetic reagents. It is a powerful reducing agent, to decompose oxygenized bodies.

Recently prepared, potassium presents the color and metallic aspect of silver; exposed to the air, it is immediately tarnished, by combining with oxygen; it then forms an oxide of potassium, or potash.

Below 32° F. this metal is very hard; at 59° it is soft and ductile; it melts at 136.4°, and distils at a high temperature.

Its specific gravity is 0.865; it is lighter than water. It decomposes this liquid at the ordinary temperature. During the reaction, the hydrogen of the decomposed water burns quickly, producing much heat. After the experiment, the water has become alkaline. The theory of this reaction is very simple. By contact with potassium, water is decomposed, hydrogen is disengaged, and the oxygen, by combining with potassium, forms the hydrate of the protoxide of potassium, which remains in solution in the water.

Potassium is preserved without alteration by keeping it in naphtha.

Potassium combines with oxygen in three proportions and forms three oxides. The suboxide and peroxide are without applications in the arts; it is not so with the protoxide, which is the essential basis of soft soaps.

Potash.

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

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

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

We must here make an important observation. Vegetables which grow on the sea-shore, or in the neighbor-

hood of salt mines, give by their incineration very small quantities of potash; they principally contain soda. Those, on the contrary, which grow inland and in soils free from chloride of sodium, yield, by their combustion, ashes which contain principally carbonate of potash, mixed with very small proportions of soda. These vegetables are the only ones employed to prepare the carbonate of potash.

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

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

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

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

Names of the vegetables.	Quantity of ashes.	Quantity of alkali.	Chemist who made the analysis.
100 parts of willow	2.80000	0.28400	Kirwan.
Elm	2.36727	0.39000	"
Oak	1.35185	0.15343	Pertuis.
Poplar	1.23476	0.07481	"
Yoke-elm	1.12830	0.12540	"
Beech	0.58432	0.14572	"
Pitch pine tree	0.31740	0.73180	de Fontenelle.
Vine	3.37900	0.55000	Kirwan.
Stalks of corn	8.86000	1.75000	"
Wormwood	9.74400	7.30000	"
Fumitory	21.90000	7.90000	"
Fumitory	22.10000	8.01500	de Fontenelle.
Vines of hops	10.00000	3.01500	Thillaye.
Vines of Windsor beans	10.00000	4.12900	"
Common nettle	10.67186	2.50330	Pertuis.
Common thistle	4.04265	0.53734	"
Ferns	5.00781	0.62590	"
Reed	3.85395	0.72234	"
Reed	3.33593	0.50811	"
Turnsole	20.70000	4.00000	"
Genista	3.00500	1.30870	de Fontenelle.
Heath	2.90190	0.84000	"
Stalks of corn	9.35100	2.00400	"
Erigeron Canadense	10.80000	2.65200	Bouillon Lagrange.
Horsechestnut tree bark	18.46000	4.84000	de Fontenelle.
Centaury	8.44000	2.00800	Kirwan.
Burdock leaves	4.84000	0.98400	de Fontenelle.
Camomile	5,63900	1.80000	"
Orange leaves	14.24000	2.40400	"

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

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

Ashes, whatever is the part of the vegetable which has furnished them, present a complex composition, va-

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

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

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

Essentially formed of carbonate of potash, a small quantity of sulphate of potash and chloride of potassium, and of a trace of silicate of potash, the soluble com-

pounds which alone have to fix our attention, present, in the relative proportions of these different salts, variations which are interesting to notice. The following table enables us to establish the composition of the mixture of soluble salts extracted from the ashes of some vegetables.

	Birch.	Yoke elm.	Elm.	Oak.	Mulberry.	Fir tree.
Carbonic acid .	0.170	0.247	0.224	0.240	0.230	0.123
Sulphuric "	0 023	0.073	0.073	0.081	0.083	0.069
Chlorine . . .	0.002	0.047	0.052	0.001	0.040	.....
Silica	0.010	0.010	0.010	0.002	.....	0.020
Potash . . .	0.795	0.507	0.641	0.676	0.520	0.506
Soda		0.121			0.115	0.282
	1.000	1.005	1.000	1.000	0.988	1.000

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

Extraction of Potash.

The industrial fabrication of potash is carried on only in countries where wood is abundant. Thus the largest quantity of that employed in the arts, comes from Russia or from this country. As we have before said, vegetables, when fully developed, contain a smaller proportion of salts of potash, than when their vegetation is less advanced. Starting from this principle, confirmed by experience, branches, small trees, and herbaceous plants must be preferred, as being richer in salts of pot-

ash. If the operation is conducted with the latter vegetables, they are to be cut carefully, and spread on a dry and smooth place, where they are left until completely dried; after their desiccation, they are collected and put into heaps, near by the place where they are to be burned. In damp countries, they are dried under large sheds. When trees are burned for the purpose of extracting potash, they are divided into large pieces and dried in the open air.

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

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

By this process, the combustion of the plants is conducted in furnaces made of refractory bricks; they are provided, at their lower part, with a cast-iron grate, under which is a large ash-pan, also made of bricks, the object of which is to receive the ashes from the incine-

ration of the plants. To render the combustion more uniform and complete, pipes disposed around the base of the furnace, bring cold air under the grate. To preserve the inside of the furnace from the destructive action of the fire, the bricks are covered with a coating of clay about one-third of an inch thick, which, before beginning the operation, is allowed to dry for several days.

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

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

During all the time of the operation, the ashes which are produced fall in the form of powder into the ash-pan placed under the grate, from which, when they have

filled the pan about three-fourths full, they are taken with a shovel and carried into a building, where they are spread on the ground in beds three or four inches thick. From time to time the surface is stirred, so as to assist the transformation of the potash into carbonate. It is to facilitate this reaction, that ashes recently calcined are exposed to the air for a few days before being lixiviated.

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

The vats being thus disposed, charge them to $\frac{4}{5}$ of their capacity with ashes, and pour on them a quantity of water sufficient to cover them entirely. After standing from fifteen to eighteen hours, open the cocks, and collect the lye in a special receiver. By using this lye instead of water for the treatment of new ashes, we obtain after twelve or fifteen hours of reaction, a new lye marking from 10° to 12° Baumé, which can be brought up to 15° or 18° by successive passages through new ashes; but this method, which is long and costly, is not much employed, the manufacturer generally preferring to have liquors at 10° or 12°.

Continue the lixiviation of the ashes by successive washings with pure water. It is ascertained that the material is completely exhausted when the liquid has

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

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

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

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

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

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

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

In Paris, they manufacture a fictitious article, which must not be confounded with the American potash. The latter has really potash for a base, while the first is a mix-

ture of caustic soda, salt, and sulphate of potash. The materials are melted together, and are colored red with oxide of copper. Fictitious potash is distinguished by a very strong saline taste, which American potash does not possess.

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

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

When carefully manufactured, the ashes of dregs give one of the best commercial potashes. In this state it contains only a very small proportion of chloride of potassium and sulphate of potash. This alkali is generally in a porous and light mass, having a greenish color with blue veins. This color is due to the oxides of iron and manganese. Pure ashes dissolve nearly entirely in water, and leave only a residuum of 7 to 8 per cent. of insoluble matters. 200 pounds of good dregs, perfectly dry, produce from 10 to 12 pounds of ashes, the titer of which varies between 25 and 33 alkalimetric degrees.

When the dregs contain much tartrate of potash, they give, by their combustion, an alkali of a much higher titer. The white potash is obtained by treating the ashes by water, which dissolves the soluble salts, and amongst them the carbonate of potash. The lye is evaporated to dryness, and the mass is bleached in a reverberatory furnace. By this refining, ashes give about half of their weight of white potash. But it is generally in the form of ashes that this alkali is found in commerce.

Potash made from Beet-root Molasses.—Chemical analysis has long since demonstrated that the salts of potash exist in a large proportion in beet-root molasses. This fact has found a useful application in industry. It is to M. Dubrunfault that is due the discovery of the processes for extracting potash from the saline residues left after the distillation of the molasses. It is, indeed, from the saline residues that potash is obtained; it is never directly extracted from the molasses, which for several years has been used to make alcohol. Potash, being undecomposable in the conditions in which the operation takes place, is found, after the decomposition of the sugar by fermentation and the extraction of the alcohol by distillation, in the liquid residuum. It is extracted from this residuum by evaporating the water, and by the incineration of the concentrated residuum. The product of the incineration constitutes a light, porous, and friable mass. It is crude potash; its titer is from 40 to 50 alkalimetric degrees. The white potash is obtained by lixiviating the crude potash in sheet-iron filters having a cylindrical form. The exhaustion takes place with warm or cold water; the use of warm water is more advantageous, but it dissolves some of the sulphuret; cold water gives a purer product, but the operation is longer, and the residuum is not so well exhausted of its alkali.

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

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

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

Composition of Commercial Potashes.—Carbonate of potash is the base of the commercial potashes, but besides this salt, they contain several others, and principally more or less considerable proportions of sulphate of potash and chloride of potassium. The presence of these salts is demonstrated by dissolving half an ounce of potash, in 3½ ounces of distilled water; the solution is saturated by

acetic or pure nitric acid. After the saturation, filter and divide the filtrate in two portions, which are separately submitted to the following reagents:—

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

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

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

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

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

	Potash of Tuscany.	Potash of Russia.	Potash of America (red).	Potash of America (pearl-ash).	Potash of the Vosges.	Potash of molasses.
Sulphate of potash . . .	13.47	14.11	15.32	14.38	38.84	1.197
Chloride of potassium . .	0.95	2.09	8.15	3.64	9.16	4.160
Carbonate of potash . . .	74.10	69.61	68.04	71.38	38.63	76.440
" of soda	3.00	3.09	5.85	2.31	4.17	16.330
Hygrometric water . . .	7.28	8 82	....	4.56	5.34	0.624
Insoluble substances and loss	1.20	2.28	2.64	3.73	3.86	1.249
	100.00	100.00	100.00	100.00	100.00	100.000
Alkalimetric degrees . . .	56.0	53.1	55.0	54.4	31.6	69.3

We see, by the above table, that independently of the sulphates and chlorides, all potashes contain soda in va-

riable proportions; the American potash is that which contains the least, and that of molasses contains the most. The insoluble residuum is partly composed of carbonates and phosphates of lime and magnesia, silicate of alumina, and oxides of manganese and iron. The first of these oxides colors them blue, the second communicates to them a red shade.

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

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

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

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

form so easily. The desiccation is achieved in the latter kettle, which is flatter.

The carbonate of potash, economically purified by this process, is used in the arts requiring a purer product than commercial potash.

CHAPTER VIII.

SODA.

Sodium—Soda—Natural Sodas—Artificial Soda—Artificial Salted Soda—Carbonate of Soda—Caustic Soda.

Sodium.

Sodium is the metallic radical of soda. This metal exists in nature, only in combination with chlorine or certain acids.

It is prepared by the same process as potassium. But since the remarkable discovery of M. Saint-Claire Deville, this metal is prepared by a process as simple as the one used to extract crude soda from salt.

To obtain it, heat at a high temperature, in a sheet-iron apparatus, a mixture of carbonate of soda, coal, and carbonate of lime; under the influence of heat a series of very complicated reactions takes place, and the sodium is set free; this metal volatilizes and is received in a condenser. By the processes used fourteen years ago, one pound of sodium was worth $300; by that of Deville, it costs about $1.

There is a great analogy between sodium and potassium in several of their chemical properties. Both are malleable and ductile at the ordinary temperature; they

present the same metallic appearance, and their color is sensibly the same, only that that of the sodium is a little more bluish.

Considered in their chemical relations, these two metals have different properties. But as these differences are of a purely scientific character, and have no connection with the art of soap-making, we shall not speak of them.

Combinations of Sodium with Oxygen.—Sodium forms with oxygen two compounds, a protoxide and a peroxide.

The latter has no application in industry. The protoxide, on the contrary, has much interest. To the chemist the protoxide indicates pure soda, that is deprived of carbonic acid, but in commerce it is the carbonate which is designated by that name.

The composition of the protoxide of sodium is thus represented:—

Sodium, one equivalent	74.17
Oxygen " "	25.83
	100.00

It is represented by the formula NaO.

Protoxide of sodium, exposed to the air, attracts water and becomes soft, but it differs from potash in this, that it never becomes deliquescent, and if the exposure to the air is prolonged, it absorbs carbonic acid, dries and effloresces; it then forms a carbonate of soda.

Hydrate of Soda.—In industry, this hydrate is prepared by decomposing the carbonate of soda, dissolved in water, by lime. By this reaction, an insoluble carbonate of lime is formed, and the soda remains in the liquor in the state of hydrate. The caustic liquor being separated from the deposit by decantation or filtration, is rapidly evaporated to dryness. The substance melted in a con-

venient vessel that is capable of resisting the action of alkalies, yields, on cooling, a white solid substance, excessively caustic. This substance is the hydrate of protoxide of sodium or soda.

Its composition is the following:—

Oxide of Sodium, one equivalent . . .	77.46
Water " " . . .	22.54
	100.00

It is represented by the formula NaO,HO.

All solid soaps have the hydrate of soda for their base.

Soda.

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

The denomination of alkali by which soda used to be designated was derived from *Kali*, the Arabian name of the plant from which this valuable substance was extracted. Indeed, for many centuries, plants were the principal source from which soda was obtained, hence its name of natural or vegetable soda. For a long time the culture of these plants constituted a flourishing trade in several European countries, particularly Spain, which produced several varieties of soda, known by the names of *Alicant*, *Malaga*, and *Carthagena*.

Natural Sodas.

The *natural sodas* are the carbonates of soda, obtained by the incineration of several species of plants growing on the sea-shore. These plants furnish very variable proportions of carbonate of soda mixed with different salts. Those which give the most are: the *Salsola soda*, and the *Salicornia Europœa*.

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

We shall examine summarily the principal varieties of natural sodas, which are yet sometimes found in commerce, but we must remark that they are very little used in soap works since the discovery of artificial soda.

Soda of Narbonne.—This soda, more generally known by the name of *salicor*, is the best manufactured in France. It is the richest in pure or carbonated soda, which is the only useful alkali in the preparation of solid soaps. The plant which produces it is designated by the name of *salicornia annua*. The plant is cultivated in several parts of the South of France. The plant is cut before its complete maturity; is spread in the sun to dry, and then incinerated. Good salicors give from 20 to 25 per cent. of carbonate of soda.

Soda of Aigues-Mortes.—This soda is prepared in the

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

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

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

The first, which is the richest in pure alkali, and consequently the most valuable, is furnished by the plant known by the name of *salsola soda*. When the plant has attained its full growth, it is cut and dried in the sun, and incinerated in cylindrical pits dug in the ground, about five feet deep. To begin the operation, a few armfuls of dry material are thrown into the pit,

and ignited, the combustion is kept up by adding little by little new dry plants, and is accelerated by stirring the mass from time to time with an iron rod. This operation lasts about four days, and is finished when the pit is filled to two-thirds or three-fourths of its depth with the products of the combustion. A few days after, the residuum is taken out, then broken into large pieces, and put into barrels.

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

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

Salted Barilla.—This kind differs from the two above, namely, by the strong proportion of neutral salts it contains, and by being less alkaline. The plants which produce it grow without culture on the sea-shore in soils strongly impregnated with salt. During their growth, these plants absorb a large quantity of salt, which is found in the ashes after the incineration. Although less pure, less alkaline, and less esteemed than the two last described, the salted barilla was yet of great use in the manufacture of Marseilles soap. Its blackish color and from being more highly sulphuretted than the others, together with the large proportion of salt it contained, caused it to play, in the fabrication of marbled soap, the same part as salted soda. The blue of the marbling was

brighter and more intense, it progressively contracted the molecules of the soap, and during the operation kept it constantly separated from the lyes. But since the discovery of artificial soda its use has been abandoned.

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

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

Commercial natron is in mass or in plates, with a grayish-white color. Its fracture is granular or crystalline, and it contains from 20 to 30 per cent. of pure soda.

In very dry years these lakes furnish about 450,000 lbs. of natron.

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

Artificial Soda.

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

Long since, the old Academy of Sciences had established a prize of 2400 francs ($446) for the conversion of chloride of sodium into carbonate of soda. Father Malherbe, in 1777, was the first who thought that he had attained the industrial solution of the problem; he proposed to convert first the salt into sulphate of soda, and then to heat this salt with charcoal and iron. Macquer and Montigny, in 1778, made a favorable report on this work. Guyton de Morveau, associated with Carny, had, a few years before, erected an establishment at Croisie, in which the salt, being mixed with lime,

was afterwards allowed to rest in contact with the air; very soon the carbonate of soda effloresced on the surface of the mixture, but the results were not economical.

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

trial process was exposed with such precision, that since that time very few changes have been made.

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

However, if the author of this discovery was dead, it was not so with the discovery itself; notwithstanding the difficulty of obtaining saltpetre to manufacture sulphuric acid, and then the sulphate of soda, the process of Leblanc was soon put in practice by several manufacturers. It was first Payen, then Carny, who applied it; the first near Paris, the second at Dieuze. The fabrication of soda was rapidly growing, and in 1806 glasses were seen at the exposition of industry,

sent by the manufacture of Saint-Gobain, prepared with artificial soda. However, the new product had one defect which often caused it to be rejected by the trade; this defect consisted in its sulphuretted nature. D'Arcet found the cause of that imperfection. Leblanc's furnace was rectangular, and the flame was not active enough in the angles, and there resulted a partial transformation of the sulphate of soda into sulphuret of sodium. D'Arcet rounded off the angles, and transformed the rectangular furnace into an elliptic one. With this improvement, the fabrication of artificial soda rapidly increased, and in 1812, notwithstanding the absolute prohibition of foreign sodas, the price of that substance had diminished fully two-thirds.

To-day, soda is manufactured exactly according to the process we have described; the method is the same, and the only changes made are in the form of the furnaces.

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

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

But at Marseilles, where the fabrication of artificial soda constitutes one of the most important trades, the greater part of the hydrochloric acid produced during

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

Salt	2000 lbs.
Sulphuric acid at 50° . . .	3200 "

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

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

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

The above quantities give from 2200 to 2260 lbs. of sulphate of soda well prepared, or from 110 to 113 lbs. of sulphate for 100 of salt.

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

The best proportions to use are :—

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

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

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

When an operation is begun, the furnace must be brought up to a strong red heat before introducing the mixture. That condition being complied with, introduce

the mixture into the furnace, and after spreading it as evenly as possible, leave it exposed for some time to the action of the heat. In order to have an equal and regular heat, the fire requires great attention, especially at the beginning of the operation.

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

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

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

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

This soda is generally in a melted and compact mass, particularly if the calcination has been pushed too far; but when the operation has been well conducted, its texture is not so compact, and sometimes is porous. It is pre-

ferred in this state, because by lixiviation it is more easy to deprive it of its soluble salts. When well prepared it resembles good Spanish sodas; it has a gray-ash color, and is without smell. Its richness in pure alkali is generally constant, and depends essentially on the purity of the sulphate. If the sulphate contains only a few hundredths of undecomposed salt, and is completely converted into carbonate by proper proportions of chalk and charcoal, a soda is obtained which generally contains thirty-six per cent. of alkali. This soda, designated by the name of soft soda, or alkaline soda, is specially used for the saponification of oils in the fabrication of marbled and white soaps.

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

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

We think it will interest the reader to know the real cost of the substances used and produced, and we give below a detailed table of the expense of manufacturing

20,000 lbs. of artificial soda in France. These numbers are very exact, and deserve full confidence.

Raw Materials.

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

Other Expenses.

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

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

We see by the above table that the expense of manufacturing 20,000 lbs. of crude soda is $275 22, which puts the price of 100 lbs. at $1 37.

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

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

to 40 per cent. of undecomposed salt. The proportions generally employed are :—

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

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

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

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

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

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

paste of the soap, the sulphuret it contains contributes to develop the beauty and intensity of the marbling.

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

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

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

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

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

To prepare this salt, select the soda which is richest in alkali, and containing the least sulphuret. The lixiviation may be effected by very various processes. In the manufacture of crude soda, where sal soda is also prepared, the process is rational, simple, and economical. Baskets made of metallic cloth are filled with coarsely powdered soda, and then successively passed through solutions of soda growing weaker and weaker. The last passage is through pure water.

By this operation a solution at 25° or 28° B. is obtained. To have it perfectly limpid, it is left to settle for several days, and is then concentrated.

This operation is generally conducted in four cast-iron kettles arranged in steps, and heated by the same hearth.

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

To obtain a very pure and very rich carbonate of soda, some manufacturers evaporate the solution until a pellicle is formed on the surface, and in this state pour it into sheet-iron vats, where it crystallizes. A few days after, the mother-liquor is decanted, and the salt is left to drain. The crystals contain only a few hundredths of foreign salts; the mother-liquor contains uncrystallizable caustic soda, sulphate of soda, and chloride of sodium.

Whatever is the method of operating, the salt of soda obtained always contains a large amount of water, interposed between its crystals. Besides, it is colored by organic substances, which give it a brownish shade.

To obtain this salt very dry and very white, calcine it in a reverberatory furnace, strongly heated. Furnaces in which the calcination takes place have their beds entirely covered with a thick and half-melted coat of salt itself; the bricks or stones being rapidly destroyed under the influence of a high temperature.

The carbonate of soda thus obtained is very white, and is much richer in pure soda when the crude soda, from which it is exhausted, is itself pure.

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

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

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

Nearly all the crystallized sal soda found in commerce is obtained by the lixiviation of artificial soda. To prepare it use the purest and richest soda. The crude soda is lixiviated in the same manner as we have indicated above.

All the solutions which mark from 20° to 25° B., are mixed in large sheet-iron vats and allowed to rest; a few days after, when all the liquors are clear, they are decanted, and submitted to a gentle ebullition in a cast-iron kettle.

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

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

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

This process yields whiter, finer, and purer crystals than those obtained by the direct treatment of the crude soda. The first, however, is generally used, because the crystallized carbonate of soda can be extracted from the crude lyes, while, by the second, it is necessary to employ the refined salt of soda.

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

Crystallized carbonate of soda contains 62.80 of water, so that 100 pounds represent only 37.20 of dry carbo-

nate. This salt is very soluble in water. Boiling water dissolves almost its own weight, and cold water almost half. In the arts, the great solubility of this salt is utilized to purify it; for this purpose it is dissolved in the least possible quantity of boiling water. The liquor is left to crystallize, and it deposits, by cooling, fine crystals of pure carbonate of soda.

This salt is thus formed:—

Carbonic acid	15.42
Soda	21.78
Water	62.80
	100.00

Caustic Salts of Soda.—The caustic salts of soda represent for the same weight, a larger quantity of pure soda than the same salts when carbonated. Starting from this principle, there is an advantage in using salts of soda, the carbonic acid of which has been partly or totally eliminated, for the ponderal quantity of the missing acid is substituted by an equivalent weight of pure soda.

It is thus that in their different applications to industry, caustic alkalies produce, at equal weights, more considerable results than when in the state of carbonates.

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

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

The furnace is at first heated moderately to dry the salt slowly without melting it, then the temperature is raised until it becomes red. This is an essential condition to expel the water, and destroy the organic matters, which color it. During the operation the mass is stirred, so as to multiply the points of contact of the substance with the caloric.

The product thus obtained is white, and excessively caustic. Exposed to the air it absorbs carbonic acid, and passes to the state of carbonate.

Salts of soda, more or less caustic, are also found in the trade. They are prepared with the mother-liquors from the fabrication of the crystal of soda. These liquors contain in solution, strong proportions of caustic soda mixed with different salts, principally with sulphates and chlorides. By concentrating them to dryness, and incinerating the residuum, a kind of caustic salt of soda is obtained. These liquors may also be used to prepare the hypochlorite of soda. For this purpose water is added to them until they mark 8° or 10° B., and the alkali is saturated by a current of chlorine gas.

CHAPTER IX.

AMMONIA.

Ammonia is not much used in soap-making, except to make a soap known by the name of *Ammoniacal Soap*.

Ammonia is a colorless gas, with a penetrating odor; it turns green the syrup of violet, and restores the blue of litmus paper reddened by an acid. It is very soluble in water, which will absorb as much as 670 times its

volume; and by this absorption the volume of the water increases in the ratio of six to ten. Its specific gravity in the gaseous state is 0.590. The specific gravity of water, saturated with ammonia, is 0.900. It is thus composed:—

Water	74.63
Ammonia	25.37
	100.00

The composition of the gas is

Nitrogen	82.353
Hydrogen	17.647
	100.000

Or one volume of nitrogen and three of hydrogen (NH^3), condensed into two volumes.

The following table represents the quantities of ammonia gas contained in ammoniacal solutions of different specific gravities:—

Specific gravity of the liquid.	Ammonia in 100 quarts of water measures of the liquid.	Ammonia in 100 parts of liquid.	Volume of gas condensed in a given volume of the liquid.
0.85	30	35.3	494
0.86	28	32.6	456
0.87	26	29.9	419
0.88	24	27.3	382
0.89	22	24.7	346
0.90	20	22.2	311
0.91	18	19.8	277
0.92	16	17.4	244
0.93	14	15.1	211
0.94	12	12.8	180
0.95	10	10.5	147
0.96	8	8.3	116
0.97	6	6.2	87
0.98	4	4.1	57
0.99	2	2.0	28

CHAPTER X.

ALKALIMETRY.

Assays of Potashes and Sodas—Method of Descroizilles—Method of Gay-Lussac—Method of Weighing the Quantity of Caustic Alkali contained in Potashes and Caustic Salts of Soda.

It is to modern chemistry that we owe the exact processes for determining the real value of commercial potash and soda, according to the quantity of pure or carbonated alkali they contain. For a long time this valuation rested only on uncertain indications, Baumé's areometer was the means of verification generally used in soap works, to ascertain approximatively the different degrees of richness of the alkalies, by the degree of the lyes.

But as ordinarily there is no exact relation between the degree of a lye and its real value in pure or carbonated alkali, for this degree may be due to the presence of sulphates and chlorides, always met in commercial potash or soda, it is evident that this instrument cannot be employed to determine, even approximatively, the quantity of alkaline matter contained in a solution of potash or soda.

Struck with these inconveniences, chemists have sought for a long time the means of remedying them. The first successful trials made in that direction are due to Vauquelin. This learned chemist thought of saturating a given weight of pure nitric acid, by a known weight of pure

alkali. Afterwards, applying this method to commercial potash or soda, he determined their alkaline value, by the quantity of acid required for the saturation. Evidently their richness was in proportion to the quantity of acid required to saturate the alkali.

However, this process was long and complicated, it required several weighings, very delicate operations, which demand extreme precision. This process, therefore, was not adapted to the wants of the arts which need a ready method for the precise valuation of the products which are operated upon.

However, Vauquelin's method of the saturation of alkalies by acids is the foundation and starting-point of that branch of analysis called *alkalimetry*.

The principle of alkalimetry is very simple. It rests on that valuable property which potash and soda possess, of combining with sulphuric acid and forming neutral sulphates. We must remark that this acid acts directly on the free or carbonated alkali, without any action on the other salts that may be mixed with the alkali.

To ascertain the exact point of saturation of the alkali, a tincture of litmus is used. As long as free or carbonated alkali, is in excess in the liquor, sulphuric acid transforms the blue color of the litmus only into a vinous red; but as soon as the saturating point has been reached, and the last portions of alkali have been transformed into the sulphate, the smallest portion of acid in excess changes the vinous red color to that of onion peel. This precise and distinct characteristic enables us to ascertain the exact point of saturation.

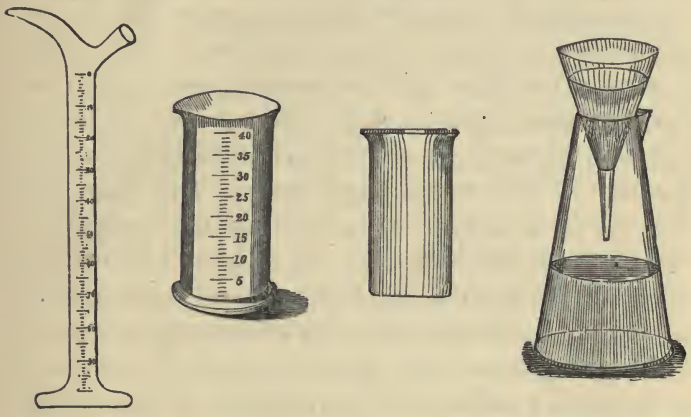
Two methods are employed to make alkalimetric assays: that of Descroizilles, and that of Gay-Lussac. We shall now proceed to describe them.

Method of Descroizilles.

Descroizilles invented for the assays of potash and soda a graduated glass which he called the *alkalimeter*.

The *alkalimeter* is a tall glass cylinder twelve inches in height, and three-fifths of an inch in internal diameter, closed at the bottom, and graduated uniformly downwards into 100 divisions. The other appliances are: a small balance with weights; a glass graduated measure; a glass mortar; one eight ounce beaker glass; one eight ounce jar with lip; a glass funnel; glass rods; filtering paper, etc.

Fig. 1. Fig. 2. Fig. 3. Fig. 4.



Preparation of the Alkalimetric Liquor.—This liquor, called also *normal acid liquor*, is prepared as follows: take a white glass bottle of one litre and a half capacity, and carefully weigh it. This done, weigh into it very exactly, 1 kilogramme of distilled water, place the bottle on a smooth table, and, at the level of the water, make a mark with a diamond or a file.

On the other hand, take the weight of a small bottle, and weigh into it 100 grammes of pure sulphuric acid

at 66° B. Take off the third or half of the water of the large bottle, and into the remaining water pour slowly the 100 grammes of sulphuric acid. While pouring the acid, mix quickly the liquors, so that the heat may not break the bottle. Wash several times the small bottle in which the acid has been weighed, and transfer the washings into the large bottle, which is afterwards filled with water as high as the diamond mark. As there has been a production of heat by the mixture of the acid with water and the liquor has sensibly expanded, let it cool to the ordinary temperature, and when cold complete the addition of the water. Thus prepared, this liquor is used to test all alkalies in general. To try an alkali, a salt of soda, for example, proceed as follows: take several specimens from the different parts of the mass to be tested, so as to have a specimen which represents the mean richness of the whole mass. This specimen is powdered in a little marble mortar, and 10 grammes of it are weighed accurately. This done, introduce the 10 grammes into a bottle of the capacity of a quarter of a litre, and pour on it a decilitre of water. To accelerate the solution introduce into the bottle about 10 grammes of small lead shot. Cork the bottle and quickly shake the mixture. By agitation, the salt is triturated by the shot, and in about eight or ten minutes is completely dissolved. Open the bottle, and to obtain a perfectly clear and limpid alkaline solution, filter it through filtering paper. Measure half a decilitre of this liquor, which is poured into a test glass large enough to be filled only to one-third; wash the measure with water, and pour the washing into the glass, containing the solution of soda. Before proceeding to the saturation, color the liquid with a few drops of tincture of litmus.

Saturation.—It is thus that is designated the operation

by which the alkali is saturated by the alkalimetric liquor. For this purpose, fill the alkalimeter with liquor to the zero point, then pour it very slowly into the glass which contains the alkaline solution previously colored blue with some litmus liquor. To render the reaction more easy, stir the mixture all the time, so as to combine the liquors more rapidly.

The first portions of acid poured in, do not produce any sensible change in the liquor. When a little more than half of the acid necessary for the saturation has been added, the alkaline liquor takes a vinous red color. This color, which must not be confounded with the color of onion peel, which the liquor assumes when saturated, is due to the disengagement of the carbonic acid gas, resulting from the decomposition of the carbonate of soda by sulphuric acid. Nevertheless, when this point is reached, the operation requires more attention; the acid is poured in drop by drop, being careful to stop when the vinous red color passes to that of onion peel.

But in order to operate with more certainty, and to be sure of not exceeding the quantity of acid necessary to saturate the alkali, it is necessary when the liquor exhibits the vinous red color to touch from time to time, with the end of the glass rod, a slip of litmus paper. If by the contact with the liquor, the color begins to turn bright red, and if the shade is permanent, the saturation is finished. If, on the contrary, the liquor gives a violet or reddish shade, it is a proof that there remains some alkali not saturated. Complete, then, the saturation by continuing to pour drop by drop the alkalimetric liquor into the alkaline solution, until a drop of the latter reddens litmus paper.

The titer of the alkali is ascertained by the number

of degrees of alkalimetric liquor used for the saturation. Let us suppose, for example, that 85 degrees of alkalimetric liquor have been required to produce the saturation of the 5 grammes of the salt of soda tested, it is then said that this salt is at 85°. According to the method of Descroizilles, which is that we have here described, the number of degrees of alkalimetric liquor employed to saturate 5 grammes of any alkali, always indicates the nominal titer of that alkali. Thus, a salt of soda which saturates only 50 degrees of the alkalimetric liquor, will be consequently at 50.°

The process is the same for the alkalimetric assay of potashes, natural and artificial sodas, and all alkaline substances in general.

When crude soda in compact masses is tried, which is very slow to dissolve in water, it is essential to reduce the specimen to a fine powder. To make these assays, take samples from different parts of the mass and reduce them to powder in an iron mortar; pass the powder through a sieve, and weigh 10 grammes, which are to be dissolved in two-half decilitres of water; accelerate the solution with leaden shot as we have seen above. But, as the soluble parts of the crude sodas are slower and more difficult to dissolve, the mixture is to be well stirred for at least half an hour; when the solution is complete, pass it through a filter. The insoluble residuum remains in the filter. Carefully measure half a decilitre of the test liquor, which is to be poured into a large test glass. Proceed to the saturation, by the alkalimetric liquor, of the alkaline solution. To ascertain the saturation, use, as we have said above, the paper and tincture of litmus.

In the assays of potash and soda, it is always very important to ascertain the hygrometric state of the alkali,

on which the operation is performed. Potash, for example, attracts moisture from the air; it contains sometimes 30 per cent. of water, and the same remark may be made of soda. It is thus evident that assays made in this condition will be inexact, and will not give the real titer of the alkali; consequently it is important to operate on dry alkalies, so as to determine the titer with precision.

Experience has shown that all waters are not favorable for the alkalimetric assays. Calcareous waters dissolve alkalies less readily than soft waters. Distilled water must be preferred for these assays, but if it is not to be had, rain water may be employed. The following table gives a record of all the assays made by Descroizilles on the different kinds of commercial potashes and sodas:—

TABLE OF THE ALKALIMETRIC RESULTS OBTAINED BY DESCROIZILLES.

American potash (pearlash) 1st quality . .	60 to 65
" " " 2d quality . .	50 to 55
" caustic potash, in reddish masses, 1st quality	60 to 66
" in gray masses, 2d quality . .	50 to 55
Russian white potash	50 to 58
Dantzic potash	45 to 52
" blue	45 to 52
Potash of Tuscany	50 to 60
Ashes of *new* wood (green wood) . . .	8½
" washed wood (drift wood) . . .	4⅔

SODA AND DERIVATES.

Artificial crude soda	32 to 40
Carbonate of soda extracted from artificial soda	75 to 85
Dry crystallized salt of soda	36
Alicante, Teneriffe, Carthagena soda . . .	20 to 32
Soda and natron of inferior quality . . .	10 to 18

Salicor of Narbonne	16 to 25
Soda of Narbonne	10 to 15
Kelp soda	2 to 10
Crude residuum from the incineration of beet molasses and wine.	50 to 55
Refined potash, 1st quality	70 to 75
" " 2d quality	50 to 60
Potash obtained by the combustion of tobacco stalks	50 to 60
Artificial salted soda	20 to 28

We see by the above table that it is very important for the soap manufacturer to know exactly the richness of the potashes and sodas he uses. Their free or carbonated alkali is the only useful product in the fabrication. It is also the only one by which their commercial value ought to be regulated.

Assays by the Perfected Method of Gay-Lussac. —Like the method of Descroizilles, that of Gay-Lussac is based on the saturation of potash and soda by diluted sulphuric acid, but it essentially differs in the quantity of alkali employed. Descroizilles had admitted in principle that 5 grammes of pure potash or soda, dissolved in one decilitre of water, ought to saturate 100 degrees of alkalimetric liquor containing 5 grammes of sulphuric acid at 66°.

Starting from that point, evidently inexact, he determined by comparison the richness of commercial alkalies, by the quantity of alkalimetric liquor they required for their saturation. Gay-Lussac, ascertained that this method was wanting in exactness and precision. He had verified by numerous experiments, that equal parts of potash or soda, by weight, saturate different quantities of acid, but keep the same ratio for each one. Starting from that principle, invariably true in theory as in practice, he found out that five grammes of sul-

phuric acid at 66° exactly saturate 3 grammes 16 centigrammes of pure and anhydrous soda, or 4 grammes 816 milligrammes of pure and anhydrous potash. He took these numbers for the equivalents of the quantity of potash and soda which have to be used for the alkalimetric assays.

The acid alkalimetric liquor employed by Gay-Lussac is the same as that of Descroizilles. It is prepared, as we have already said, by dissolving 100 grammes of sulphuric acid at 66° B., in a quantity of water, so as to make one litre at the ordinary temperature.

The alkalimeter of Descroizilles, being graduated like that of Gay-Lussac, may be used. The difference between the two processes rests on the different quantities of potash or soda to be employed. The method of operating is as follows : As the weights 3.16 for the soda, and 4.816 for the potash, ought to be very exact, and the weighing of such small quantities is a delicate operation, Gay-Lussac advises operating on quantities ten times as large, that is, on 31 grammes 6 centigrammes of soda, or 48 grammes 16 centigrammes of potash.

On the other hand, weigh 500 grammes of pure water in a bottle of a capacity of about three-quarters of a litre, and with a diamond or a file make a mark at the level of the liquid. This done, pour out about one-fifth of the water from the bottle, and into the remaining water dissolve the 48 grammes 16 centigrammes of potash. When the solution is complete, fill the bottle with water to the mark. Stir a little and filter through paper; then measure half a decilitre of this liquor in a test glass. It is evident that this half decilitre represents the tenth part of the water used for the treatment of the potash, that is, 4 grammes 816 milligrammes.

The alkaline solution is colored blue with the tincture

of litmus, and is then saturated with the alkalimetric liquor. The acid is measured in the alkalimeter as far as the 0 of the graduation. Until half of the necessary acid is added, the liquor does not sensibly change its color, but a new addition of acid changes the color to a vinous red, because it successively decomposes the bicarbonate which has been formed during the first period of the operation, and disengages the carbonic acid. When the bicarbonate is entirely decomposed, the vinous color passes to that of onion peel, and the saturation is then complete.

The advantage of this method is to give directly and integrally the ponderal titer of the analyzed alkali, by the number of divisions or degrees of acid liquor used for the saturation. Let us suppose, for example, that the 4 grammes 81 centigrammes of potash have saturated 65 divisions of acid liquor, we conclude that 100 pounds of that potash contain 65 pounds of pure and anhydrous potash.

To resume, by operating by Gay-Lussac's method, the number of degrees or divisions of acid liquor employed to produce the saturation, directly gives the hundredth of real alkali—pure soda or potash—contained in the caustic or carbonated products.

Method of ascertaining the Quantity of Caustic Alkali contained in Potashes and Caustic Salts of Soda.—This method, as ingenious as simple, rests on the property possessed by concentrated alcohol of dissolving caustic potash and soda, without having any action on the sulphates, chlorides, carbonates, with which these alkalies are generally mixed.

Notwithstanding their designation of caustic, the commercial potashes and sodas are never in that state. Deducting the foreign salts, the word caustic is a relative and conventional word, meaning that a greater or less

part of the alkali is free, while the other is combined with carbonic acid. Indeed, the salts of soda called caustic at 80° or 85°, contain only 40 or 50 per cent. of caustic soda, the balance is in the state of carbonate.

To ascertain the ponderal quantities of caustic alkali in a potash or a soda, operate as follows: Let us suppose that we have to ascertain the quantity of caustic soda in a commercial salt of soda; take a specimen weighing 30 to 40 grammes, reduce it to powder in a marble mortar, then weigh exactly 20 grammes of the powder, which is then introduced into a bottle of about one-quarter of a litre. This being done, pour into the bottle from 80 to 100 grammes of alcohol at 95°, and stir well, so as to facilitate the solution. Set to rest five hours. Decant the clear liquor, and wash the settling with a new quantity of alcohol, from 15 to 20 grammes, which after filtration is mixed with the first liquor.

The alcoholic liquors retain in solution all the pure and caustic alkali of the salt of soda; the crystalline deposit formed at the bottom of the bottle is principally composed of sulphate and carbonate of soda, salts which alcohol leaves undissolved. To obtain the pure alkali evaporate rapidly the alcoholic liquors, and at the end of the operation heat the dish to redness, in order to melt the alkali.

By this process a white, solid, and excessively caustic substance is obtained. This substance is the hydrate of soda or pure soda; it represents the caustic alkali contained in the twenty grammes of salt submitted to analysis. If the weight of the substance is five grammes, we conclude that the salt contains twenty-five per cent. of caustic alkali. The process is exactly the same for the assay of caustic potashes.

Preparation of Lyes.—The process used for the prepa-

ration of lyes varies according to the state in which the alkali may be. Sometimes the substance is washed in filters; it is the best treatment, and that which is generally employed when the alkalies are mixed with more or less insoluble substances.

When, on the contrary, the operation is performed on alkalies deprived of insoluble matters, such as the salts of soda, and the different refined commercial potashes, proceed by the direct solution of the alkali in warm or cold water.

We shall not enter into a description of the different processes used to prepare the lyes. These processes will be described at the same time as the fabrication of the soaps to which they belong. We here remark only the very remarkable influence which the proportion of water employed for the preparation of lyes exercises on the more or less complete transformation of the alkaline carbonate into a caustic lye.

It is necessary to start from this principle, that commercial potashes and sodas contain the alkali, at least partly, in the state of carbonate; that is, combined with carbonic acid. Then, to transform this carbonate into oxide, lime alone is not sufficient. Precise experiments, by Descroizilles, have demonstrated that when the proportion of water is not in the proportion of seven to one of the alkali, there is always a certain quantity of carbonate undecomposed and left dissolved in the lye.

In the saponification, the fatty bodies play the part of acids, and potash and soda that of bases; then, if in the preparation of lyes the decomposition of the carbonate is not complete, the caustic alkali alone combines with the fatty body, whilst the carbonate remains in the lye, without assisting in the operation. It evidently results that, to convert a given weight of fatty matters into soap, a

larger quantity of lye is required, than if all the alkali is in a caustic state. When a perfectly caustic lye is to be obtained, operate as follows:—

Let us suppose that we have to prepare a lye of potash with 100 pounds of alkali; for this quantity take a sheet or cast-iron kettle, of a capacity of 150 to 250 gallons, into which 88 gallons of water are introduced and heated by fire or by steam. When the water is boiling, dissolve in it 100 pounds of good pearlash, the richest in alkalimetric degrees. To deprive the potash of its carbonic acid, pour by degrees into the boiling liquor, and in small portions, 80 pounds of quicklime, previously slacked and diluted with the necessary quantity of water to give it the consistence of milk.

Experience proves that, to obtain a complete decomposition of the carbonate of potash, it is essential that the ebullition of the mixture should not be interrupted; it is also necessary that the lime should be diluted with water, for if added in its natural state, the effect would not be the same. With these precautions, the carbonate of lime formed is heavy, and easily falls to the bottom of the kettle.

To ascertain if the decomposition of the carbonate has taken place, take a small quantity of liquor which is allowed to cool, and filter it. Pour a portion of the clear liquor into a test glass, and add nitric acid in slight excess, so as to saturate all the alkali. If the carbonate has been entirely transformed into caustic potash, no effervescence is produced, for the effervescence will be due to a disengagement of carbonic acid. If otherwise, continue to boil the mixture gently, until the nitric acid does not produce any effervescence.

This result being obtained, cut off the heat, and after covering the kettle, permit the liquid to clarify itself for

twelve or fifteen hours. This liquor constitutes the lye of caustic potash; decant it and collect it in a well-closed vessel, to prevent the absorption of the carbonic acid from the air. If the boiling has been long enough, the lye marks from 20° to 25° B.

The deposit in the kettle is washed two or three times with water; if the liquor from the first washing marks 18° or 20°, mix it with the first lye. The weak liquors from the last washings are employed in a new operation, or concentrated to 20° B. to be mixed with the first lye.

To resume, the essential conditions to obtain a perfectly caustic lye of potash or soda, are: 1. That the alkaline carbonate on which we operate, shall be dissolved in seven or eight times its weight of water. 2. That the lime shall be hydrated, until it forms a thick milk with water, for it is only in this state that it will completely deprive the carbonates of their carbonic acid.

The theory of the transformation of the carbonates into caustic alkalies, rests on the double property that lime possesses of depriving these compounds of their carbonic acid, and of forming with this acid an insoluble carbonate of lime. Indeed, whenever a carbonate of potash or soda is brought in contact with quicklime and water, a double decomposition takes place. The carbonic acid of the soluble carbonate combines with the lime to form an insoluble carbonate of lime; the alkali set free remains in solution in the liquor, in the state of hydrate, and constitutes the caustic lye of the soap makers.

The preparation of caustic lyes is only based on the decomposition of the carbonates of potash or soda by lime. Whatever is the mode of preparation, the theory is always the same. The essential point is to decompose as completely as possible the alkaline carbonate. The pure

alkali, that is free from carbonic acid, is the only useful agent; it is the only one in fact which directly participates in the saponification of fatty substances.

Lime is the active agent indispensable to the caustification of the alkalies, but its only office is to deprive them of the carbonic acid with which they are combined. To have it to act effectually, it must be of good quality, recently burned, entirely caustic, and formed into a homogeneous paste with water. As for the quantity of lime to use, it varies according to the alkalimetric richness of the carbonated alkalies. Theoretically, to decompose one equivalent of carbonate of potash or soda, one equivalent of lime is sufficient, but as in practice the indications of the theory are not always realized, it is proper to add one-fifth more of lime than is indicated by the theory, the reaction is more rapid and more complete.

Water is also an indispensable agent in preparing lyes, but all waters are not good for this operation. Rain water is the best, because it is the purest; but river waters, well clarified, may be successfully used. Calcareous waters, retaining in solution carbonate and sulphate of lime, cause a loss of alkali which it is easy to avoid by using purer waters.

It is useful also in the fabrication of soaps, to employ only lyes well deposited and perfectly limpid. To obtain them in this state, they must remain a few days in large sheet-iron vats. By resting, the foreign substances deposit at the bottom, and the perfectly clear lye can be used. The vessels which contain it must be well covered, so as to keep the lye always clean, and also to avoid the absorption of carbonic acid from the air.

To separate the lyes from the deposit which remains in the bottom of the vessels, throw these deposits into a barrel, the bottom of which is covered with a bed of sand

about four inches thick. By removing a cork placed at the bottom, the lye is drawn off, very clear and limpid.

It is often important for the manufacturer to exactly determine the quantity of pure alkali contained in one litre of caustic potash or soda. Several chemists have been engaged on this subject, but among the different processes indicated all are not exact. The areometer does not indicate, even approximately, the alkaline richness of a lye, the density of the liquid in which it is plunged not being in proportion to its purity; because this liquid may contain foreign substances which render the indications of the instrument uncertain. Chemistry has furnished a process capable of giving rigorous results. The ponderal quantity of pure alkali contained in a lye, is determined by the number of degrees of alkalimetric acid liquor required for its saturation. The operation is conducted as follows :—

Let us suppose, for example, that it is required to know how much pure potash is contained in one litre of lye of potash. Measure exactly half a decilitre of the lye to be tested, and pour it into a test glass. On the other hand, fill the alkalimeter to the *zero*, with the alkalimetric liquor, and pour it little by little into the lye, being careful to stir it all the time. When the alkali is saturated, the tincture of litmus will turn red.

To establish the exact relation existing between the alkalimetric degree of a lye, and the quantity of pure alkali it contains, multiply the number of hundredths or degrees of acid liquor employed to saturate half a decilitre of the analyzed lye, by the weight of the pure alkali equivalent to that of five grammes of sulphuric acid at 66°. This weight is 4.816 grammes for potash and 3.16 grammes for soda.

Example.—Let us suppose that the half decilitre of

lye of potash, taken for base, has saturated 60 degrees or divisions of alkalimetric liquor, we shall say: Since 100 divisions of alkalimetric liquor, representing five grammes of sulphuric acid at 66°, exactly saturate 4.816 grammes of pure potash, how much will saturate 60 degrees of the same liquor. The following equation answers the question:—

$$100 : 4.816 :: 60 : x$$

$$\frac{4.816 \times 60}{100} = 2.8896 \text{ grammes of pure potash.}$$

It results that the half decilitre of the lye of potash contains 2.8896 grammes of pure and anhydrous potash; this quantity multiplied by 20 gives 58 grammes for the weight of the potash contained in each litre. The process is the same for lyes of soda, only multiply the degrees of the alkalimetric liquor by 3.16, which represents the equivalent weight of the pure soda.

Whilst the calculations are neither long nor complicated, to relieve manufacturers from the trouble of making them, we give two tables, one for the potash, the other for the soda, presenting for each alkalimetric degree the quantity of pure alkali contained in one litre of potash or soda lye.

Table indicating, for each degree of the alkalimeter, how much pure Potash is contained in one Litre of Lye of Potash.

Alkalimetric degrees.	Pure potash contained in 1 litre of lye.	Alkalimetric degrees.	Pure potash contained in 1 litre of lye.	Alkalimetric degrees.	Pure potash contained in 1 litre of lye.
1	0.96	22	21.12	43	41.28
2	1.92	23	22.08	44	42.24
3	2.88	24	23.04	45	43.20
4	3.84	25	24.00	46	44.16
5	4.80	26	24.96	47	45.12
6	5.76	27	25.92	48	46.08
7	6.72	28	26.88	49	47.04
8	7.68	29	27.84	50	48.00
9	8 64	30	28.80	51	48.96
10	9.60	31	29.76	52	49.92
11	10.56	32	30.72	53	50.88
12	11.52	33	31.68	54	51.84
13	12.48	34	32.64	55	52.80
14	13.44	35	33.60	56	53.76
15	14.40	36	34.56	57	54.72
16	15.36	37	35.52	58	55.68
17	16.32	38	36.48	59	56.64
18	17.28	39	37.44	60	57.60
19	18.24	40	38.40	61	58.56
20	19.20	41	39.36	62	59.52
21	20.16	42	40.32	63[1]	60.48

[1] Commercial potash rarely exceeds this last number.

Table indicating, for each Alkalimetric Degree, the Quantity of Pure Soda contained in one Litre of Soda.

Alkalimetric degrees.	Pure soda contained in 1 litre of lye.	Alkalimetric degrees.	Pure soda contained in 1 litre of lye.	Alkalimetric degrees.	Pure soda contained in 1 litre of lye.
1	0.64	28	17.92	55	35.20
2	1.28	29	18.56	56	35.84
3	1.92	30	19.20	57	36.48
4	2.56	31	19.84	58	37.12
5	3.20	32	20.48	59	37.76
6	3.84	33	21.12	60	38.40
7	4.48	34	21.76	61	39.04
8	5.12	35	22.40	62	39.68
9	5.76	36	23.04	63	40.32
10	6.40	37	23.68	64	40.96
11	7.04	38	24.32	65	41.60
12	7.68	39	24.96	66	42.24
13	8.32	40	25.60	67	42.88
14	8.96	41	26.24	68	43.52
15	9.60	42	26.88	69	44.16
16	10.24	43	27.52	70	44.80
17	10.88	44	28.16	71	45.44
18	11.52	45	28.80	72	46.08
19	12.16	46	29.44	73	46.72
20	12.80	47	30.08	74	47.36
21	13.44	48	30.72	75	48.00
22	14.08	49	31.36	76	48.64
23	14.72	50	32.00	77	49.28
24	15.36	51	32.64	78	49.92
25	16.00	52	33.28	79	50.56
26	16.64	53	33.92	80	51.20
27	17.28	54	34.56		

Under some circumstances, the manufacturer is obliged to dilute his lyes with water, in order to reduce them to a required degree. To be exact, this work requires much precision, and we have thought it will be of interest to the reader to proceed on a sure foundation; it is for this purpose that we have composed four tables for the reduction of lyes of soda of high degrees. For the first two tables we have taken a lye at 36°, for the last two we have employed a lye at 30°. The first column on the left indicates the quantity and degree of the lye to be reduced, the second indicates the quantity of water to be

added, the third gives the quantity of lye obtained, the fourth and last indicates the areometric degree of the lye.

TABLE No. 1.—*Indicating the different areometric degrees, which result from the mixture of* 100 *litres of a lye of salt of soda at* 36° *B., with quantities of water varying from* 100 *to* 900 *litres.*

Quantity of litres of lye at 36°.	Quantity of litres of water.	Quantity of lye obtained.	Areometric degree of the lye.
100	100	200	23
100	200	300	17
100	300	400	14
100	400	500	12
100	500	600	10
100	600	700	9
100	700	800	8
100	800	900	7¼
100	900	1000	6¾

100 litres of lye at 36° B. weigh 135 kilogrammes.

TABLE No. 2.—*Indicating the different areometric degrees, resulting from the mixture of* 100 *kilogrammes of a lye of salt of soda at* 36° *B., with quantities of water varying from* 100 *to* 900 *kilogrammes.*

Quantity of kilog. of lye at 36°.	Quantity of kilog. of water to use.	Quantity of kilog. of lye obtained.	Areometric degree of the lye.
100	100	200	21
100	200	300	14½
100	300	400	11
100	400	500	10
100	500	600	9
100	600	700	8
100	700	800	6½
100	800	900	5½
100	900	1000	5 (weak).

74 litres of lye at 36° B. weigh 100 kilogrammes.

TABLE No. 3.—*Indicating the different areometric degrees, resulting from the mixture of* 100 *litres of a lye of salt of soda at* 30° B., *with quantities of water varying from* 100 *to* 900 *litres.*

Quantity of litres of lye at 36°.	Quantity of litres of water to use.	Quantity of litres of lye obtained.	Areometric degree of the lye.
100	100	200	19
100	200	300	14 (weak).
100	300	400	11
100	400	500	9
100	500	600	8
100	600	700	7
100	700	800	6
100	800	900	5
100	900	1000	4½

100 litres of lye of soda at 30° weigh 125 kilogrammes; 75 litres of this lye and 25 litres of water give 100 litres of lye at 25°. It requires 30 kilogrammes of salt of soda to make 100 litres of lye at 30° B.

TABLE No. 4.—*Indicating the different areometric degrees, resulting from the mixture of* 100 *kilogrammes of a lye of salt of soda at* 30° *B., with quantities of water varying from* 100 *to* 900 *kilogrammes.*

Quantity of kilog. of lye at 30°.	Quantity of kilog. of water to use.	Quantity of kilog. of lye obtained.	Areometric degree of the lye.
100	100	200	17
100	200	300	12
100	300	400	9½
100	400	500	7½
100	500	600	6½
100	600	700	5½
100	700	800	5 or 5¼
100	800	900	4½
100	900	1000	4

80 litres of lye at 30° B. weigh 100 kilogrammes.

CHAPTER XI.

ACIDS.

Carbonic Acid—Sulphuric Acid—Hydrochloric Acid—Nitric Acid.—The only important acids for the soap manufacturer may be ranked in two classes: the inorganic and organic acids. The latter will be studied in treating of the fatty substances. Among the first we shall only examine carbonic, sulphuric, hydrochloric, and nitric acids.

Carbonic Acid.—This acid at the ordinary temperature is gaseous, with a slightly pungent odor; its taste is a little sour. It feebly reddens blue vegetable colors; it extinguishes bodies in combustion. Water under the ordinary atmospheric pressure, and at the temperature of 68°, will dissolve its volume of this gas. It is formed of

1 vol. vapor of carbon.
1 " oxygen.

These two gases condense into one volume. It is formed in weight of

Carbon	27.67
Oxygen	72.33
Its specific gravity=	1.5277

It combines with nearly all bases, and forms salts called carbonates.

Sulphuric Acid.—This acid is liquid, colorless, transparent; its consistency is like oil, which has caused it to receive the name of oil of vitriol. Its specific gravity =1.842, at 66° of Baumé's areometer. It is one of the

most energetic acids; its corrosive property is so great that it destroys all animal and vegetable substances. Exposed to a cold of—15° it crystallizes; if mixed with a small quantity of water it freezes more readily, and it may well solidify at five degrees below the freezing point; however, it may be kept solid above that point. Submitted in a retort to the action of heat, it volatilizes and distils without decomposition. Its composition is:—

Sulphur	40.14
Oxygen	59.86
	100.00

Hydrochloric Acid.—Hydrochloric acid is gaseous at the ordinary temperature; it is colorless, and produces whitish vapors when in contact with the air. It strongly reddens litmus paper and the syrup of violets. Its specific gravity=1.2474. It is very soluble in water, which at the temperature of 68° dissolves 464 times its volume. Its composition is 1 vol. of chlorine, and 1 vol. of hydrogen, or in weight:—

Chlorine	97.26
Hydrogen	2.74
	100.00

In commerce, hydrochloric acid is always in solution in water; it marks 22° on Baumé's areometer. It has a yellowish color, and contains a certain quantity of sulphurous acid. The yellowish color is often produced by oxide of iron.

Nitric Acid.—Nitric acid, as found in drug stores, always contains water. It is colorless, with a strong odor, and is sapid, and corrosive. Its specific gravity, according to Kirwan,=1.5543; according to Gay-Lussac, it is=1.513. The most concentrated acid is thus formed:—

Water	14.286
Acid	85.714
	100.000

Its specific gravity = 1.55. As it is very important to know the quantity of real acid contained in 100 parts of a mixture of a known density, we give the following table :—

Quantity of water in 100 parts.	Quantity of acid in 100 parts.	Specific gravity of the mixture.
14.286	85.714	1.53
25.000	75.000	1.4855
33.332	66.668	1.4546
40.000	60.000	1.4237
45.455	54.545	1.3928
50.000	50.000	1.3692
53.740	46.260	1.3456
60.000	40.000	1.3032
62.500	37.500	1.2844
64.706	35.294	1.2656
67.426	32.574	1.2495
68.421	31.579	1.2334
70.000	30.000	1.2173
71.429	28.571	1.2012

The acid which contains sixty per cent. of pure acid, seems to be the more fixed combination. It boils at 248°. That of a specific gravity 1.3692 boils at 242.6°. The boiling point varies according to the specific gravity. The reagents to ascertain the presence of this acid are: 1. Its peculiar odor; 2. Copper filings which, in contact with it, cause a disengagement of red vapors. Its composition is :—

	In vol.	Equiv.	In weight.
Nitrogen	2	1	25.92
Oxygen	5	5	74.08

SECTION III.

FATTY SUBSTANCES USED IN THE FABRICATION OF SOAPS.

Having studied in detail, the chemical history of the alkalies employed in the fabrication of soaps, we shall now treat of the different saponifiable fatty substances. They are divided into two distinct classes: the first comprises the fatty substances of vegetable origin, which are generally designated by the name of *oils;* the second comprises the fatty bodies of animal origin, and to this class belong the tallows, lards, and other greases from herbivorous animals. But before commencing this study, it is important to give a short history of the principal physical and chemical properties, which are common to fatty substances in general.

CHAPTER XII.

GENERAL OBSERVATIONS ON FATTY SUBSTANCES.

The industrial fatty bodies, of which we propose to make a complete and comparative study, are the products of the two living kingdoms, vegetable and animal.

Division of Fatty Bodies.—According to the state in which the fatty bodies occur under ordinary circum-

stances, they receive particular names; thus they are called *oils*, *butters* or *concrete oils*, *greases*, *tallows*, *waxes*.

The *oils* are liquid at the ordinary temperature; they are vegetable or animal.

The *butters* or *concrete oils* are vegetable oils, soft or solid at the ordinary temperature, soft at 64.4° F., and fusible at 96.8°.

The *greases* and *tallows* are extracted from the animal organism; the first are soft and very fusible, the tallows are solid and melt only at 100°.

Lastly, the *waxes* may be of vegetable or animal origin; they are hard and brittle, begin to soften at 95°, and generally melt at 147°.

In the Vegetables.—In vegetables, the fatty oils are generally met in the seeds; they are contained in the part which gives birth to the cotyledons, but the substance of the plumule and the radicle does not contain any. The seeds of the *cruciferæ*, *drupaceæ*, *amentaceæ*, *solana*, and *papaveraceæ*, deserve to be named on account of their richness in oil.

It is very rare that fatty substances are met with in the pulpy parts of the fruits. We know only the olive, the cornel-tree, and the laurels, the fruits of which containoil in their pulpy part. The *cyperus esculentus* presents the very rare case of an oil in its root.

In the seeds of plants, the oils are generally accompanied by vegetable albumen; thus, when they are triturated with water, the albumen keeps the oil in suspension in this liquid, which then becomes white and opalescent like milk, and takes the name of *emulsion*.

Among the vegetable oils, there are some which are as hard as mutton tallow; they receive then the name of *concrete oils* or *butters*. Such are those of *palm*, *coco*, *nutmeg*, *cacao*, *laurel*, etc.

In the Animals.—The fatty matter, *grease* or *tallow*, is found in the cavities of the cellular tissue, but it principally affects certain parts of the body; ordinarily it is abundant under the skin, at the surface of muscles, around the kidneys, and near the intestines. It presents modifications in the different classes of animals.

In the herbivorous, it is firmer, more solid, less odoriferous than in the carnivorous. The grease of birds is soft, unctuous, and very fusible. That of fishes and cetacei is nearly fluid and very odoriferous. White and abundant in young animals, it becomes yellow and diminishes in quantity with age.

Animal Wax.—Waxes are animal or vegetable concretions. Animal wax is produced by a few insects of the family of the *hymenoptera*, by bees in particular; it is secreted under the rings of the stomach of these precious insects.

Vegetable wax is abundantly met with in vegetables. It constitutes the greater part of the chlorophyl or green substance of the different organs of plants; it exists in the pollen of flowers, in the fruit of the beech tree, poplar, etc.; it covers the envelopes of many stone fruits; it forms the varnish of leaves, is met at the surface of the leaves of the palm tree (carnauba wax), on the bark of the violet sugar cane; it surrounds the berries of the *myristica* of Para and French Guiana, of the *Chinese fustic*, of all the *myrica* of the Indias, America, and Louisiana.

Extraction of Fatty Bodies.

Vegetable Oils.—The extraction of fatty bodies varies according to their consistency. The vegetable oils used as food or for lighting purposes, are obtained by submit-

ting the seeds, which contain them, to the action of a strong press between metallic plates. When the vegetable fatty substances are concrete at the ordinary temperature, as palm oil, etc., the expression is effected between warm metallic plates; or the oleaginous seeds, after being bruised, are boiled with water. The oil escapes from the cells which contain it, and collects at the surface of the water, where it solidifies on cooling.

Virgin Oil.—Oils principally used for lighting and other industrial purposes, are also obtained by expression; the seeds are bruised and pressed the first time so as to extract the purest oil, called *virgin oil;* they are bruised anew, heated at a temperature of 122° to 131°, on metallic plates, for the purpose of destroying and coagulating the albumen and mucilage which prevent the running of the oil, and they are pressed a second time to extract another quality of oil, less pure than the first.

Quantity of Oil Furnished by Seeds.—The quantity of oil furnished by seeds, varies according to the species and also to the season and climate. Nuts contain half of their weight of oil; colza seeds, one third; that of rape seed, two-fifths; poppy seed, forty-seven per cent.; hempseed, one-quarter; linseed, one-fifth, etc.

The use of heat to facilitate the running of oils by pressure, has the inconvenience of altering the oils a little, giving them an acrid taste, and rendering them susceptible of becoming rancid, much quicker than oils expressed at the ordinary temperature. Notwithstanding the preliminary torrefaction, all the albuminous or mucilaginous matter is not destroyed, and a certain quantity is always found in the oil, which is muddy, does not burn well, gives much smoke, and carbonizes the wick. These oils have to be refined.

Purification of Vegetable Oils.—The process most generally followed to purify burning oils, consists in stirring them thoroughly with a little sulphuric acid, and afterwards washing them with warm and cold water to deprive them of the acid used. Sulphuric acid carbonizes the mucilaginous substances, which then separate in the form of a black and thick mass, below the oil which has become entirely limpid. The loss by purification varies from 1.5 to 2 per cent. according to the quality, process of purification, etc.

Extraction of Animal Oils.—Animal oils are extracted from herbivorous and ruminant animals (the ox, the sheep, etc.), and from fish. The first, called neats' foot oil, sheep oil, etc., are extracted by boiling with water the heads, feet, etc., of certain mammifers, and collecting the oil which floats on the surface. Fish oils are extracted either by boiling with water the fat of large cetacei (whale oil), or by direct coction of other fishes, (herring oil, etc.); or from the livers of the cod, etc., which are abandoned to a spontaneous putrefaction.

Purification of Fish Oils.—The oil is heated over a water-bath in deep copper kettles, then submitted to a slow cooling until it reaches 53° or 59°. By standing, the more solid parts separate and precipitate, and the oil is decanted and purified as follows: It is heated over a water-bath at about 212° F., mixed by an energetic stirring with $\frac{1}{100}$ of its volume of an aqueous solution of caustic soda, a kind of insoluble soap is formed with the brown and odoriferous fatty acids, and the oil becomes limpid and nearly colorless. It is then filtered.

As for the thick fatty substance, which separates by the heat from the crude oil, it is purified by melting it by steam in a wooden vat. When the liquid is at 212°, add to it one or two per cent. of hydrochloric or

tartaric acid, the whole is well stirred, and let to cool slowly. The purified fatty substance solidifies, and may be used as common tallows.

Extraction of Greases and Tallows.—For animal greases, the process generally followed for extracting them, consists in heating by fire, in large copper kettles, the parts which contained them, and which are divided as much as possible before melting them. With skimmers or pails pierced with holes, the fatty matter is separated from the membranes, which in the extraction of tallows have received the name of *scratchings*.

Instead of operating with an open fire, it is better to use d'Arcet's process, which consists in heating by steam the tallow which is covered with water acidulated by sulphuric acid; this acid disaggregates the adipous tissue, and even partly dissolves it, and the fatty substance forms, at the surface of the bath, a liquid layer, which is drawn off into suitable receivers. The membranes, and the meat more or less dissolved, fall to the bottom of the bath, where they form a deposit. For 1000 lbs. of tallow, add 25 gls. of water and 10 lbs. of sulphuric acid at 66°.

This treatment has the advantage of not giving rise to an infectious odor, which is generally produced during the carbonization of animal substances; and the tallow obtained by acid is whiter than that produced by other processes.

M. Evrard has invented a process of extracting tallow, based on the property that caustic alkalies possess, when very diluted, of dissolving the membranes which constitute the adipous tissue without attacking the fatty substances. He employs a weak solution (marking 1° to 1.5°) of caustic soda for 100 pounds of tallow, just as it is extracted from the animal without cutting it.

By the influence of heat and the alkaline solution, the

adipous tissue swells considerably, the fatty matter separates and floats on the surface of the bath. It is sufficient to wash it with warm water, and keep it liquid for seven or eight hours, to obtain it perfectly limpid. Another remarkable effect is produced; the odoriferous fatty acids contained in tallow dissolving in the alkaline liquor, the tallow is nearly odorless, and does not become rancid so easily.

Extraction of Animal and Vegetable Waxes.—Beeswax, a true animal secretion, is obtained by submitting the combs to the action of a press, so as to extract the greater part of the honey; the cakes are melted in boiling water, and the wax is left to solidify at the surface; it is melted anew and run into earthen jars; the product thus obtained constitutes the *beeswax*, or virgin wax.

The vegetable waxes are extracted by boiling with water the vegetable parts (leaves, berries, etc.), in which is the waxy matter. The melted wax rises to the surface, and solidifies by cooling.

Properties of the Fatty Substances. Color.—In a pure state, all fatty substances are colorless; but when recently extracted from the organs which contain them, they are always slightly colored yellow or brown; some, as fish oils, palm oil, croton oil, etc., are strongly colored yellow.

The green or yellow color of many oils is due to a coloring matter which dissolves into them at the time of the manufacture, and which has developed itself by the alteration of some of the constituent principles.

Odor.—When fatty substances have any odor, it is generally due to some volatile acids, as butyric, valerianic, caproic acids, etc., which are contained in them in small quantity. Vegetable oils have nearly all the same

odor as the plants which furnish them, at least while they are fresh.

Taste.—Properly speaking, fatty substances have no taste, and occasion a feeling on the tongue only by their unctuosity and their insipidness.

Consistency.—Their consistency is very variable; the oils are liquid; butters and greases are soft; tallows and waxes are hard and even brittle.

Density.—Their density, always less than water, varies between 0.90 and 0.93.

Action of Cold and Heat.—Cold hardens fatty bodies which are already solid, and freezes or solidifies those which are fluid under ordinary circumstances. Heat, on the contrary, renders more fluid the fatty bodies which are already in that state, and liquefies those which are generally solid.

Penetration of Bodies.—Natural fatty bodies stain paper, that is, render it transparent, without being reduced to their primitive state by heat. They easily penetrate the bodies with which they are placed in contact, oils especially, but do not soften them as water does.

Oils, greases, tallows, etc., can be easily introduced into clay; and this property is employed to remove grease spots from paper, cloth, wood, etc., by covering these spots with clay reduced to a firm paste with alcohol or water; during the desiccation the clay absorbs the fatty matter.

Solubility in Water.—Fatty bodies are nearly insoluble in water, and generally they may be considered as entirely insoluble. However, when an oil is stirred with perfectly pure water, and the mixture is left to clarify, it is possible, by stirring the water afterwards with ether, to extract a trace of oil which is discovered after the evaporation of the ether. Reciprocally, oils dissolve

a little water, which is disengaged by evaporation at a gentle heat.

Action of Solvents.—Cold alcohol dissolves very little of the fatty bodies; boiling alcohol dissolves a certain proportion, the greater part of which deposits on cooling. Castor and croton oils are exceptions; they are very soluble in alcohol, especially when it is anhydrous.

Ether is the best solvent of fatty matters in general; naphtha, benzine, and natural and artificial essential oils, dissolve them with facility.

Dissolving Action of Fatty Bodies.—Fatty bodies in general, and oils in particular, dissolve at the ordinary temperature small quantities of sulphur, phosphorus, selenium; when warm they will dissolve more, and these substances will crystallize by cooling; they mix also with the chlorides of phosphorus, of sulphur, of arsenic, and the sulphide of carbon.

A few salts, such as the alkaline carbonates, chloride of sodium, the subsalts of copper, verdigris, for example, dissolve in liquid fatty bodies, but without saponifying them. Oils dissolve several alkaloids, such as morphia, cinchonia, quinia, strychnia, etc.

Neutrality.—In general, fatty bodies are neutral to litmus paper. However, the oils of cetacei, such as whale, etc., are slightly acid.

Action of the Air.—They can be kept for a long time without alteration, when protected from the contact of the air; but, submitted to the action of this agent, they are not long in presenting an acrid and disagreeable taste, and reddening litmus paper; then they are said to be rancid.

Siccativity.—At the same time that the above effects are produced, several fatty bodies, especially certain vegetable oils, lose their limpidity by degrees, absorb

oxygen from the air, and dry in the form of a yellowish, supple, and transparent substance, which dissolves with difficulty in boiling alcohol. The oils which are thus dried take the name of *siccative* or *drying oils.* This property renders them valuable for the preparation of varnishes and oil colors.

Oils not Siccative.—These oils, without presenting such profound changes by the action of the air, are more or less modified. Thus they are progressively and completely discolored, sensibly increase in density, lose a little of their fluidity, become less combustible, and carbonize the wick when burned.

The absorption of oxygen by oils at first is slow, then is very rapid, and if it takes place in masses, the produced heat is sufficient to inflame the fatty body.

The different changes produced by air in the fatty bodies are due to the absorption of oxygen. Carbonic acid gas is formed, the volume of which does not represent all the absorbed oxygen; and as M. Chevreul has observed in the fat of pork, fatty acids are formed, such as oleic and margaric acids, odoriferous volatile principles, and one or two volatile acids. It is to these latter compounds that the greases and other fatty substances, when rancid, owe their disagreeable odor and taste. Rancid fatty bodies may be regenerated by exhausting them by boiling water, and treating them at the ordinary temperature by a small quantity of an alkaline lye.

The action of the air is provoked by the foreign substances which always exist in commercial fatty bodies; for the stearin, margarin, and olein, when chemically pure, do not become rancid, and greases in general are less apt to assume this condition when they contain less of foreign substances.

Immediate and Elementary Composition. Immediate Composition.—The natural fatty bodies are formed, with very few exceptions, by a mixture of immediate principles discovered about the same time in 1813, by M. Chevreul and M. Braconnot, and which they have called *stearin, margarin, olein, butyrin, caprin, caproin, phocenin.*

These immediate principles, under the influence of alkalies, are transformed into *glycerin*, or the *sweet principle of oils*, and into particular fatty acids which have been called *stearic, margaric, oleic, butyric, capric, caproic*, and *phocenic*. Vegetable oils are essentially formed of *olein* and *margarin;* the fatty bodies of animal origin, greases and tallows, are formed of *olein, margarin*, and *stearin;* waxes are formed of three substances, the *cerin, myricin*, and *cerolein.*

Olein is the liquid part of the oils, the stearin and margarin are solid, etc.

Independently of these immediate principles, the fatty bodies contain, in a small quantity, coloring and odoriferous principles which vary for each kind, and of which they may be deprived by the use of animal black, without losing their characteristic properties. Their yellowish or brownish color is particularly due to the coloration of the liquid part.

Proportions of the Immediate Principles.—The different kinds of fatty bodies do not contain the same proportions of stearin, margarin, and olein, as shown in the following table, made according to the researches of MM. Chevreul and Braconnot :—

Fatty matters from vegetables.			Fatty matters from animals.		
	Margarin.	Olein.		Margarin.	Olein.
Rape-seed oil .	46	54	Sheep tallow .	80	20
Olive oil . .	28	72	Beef marrow .	76	24
Sweet almond oil	24	76	" tallow .	70	30
butter.			Pork grease .	38	62
Winter butter .	65	35	Goose " .	32	68
Summer "	40	60	Duck " .	28	72
			Turkey " .	26	74
			Sheep marrow .	26	74

Their consistency is in direct proportion to the quantity of solid substance (stearin, margarin, etc.) they contain. The unequal fusibility of these bodies is due to the variation in the proportions of their immediate principles. The fusibility increases with the proportion of olein.

Elementary Composition.—Whatever is their origin, fatty bodies have the same elementary composition. There is generally no nitrogen, but they contain oxygen and are very rich in carbon and hydrogen. The following table presents the analysis of some of them, according to MM. Chevreul and Th. de Saussure.

Fatty bodies.	Carbon.	Hydrogen.	Oxygen.
Mutton grease . . .	79.0	11.7	9.3
Pork "	79.0	11.1	9.8
Human "	79.0	11.4	9.6
Nut oil	79.7	10.5	9.1
Almond oil	77.4	11.5	10.8
Linseed "	76.0	11.3	12.6
Castor "	74.0	11.0	14.7
Olive "	77.2	13.3	9.4

Action of Heat, Alkalies, and Acids.

Volatility and Ebullition.—Fatty bodies are not volatilized without decomposition; they boil at an elevated

temperature, different for each one, and are not decomposed at a temperature of 482° F.

Action of Heat in the Open Air.—Kept boiling in contact with the air, fatty substances are decomposed, disengaging carbonic acid, liquid, and gaseous hydro-carbons, and a volatile oil called *acrolein*, the vapor of which irritates the eyes and respiratory organs, and which essentially characterizes the destruction of fatty substances by heat. Submitted to distillation in closed vessels, they yield in the receiver the same products, but also an oily matter, becoming concrete, and composed of three fatty acids: a liquid, *oleic acid;* and two other solid, the *margaric* and *sebacic* acid, which have been produced at the expense of the olein, margarin, and stearin; and lastly, a small proportion of odoriferous acids (acetic, butyric, etc.), and acrolein. From the three fatty acids obtained by the dry distillation of fatty bodies, the margaric acid is the one which predominates in crude concrete substances, and is easily isolated by pressure. Its percentage in animal greases is greater than in oils, generally from 36 to 45 per cent. The knowledge of these important facts is especially due to MM. Bussy and Lecanu. For several years this process was used in the arts to obtain margaric acid for the fabrication of candles, but it is now obtained by a more simple method.

If, instead of progressively heating fatty bodies in closed vessels, they are suddenly submitted to the action of a red heat, they are entirely decomposed and are in the greater part transformed into carburetted hydrogen gases, which may be used for lighting. Impure seed oils, and crude fish oils, have also been used to manufacture illuminating gas instead of coal, in certain places where their low price permits them to be employed with advantage.

The gas furnished by fatty substances is more abundant, has more illuminating power, and is purer than that from coal; indeed, they give about 230 litres of gas for every kilogramme.

The gas from oil does not generally contain ammoniacal salts, or sulphuretted hydrogen, but it contains several very combustible compounds, very little different from bicarburetted hydrogen. This latter is more abundant than in coal gas, hence its illuminating power is three times and a half greater.

Experience has demonstrated that 800 litres of oil gas give a light equivalent to 2800 litres of coal gas.

Action of Alkalies.—Alkalies, alkaline earths, lime, baryta, etc., some metallic oxides (oxides of lead, zinc, etc.), saponify fatty bodies and set free the glycerin. The compounds resulting from the combination of the fatty acids with the alkalies have received the name of SOAPS. Potash gives *soft soaps*, and soda *hard soaps*.

Soaps may be considered as true salts; they obey the laws of mutual affinity; the insoluble soaps are produced by a double exchange as the other insoluble salts.

Action of Acids.—Energetic acids gradually destroy fatty bodies, and convert them into products similar to those obtained by the action of heat, that is, there is a production of fatty acids.

Concentrated Sulphuric Acid grows warm with fatty bodies, and easily determines a disengagement of sulphurous acid, if the mixture is not cooled down. Under these circumstances the fatty substances experience a decomposition similar to that produced by alkalies; sulpho-glyceric acid is obtained, and also combinations of margaric and stearic acids with sulphuric acid, which are decomposed by the action of water, which sets free the fatty acids.

Concentrated Nitric Acid attacks fatty bodies with violence; sometimes the substance takes fire. Diluted nitric acid acts slower, and gives birth to the same products obtained by operating separately on glycerin and the fatty acids. Nitric acid, by the help of a prolonged ebullition, transforms fatty bodies into oxalic acid.

Hyponitric or *nitrous acid* solidifies the olein of some non-siccative oils, and transforms it into elaidin. This property is used to ascertain the falsification of olive oil by common oils.

Chromic acid, an energetic oxidizing agent, alters fatty bodies; the products obtained in the reaction have not yet been well studied.

Chlorine, *Bromine*, *Iodine*, attack all the fatty bodies, by producing hydrochloric, hydrobromic, and hydroiodic acids, and giving derivatives by substitution, that is, fatty bodies in which hydrogen is substituted, in all or in part, by chlorine, bromine, or iodine.

With chlorine, the reaction takes place with a disengagement of heat, but without explosion; bromine on the contrary acts violently.

Chlorine immediately colors fish oils black.

The chlorinated and brominated fatty bodies have generally a yellowish shade, except the fish oils.

The iodized products are colorless. The ordinary reagents do not attest the presence of iodine, it is the same for the chlorinated and brominated products. The iodized products may dissolve more iodine and become black.

Uses of Fatty Bodies.

Fatty bodies render a great many services in industry, domestic economy, and medicine. In industry, fatty bodies are employed to manufacture soaps and varnishes;

to dilute colors for painting; to coat a multitude of substances, so as to render them soft and flexible. They are used also to lubricate machinery, etc.

Their greatest use is in the fabrication of soaps, and for purposes of illumination.

CHAPTER XIII.

IMMEDIATE PRINCIPLES OF FATTY BODIES.

Stearin—Margarin—Olein—Elaidin—Butyrin—Phocenin—Palmin—Palmitin—Myristin—Hircin—Cetin—Myricin—Cerin—Cerolein—Cholesterin—Glycerin—Ethal.

Before the remarkable works of M. Chevreul on fatty bodies were published, these substances were nearly unknown. It was, however, known that several fatty substances, when treated by alkalies or oxide of lead, produced soaps and plasters.

The celebrated Swedish chemist, Scheele, had ascertained, in the products of the action of oxide of lead upon oils, the existence of a sweet soluble substance, which he called *sweet principle of oil* (*glycerin*), but the theory of saponification was entirely unknown, and consequently the composition of fatty bodies was completely ignored. It was for the illustrious master of the author of this work, M. Chevreul, that it was reserved to establish in a precise and clear manner the constitution of fatty substances. He published the results of his researches in 1815.

He demonstrated that the fatty substances known by

the name of *oils, butters, greases, tallows,* were formed by a mixture of immediate principles which he called stearin, margarin, olein, butyrin, phocenin, etc.; that these immediate principles were convertible under the influence of alkalies* into glycerin and certain peculiar fatty acids;—thus stearin produced glycerin and stearic acid; olein, oleic acid and glycerin, etc.—and he made the remark that if in the saponification, mixtures of different fatty acids were formed, it was because the neutral fatty bodies submitted to the action of the alkalies were mixtures of stearin, margarin, olein, etc.

Since the works of M. Chevreul, MM. Dumas, Peligot, Berzelius, Pelouze, and Gelis were engaged in the same inquiries; and a few years ago, Berthelot published a remarkable work, the results of which have confirmed the hypothesis, uttered forty years before by M. Chevreul, that fatty bodies were compounds similar to ethers.

Berthelot has, indeed, succeeded not only in *reproducing* nearly all neutral fatty bodies by directly uniting glycerin with the different fatty acids, but also in preparing several new fatty bodies by combining glycerin with several mineral and organic acids.

Stearin.

From the Greek word στεαρ, *tallow.*

Syn.—Stearate of glycerin, or Tri-stearin of Berthelot.

This substance, discovered by M. Chevreul, was obtained pure by Braconnot, and artificially by Berthelot.

Stearin exists in nearly all the solid greases, and in several vegetable oils. Its proportion in fatty bodies is

* This operation has received the name of *Saponification.*

the more considerable that their consistency is greater and their melting point more elevated. Stearin is ordinarily extracted from sheep or beef tallow. It is sufficient to heat the tallow with eight or ten times its weight of ether, and to filter. On cooling, nacreous crystals of stearin deposit, and the liquor retains in solution the margarin and olein. The crystals, after being strongly pressed in blotting paper, are redissolved in ether until their melting point remains fixed.

Braconnot obtained it by melting tallow and adding to it spirit of turpentine, and when, by cooling, the mixture had solidified, he pressed it in a cloth. The olein and margarin which are in solution in the spirit escape, while the stearin remains in the cloth. This residue is treated once or twice by spirit of turpentine to obtain it pure, and is afterwards kept melted for some time to deprive it of any turpentine.

Artificial stearin is produced by heating at 518° F. for three hours, the *mono stearin* (combination of stearin and glycerin) with 15 or 20 times it weight of stearic acid.

Stearin has the following composition :—

	From mutton suet. Chevreul.	From olive oil. De Saussure.
Carbon . . .	78.776	82.170
Hydrogen . . .	11.770	11.232
Oxygen . . .	9.454	6.302
Nitrogen . . .	"	0.296
	100.000	100.000

These analyses present a remarkable fact: it is that vegetable stearin is nitrogenized, while the animal one contains no nitrogen, but more oxygen and less carbon.

Natural or artificial stearin is white, inodorous, without taste, very combustible, and insoluble in water.

Boiling alcohol dissolves about $\frac{1}{7}$ of its weight of stearin, the greater part of which deposits by cooling. It is more soluble in boiling alcohol, but this liquid, when cold, dissolves only $\frac{1}{225}$ of its weight.

Stearin is fusible, and by cooling takes the form of a waxy mass. Its melting point is ordinarily 143.6° F, but it is possible by several crystallizations in ether to raise this point to 145.4° and even 147.2°.

According to Duffay, stearin presents itself in three distinct physical modifications—a stearin melting at 123.8°, one modification melting at 141.8°, and one which liquefies at 151.7°.

The density of stearin varies with its melting point.

Melting point.	Density.	
129.2°	0.986	It does not conduct electricity.
145.4°	1.010	
151.7°	1.017	

When distilled, stearin is decomposed, producing margaric acid, margarone, and several *carburetted hydrogens*. It leaves a slight residuum of charcoal.

Chlorine and bromine attack stearin, and produce chlorinated and brominated compounds by substitution.

Bases, and particularly alkalies and lime, decompose stearin in the presence of water, and by a prolonged ebullition. In this reaction the stearin is transformed into stearic acid, which unites with the alkali to produce a stearate, and into hydrated glycerin, which remains in solution in water.

A curious fact which we must notice here, is that the weight of the free stearic acid, after its elimination from the soap by an acid, added to that of the glycerin, is more than the weight of the fatty matter submitted to the action of the hydrated alkali. This increase of weight is manifested in the saponification of all neutral fatty

matters, and is due to the fixation of the elements of water.

Margarin.

From the Greek, Μάργαρον, *pearl.*
Syn.—Margarate of glycerin, Tri-margarin of Berthelot.

Margarin, discovered by M. Chevreul, is met with in nearly all fatty substances, such as human fat, lard, goose fat, butter, olive oil, linseed oil, etc. In all of these substances it is mixed with olein, and also very often with stearin.

To obtain it, it is sufficient to treat human fat by boiling alcohol; the margarin precipitates in micaceous scales, and is purified by several crystallizations.

To prepare it, olive oil, butter, or goose's fat, can be more advantageously used. The olive oil is cooled down to 39.2°, and when congealed is pressed, so as to exhaust the greater part of the olein.

The pressed substance is melted at a gentle heat, and cooled very slowly, so as to permit it to deposit in grains as large as possible. The mass cooled at 53.6° or 59°, is pressed anew. The solid residuum of this last operation is nearly pure margarin. Its purification is completed by crystallizing it several times in alcohol.

As for butter and goose's fat, they are cooled slowly and pressed, the first time at 53° or 59°, then a second time at 68°. By repeated fusions and coolings at a gradually but slightly increased temperature, a solid fatty matter is obtained which melts at 96.8°. It is dissolved to complete saturation in a boiling mixture of two parts of alcohol and three of ether; by cooling, the margarin deposits in grains, whilst the olein remains in solution. The deposit of margarin is pressed and submitted to new crystallizations.

Berthelot produces artificial margarin by heating at 518°, for a few hours, three equivalents of margaric acid with one equivalent of mono-margarin (combination of margaric acid and glycerin).

Margarin crystallizes in micaceous scales; it resembles stearin, but differs by its melting point, which is 116.6°. It crystallizes in alcohol in the form of colorless needles, and loses all crystalline appearance by pressure. 100 parts of anhydrous and boiling alcohol dissolve 2.5 parts of margarin, and deposit nearly the whole of it by cooling.

Chlorine and bromine act on it in the same manner as on stearin. Margarin is saponified like stearin under the influence of alkalies and a few metallic oxides, and is transformed into glycerin and margaric acid, which unites with the base.

Olein.

From the Latin *oleum*, on account of its fluidity.

Syn.—Tri-olein of Berthelot; Elain, from the Greek word Ελαιον, oil.

Olein or *Elain*, is the fatty substance which enters into the composition of nearly all the greases, especially of the oils of which it forms the liquid part. It is not abundant in greases, but predominates in oils; generally it holds in solution a certain quantity of stearin and margarin.

Siccative oils do not contain olein. Several processes have been proposed for extracting it, but none yet has produced it in a perfectly pure state.

According to M. Chevreul, boil in a glass balloon human fat, lard, or grease, etc., with alcohol; filter the solution which, when cold, deposits the stearin and margarin; the olein remains in solution and is obtained by the evaporation of the alcohol. It is purified by pressing it after cooling it down to 32°. The solid

part separates from the liquid, and olein is thus obtained which does not solidify at 32°.

Olein is also obtained by pressing solid greases in filtering paper, which takes off the olein, which afterwards is extracted by alcohol.

Olive oil or oil of sweet almonds can be shaken with *cold* alcohol, and the filtered solution evaporated; but this process yields an impure olein.

Peclet has proposed, to prepare olein, to treat olive oil by a lye of soda, of a medium degree of concentration, and to boil the mixture for twenty-four hours. Under these circumstances the stearin and margarin alone are saponified, and the olein is left in a pure state.

The operation may also be effected without boiling: Pour on the oil a concentrated solution of caustic soda; stir, heat slightly to separate the olein from the soap of stearin, filter through a cloth, and separate by decantation the olein from the excess of alkaline solution. This process succeeds with all the oils except those that are rancid, and those which have been altered by heat.

According to M. Chevreul, the composition of the oleins of different greases is:—

	Human.	Pork.	Sheep.
Oxygen	9.987	9.548	9.556
Carbon	78.566	79.030	79.354
Hydrogen . . .	11.447	11.422	11.090
	100.000	100.000	100.000

As olein extracted from the different greases is not entirely pure, it does not present constantly the same properties. Whatever is the mode of extraction, olein is liquid, slightly yellowish, without taste or smell, and insoluble in water. This substance is discolored by the direct light of the sun, remains liquid when exposed to

a cold of 32°, absorbs oxygen from the air, disengages carbonic acid, and becomes resinified.

Submitted to a dry distillation, olein, besides gaseous products, gives several liquid hydrocarburets, sebacic acid, and acrolein. This reaction enables us to discover olein in other fatty substances. If, indeed, the product of the distillation of olein is exhausted by boiling water, a liquid is obtained which, by cooling, deposits small needles of sebacic acid. Nitrous acid converts olein into Elaidin. This character distinguishes olein from the liquid principle contained in siccative or drying oils.

Chlorine and bromine attack olein and give rise to chlorinated and brominated compounds.

Like the two other fatty bodies named above, olein may be saponified under the influence of alkalies, and may be transformed into glycerin and a liquid fatty acid, *oleic acid*.

Under the influence of concentrated sulphuric acid, olein is transformed into sulpholeic and sulphoglyceric acids.

Olein, mixed in different proportions with margarin and stearin, reproduces a great many fatty bodies of vegetable or animal origin.

Berthelot has reproduced natural olein with oleic acid and glycerin; he calls it *tri-olein*.

Elaidin.

Olein treated by hyponitric acid is transformed into a concrete substance called elaidin.

This new fatty substance was discovered in 1780, by Fillet, reproduced anew by Poutet, of Marseilles, and studied in 1832, by M. Felix Boudet, who made of it a complete chemical study, and gave it the name of *elaidin*.

This chemist demonstrated that the solidification of oils by the acid nitrate of mercury is due only to the action of the nitrous acid contained in this salt; and he directly produced elaidin by putting the olein in contact with that acid.

Olein not having been as yet obtained perfectly pure, elaidin has not been obtained in a state proper for analysis; elaidin is always contaminated with margarin, and a certain oily substance which becomes red by the action of potash.

To purify it, Mayer advises to dissolve it in ether, to expose the solution to a temperature of 32°, and wash the deposit with ether. Elaidin thus obtained much resembles stearin, it melts at 89.6°. It is nearly insoluble in alcohol, but very soluble in ether.

Alkalies saponify it and produce glycerin and an alkaline elaidate. Submitted to dry distillation, it gives acrolein, elaidic acid, and several hydrocarbons.

Butyrin.

Syn.—Butyrate of glycerin.

Butyrin is a neutral fatty substance found in small quantity in butter, mixed with a few other immediate fatty principles, such as olein, margarin, etc. It was discovered and extracted for the first time by M. Chevreul. It is very difficult, if not impossible, to extract it from butter in a pure state.

It is better now to prepare it artificially by synthesis, by the process of MM. Pelouze and Gelis, which consists in slightly heating a mixture of butyric acid, glycerin, and concentrated sulphuric acid, diluted afterwards with a great deal of water. Butyrin then ascends to the surface of the liquor.

Butyrin is soluble in all proportions in concentrated alcohol and ether; water separates it easily.

Saponified by caustic potash, it gives glycerin and butyrate of potash. Its density=0.908; it has an odor of warm butter, and congeals only at 32°.

The CAPRIN and *caproin* are also neutral fatty bodies, the presence of which has been demonstrated by M. Chevreul in butter. These neutral substances, under the influence of alkalies, are transformed into glycerin and *capric* and *caproic* acids, which combine with the bases.

PHOCENIN.

From *Phocæna*, Latin name of the *dolphin*.
Syn.—Valerine ; Valerate of glycerin.

Phocenin was discovered by M. Chevreul in 1818. It has been extracted from dolphin oil. This oil contains olein, phocenin, and phocenic acid, and a certain quantity of cetin.

To separate the phocenin, treat 100 parts of the oil by 90 parts of anhydrous and boiling alcohol; after the cooling of the alcoholic solution, decant it, so as to separate a certain quantity of undissolved substance, and evaporate the product of the decantation over a water-bath. The oleaginous residuum is then treated by cold alcohol diluted with one-quarter of its weight of water, and magnesia afterwards added, which combines with the phocenic acid. Filter, and evaporate the filtrate to obtain the phocenin.

Thus prepared, phocenin is very fluid and oleaginous; it has a peculiar odor, somewhat similar to that of ether. Its specific gravity=0.954. It has no action on litmus paper. It is insoluble in water, but very soluble in alco-

hol, even cold. Saponified with potash, it gives phocenic acid, hydrated oleic acid, and glycerin.

Palmin.

A neutral fatty substance extracted from castor oil, which has been treated by hyponitric or sulphurous acid, without heat.

Pure palmin is white, insipid, fusible at 109.4°, insoluble in water, soluble at 86° in the double of its weight of alcohol, and very soluble in ether.

It is transformed by saponification into glycerin, and palmitic acid.

Palmitin.

A neutral fatty substance found by M. Fremy in palm oil, and which exists in Japan wax, human fat, and coffee berries.

To obtain it from palm oil, press the oil, wash the residuum with boiling alcohol, and purify it by successive crystallizations in ether.

By saponification it is transformed into glycerin and palmitic acid.

Myristin.

A fatty immediate principle contained in the butter or oil of nutmegs, and which is obtained by submitting the butter to pressure in blotting paper, and to the action of repeated solutions and crystallizations in alcohol. It melts at 87.8°, and is soluble in boiling alcohol. Treated by alkalies, it is transformed into myristic acid and glycerin.

Hircin.

This name is derived from *hircus*, buck. It was discovered by M. Chevreul in the grease of the buck and the sheep. It is this substance which, with olein, forms the liquid part of tallow. It is insoluble in water and more soluble in alcohol; by saponification it is transformed into hircic acid.

Cetin

Is the name given by M. Chevreul to the crystallizable substance extracted by this chemist from spermaceti, by treating it with boiling alcohol, which by cooling deposits it in the form of white crystalline laminæ, soft to the touch, insipid, nearly odorless, brittle, and fusible at 120.2°. It does not redden litmus paper. Cetin is insoluble in water, and soluble in 40 parts of boiling alcohol, of a specific gravity = 0.821. It saponifies easily by heating it with its weight of hydrate of potash, and twice its weight of water. The products of the reaction are: ethal, margaric and oleic acids. According to M. Chevreul, cetin is formed of

Carbon	81.66
Hydrogen	12.86
Oxygen	5.48
	100.00

Myricin.

It constitutes that part of wax which is nearly insoluble in alcohol, 200 parts of boiling alcohol being required to dissolve one part of it, which is again deposited during the cooling in white flakes. It requires

about 100 parts of cold ether for its solution; it melts at 161.6°, and partly sublimes, without change, at a higher temperature. Its elementary composition corresponds to the formula $C^{82}H^{92}O^{4}$, and when heated for a long time with a concentrated alkali, it is converted into palmitic acid and a neutral substance called melissin, which, in its chemical reactions resembles ethal.

Cerin.

When wax is boiled for some time with alcohol, and the liquid allowed to cool, the deposit which is formed is composed chiefly of cerin and myricin, which must be again dissolved in boiling alcohol, until the substance deposited during the cooling of the liquid melts only at 158°. It is re-dissolved in boiling alcohol, and acetate of lead is added to it, the precipitate of cerotate of lead being washed when hot with alcohol and ether, and then decomposed by concentrated acetic acid. The cerotic acid is crystallized after solution in boiling alcohol. The pure acid which melts at 172° is insoluble in water; wax contains of it 22 per cent.

Cerolein.

This principle, discovered by M. Lewy in wax, is obtained by the evaporation of the alcohol when the cerin has deposited; it is soft, and very soluble in cold alcohol and ether. It melts at 87.3°; it is acid. Wax contains 4 or 5 per cent. of this substance.

Ethal.

This name has been given by M. Chevreul, because its constituent principle makes it similar to alcohol and ether, and its name is formed with the first syllables of

ether and alcohol, *Eth-al.* Ethal is a solid grease, without color and taste, crystallizable in thin, soft spangles, half transparent, and melts at 118.6°. Insoluble in water, soluble in alcohol, it is not attacked by alkalies, and consequently is not saponifiable. Ethal burns like wax. It is prepared by saponifying cetin by potash, and the soap thus obtained is decomposed by an acid. The fatty acids and ethal are precipitated, and after washing them with water they are saturated with baryta water; the excess of baryta is washed away with water, and the whole is dried. The residuum which contains the ethal and fatty acids, combined with the baryta, is treated by cold alcohol or ether, which dissolves the ethal and leaves the margarate and oleate of baryta. The solution being evaporated leaves ethal as a residuum. Its composition is:—

Carbon	79.68
Hydrogen	13.81
Oxygen	6.51
	100.00

Cholesterin.

A fatty substance extracted from *biliary calculi*, and discovered in 1788 by Green. M. Chevreul has found it also in fresh bile. As it is not saponifiable, we shall not speak of its properties; we shall only say that, of all the fatty bodies studied until now, cholesterin is the one which contains the largest proportion of carbon. Its constituent principles are:—

Carbon	85.095
Hydrogen	11.880
Oxygen	3.025
	100.000

Glycerin.

From the Greek γλυκυς, *sweet.*
Syn.—Sweet principle of oils; Hydrate of oxide of lipyle.

Was discovered in 1799 by Scheele, while preparing the *diapalm* plaster. The chemical history of this substance is due particularly to Chevreul, Pelouze, and Redtenbacher.

Glycerin always accompanies the products of the saponification of oils and neutral fatty bodies. Spermaceti alone is an exception; for, under the influence of hydrated alkalies it gives *ethal* instead of glycerin.

Some vegetable oils, such as palm oil, for example, contain glycerin in a free state, and it can be extracted by a simple treatment with boiling water.

There are several processes for extracting glycerin. The most simple consists in saponifying olive oil by oxide of lead (litharge), and when the plaster (mixture of oleate and margarate of lead) is finished, warm water is added. The liquid is decanted, then filtered, and a current of sulphuretted hydrogen gas passed through it. Lastly, the liquor is filtered, and evaporated over a water bath.

Glycerin is also obtained as an accessory product in the fabrication of stearic acid candles. It is produced by the saponification of tallow by lime, and is in the state of a yellowish brown solution, which it is necessary to purify.

Concentrated in vacuo and pure, glycerin is a syrupy, colorless and odorless liquid; its taste is very sweet; it is insoluble in ether. It has the property of dissolving nearly all the substances that water itself will dissolve.

Concentrated nitric acid attacks it with energy and transforms it into nitro-glycerin; the diluted acid trans-

forms it into a deliquescent substance which, by a slow oxidation, is transformed into oxalic and carbonic acids.

Glycerin yields formic acid when treated by the aid of heat with a mixture of binoxide of manganese, and diluted sulphuric or concentrated hydrochloric acids.

Submitted to distillation, it is partly decomposed, and yields inflammable gases, acetic acid, a small portion of glycerin distilled without alteration, and acrolein. This latter substance, by its disagreeable odor, characterizes the decomposition of greases, tallows, and oils, by heat.

CHAPTER XIV.

FATTY ACIDS.

Stearic Acid—Margaric Acid—Oleic Acid—Elaidic Acid—Butyric Acid—Capric Acid—Caproic Acid—Phocenic Acid—Palmic Acid—Palmitic Acid—Hircic Acid.

Stearic Acid.

From the Greek word στεαρ—tallow.

Syn.—Bassic acid; Stearophanic acid; Anamirtic acid.

Was discovered by M. Chevreul in 1811.

This acid is produced in a pure state by the saponification of pure stearin by potash; the alkaline stearate is then decomposed by an acid; the stearic acid which is insoluble in water, is separated, and is afterwards purified by crystallization from its alcoholic solution. It may also be obtained in a pure state by crystallizing commercial stearic acid in alcohol.

Commercial stearic acid is prepared by saponifying

at 212° tallow, greases, palm oil, etc., by potash or lime, and decomposing the soap by sulphuric acid. The fatty matter which separates is a mixture of fatty acids, which, being submitted to pressure and proper purification, abandons the oleic acid, to leave only the stearic and margaric acids. This latter mixture is used to prepare stearic acid candles.

Pure stearic acid is white, without taste and odor; by fusion it crystallizes in bright needles; it has a greasy touch, and is soluble in all proportions in alcohol and ether. It reddens litmus paper, is combustible, and burns with a white flame. It melts at 167°, and solidifies at 158°.

It is difficult to volatilize; when distilled, it is decomposed into margaric acid, margarone, carbonic acid, and carburetted hydrogen; however, if the operation is performed on small quantities, at most half an ounce, it may be distilled without alteration, being careful to stop the operation as soon as the last portions acquire a slight brownish color.

Nitric acid transforms it into margaric, succinic, and suberic acids (these last two acids are extracted, the first from *amber*, the second from cork). Stearic acid unites with bases to form salts called *stearates*.

This acid enters into the fabrication of stearic acid candles, and into the manufacture of soaps.

Stearate of Potash.—This salt is obtained by heating in a porcelain dish, one part of stearic acid with its weight of pure potash dissolved in 20 parts of water. When the combination is effected and allowed to cool, the salt separates in the form of granular crystals which are collected in a filter, and then strongly pressed to deprive them of the mother liquor they contain. To purify them, dissolve them in 15 or 20 times their weight of pure alcohol, and after

a few minutes of ebullition, let them cool. This salt crystallizes in whitish and bright spangles; it is soft to the touch, with a slightly alkaline taste. Air has no action on it. Mixed with 10 times its weight of cold water, it presents the appearance of a mucilaginous mass; if, on the contrary, the water is boiling, and the solution diluted with much cold water, it is decomposed and precipitated in the form of nacreous spangles. A part of the potash is retained in solution in the liquid, while the balance remains combined with all the acid, and forms an acid salt insoluble in water and soluble in $6\frac{2}{3}$ of anhydrous boiling alcohol.

The neutral stearate is formed of

Stearic acid	84.74
Potash	15.26
	100.00

The bi-stearate, obtained as we have seen above, has the form of small needles with a silvery brightness, and is odorless, and soft to the touch. Its composition is

Stearic acid	91.76
Potash	8.24
	100.00

Stearate of Soda is obtained in the same manner as the stearate of potash. It has the form of bright crystals, or half transparent plates. It is insipid, but afterwards leaves an alkaline taste. It is formed of

Stearic acid	89.02
Soda	10.98
	100.00

Like the stearate of potash, it is converted into bi-stearate when diluted with water. It is then white, crys-

talline, insipid, odorless, insoluble in water, but soluble in alcohol. It is formed of

Stearic acid	95.27
Soda	4.73
	100.00

Stearate of Lime is obtained by pouring a solution of chloride of calcium into a solution of stearate of potash; the precipitate is collected on a filter, washed well with water and dried.

It is composed of

Stearic acid	90.04
Lime	9.96
	100.00

Stearate of Ammonia is obtained by exposing the stearic acid in the midst of an atmosphere of ammoniac gas. This salt is white, nearly odorless, its taste is alkaline, and it dissolves in warm water containing a certain quantity of ammonia. By cooling, it deposits a bi-stearate, in the form of bright needles. Dry stearate of ammonia is formed of

Stearic acid	93.73
Ammonia	6.27
	100.00

Stearate of Lead is prepared by mixing together boiling solutions of stearate of potash and nitrate of lead; the precipitate is collected on a filter, washed and dried. It is composed of

Stearic acid	70.50
Oxide of lead	29.50
	100.00

There may be formed also a sub-stearate of lead composed of

Stearic acid	54.00
Oxide of lead	46.00
	100.00

Margaric Acid.

Discovered by M. Chevreul, who gave it this name, derived from the Greek (*μαργαρον*) which means a *Pearl*. It is prepared by several processes—

1. By precipitating by means of a salt of lead or lime, a solution of Marseilles soap prepared with olive oil. This soap, which may be considered as a mixture of an alkaline margarate and oleate, is transformed by double decomposition into a margarate and oleate of lead or lime. By treating these two salts by ether, the oleate of lead alone will be dissolved, leaving the margarate to be decomposed by sulphuric or hydrochloric acid.

2. By treating stearic acid by nitric acid at 32°, the action is very rapid. After cooling, the mass is washed with water, and then dissolved in boiling alcohol. The alcoholic solution deposits crystals which, purified by alcohol, may be considered as pure margaric acid.

3. By submitting stearic acid to distillation, a crystalline mass is obtained which contains margaric acid. This acid is generally purified by saponifying it by alkalies, and decomposing the soap thus formed by an acid.

4. It may also be obtained by the transformation of the neutral margarate and stearate of potash into acid salts; the two acid salts are then treated by alcohol, which dissolves the bi-margarate more readily than the bi-stearate.

This acid greatly resembles stearic acid; it is white, solid, and has the appearance of nacreous needles. It melts at 140°, is insoluble in water, soluble in alcohol and ether, feebly reddens litmus, and decomposes alkaline carbonates.

A small quantity will distil by the action of heat without alteration; but if the operation is conducted on a large quantity, it is partly decomposed into carbonic acid and a neutral fatty body, called *margarone*, which has the form of nacreous scales.

Nitric acid transforms it into succinic and suberic acids.

According to Heintz, margaric acid is a mixture of stearic and palmitic acids.

Thus, when margaric acid has been made to crystallize several times in alcohol, pure palmitic acid fusible at 143.6° is obtained, which does not crystallize in needles. In the same manner, if a mixture of nine or ten parts of palmitic acid, and one part of stearic acid is melted, a crystalline mass, having all the characteristics of margaric acid, is obtained.

Margaric acid and margarates have the same applications as stearic acid and its salts.

Margarate of Potash is obtained by boiling together equal parts of margaric acid, and potash dissolved in ten times its weight of water; on cooling the salt deposits. After separating it from the mother liquor, it is dissolved in boiling alcohol, and on cooling, it crystallizes in spangles. In contact with water, it swells and forms a transparent jelly. If the volume of the water is increased, the salt is decomposed and transformed into the bi-margarate. At the ordinary temperature, 100 parts of alcohol dissolve only 1.21 to 1.40 of the neutral margarate. If ten parts of this salt are dissolved in 100

parts of boiling alcohol, the solution is complete, but on cooling the mixture solidifies.

Its composition is:—

Margaric acid	85.00
Potash	15.00
	100.00

Margarate of potash treated by water is transformed into the bi-margarate, which is composed of:—

Margaric acid	91.935
Potash	8.065
	100.000

Margarate of Soda is prepared in the same manner as the margarate of potash; its taste, which is slightly alkaline, is sensible only after a few seconds. Submitted to the action of heat, it melts; very little soluble in cold water; soluble in 10 times its weight of water at 176°. On cooling, it takes the form of a gelatinous mass. Its composition is:—

Margaric acid	88.94
Soda	11.06
	100.00

The bimargarate is thus formed:—

Margaric acid	94.41
Soda	5.59
	100.00

It is soluble in water; more fusible and more soluble in alcohol than the former salt.

Margarate of Lime, obtained by double decomposition, is white, insoluble in water, and formed of:—

Margaric acid	90.03
Lime	9.97
	100.00

Oleic Acid.

Oleic acid is obtained as an accessory product in the fabrication of stearic acid candles; it may be thus obtained at a low price, but in this state it is mixed with much olein, and besides contains solid fatty acids in solution.

M. Chevreul was the first to make mention of this acid. M. Gottlieb has published the method of obtaining it perfectly pure.

To purify commercial oleic acid, boil it with a lye of caustic potash (containing one-fourth of its weight of solid potash), so as to saponify all the olein; afterward separate the oleic acid by hydrochloric acid, wash with water, and expose it for a few days to a temperature of 39° or even 32°; the solid fatty bodies crystallize, and the oleic acid is separated by pressure, at a low temperature. Add afterwards alcohol at 0.84 to the oily acid, cool anew the alcoholic solution, and decant the liquid part. Lastly, distil in a retort to save the alcohol, and the oleic acid floats on the surface of the aqueous liquor remaining in the retort. This acid is not chemically pure; it is yellow, and contains products of oxidation.

According to Warrentrapp, the fat oil of sweet almonds is the best for preparing pure oleic acid. Saponify this oil with potash or soda, and decompose by a mineral acid the salts of margaric and oleic acid formed, which are then digested with half their weight of oxide of lead for a few hours; a mixture of oleate and margarate of lead is thus obtained. Add to this mixture twice its volume of ether, and allow it to digest for 24 hours; the oleate of lead dissolves, while the margarate remains insoluble. Decompose the ethereal solution by diluted hydrochloric acid, which sets free the

oleic acid which is dissolved by the ether. Evaporate and saponify the acid by an alkali; purify the soap by dissolving it in water, separate by common salt, and dissolve anew. Lastly, separate the oleic acid by tartaric acid, and dry the product over a water bath.

The process is the same when any other grease, olive oil, butter, etc., is employed.

Oleic acid obtained by the above process is not absolutely pure; it is contaminated with products which are formed by the oxidation of the acid by the air, and by a brown coloring matter.

Gottlieb advises that it shall be purified as follows:—

It is mixed with a large excess of ammonia so as to avoid the formation of an acid salt, and precipitated by chloride of barium. Oleate of baryta is thus formed, which is dried and boiled with alcohol. This salt melts into a transparent and viscous mass; a certain quantity becomes dissolved, but by cooling, precipitates in small crystalline spangles. This treatment is renewed, and the salt is crystallized once or twice more in alcohol. It is obtained in the form of a white, light, crystalline powder, which does not melt at 212°. Alcohol retains the impurities which render the oleate of baryta so fusible.

To extract the oleic acid from the salt thus purified, it is decomposed by tartaric acid, and the product is washed with water.

The following process also gives pure oleic acid; it is more simple than the one above. If the crude acid is exposed to a cold of 21.2° or 19.4°, it forms a crystalline mass of more or less consistency; oleic acid is the only one which thus concretes, the parts already oxidized remain fluid. The mass is pressed in filtering paper, washed with a little alcohol, and submitted again to the cold.

In this manner the acid is obtained in fine needles perfectly white. Press it again and repeat these operations until the pure acid, dried in a current of carbonic acid gas, melts at 57.2°.

Pure oleic acid constitutes, above 57.2°, a colorless and limpid liquid, lighter than water, of an oily consistency, without smell or taste, and which does not redden litmus even when in solution in alcohol. At about 39° it concretes and forms a very hard crystalline mass; it deposits in alcohol, by cold, in the form of thin needles; it cannot be distilled without alteration; the impure acid reddens litmus, has an acrid taste and a slight rancid odor. When solid, it is not altered by oxygen, but when liquid it quickly oxidizes. At the ordinary temperature it rapidly absorbs twenty times its volume of oxygen without disengagement of carbonic acid and water; maintained for a few hours at 212° in a current of air, it becomes rancid, and is no longer congealed by cold.

Submitted to distillation, pure oleic acid is decomposed, and yields a large volume of carburetted gases, with carbonic, acetic, caprylic, capric acids, and a hydrocarburetted oil, saturated with sebacic acid. The formation of sebacic acid by distillation is used to distinguish oleic acid from other oily acids.

In contact with nitrous acid, oleic acid is transformed into *elaidic acid.*

Concentrated nitric acid quickly attacks oleic acid, with disengagement of red vapors, according to the duration of the reaction. In the residuum, suberic, pimelic, and adipic acids are found; while acetic, propionic, butyric, valerianic, caproic, œnanthylic, caprylic, and pelargonic acids distil over.

Concentrated sulphuric acid dissolves oleic acid, and

the solution is precipitated by water. If the solution is heated, it blackens and disengages sulphurous acid.

Chlorine attacks it and produces an oily acid with disengagement of hydrochloric acid.

When oleic acid is melted with hydrate of potash and a little water, hydrogen gas is disengaged, and a mixture of palmitate and acetate of potash is obtained. Commercial oleic acid, such as is obtained as an accessory product in the fabrication of stearic acid from tallow, is coarsely purified by filtration through thin cloths.

The oil thus obtained is brown, reddish-yellow in large masses, and yellow in small quantity; it reddens litmus and has an acrid taste and a slight rancid odor; at 21.2° or at 19.4° it congeals into a crystalline mass.

Its specific gravity=0.9003 at 60°. It is the lightest of all the liquid fatty bodies.

It is particularly employed in the fabrication of soap, and in woollen manufactures.

Oleate of Potash is obtained by heating a mixture of one part of oleic acid and one part of potash dissolved in five parts of water. During the reaction the mixture must be stirred all the time. The combination being effected, allow it to cool, and to separate from the excess of potash, and press it in blotting paper. Dissolve it then in 12 or 15 times its weight of boiling alcohol.

Filter the hot solution, and by this operation the subcarbonate is separated; by evaporating the alcohol, the oleate is obtained perfectly pure.

Oleate of potash is colorless, its taste is slightly bitter and alkaline; sometimes it has a slight odor according to the fatty matter used to prepare it. It is pulverulent and deliquescent, and soluble in water. One part of this salt and two parts of cold water give a transparent jelly; with four parts of water, a syrupy solution

is obtained; lastly, if much water is added, the salt is decomposed into two parts, an acid salt very little soluble, and potash. Its composition is

Oleic acid	84.81
Potash	15.19
	100.00

This salt enters into the composition of soft soaps. Sometimes it enters into the composition of hard soaps with soda. It is principally met with in tallow soaps.

Oleate of Soda is prepared like the above salt, only the proportions are one of acid and 0.66 of soda. It is colorless, and its taste is the same as the oleate of potash. It attracts moisture without being deliquescent. Ten parts of water at 53.6° dissolve one part of this salt, which is less soluble in alcohol than the above one. 100 parts of alcohol at 55.4° F. dissolve 4.84 of oleate. Its composition is

Oleic acid	89.39
Soda	10.61
	100.00

This salt enters into the composition of all soaps with soda for their base.

Oleate of Lime is obtained by double decomposition. It is precipitated in the form of a white powder, which is well washed and dried.

It is pulverulent, white, insoluble in water, and is formed of

Oleic acid	91.2
Lime	8.8
	100.0

Oleate of Ammonia.—Oleic acid readily unites with ammonia and forms a salt soluble in water, which has

the property of becoming turbid when it is boiled, which is due to a disengagement of ammonia. This salt passes then to the state of bi-oleate, which is much less soluble.

Elaidic Acid.

This body results from the action of bases on elaidin.

It is also obtained by passing hyponitric acid through oleic acid; abundant lamellar crystals of elaidic acid are formed, which are first washed with boiling water, and then dissolved in alcohol; abundant nacreous plates of perfectly white elaidic acid, are deposited.

It melts between 111.2° and 113°.

Butyric Acid.

Discovered in 1814, by M. Chevreul, in the products of the saponification of butter.

It exists also in nature, in several fruits and milky saps.

The most different reactions may produce this acid; it is formed when cheese, fibrin, gelatin, &c., are heated with a mixture of peroxide of manganese and sulphuric acid; it is found in tobacco smoke, in the state of butyrate of ammonia; it is formed by the action of nitric acid on oleic acid.

It is artificially prepared by the process of MM. Pelouze, and Gelis, which consists in submitting to the prolonged action of *yeast*, and especially of the caseum, a mixture of cane sugar or glucose, chalk, and water.

Pure butyric acid is a colorless liquid, perfectly transparent, very fluid, with a smell similar to that of vinegar and rancid butter. Its taste is acid and burning. It is soluble in all proportions in water, alcohol, and

wood spirit; a cold of —4° does not congeal it; it begins to boil at 327.2°. This acid dissolves some neutral fatty bodies such as tallow, lard, and fixed oils. It has no industrial applications.

Butyrate of Potash.—This salt has a sweet taste with the smell of butyric acid. It is very deliquescent; at 59° 100 parts of water dissolve 125 parts of this salt. Its composition is

Butyric acid	62.04
Potash	37.96
	100.00

Butyrate of Soda has the same properties as the above salt, only it is less deliquescent. Its composition is

Butyric acid	71.22
Soda	28.78
	100.00

Butyrate of Lime crystallizes in transparent prismatic needles. Its odor is the same as that of the other butyrates. It is soluble in water. Its composition is represented by

Butyric acid	73.005
Lime	26.995
	100.000

Capric Acid.

Discovered by M. Chevreul in the products of the saponification of butter; it is due to the decomposition of *caprin* under the influence of alkalies.

It is also met in the products resulting from the oxidation of oleic acid by nitric acid.

Water, distilled on Limbourg cheese, contains a small

quantity of this acid. Capric acid is solid at 244.4°. It crystallizes in colorless needles, with a slight odor of the goat; its taste is acrid and burning.

Caproic Acid.

Discovered in 1818, by M. Chevreul, among the products of the saponification of butter. This acid is fluid, and very inflammable; its odor is similar to that of vinegar and sweat. It has a pungent acid taste, and is slightly soluble in water, but very soluble in alcohol and ether. It boils at about 392°, and distils without alteration.

Phocenic Acid.

Extracted for the first time by M. Chevreul, from dolphin oil. Afterwards, MM. Pentz and Grote found it in the valerian root. Since, this acid has been found in the angelica root, in that of the *athamanta oreoselinum*, in the berries of the *viburnum opulus*, in assafœtida, etc. It is also artificially produced.

Phocenic acid is a very fluid and colorless liquor, with a strong odor of valerian and rotten cheese, and with an acid and pungent taste. It boils at about 347°; at 5° it remains limpid.

Palmic Acid.

Obtained by treating palmin with alkalies. It is obtained also not only by treating castor oil, but hot palm oil, by nitric or hyponitric acid. Pure, it crystallizes in stars, and melts at 111.2°

Palmitic Acid.

Discovered a few years ago by Fremy, in palm oil soap. It crystallizes in bright spangles looking like those of margaric acid. It melts at 136.4°

Hircic Acid.

This acid is volatile, and is found in the products of the saponification of suet from the goat. It is this acid which causes the characteristic odor to that animal's grease.

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. Parts.	Parts.	Melts at	Solidifies at	Form of solidification.
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 AND MYRISTIC ACIDS. 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	124.34	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.

CHAPTER XV.

ACTION OF ACIDS ON FATTY BODIES.

When sulphuric acid is made to act on stearin, the latter is decomposed in the same manner as when in contact with hydrated alkalies; stearic acid being set free, and the glycerin combining with sulphuric acid to form *sulphoglyceric acid.* It is as yet unknown what reaction sulphuric acid exerts on margarin or on olein when isolated; the reaction on the natural fats, which are mixtures of these two substances, and particularly on olive oil, having hitherto only been studied.

When olive oil is treated with one-half of its weight of concentrated sulphuric acid, the bottle containing the two substances being placed in a refrigerating mixture, in order to prevent an elevation of temperature, a homogeneous liquid of a viscous consistency is formed, composed of sulphoglyceric acid, and two new compounds called *sulphomargaric* and *sulpholeic* acids. By adding a great excess of cold sulphuric acid, the sulphomargaric and sulpholeic acids are separated from the sulphoglyceric acid, which remains in the solution, while they form an oily layer on the surface, which is removed and washed with a small quantity of water, to free it from the sulphuric acid. These acids dissolve readily in water and alcohol, and form definite salts. Their aqueous solutions decompose spontaneously in the cold, and more rapidly at the boiling point, into sulphuric acid, and new fatty acids, which appear to differ from margaric and oleic acids

only by the addition of one or more equivalents of water. Margarin yields the three acids *metamargaric*, *hydromargaric*, and *hydromargaritic*; while oleic acid furnishes but two: *metoleic*, and *hydroleic* acids. The three acids derived from margarin are solid at the ordinary temperature, metamargaric acid melting at 122°, hydromargaric at 140°, and hydromargaritic at 154°, while metoleic and hydroleic acids are oily liquids. All the new fatty acids are insoluble in water, but readily soluble in alcohol and ether.

Metoleic and hydroleic acids, carefully heated in a retort, are decomposed and disengage pure carbonic acid; while together with some empyreumatic substances, an oily liquid, composed of two isomeric carburetted hydrogens presenting the composition of olefiant gas, they condense in the receiver, and may be separated by distillation at different temperatures. The first, *oleen*, boils at 131°, and has a disagreeable and penetrating odor; the density of its vapor has been found to be 2.87, while its formula is $C^{12}H^{12}$. The second compound is *elaen*, the formula of which appears to be $C^{18}H^{18}$; it boils at 230°.

Action of Nitric Acid.—This acid reacts energetically on fatty acids, forming with them very complicated products, among which are some new and highly interesting acids. Since during the first period of the reaction of nitric acid on stearic acid, the latter is converted into margaric acid, the products afforded by margaric and oleic acids only remain to be described. The ultimate products of the reaction are very complicated, and may be divided into two classes: the volatile acids which condense in the receiver, and the fixed or slightly volatile acids which remain in the retort. We shall here enumerate them with their formulæ, in order that the curious relations between them may be more easily seen.

The last column contains the carburetted hydrogens from which they may be supposed to be derived by substitution.

Volatile acids.			
Formic acid	$C^2 H^2 O^4$ or	$C^2 H O^3,HO$ —	$C^2 H^4$
Acetic acid	$C^4 H^4 O^4$ "	$C^4 H^3 O^3,HO$ —	$C^4 H^6$
Acetonic acid	$C^6 H^6 O^4$ "	$C^6 H^5 O^3,HO$ —	$C^6 H^8$
Butyric acid	$C^8 H^8 O^4$ "	$C^8 H^7 O^3,HO$ —	$C^8 H^{10}$
Valerianic acid	$C^{10}H^{10}O^4$ "	$C^{10}H^9 O^3,HO$ —	$C^{10}H^{12}$
Caproic acid	$C^{12}H^{12}O^4$ "	$C^{12}H^{11}O^3,HO$ —	$C^{12}H^{14}$
Œnanthylic acid	$C^{14}H^{14}O^4$ "	$C^{14}H^{13}O^3,HO$ —	$C^{14}H^{16}$
Caprylic acid	$C^{16}H^{16}O^4$ "	$C^{16}H^{15}O^3,HO$ —	$C^{16}H^{18}$
Pelargonic acid	$C^{18}H^{18}O^4$ "	$C^{18}H^{17}O^3,HO$ —	$C^{18}H^{20}$
Capric acid	$C^{20}H^{20}O^4$ "	$C^{20}H^{19}O^3,HO$ —	$C^{20}H^{22}$

It will be seen that if the equivalent of basic water be not separated in the formula, all these acids may be regarded as compounds of four equivalents of oxygen with carburetted hydrogens isomeric with olefiant gas. If, on the contrary, the basic water be isolated, they may be regarded as resulting from the substitution of three equivalents of oxygen for three equivalents of hydrogen in carburetted hydrogens of which the general formula is $C^{2n}H^{2n}+^2$ (n being a whole number); but only one of these carburetted hydrogens, the protocarburet C^2H^4, is yet known with certainty.

The slightly volatile acids which remain in the retort are

Succinic acid	$C^8 H^6 O^8$ or	$C^8 H^4 O^6,2HO$
Adipic acid	$C^{12}H^{10}O^8$ "	$C^{12}H^8 O^6,2HO$
Pimelic acid	$C^{14}H^{12}O^8$ "	$C^{14}H^{10}O^6,2HO$
Suberic acid	$C^{16}H^{14}O^8$ "	$C^{16}H^{12}O^6,2HO$
Sebacic acid	$C^{20}H^{18}O^8$ "	$C^{20}H^{16}O^6,2HO$

If we omit the basic water contained in the formulæ, we shall find all these acids to result from the combina-

tion of eight equivalents of oxygen with the carburetted hydrogens, of which the general formula is $C^{2n}H^{2(n-1)}$.

In order to obtain these various products, it is necessary to operate on a somewhat considerable quantity of oelic acid. The nitric acid should be first introduced by itself in a tubulated retort and heated to 120° or 140°, the oleic acid being added in small quantities at a time. A violent reaction ensues at each addition; and when all the oleic acid has been poured into the retort, the heat is continued until all reaction ceases. The liquid collected in the receiver consists of water containing the most soluble of the volatile acids, and covered by a layer which contains the other acids. This layer is decanted, saturated with baryta water, and the various salts of baryta formed are separated by successive crystallizations. The caproate of baryta crystallizes first, and then successively the others.

The more volatile acids, when dissolved in water, are saturated by carbonate of soda, and the solution concentrated. The first crystals deposited from the cold solution are acetate of soda, and if sulphuric acid be then poured into the mother liquor, an oily layer composed of butyric and metacetonic acids is separated.

When the slightly volatile acids which remain in the retort are chiefly sought to be obtained, the action of the nitric acid must not be too much prolonged, since a portion of them would be destroyed. The oleic acid is then acted on by double its weight of nitric acid, and the action is continued until no more reddish vapors are disengaged, when a portion of the oleic acid has disappeared, being converted into products which dissolve in the aqueous liquid. The supernatant oil is decanted, and again acted on by nitric acid; this process

being continued until it has nearly disappeared, when the slightly volatile acids are found in the watery liquids arising from this treatment.

CHAPTER XVI.

GENERAL CONSIDERATIONS ON FIXED OILS.

Since the most remote antiquity, the word oil has been used to designate certain immediate principles of vegetables which are more or less liquid, unctuous, inflammable, penetrating paper, communicating to it a half transparency, and producing a greasy spot. The enumeration of every kind of oil would require a work of itself. In this examination we shall study only those employed in the fabrication of soaps.

Fixed or sweet oils exist in the seeds of vegetables; they have not been found as yet in their trunks, barks, leaves, flowers, etc.; sometimes they are contained in the flesh of some fruits, but this is rare. Oleaginous seeds contain, at the same time, fecula, and a kind of mucilage, which, rendering them miscible with water, give, with this liquid, a white liquor known by the name of *emulsion*. We present below a table of the principal fixed oils, with the vegetables which produce them.

Fixed oils.	Vegetables which produce them.
Olive oil	Olea Europœa.
Groundnut oil	Arachis hypogæa.
Hempseed oil	Cannabis sativa.
Almond oil	Amygdalus communis.
Coleseed oil	Brassica oleracea.
Rapeseed oil	Brassica napus.

Fixed Oils.	Vegetables which produce them.
Beechnut oil	Fagus sylvatica.
Cacao oil	Theobroma cacao.
Hazel-nut oil	Corylus avellana.
Poppy oil	Papaver somniferum.
Ben oil	Guilandina moringa.
Laurel oil	Laurus nobilis.
Linseed oil	Linum usitatissimum.
Castor oil	Ricinus communis.
Camelina oil	Myagrum sativum.
Nut oil	Juglans regia.
Sunflower-seed oil	Helianthus annuus.
Sesamum oil	Sesamum orientale.
Pitch-tree oil	Pinus abies.
Pine oil	Pinus sylvestris.

Etc. etc.

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

100 parts in weight.	Oil extracted.	100 parts in weight.	Oil extracted.
Nut	40 to 70	Euphorbium	30
Castor	62	Wild mustard	30
Hazel-nut	60	Camelina	28
Cress	56 to 58	Woad	29 to 36
Sweet almonds	40 to 54	Gourd	25
Bitter "	28 to 46	Lemon-tree	25
Black garden poppy	56 to 63	Onoporde acanthe	25
Radishes	50	Epicea seeds	24
Sesamum	50	Hempseed	14 to 25
Linden	48	Linseed	11 to 22
Earth nut	43	Black mustard	15
Cabbage	30 to 39	Beech	15 to 17
White mustard	36 to 38	Sunflower seed	15
Turnip	33.5	Apples	15
Plum	33.5	Grapestone	1.4 to 22
Coleseed	36 to 40	Horsechestnut	1, 2 to 8
Rapeseed	30 to 36	Olive	10 to 12

Physical Properties of Oils.—Fixed oils, at the ordinary temperature, are nearly always liquid; however, some, as palm oil, coco, etc. are more or less consistent; they are also more or less glutinous, with a feeble taste, sometimes dis-

agreeable. Some are colorless, but generally they have a slight yellow tint; some are of a greenish-yellow color, and this color is due to a peculiar principle they hold in solution. Their specific gravity is less than that of water; they all float on this liquid, but their specific gravity is not the same for all of them.

Specific Gravity of Oils.—The specific gravity of all the oils has not yet been determined; the only ones, the density of which is known, are found in the following table:—

Oils of the seeds of	Sp. grav. at 60°.	Color.	Siccative property.
Prunus domestica	0.9127	Yellow, brownish	Unctuous
Brassica napus ole.	0.9128	" "	"
" campestris ole.	0.9136	" "	"
" precox	0.9139	" "	"
" napo brassica	0.9141	" "	"
Sinapis alba	0.9142	Light yellow	"
Brassica rapa	0.9167	Yellow brown	"
Sinapis nigra	0.9170	"	"
Olea Europæa	0.9176	Colorless	"
Amygdalus comm.	0.9180	"	"
Rhaphanus sativus	0.9187	Yellow brown	"
Vitis vinifera	0.9202	Yellow green	Dries slowly
Fagus sylvatica	0.9225	Yellowish	Unctuous
Cucurbita pepo	0.9231	Brown, light yell'w	Dries slowly
Nicotiana tabacum	0.9232	Yellowish	Siccative
Lepidium sativum	0.9240	Yellow brown	Dries slowly
Corylus avellana	0.9242	Light yellow	Unctuous
Papaver somniferum	0.9243	"	Siccative
Atropa belladonna	0.9250	"	Dries slowly
Myagrum sativum	0.9252	Yellowish	Siccative
Juglans regia	0.9260	Light yellow	"
Helianthus annuus	0.9262	"	Dries slowly
Cannabis sativa	0.9276	Yellow green	Siccative
Hesperis matrondis	0.9282	Brownish	"
Pinus picea	0.9228	Light yellow	"
Pinus sylvestris	0.9312	Gray yellow	"
Linum usitatiss.	0.9347	Light yellow	"
Reseda luteola	0.9358	Green	"
Euonymus Europœus	0.9360	Red-brown	Unctuous
Ricinus comm.	0.9611	Yellowish	Dries slowly

The specific gravity of the above oils varies much according to their state of purity, and this property is

not characteristic enough to distinguish them from each other.

An oil which has not sufficiently settled and is not very pure, has generally a greater specific gravity than a pure one, on account of the mucilaginous substances it contains.

An old oil, which sometimes has deposited a little stearin, is lighter than a new one.

When an oil is siccative, it absorbs in a short time the oxygen of the air; it then becomes viscous and consistent, and is consequently of a greater specific gravity than when new and has not yet absorbed any oxygen.

Lastly, the temperature causes a great variation in the specific gravity.

Chemical Properties.—Oils exposed to the action of the air, or in contact with oxygen gas, experience a more or less rapid alteration. Indeed with time, and gradually, their fluidity diminishes, they thicken and some become hard; the latter have received the name of *siccative* or *drying oils;* amongst them are linseed oil, nut oil, etc. etc.

De Saussure has ascertained that a layer of nut oil three inches in diameter and one-quarter of an inch thick, placed on quicksilver in the shade, in pure oxygen, had absorbed a volume of this gas equal to three times that of the oil, in eight months; but in the ten following days it had absorbed 60 times its volume; after eleven months, the absorption of the gas was not perceptible; the quantity of oxygen absorbed by the oil was then 145 times its volume, with a production of 21 times its volume of carbonic acid without any trace of water. The oil thus treated formed a kind of transparent jelly which did not stain paper. The oils which do not sufficiently

thicken by contact with the air are called *non-siccative.* Oils exposed in a retort at a temperature elevated enough to cause their distillation, are partly decomposed into gaseous hydrocarbons, and a brownish-yellow oil; the residuum consists of a carbonaceous substance. Oils exposed to the cold solidify at different temperatures, according to the proportions of the two principles, the olein and stearin, which constitute them; the richer in stearin they are, the quicker they solidify.

Sweet oils are insoluble in water; the greater number are more or less soluble in alcohol and ether. A curious fact remarked by M. de Saussure is, that their solubility increases with the quantity of oxygen they contain. Oils dissolve phosphorus and sulphur, and by cooling deposit them in fine crystals.

Chlorine and iodine deprive them of their hydrogen and form new compounds.

Nearly all powerful acids unite with oils and produce unctuous and pasty compounds, especially if their action is assisted by heat; these compounds are soluble in water and foam like soap.

Combustibility of Oils.—Oils are very combustible, and may be advantageously applied to lighting. The following table presents a comparison of the combustibility of some of them. These experiments are due to M. de Villeneuve, who has ascertained that, with an equal flame, a small lamp burns in 12 hours :—

Oil of flanders . .	2	ounces	7	drachms
" olive or colza .	3	"	1	"
" nut . . .	3	"	$2\frac{1}{2}$	"
" linseed . . .	3	"	5	"
" black mustard .	3	"	7	"
" white mustard .	4	"	0	"
" grapestone . .	3	"	0	"

Solubility of Fixed Oils.—The experiments were made with 1000 drops of alcohol at 95°, at the temperature of 54.5°. The following table gives the quantities of oil dissolved in this menstruum.

Poppy oil (one year old)	8 drops
" (new)	4 "
Linseed oil	6 "
Nut oil	6 "
Beech oil	4 "
Olive oil	3 "
Sweet almond oil	3 "
Hazel-nut oil	3 "
Grape-stone oil	6 "
Castor oil	in all proportions.

We have examined above the action of the oxides on the oils which are decomposed into oleic and margaric acids, and glycerin, and we do not need to repeat what has already been said.

CHAPTER XVII.

FIXED OILS.

Olive Oil.—Extracted by expression from the fruit of the EUROPEAN OLIVE TREE, *olea Europœa.*

History. Olive oil is of all the oils the oldest known, and the tree which furnishes it is one of those, the culture of which dates from the most remote antiquity. The olive tree was called by the ancients *tree of Minerva;* it was the symbol of peace, chastity, clemency, and in general, of all the peaceable virtues. We see in Genesis, that after the flood, a dove brought to Noah a branch of

the olive tree as a sign of hope. The Egyptians used to press the fruit of the olive tree to extract the oil.

Properties of Pure Olive Oil.—This oil is very fluid, unctuous, transparent, slightly odoriferous when new, but by time it acquires a rancid odor. Sometimes its color is greenish-yellow, sometimes pale yellow, or golden-yellow, sometimes colorless. Its taste is sweet and agreeable; its density varies according to the temperature.

According to De Saussure at		53.6°	it is	0.9192
"	"	77°	"	0.9109
"	"	122°	"	0.8932
"	"	201.2°	"	0.8625

It will mix with gum-water. At a few degrees above the freezing point it becomes nebulous, and begins to deposit white grains of stearin; with oil obtained by hot pressure, this deposit is more abundant and is formed quicker than in the oil pressed cold; it has then the appearance of a granular mass, which is the more firm that it is colder. At 21.2° it deposits 0.28 of stearin, and leaves 0.72 of olein.

Heated up to 248° it loses a little of its fluidity; at 356° it disengages white vapors; at 428° it is colorless; however, if left to cool, it returns to its original color, but has a rancid taste and odor; at 622.4° it begins to boil, but the thermometer continues to rise up to 741.2°.

During this time the oil assumes a darker color. After one minute, the temperature falls to 729.5°; a second minute brings it to 716°; a third to 711.5°. During the four following minutes, the instrument remains fixed at 699.8°, and that for 2 minutes, then rapidly falls to 696.2°. Five minutes after, the column descends to 693.5°, and lastly, two other minutes bring it to 687.2°. At this point, olive oil has a fine golden-yellow color, even when cold; it seems syrupy, and submitted

to an oblique light it reflects traces of a yellowish-green. After resting for 24 hours a crystalline white mass separates.

The solubility in alcohol and ether is the same for fresh olive oil and that of sweet almonds : 1000 drops of alcohol dissolve 3 drops of oil.

According to M. Braconnot, 100 parts of olive oil are composed of 72 parts of olein and 28 of stearin.

Extraction of the Oil for the Preparation of Soaps.— This oil is the product of the residuum, that is of the cake (tourteaux) of the second pressure, treated by water. When all the oil which can be possibly obtained from the ground olive by presses has been extracted, there remains a dry paste hardened by the pressure, which is the residuum. This residuum yet contains oil ; it is broken in a mill, often moistening it with warm water ; it is then thrown into a vat through which passes a current of steam, is stirred, and the whole is left to settle. All the oil separates, rises to the surface of the water, and passes through a second vat communicating with the first ; then through a third, a fourth, etc., until it is received in the last vat deprived of the dregs and seeds. This oil has a green color and a strong odor ; it is very pasty, and when allowed to freeze in the barrels, they have to be broken to remove it. By resting, this oil separates into two layers ; the upper one which is limpid and used for greasing machines, and the lower one employed in the fabrication of soaps.

The consumption of this oil is very great. It has much energy and a very valuable siccative property ; it is used to correct the weakness of seed oils, and it enters into the composition of solid soaps which stand an elevated temperature. The use of seed oils in the fabrication of soaps, renders necessary the addition of olive oil

the proportion of which is doubled in summer so as to give the soaps all the firmness necessary to resist the heat.

Oil of manufacture is the Marseilles name of all the olive oils, more or less muddy, which are unfit for the table, but which are used in the fabrication of soaps. At Marseilles alone, the consumption of olive oil is annually of about 3,250,000 gallons. For the assay of these oils and the processes of ascertaining their purity, we refer the reader to the special chapter on this subject.

Oil of Sweet Almonds.—Extracted by expression from the sweet and bitter almonds, fruit of the common almond tree, *amygdalus communis,* originating from Asia and the North of Africa.

Composition of the Almonds.—M. Boulay has found that sweet almonds were composed of

Yellowish and sweet oil	54.00
Albumen	24.00
Sugar	6.00
Gum	3.00
Outside pellicles	5.00
Fibrous parts	5.00
Acetic acid	traces
	97.00

Bitter almonds have a similar composition; according to Vogel their composition is :—

Oil	26.0
Uncrystallizable sugar	0.5
Gum	3.0
Ligneous fibre	5.0
Pericarp	8.5
Caseous matter	0.0
Prussic acid	undetermined quantity

Properties.—Oil of sweet almonds is of a light yellow

color, very fluid, without odor, and of an agreeable taste. Its density is from 0.917 to 0.920 at 60°.

At 14° it gives 0.24 stearin, which melts at 21.2°, and 0.76 of olein.

According to Schubler it becomes muddy and whitish at 4° below 0°, and completely solidifies at 13° below 0°.

According to Gusserow, this oil does not contain stearin. This chemist, pressing the almonds first at 10.4°, then again at 24.8°, and lastly at a few degrees above the freezing point, always obtained the same oil.

Oil of sweet almonds easily becomes rancid and increases in density. When of good quality, it ought not to have a rancid odor, nor that of prussic acid; the last odor is developed under the influence of dampness in the fatty oil extracted from bitter almonds, which then contains some essential oil.

This oil is readily soluble in ether; alcohol dissolves $\frac{1}{24}$th of its weight.

Extraction. — To extract the oil, the most recent almonds are selected; however, they must not be too fresh, for in that event they would yield less oil. The sweet almonds are crushed with their epidermis; if the almonds are bitter, they are peeled off, and deprived of their essential oil. The almonds are sifted in a bag of coarse cloth, and crushed by passing them under a mill; the paste is then introduced into bags of strong cloth which are submitted to pressure.

Bitter almonds are generally preferred, because they are cheaper and the marc is used by the perfumers.

Uses.—Is employed in perfumery, pharmacy, and the fabrication of fancy soaps.

Hazel-nut Oil.—Extracted by expression from the

fruit of the hazel-tree, *corylus avellana*, which yields 60 per cent. of oil.

This oil is limpid, light yellow, of a sweet and agreeable taste; it becomes rancid very quickly.

Its specific gravity=0.9242 at 60°. It freezes at 14°, and is used in perfumery.

It is prepared by the same method as the oil of sweet almonds, with which it is often mixed.

Rapeseed Oil.—Extracted by expression from the seeds of the navette, *brassica napus.*

Properties.—This oil is viscous, of a pale yellow color, with a peculiar odor similar to that of the cruciferæ; its taste is sweet and agreeable.

The specific gravity is 0.9128 at 60°.

At 42.8 it deposits white globules of stearin, and at 25.25° it takes the form of a yellow butter-like mass. It is formed of 46 of stearin, melting at 45.5°, and of 54 of olein. This oil has much analogy with the oils of colza, hempseed, and cameline, and is used for similar purposes.

Coleseed Oil.—A kind of rapeseed oil of excellent quality, extracted by pressure from the coleseed, *brassica campestris.*

The chemical composition of the seeds varies a little as shown in the following analysis by MM. Boussingault and Moride :—

	Alsace seeds.	Saumur seeds.	Belle-isle seeds.
Oil	50.00	30.12	38.50
Organic matters . .	12.40		
Nitrogenized org. matters	17.40	61.36	55.44
Lignin	5.30		
Ashes	3.90	4.17	3.50
Water	11.00	4.35	2.56
	100.00	100.00	100.00

Properties.—Whatever is the process used for extracting the oil, it has a yellow color; it is light, limpid, with a strong smell and a disagreeable taste. It bleaches by contact with the air, and loses of its combustibility. Its density at 60° is 0.9136; at 20.75° it freezes in small needles which reunite in a star like shape.

It is very slightly soluble in alcohol, and easily dissolves sulphur and phosphorus. It contains 46 of stearin and 54 of olein.

Extraction.—When the seed has been carefully sifted, it is carried to the mill to be reduced to a paste or unctuous powder; it is then introduced into bags which are exposed to steam or dipped in boiling water, and submitted to the action of a strong press. To obtain a greater product, the plates of cast iron between which are the bags, are strongly heated; but if by this process the quantity increases, the quality diminishes. After the pressure some oil is still left in the cakes, which have the following composition :—

Oil	14.10
Organic matter	66.20
Salts	6.50
Water	13.20
	100.00

The large quantity of mucilage carried off by the oil during its extraction renders it necessary to purify it. This is done by means of two per cent. of sulphuric acid. This purification renders the oil less colored and diminished its density.

Uses.—It is employed for lighting and manufacturing soft soaps.

Sesame Oil.—Extracted by expression from the sesame, fruit of the *sesamum orientale.*

Properties.—It is of a golden-yellow color, its taste is analogous to that of hempseed; it has no odor. Exposed to the air it oxidizes, loses its taste, and takes a weak rancid odor.

Its density at 60°=0.9230
" "63.6°=0.9210 } water being taken as unity
" "70.8°=0.9184

The change of 1.8° causes in the density a modification of 0.00075.

At 39.2° it is yet clear, although it is a little less fluid; at 23° it congeals in the form of a mass of a yellowish-white color, translucent, a little greasy, and having the consistence of palm oil, which it greatly resembles.

At 212° it begins to boil, but the formation of vapors lasts only a short time; at 302° it begins to change color and becomes more and more pale, until it reaches 419°, at which temperature it disengages white vapors; however, by cooling, it returns to its natural color. At 635°, begins a disengagement of vapors accompanied by a strong odor; if the action of the heat is continued without interruption the thermometer will rise to 748.4°, but soon it begins to fall. It briskly falls back to 734°, and one minute after to 725.9°; it then remains stationary for five minutes, falls to 720.5°, and remains fixed for four minutes, then descends to 708.8°, after two more minutes. After five minutes of rest, the thermometer descends to 704.3°, where it remains stationary for ten minutes, during which time the oil is submitted to an apparent ebullition. From 572°, the oil becomes more and more colored, and takes a dark brownish-yellow color. Cooled, it gives by reflection a light yellow-green color.

Agitated with ether, it forms a white emulsion. After

a short rest the two liquors separate, but the oil is nearly discolored.

Preparation.—There are several varieties of sesame. The eastern sesame yields 50 lbs. of oil for 100 lbs. of seeds thus reported:—

Surfine oil, first pressure . . .	30 lbs.
Fine oil, second pressure . . .	10 "
Ordinary oil, third pressure . .	10 "

The sesame of Calcutta yields fine oil, first pressure, 36 lbs.; oil of second pressure, 11 lbs.; in all 47 lbs.

The sesame of Bombay gives about the same results.

The seed is reduced to a pulp which is introduced into woollen bags, and submitted to a strong pressure at the ordinary temperature. After this first pressure the oil cakes are reduced anew to a pulp, under a stone mill, and pressed a second time with the aid of heat.

Uses.—It is employed in the fabrication of castile soaps, and soft soaps.

Earth-nut Oil.—Extracted from the seed of the earth-nut, *arachis hypogœa.*

Properties.—Obtained by pressure, without heat, earth-nut oil is nearly colorless and odorless. Extracted with the help of heat, it is yellow and possesses a disagreeable odor.

Its taste is analogous to that of green beans. Its specific gravity at 60°=0.9163.

Exposed to the air it does not dry; submitted to the action of cold, it forms a mass like olive oil at a few degrees above the freezing point; it is completely solidified at 26.6°.

This oil, in a bad condition of preservation, is colored by reagents in the same manner as the oil which has been well preserved. It is insoluble in alcohol, but very soluble in acetic ether.

Extraction.—According to MM. Payen and Hervey, 1950 parts of earth-nut yield 1495 parts of kernels, which furnish the following products:—

Oil obtained without heat	229
" " with heat	302
" extracted by ether	33
Residuum	792
Loss	129
	1485

The kernel yields by analysis *fixed oil, caseum, water, lignin, crystallizable lignin, phosphate and malate of lime, gum, coloring matter, sulphur, starch, an essential oil, chloride of potassium, and free malic acid.* To obtain the oil, the seeds are reduced to a pulp, under stone mills, and this pulp is introduced into woollen bags. The first pressure is made at the ordinary temperature. The second quality of oil is obtained by heating the residuum of the first operation, and submitting it to a more energetic pressure. The oil obtained is less pure than the first, and has not so agreeable a taste. 100 lbs. of earth-nut give 30 lbs. of oil.

Uses.—It is employed in the fabrication of marbled soaps.

Cameline Oil.—Extracted by expression from the seeds of the cultivated cameline, *camelina sativa*, or *myagrum sativum.*

Properties.—It has a light golden yellow color with a peculiar odor and taste. Its specific gravity=0.9252 at 60°. It congeals at 0°, and rapidly dries in the air.

Extraction.—It is obtained by pressure, first at the ordinary temperature, and then with the help of heat.

Uses.—It is much employed in the fabrication of soft soaps.

Beech Oil.—Extracted from the fruit of the beech (*fagus sylvatica.*)

Properties.—This oil is of a light yellow color, with a peculiar odor, a sickly taste, thick and muddy when first extracted; it is limpid, although a little viscous, after a sufficient rest. Its specific gravity = 0.9225 at 60°; at 1.4° it congeals into a yellowish-white mass. It may be kept a long time without alteration, and, unlike other oils, it improves by age. It forms with soda a soap firm enough, but which remains greasy.

Extraction.—The kernels are reduced to a pulp, which is introduced into coarse cotton bags, and submitted to the action of the press; the resulting oil is stored in large jars, to allow it to deposit the mucous parts, and the oil thus refined is ready for the market. This process generally gives from 14 to 15 per cent. of oil.

Cotton-seed Oil.—Extracted from the seeds of the cotton tree, *gossypium usitatissimum.*

Properties.—This oil is reddish in large masses, and a dirty dark yellow in small quantities. Its specific gravity = 0.9306 at 60°.

Extraction.—It is also obtained by pressure.

Ben Oil.—Is extracted from the seeds of the *guilandina moringa.*

Properties.—This oil is sweet, nearly colorless, and becomes rancid with difficulty; it is completely odorless, and has an agreeable taste.

Its specific gravity = 0.9120; it is thick at 60°, and solid in winter. It is neutral to test paper.

At a low temperature, Ben oil separates into two parts: one solid, composed of *stearin* and *margarin;* the other liquid, *olein.* The constant condition of fluidity of the latter renders it proper to be used by watch-makers. This oil is rare in commerce; it is substituted by virgin olive oil.

According to Voelcker, potash saponifies it well, and gives a mixture of solid fatty acids, slightly soluble in alcohol. The soluble part is composed of margaric acid, fusible at 140°, and *benic acid* fusible at 168.8°; benic acid crystallizes in colorless needles.

According to Walter, ben oil gives by saponification four fixed fatty bodies, viz: stearic, and margaric acids, and the peculiar ones, *benic* and *moringic.*

The latter is liquid, colorless, or slightly yellowish. Its specific gravity = 0.9080. Its taste is sickly; its color is feeble. It is soluble in ordinary alcohol, even when cold. It solidifies at 32°. It is decomposed by warm sulphuric acid.

Extraction.—The kernels are reduced to a paste and carefully pressed, in the same manner as the above oils.

Uses.—It is employed in the fabrication of some kinds of soaps, and in perfumery.

Linseed Oil.—Extracted by compression from the seeds of the cultivated flax, *linum usitatissimum.* The summer and winter seeds yield, according to the analysis of MM. Boussingault and Moride, the following products:—

		Summer seeds.	Winter seeds.
Oil	39.00	33.96	35.60
Organic matter	19.00		
" " nitrogenized	20.50	59.48	58.04
Lignin	3.20		
Phosphates and other salts	6.00	3.96	3.56
Water	12.30	2.60	2.80
	100.00	100.00	100.00

Properties.—Linseed oil pressed at the ordinary temperature is of a light yellow color; pressed with the help of heat it is brownish-yellow.

Its odor and taste are peculiar. It becomes rancid very easily. At 4° below 0° it takes a lighter color, without depositing stearin and without congealing; at 16.6° below 0° it is solidified into a yellow mass.

Its specific gravity	=	0.9395 at 53.6°
"	=	0.9300 " 77°
"	=	0.9125 " 122°
"	=	0.8815 " 201.2°

It dissolves in 5 parts of boiling, and 40 parts of cold alcohol; it is soluble in 1.6 part of ether.

Extraction.—The oil forms about one-sixth of the weight of the seeds, which are allowed to stand for three or four months in a dry place. Afterwards by means of a slight torrefaction, in earthen vessels, the mucilage which covers their surface is destroyed. They are then reduced to flour in a mill, introduced into bags made of coarse cloth, and pressed; the oil is collected in jars and abandoned to a spontaneous clarification, or it is filtered and purified with sulphuric acid.

The seed yields from 12 to 22 per cent. of oil, whilst it contains from 33 to 34 per cent.

Uses.—Linseed oil is used in painting, and in the fabrication of soft soaps.

Fresh linseed oil, pressed at the ordinary temperature, is easily saponified; it produces with soda a yellow soft soap. Hydrochloric acid separates from the aqueous solution of this soap a liquid oil which deposits, on cooling, crystals of margaric acid.

M. Sacc has examined the fatty acid extracted from linseed oil, and has given it the name of *linoleic acid.* This acid is of a pale yellow color, odorless, very fluid, and it absorbs the oxygen of the air very rapidly.

Heated with nitric acid diluted with four times its weight of water, linseed oil takes a fine red color, and evolves some gas without nitrous vapors. By continuing the action of nitric acid on the oil, the nitrous vapors are abundant, and a kind of viscous membrane is formed in the mixture.

Linseed oil exposed to a high temperature, becomes thick. By boiling this residuum for several hours with water acidulated with nitric acid, a substance of a plastic consistency, which hardens in the air, is obtained. This substance softens without melting by the heat of boiling water, and acquires much elasticity; it has much similarity with India-rubber.

Black Poppy Oil.—Extracted by expression from the seeds of the *papaver somniferum.*

Properties.—Pure, it resembles olive oil in its appearance and taste. It is nearly colorless, or of a yellow color. Its specific gravity = 0.9249 at 60°. It solidifies at 0°. The concrete oil sometimes retains this state at 28°. It becomes rancid with difficulty. It is soluble in 25 parts of cold, and 6 of boiling alcohol; it mixes in all proportions with ether. It is very siccative. It has nothing of the narcotic properties of the poppy.

Extraction.—To effect its extraction, break the capsules as soon as they have experienced a certain degree

of desiccation. Separate the seeds, and sift them so as to get rid of the dirt; reduce them to a kind of flour, which is introduced into coarse cloth bags, and submitted to the action of the press. The oil is collected in earthen jars and abandoned to rest; decant afterwards and introduce into barrels.

Uses.—Before the introduction of sesame and earth-nut oils into the fabrication of Marseilles soap, this oil was used in a certain proportion for the fabrication of marbled soap. The reason for such an addition is that olive oil alone gave too consistent and too hard a soap; an addition of from 10 to 20 per cent. of black poppy oil attenuated the strong consistency of this soap and rendered it more unctuous and soft.

Hempseed Oil.—Extracted from the seeds of the cultivated hemp, *Cannabis sativa.*

The composition of hempseed varies a little according to the specimen, as may be seen by the following analysis:—

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

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

Extraction.—The process for obtaining it consists, the

same as with all the other oils, in reducing the seeds to flour, submitting the latter to the action of the press, and purifying the oil obtained by sulphuric acid. When the oil has been extracted by pressure from the hemp-seeds, the cake contains a certain proportion of oil, as shown by the following composition :—

Oil	6.3
Organic matter	69.4
Salts	10.5
Water	13.8
	100.0

Uses.—It is used in the fabrication of soft soaps, of green soaps, especially when this fabrication is carried on in winter, because it can be submitted to a very intense cold without solidifying.

Nut Oil.—Extracted from the walnut, fruit of the royal nut tree *juglans regia.*

Properties.—The oil recently extracted is fluid, nearly colorless, with a faint odor, and a taste which is not disagreeable; the oil of the second pressure is greenish, caustic and siccative. The virgin oil extracted from the unpeeled kernel has generally a greenish-yellow color.

Its specific gravity at	53.6° = 0.9283
" "	77° = 0.9194
" "	201.2° = 0.8710

At 5° it thickens, and at 15° below 0° it takes the consistence of a white mass.

Extraction.—The extraction of the oil must be made only two or three months after the fruit has been gathered. After separating the kernels and peeling them, they are crushed, so as to form a paste which is intro-

duced into bags, and submitted to the action of the press. The oil which runs first is called virgin oil, and is used as an aliment; the residuum is moistened with boiling water, and is pressed anew; this second oil is reserved for manufacturing purposes. Nuts give about 50 per cent. of oil.

Uses.—This oil enters into the composition of green soaps; it is employed also for lighting.

Castor Oil.—Extracted from the seeds of the *ricinus communis.*

Properties.—Castor oil (cold pressed) is thick, transparent, odorless, with a sweet taste, without acridity; it is siccative, and slightly colored yellow. Its Sp. Gr. =0.9699 at 53°; 0.9575 at 77°; and 0.9081 at 201.2°. At 0° it is transformed into a yellow transparent mass. Exposed to the air it becomes rancid, viscous, thick, and dries, at the same time it acquires a very acrid taste. It may be dissolved in all proportions in concentrated alcohol and ether, and the foreign matters become separated. This solubility establishes an important difference between castor oil and the other fixed oils, but the solubility rapidly diminishes with the strength of the alcohol; that at 88° dissolves only $\frac{1}{6}$ of its weight. When castor oil is kept in a retort at the temperature of 509°, it begins to boil, and an oleaginous substance distils over, without development of gas in appreciable quantity; $\frac{1}{3}$ of the oil passes over; if the temperature is raised, the substance swells considerably. If the distillation is stopped before the swelling begins, a residuum insoluble in water, alcohol, ether, or oils, is found in the retort. This residuum, treated first by ether, which dissolves the castor oil which has not been decomposed, is then dissolved in potash; the soap thus obtained contains a viscous fatty acid, fusible between 64° and 67.6°, very

soluble in absolute alcohol, but slightly soluble in weak alcohol.

The volatile products collected by the dry distillation of castor oil, contain a hydrocarburet, called hydride of œnanthyle, œnanthylic acid, a small quantity of acrolein, and solid fatty acids.

Chlorine and bromine, by acting on castor oil, give products extremely thick and colored.

Hot nitric acid quickly attacks castor oil; if the ebullition is kept up until no more red vapors are evolved, a certain quantity of œnanthylic acid is collected, while the residuum contains suberic acid, which deposits during the cooling of the nitric liquor; a large proportion of oxalic acid is found in the mother liquor.

When a mixture of sulphuric acid and bichromate of potash is made to act on castor oil, œnanthylic acid is obtained, and also a neutral oil, colorless, very fluid, acrid, and giving, with nitrate of silver, a precipitate which is quickly reduced.

Dissolved in alcohol and exposed to the action of hydrochloric acid gas, castor oil is transformed into glycerin and fatty acids, which combine with the ethereal compounds which are produced.

Hyponitric acid concretes castor oil; the acid nitrate of mercury also solidifies it.

The name of *palmin* has been given to the new substance resulting from the action, at the ordinary temperature, of hyponitric acid on castor oil. It has the following properties: it is white, presents a waxy fracture, melts at 114.8°, has an odor analogous to the volatile oil described by Bussy and Lecanu, among the constituent principles of castor oil. It is soluble at 86° in alcohol, in the proportion of 50 per cent.; when melted, it is soluble in ether in all proportions. Saponi-

fication changes it into glycerin and palmitic acid. According to Boudet, castor oil becomes solid under the influence of sulphurous acid.

Castor oil is easily saponified when mixed with a lye of potash, in the proportion of 8 parts of oil for 2 parts of caustic potash, dissolved in 2 parts of water; the soap resulting from this mixture is white and transparent; it dissolves in pure water; the solution will foam by stirring.

Distilled with a solution of potash, castor oil yields caprilic alcohol, discovered by J. Bouis, which passes over during the distillation, while a sebate of potash remains in the retort.

Ammonia converts castor oil into *ricinolamide.*

This oil is composed, for the greater part, of ricinoleic acid combined with glycerin. This fatty acid is solid, and melts at 165.2°. The liquid part contains a fatty acid, fluid at the ordinary temperature, yellowish, without smell, with an acrid and persistent taste, soluble in alcohol, and solid at 14°.

Extraction.—The castor bean has the following chemical composition:—

Oil	46.19
Starch	20.00
Albumen	0.50
Gum	4.31
Brown resin and bitter principle	1.91
Ligneous fibre	20.00
Water	7.09
	100.00

This chemical composition is distributed in the seed as follows:—

The bean is formed of 23.82 of pericarp and 76.58 of seeds. This 23.82 of pericarp contains:—

Brown resin and a trace of a bitter principle	1.91
Gum	1.91
Ligneous fibre	20.00

The 76.58 parts of seeds contain:—

Fatty oil	46.19
Gum	2.40
Starch	20.40
Albumen	0.50
Water	7.09

Several processes have been proposed for extracting the oil; the one longest known, and which is yet in use in this country, consists in reducing the seeds by crushing to a paste, boiling this paste with water, and taking off the oil which separates, as fast as it rises to the surface of the liquid. This very defective process gives an oil which is reddish, with an acrid taste and odor.

The process by pressing the seeds at the ordinary temperature, yields an oil nearly colorless, odorless, and with a pungent taste.

Figuier has invented a third process, founded on the property that this oil possesses, of being entirely soluble in alcohol. He mixes, at the ordinary temperature, 1 pound of the paste of the seeds, previously deprived of their cortical envelopes, with 4 ounces of alcohol at 95°, and presses the mixture in a cotton cloth bag. By this process he obtains 10½ ounces of oil for every pound.

Uses.—Castor oil is much employed in medicine, pharmacy, and perfumery. It is used also for lighting purposes in Central and South America.

CONCRETE OILS.

Palm Oil.

Extracted from the fruit of the *Avoira* of Guinea —*Elais Guineensis* or *avoira elœis.*

Properties.—Palm oil as found in the markets is solid, orange yellow, and of the consistence of butter; its taste is sweet and perfumed. Its odor is analogous to that of the orris-root, or violet.

Recently prepared it melts at 80.6°, but with time the melting point rises to 87.4°, and even to 96.4°.

Melted, it has a dark orange color. It is completely insoluble in cold or boiling water.

It is soluble in cold alcohol at 95°, but more soluble when warm, and is partly precipitated by cooling.

It is soluble in all proportions in ether. This oil is composed of 31 parts of stearin, 69 of olein, a coloring principle united to olein, and a volatile odoriferous principle.

Natural palm oil treated by alkalies, forms soaps, the consistency of which vary according to the alkali used. With potash a soft soap is obtained, which is of a fine yellow color, with a half translucid appearance.

The saponification by soda produces a very consistent and very hard soap, with an aromatic odor, and a fine yellow color; but it is rarely that this oil is employed alone without being mixed with some other fatty body. It is nearly always mixed in the proportion of 20 to 30 per cent. with tallow, greases, and even resins, to prepare a yellow soap. In commerce, smooth soaps of a fine yellow color are met with, which are called palm oil soaps; the name is not correct, these soaps being

obtained by a mixture of 90 parts of coco oil and 10 parts of palm oil, saponified by concentrated lyes.

Extraction.—The fruit of the avoira is of the size of a pigeon's egg, with a golden yellow color. From this fruit two oils are obtained—one extracted from the fibrous sarcocarp which surrounds the stone of the fruit, the other from the almond contained in the stone. The first is yellow, and always liquid in warm climates.

The second is white, solid even under a tropical climate, and is designated by the name of *butter of palm.*

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.

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 Mr. Morfit has verified by his own experiments. The expense attendant upon this process per ton of oil, labor included, reaches ten dollars, and he strongly recommends 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 potash 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. Watt's proportions; some bleachers take ten pounds of bichromate of potash, 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 to rest for a half hour or more, so that the aqueous solution of chloride of chromium, sulphate of potash, 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 potash, 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 chromium, and the sulphuric acid takes up with the liberated potash. 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.

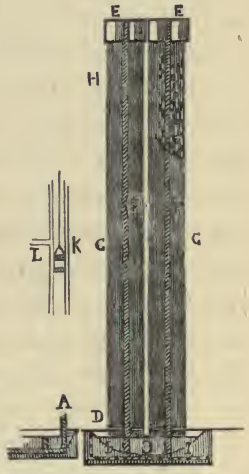
The difficulty in keeping the whole mass of oil at the same temperature, and preventing carbonization of the lower stratum nearest the fire, has caused some objec-

tions 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, consists of a large steam pipe, A, Fig. 5, 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.

Fig. 5.



"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 has 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 a small scale, that the rapidity of the bleaching action is not sensibly lessened by loosely covering the containing 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 a large scale as will, while not excluding 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.

Coco Oil.—Extracted by expression or by fusion from the almond of the fruit of some coco trees, *cocos nucifera*, and the fruit of the *elais butyracea*.

Properties.—This oil is white. In tropical climates it is nearly as fluid and limpid as water, but it solidifies between 60.8° and 64.4°; so we often see it solid, opaque, and unctuous, looking much like purified tallow. In this state it is fusible at 68°. When fresh its odor and taste are sweet and agreeable; it becomes rancid very quickly.

Its composition is very complex; by saponification it yields glycerin and six new fatty acids, nearly all of which are concrete.

Extraction.—The oil is obtained by grinding the fruit and dipping it into buckets full of hot water. The oil is not long in solidifying at the surface, on cooling, and is taken off. When fresh its odor is aromatic, with a red-

dish color, a butyrous consistence; it begins to melt at 80.6°.

Soap manufacturers use large quantities of this oil. It forms with soda a dry brittle soap, foaming much with water.

Oil of Cacao.—Extracted from the roasted seeds of the cacao tree, *theobroma cacao.*

Properties.—Pure and recently prepared, its color is yellowish; it bleaches by growing old. Its odor and taste are sweet. It becomes rancid very slowly, and may be kept for several years in a cool and dry place. It is soluble in alcohol, especially when warm; very soluble in ether and spirits of turpentine. Pure, it melts at 84.2°, and solidifies at 73.4°.

The butter of cacao is nearly entirely formed, according to MM. Pelouze and Boudet, of a crystallizable substance, fusible at 84.2°, in which the stearin is combined with olein, which saponification converts into oleic and stearic acids.

Extraction.—Whatever is the process used, the seeds have to be roasted. The old process consisted in grinding the roasted seeds and submitting them to a prolonged ebullition with water; the concrete oil separated by degrees, and floated on the surface; it was then taken off as fast as produced and filtered. This process had not only the inconvenience of dissipating the aroma of the cacao, but besides, of communicating to the latter the taste of the foreign substances with which it was in contact in the almond.

The other process consists in inclosing the cacao previously crushed, in cotton bags, which are dipped into boiling water, or submitted to the action of steam as long as may be necessary to render the butter fluid. These bags are then placed between heated tin plates,

and submitted to the press; by a gradually increased pressure the butter runs off in a state pure enough not to require filtering.

Butter of Nutmegs.—Extracted from the kernel of the nutmeg, fruit of the nutmeg tree, *myristica aromatica*, *m. officinalis*, *m. moschata*.

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

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

By pressure, in filtering paper, and by repeated solutions, and crystallizations in ether, a solid matter is extracted from the butter of nutmeg, called *myristin*. Submitted to distillation it yields about $\frac{1}{8}$ of its weight of volatile oil.

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

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

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

TALLOW OF VIROLA.—Extracted from the fruit of the *myristica sebifera.*

Properties.—This kind of vegetable tallow is found in commerce in the form of square masses, similar to cakes of soap, but not so long nor so thick. They are often covered with a kind of efflorescence of a nacreous appearance, which exudes in the same manner as benzoic acid.

This tallow melts at 110.75°; it is soluble in alcohol and ether.

Extraction.—The mode of extraction consists in crushing the kernels and boiling the paste in water; the fatty substance separates and collects on the surface, where it solidifies on cooling.

OIL OF LAUREL.—Extracted by expression from the berries of the laurel of Apollo, *laurus nobilis.*

Properties.—The oil of laurel found in commerce is green, with a butyrous consistency, and slightly granular, similar in appearance to half-solidified olive oil.

It contains a volatile oil which gives it a disagreeable odor. It melts by the heat of the hand at about 104°.

Alcohol extracts from it the green coloring substance and the volatile oils; it leaves a colorless, concrete oil, similar to tallow. This solid part has received the name of *Laurine.*

Extraction.—The fruit of the laurel contains two kinds of oils—one volatile, which resides in the peri-

carp; the other fixed, which is furnished by the kernel. The first is obtained by distillation, and the other by decoction.

To obtain the concrete oil, the fruit is crushed and reduced to a paste which is boiled with water; the mixture is strained and pressed; the grease formed of fixed and volatile oil solidifies on the surface, and is removed and melted anew over a water bath to expel the water. It is kept in closed vessels.

Butter of Galam.—This butter is extracted from the fruit of the *bassia parkii*, and also from the fruit of the *butyrous illipe, illipus bassia.*

Properties.—It is of a dirty white color, sometimes slightly reddish, and has the appearance of tallow in cakes. It is more unctuous than tallow; it greases the fingers like lard. It may be kept a long time without becoming rancid. It has a slight odor, and a sweet taste free from acridity. It melts only above 86°.

The butter of galam melted over a water-bath, deposits reddish flakes of a sweet, agreeable substance. Slowly cooled, it begins to solidify at 84.2°, but is completely solid only at 70.25°. It completely dissolves in cold spirit of turpentine, incompletely in ether, and the insoluble matter appears to be stearin.

It is nearly insoluble in alcohol, and easily saponified by alkalies.

Extraction.—The kernels are reduced to a paste and boiled with water. The oil with a butyrous consistence solidifies by cooling; it is purified by a second melting.

It is also extracted by expression, by grinding the kernels, and submitting them to the action of the press.

Vegetable Tallow, or Chou-Lah of the Chinese, is a concrete fatty substance extracted from the berries of the *croton sebiferum*, or *stillingia sebifera*, or the tallow

tree. To extract the fatty matter, the berries are boiled in water; they form at the surface two fatty layers—one of tallow, which floats and solidifies by cooling, into a crust easily removed; the other, the oil which collects below. Well prepared, this tallow is firmer and less fusible than animal tallow. It has no bad smell, and burns with a fine white flame.

CHAPTER XVIII.

ANIMAL GREASES.

Greases—Tallows—Animal Oils—Fish Oils.

Greases.

In common language, the name of *grease* is given only to the fatty substances, more or less soft, but at least solid at the ordinary temperature, which, in the mammiferæ and birds, fill the cavities of the adipose tissue, and accumulate in preference, in more or less quantity on the surface of the intestines, around the kidneys, between the muscles and the skin, and in some other parts of the body.

The greases of the cetacei and fishes, on account of their fluidity, are considered as animal oils; such also is the case with certain liquid fatty substances, furnished by animals, such as neat's foot oil, etc.

Greases are insoluble in water. Their specific gravity is always less than that of this liquid; their odor and taste are variable, sometimes weak and not disagreeable, as in the domestic herbivoræ and in poultry, sometimes strong and disgusting, as in that of the carnivoræ.

They melt between 77° and 86°, take fire when in contact with a substance in ignition, and burn with a bright flame, which always gives much smoke.

The consistence of greases varies according to the parts of the body of the animal from which they are extracted; under the skin and around the kidneys, they are firmer than in the neighborhood of the mobile viscera.

Greases are always essentially formed of three immediate principles, viz.: stearin, margarin, and olein, or elain, united in variable proportions, and which may be easily extracted and isolated.

The more or less fusibility and softness of greases depend on the proportion of olein they contain.

Greases are partly soluble in alcohol, but very soluble in ether, and in essential and fatty oils.

Pure, they are white, as in pork, veal, sheep, or slightly yellowish, as in beef marrow, bear's grease, etc. A deeper coloration is always a sign of their alteration, either by the effect of a chemical agent, or by the admixture of foreign substances.

When greases are exposed to the contact of the air or of aërated water, they are not slow to experience a profound alteration, known by the name of rancidity, and which results from their oxidation, in consequence of the development of some fatty oils and the setting free of some acrid and odoriferous principles.

Rancid greases are easily detected by their odor and taste, and are not fit to be used as food.

Tallows, and in general, animal greases, are susceptible of alterations which are injurious to the health, when the fatty substances are destined for food. All animal greases must be rejected when rancid, when they have a repulsive odor and a disagreeable taste. Treated by boiling alcohol, such greases leave after

evaporation a brown substance, soft, acid, with an odor slightly disagreeable, and a pungent, nauseous taste, which irritates the mouth.

All the greases, even those of the worst quality, may enter into the fabrication of soaps.

The fat residues of different industries are used for the greasing of wagons, etc.

We shall divide the greases into two parts: the first comprises the *greases*, properly so called; the second the tallows.

Greases, properly so called.—This class comprises butter, lard, beef marrow, goose grease, bear's grease, etc.

Butter.

Butter is the fatty substance with which the globules of milk are formed. These globules do not freely float in this liquid; they are surrounded by a very thin membrane, which prevents them from joining together. When, by any process, they can be united, butter is formed.

A butter well prepared must be of a fine yellow color, of a middling consistence, with a peculiar and slightly aromatic odor, and an agreeable taste. It must be easy to cut into slices.

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

According to Heintz, butter contains ordinarily olein, much palmitin, a little stearin, and small quantities of

neutral bodies giving by saponification myristic and butic acid.

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

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

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

Margarin	68
Butyrolein	30
Butyrin, Caprin, Caproin	2

Considered as a fatty substance, butter could be very useful in soap making if it were not for its high price. It not only forms a good soap, but the amount obtained is very advantageous.

Lard

Is extracted from the adipose tissue accumulated on the surface of the intestines of the hog.

This grease is white or slightly yellowish and soft at the ordinary temperature, nearly odorless, with a sickening taste. Its melting point varies, according to the different species of pork, between 78.8° and 87.8°. At the moment it solidifies the temperature rises a little.

Its specific gravity compared with that of water at 60°= 0.938; at 122°=0.8918; at 156.2°=0.8811; and at 201.2°= 0.8628.

When strongly pressed for some time at 32° in filtering paper, the paper absorbs about 0.62 of the weight of lard of a colorless olein which remains liquid even when very cold.

Exposed to the air for some time, lard becomes yellow and rancid, acquires a strong odor and reddens litmus paper, then a volatile fatty acid analogous to caproic acid is disengaged.

According to Braconnot, lard is composed of

Olein	62
Stearin	38

By saponification, 100 parts of lard give 9 parts of glycerin and 94.65 of margaric and oleic acids, which, after being melted, begin to solidify at 131°, and are completely solid at 125.6°.

Lard dissolves in 36 parts of boiling alcohol at 95°.

Lard 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 upon 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 constructed 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 of Ohio. 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.

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.

Extraction.—In the years 1842 and 1843, when 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, Mr. Morfit 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, he 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, his attention was again called to the matter by a gentleman who desired instruction from him 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 him, that as lard consisted 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, it would entirely drive the tallow candles from the market.

His 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 this 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 his 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 exa-

mination at the exhibition, in 1843, a sample of the stearin in every progressive stage of the process, up to the finished candle—gave its approval to the results.

"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 knows 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 his 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 the 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 the 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 apparatus, 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 takes place too slowly; 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 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.

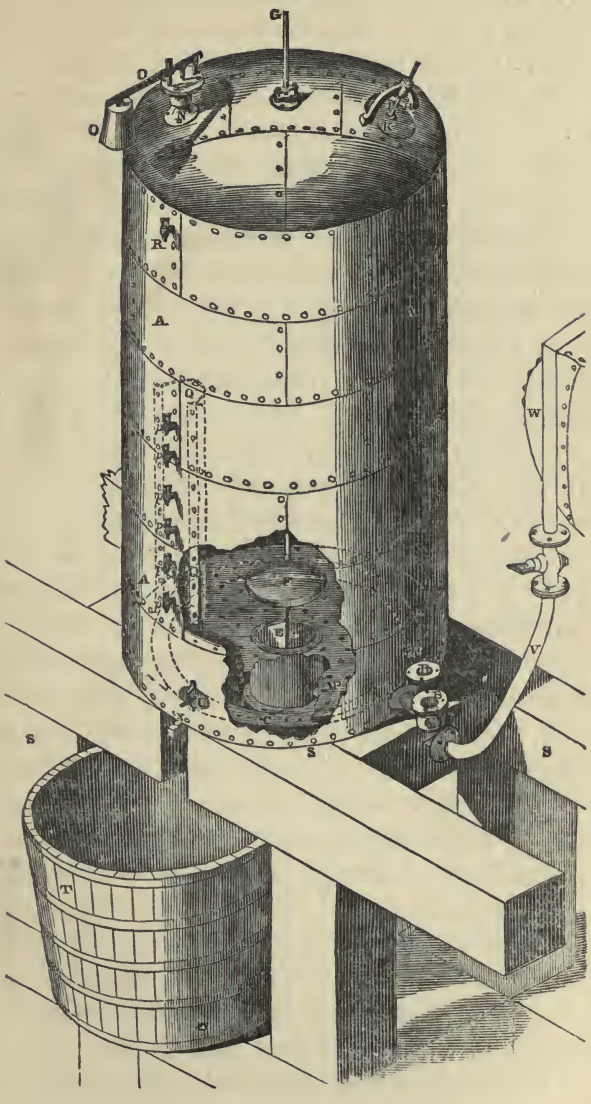
This oil is the "LARD OIL" of commerce, and when good lard has been used, is very pure and white, but of a brown color when it has been pressed from burned or scorched lard. It is considered much superior to sperm or olive oil for greasing wool, and being more economical in price, is very largely used. 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.

Rendering by Steam. Wilson's Process.—The apparatus consists of a series of steam-tight digesters, each of 1200 to 1500 gallons capacity. These digesters are composed of boiler-iron plates, tightly riveted together in the form of an inclosed cylinder, in length about two and one-half times greater than the diameter, and are furnished with diaphragms or false bottoms. The drawing itself is very explicit, and the mode of working these machines, and the use and application of their various appointments will be mentioned in reciting the process as practically carried through in the laboratory of the inventor. It is as follows: The false bottom being arranged in its place, and the discharging hole closed up, the steam-tight iron tank or cylinder is filled through the man-hole with the rough lard material, to within about two and a half feet of the top. This done, the man-plate K is securely fitted into the man-hole H, and steam let on from an ordinary steam boiler, through the foot valve, into the perforated pipe C within the tank. Set the weight on the valve at the requisite pressure, and during the steaming, frequently and carefully essay as to the

Fig. 6.



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 run from the try-cock aforesaid. After ten or fifteen hours' continued ebullition, the steam is stopped off, and that excess already in and uncondensed, allowed to escape through the try-cock and safety-valve. After sufficient repose, the fatty matter separates entirely from water and foreign admixture, and forms the upper stratum. It is drawn off through the cocks P P in the side of the tank, into coolers of ordinary construction. The tank, being emptied of its lard contents, the cover F is raised by means of the rod G, from the discharging hole E, and the residual matters at the bottom, let out into the tub T. If, on inspection, the contents of this tub have retained anything of fat, it must be again returned to the tanks, when they are being filled for a fresh operation. Experience has determined that, to produce the best result, the steam pressure should not be less than fifty pounds to the inch, though the weight generally used is seventy-five pounds, and may be augmented to one hundred pounds, when it is desired to expedite the operation. We should, however, advise against so high a pressure in the preparation of tallow; it may do well enough for lard; but if these closed tanks are made to operate as digesters, the effect produced by the decomposition of bones and other matters, which, in the wholesale way of preparing fats at the West, are generally thrown in indiscriminately with the rough suet, would be to deteriorate its quality. The better way is to take a little more time, and thus insure a better result. The process is sufficiently economical as it is, for whilst by a pres-

sure of between fifty and seventy pounds, the bones, etc., are made to yield all their oleaginous or fatty matter, there is no action occasioned which will convert them into 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 fall 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.

Beef Marrow.

This grease is contained in the tubular canal of the long bones of mammiferous animals.

This marrow is absolutely of the same nature as the rest of the grease of the same animal. The difference of taste which exists between the marrow of boiled bones and the ordinary melted grease, is due to foreign substances proceeding from the liquids which circulate in the cellular tissue by which the grease is surrounded, and especially to an extractive substance called by chemists *osmazon*.

Tallows.

Bone Tallow.—Bones contain a considerable quantity of grease which finds an advantageous use in the fabrication of soaps. To extract this grease, the bones are broken into pieces, dividing them as much as possible in the direction of their length. However in some manufactures they are crushed. This last process is the quickest. The bones must be fresh, for experience has shown that in old bones the grease has penetrated the bony tissue, which renders the extraction more difficult.

Then fill to one-third with water a cast-iron kettle, and while the water is heating add the bones, and boil gently. By the action of heat the grease melts and floats on the surface of the liquid; it is then taken off and passed through a sieve placed above a barrel. The foreign substances remain on the sieve, and the grease separates from the water which falls to the bottom of the barrel. When there is no more grease on the surface of the liquid, the bones are removed and drained.

Generally, when the operation is performed with fresh

bones, about five per cent. of grease is obtained. This kind of tallow is brownish-white, soft, oily, and odoriferous; it is exclusively prepared in the manufacture of bone black, where it is obtained by skimming the fat off from the bones. The tallow will be whiter and purer by treating the bones by steam, in an apparatus similar to the one used to obtain lard.

Horse Grease.—There exist several varieties of this grease, from the white to the brown. It is obtained by submitting to the action of steam, in closed vessels, the flesh, tissues, and bones of horses. The time of the operation varies from fifteen to twenty hours. During the operation the grease is disengaged from the tissues which contain it, and forms a layer on the surface of the liquid; it is allowed to cool, and is taken off. To purify it, it is melted and passed through a hair sieve. A horse yields about fifty pounds of grease; but there are some which yield as much as one hundred pounds.

This grease has more or less odor, according to the state of preservation of the animals which furnish it; it is always soft and unctuous, and during the heat of summer a part becomes completely liquid.

The soap made with it is white when it has been prepared with lyes of soda; but the odor is disagreeable. This odor may be considerably lessened by successive series of new lyes. In our opinion this grease can be advantageously used only in the preparation of half palm, and resinous soaps.

Green Grease.—Under this name a grease is sold, which is obtained from the residues of culinary operations, collected in private houses, hotels, eating-houses, hospitals, etc. These greases are purified, then mixed with bone tallow, and principally used in soap-making.

Tallows.—Tallow is the melted grease of the sheep,

the lamb, the ox, the calf, and the goat. Its characteristic appearance and properties sensibly differ, according to the kind, age, and sex of the animal which furnishes it.

Tallows are solid at the ordinary temperature; white, or dirty white; odoriferous, fusible, and saponifiable. They are generally composed of stearin, margarin, and olein.

The best tallow is that furnished by the male animal, well fed—such as oxen and sheep. The latter is the most esteemed.

The tallow of the goat and buck enters only to a small extent into the composition of commercial tallow.

The grease, when taken from the animal, is enveloped in membranes, and contained in the cellular tissue. It is distinguished by the name of *rough suet.* It is in this form that it is delivered by butchers to the melters. The rough suet yields about eighty per cent. of its weight of melted tallow. The proportion increases when the rough suet has been freed, by an exposure of a few days to the open air, from the water interposed in the membranes.

The proportion is much more considerable when the tallow is obtained from very fat animals, especially sheep.

Its applications are very numerous. The principal are: the preparation of soaps, candles, fatty acids, etc. Several kinds of tallows are known in commerce, and are designated according to their place of production. France generally produces the best qualities of tallow, but there are some differences according to the localities; thus, the North produces a tallow whiter and firmer than the South.

The Spanish tallows are of very different qualities,

but generally they are very good and very white. In that country the tallow is exposed a more or less considerable time in well-ventilated drying-rooms. The tallow thus prepared is hard and brittle, and does not contain water. The tallows of the Papal States have a great analogy with those of Spain; they are very white and very pure, and saponify well. The tallows of Ireland are much esteemed; they furnish very white and very hard soaps. The tallows of Russia essentially vary in quality, whiteness, and consistence. Among the most esteemed qualities are those of Waga, Kasan, and those of Siberia, which are principally used in the fabrication of soaps.

The tallows of the United States vary with the localities. Those produced in the country are generally the most esteemed. Large quantities are exported; the exports for the year 1867 having been 28,123,953 lbs. of the value of $3,142,354.

Sheep Tallow.—Under this name we also include the tallow of lambs, bucks, and goats. Externally it very much resembles beef tallow. It is white or pinkish, hard, opaque in thin cakes; it quickly putrefies, and covers itself with a green mould. When melted, it is milky-white, with a nacreous appearance; it is hard, and translucent in thin cakes.

After having been exposed for some time to the air it acquires a peculiar odor.

When melted, it sometimes begins to solidify at 98.6°, and the temperature then rises to 102.2°; but sometimes it solidifies only at 104°, and then the temperature rises to 105.8°. It requires 44 parts of boiling alcohol at 82°, to dissolve 1 of this tallow.

Braconnot has found it composed of 30 parts of olein and 70 of stearin, but it is evident that the proportions

of the constituents must vary according to the climate, the animal, etc. This tallow furnishes, by saponification with the lyes of soda ash, a very white soap; but the large proportion of stearin it contains renders the soap too hard and too brittle. To obtain a softer product, this tallow is mixed with 15 or 20 per cent. of lard or coco oil.

Beef Tallow.—Under this denomination we comprise that of the cow and the bull, without forgetting, however, that the grease of the ox is softer than the others.

In a rough state it is pinkish-white, hard, and may be kept in a cool place without moulding.

Melted, it is grayish-white, slightly yellowish, hard, opaque in thin cakes, and has no nacreous appearance at the surface.

After being melted, it begins to solidify at 98.6°, and the temperature rises up to 102.2°. It requires forty parts of alcohol at 82° to dissolve it.

According to M. Chevreul, 100 parts of this tallow contain 70 of stearin and 30 of olein.

When saponified with lyes of soda, a very white and firm soap is obtained. This soap can be perfectly refined.

Veal Tallow.—In the rough state it is pinkish-white; it easily melts; when pressed between the fingers it is very soft, opaque, and not nacreous.

Melted, it is milky-white, soft, and translucent when in thin cakes. It easily putrefies, more readily than that of sheep.

Tripe Tallow (Gut Fat).—This tallow is extracted by boiling the stomachs, heads, and feet of sheep, oxen, calves, etc.

As these substances are easily putrefied, they must be washed immediately in cold water, to separate the blood

and mucous substances which are adherent to them. This done, the materials are thrown into large copper kettles, in which they are submitted, with a sufficient quantity of water, to a gentle heat for five or six hours. By the heat, the grease separates and floats on the surface of the water, from which it is removed. When a sufficient quantity has been collected, it is re-melted and passed through a hair sieve.

This tallow is white, slightly reddish, less consistent and more oily than beef tallow. It produces a white soap of a very good quality. It presents the remarkable peculiarity that it contains less gelatinous parts than melted tallow. The lyes obtained from its saponification are perfectly limpid, even when cold.

Extraction of Tallow.—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 establishments 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 as the meat whence it was extracted, viz: either to an eastern or a foreign market.

Although the butchers' and packers' establishments 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 such 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. 7 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. 8), 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 unskil-

Fig. 7.

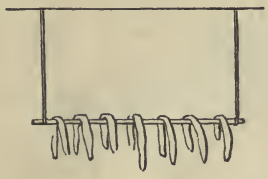
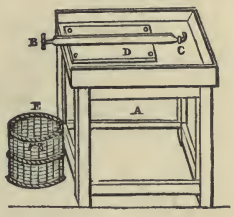
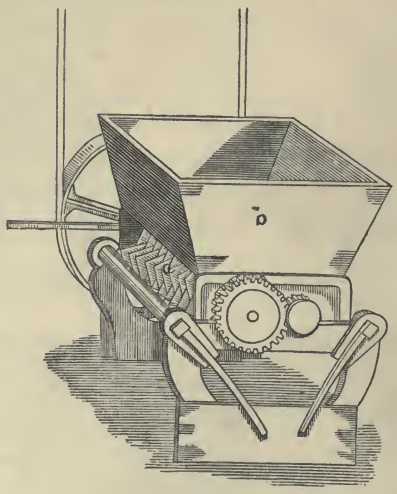


Fig. 8.



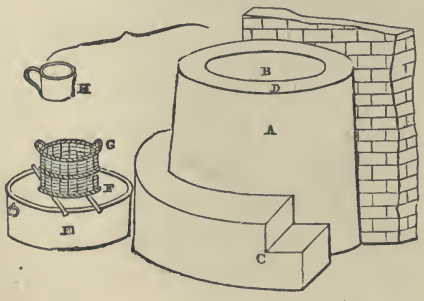
ful hands. It is advantageous to fix upon the table where the edge of the knife constantly comes down, a piece of beech wood plank (D) of an inch thickness, and fastened by screws, so that when it becomes worn out by repeated hacking, it can be replaced by a new piece. In this way the top of the table 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. 9. 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 machine, a workman cuts the rough fat into small pieces, and collects them in a basket E, placed under the table for 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

Fig. 9.



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. 10 shows the whole

Fig. 10.



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 fur-

nace, 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 inconvenience 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 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. 10. 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 factory, 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,

Fig. 11.

1, 1, 1 (Fig. 11), 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 slipping. 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

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. fall 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 potash and Prussian blue. We 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. 12. It is formed of two

Fig. 12.

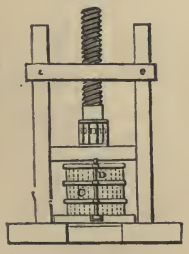
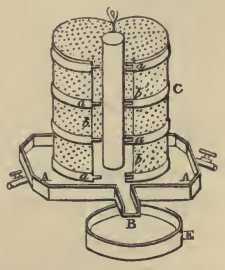


Fig. 13.



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. 13), at least two inches deep, and to the front of which is adapted a gutter B for the conveyance of the liquid fat, which collects 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, it is divisioned off, alternately, into equal parts by zones or belts. The zones *a a* are a full inch broad; the partition *b*, etc., 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. 11. 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.

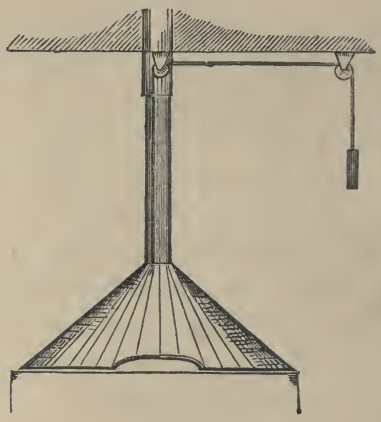
The different kinds and qualities of suet should be rendered separately, and without salt, for it decrepitates during the combustion of the candles, and causes them to run. The tallow keeps well enough without being salted, as the disagreeable odor it acquires by age is inevitable.

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. 14, 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.

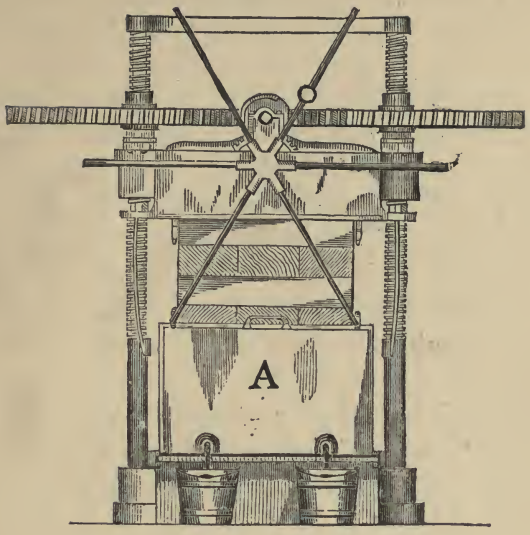
Fig. 14.



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. 15. The cullendered box is square, and of wrought iron, as is seen by Fig. 16, 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 a low grade soap stock.

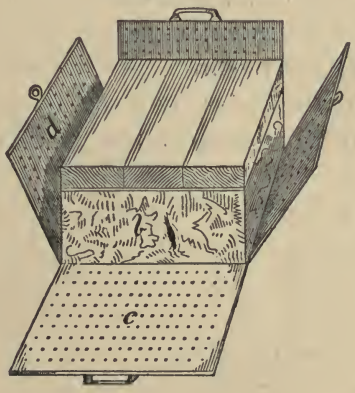
The plan of rendering in the open pan, over the naked fire, is, in many points, very objectionable, since it not only endangers the whiteness of the fat, and imparts a

Fig. 15.



stronger odor to it, but also occasions during the process a plentiful amount of offensive and unhealthy vapors,

Fig. 16.



which justly constitute a serious nuisance to the neighborhood. Moreover, it only imperfectly accomplishes

the object of the rendering operation, for the cellular matter is either only partially destroyed or so hardened that the 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 273 ; 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, etc., 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 assay 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 assays, 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. This process has been described in the chapter on lard.

3. *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 $\frac{1}{2}$ 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 potash, dissolved in a mixture of 10 pounds of water and 2 pounds of commercial oil of vitriol. This treatment arrested all offensive 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 preceding essays. Finally abandoning this train of experiment, he resolved upon a very simple expedient, which as supplementary to either the sulphuric acid, or naked fire process, produces most gratifying results. We shall consider it under the distinctive head of:—

4. *Stein's Process.*—This is based upon a chemico-mechanical arrangement, and consists in the use of a mixture of slaked lime and small lumps of freshly burned charcoal. It must be spread upon a coarse crash cloth, stretched over a hoop of two inches depth, and of circumference corresponding 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. The emanations from the rendering pan, in necessarily passing this sieve, are either neutralized or disinfected, and thus all cause of complaints against tallow factories as health destroying nuisances, is effectually removed.

Extraction of Fatty Bodies from Soapy Waters.—Generally, the soapy waters obtained from the scouring of wool by soap, are completely lost, although they contained in solution considerable quantities of saponified substances. For a long time this fact attracted the attention of chemists who proposed different methods to extract the soap. A process due to M. Houzeau-Muiron, and which has for its object the extraction of the fatty matters from soapy waters, by treating them by sulphuric acid, has completely solved the problem.

These waters are deposited in large wooden vats lined with lead; these vats are filled to four-fifths of their capacity, and a slight excess of sulphuric or hydrochloric

acid is slowly poured into them, in order to completely saturate the alkaline base. To render the reaction more easy and rapid, the liquid is stirred all the time. A few hours after, a more or less abundant layer of fatty matter is formed at the surface of the liquid. This is removed and heated in a large copper kettle, so as to melt it. Under the influence of heat it separates into two layers; the upper one is fluid and limpid; it is the pure oil which is separated by decantation; the lower one is a mixture of foreign substances and oil. To separate the oil, the deposit is introduced into woollen bags, which permit the oil to filter. When the oil passes only drop by drop, the last portions are separated by placing plates of iron heated by steam, between the bags which are strongly pressed. The oil obtained is pure enough to be converted into soap, or to be used in the greasing of machinery.

Animal Oils.

Animal oils are divided into two classes: 1. Oils obtained from animal remains, and called *animal oils*. 2. Oils obtained from sea animals, and called *sperm oils* and *fish oils*.

Animal Oils have been very little studied, and there is only one well known, *neat's foot oil*.

Neat's Foot Oil.—This oil is prepared by boiling in water the feet of cattle perfectly deprived of flesh and sinews, and removing the grease which floats on the surface. It is of a yellow-straw color, or straw a little greenish; sometimes it is colorless. When fresh it has no smell. Its taste is agreeable; it is limpid, and becomes solid only at a very low temperature.

Its specific gravity at 60° = 0.9160.

A current of chlorine bleaches it, and does not color it brown, as is the case with fish oils.

Among other animal oils of this class are those obtained from sheep and horse feet, the oil of eggs, etc., which have no interest for the soap-maker, and oleic acid which has been studied in another chapter.

Oils of Cetacei.

The animals of the order of the cetacei, *whale*, *cachalot*, *porpoise*, *seal*, *walrus*, have, between the flesh and the skin, a coating, more or less thick, of fat, which contains with the solid fatty body a large proportion of oil or grease, liquid at the ordinary temperature.

These oils used to be the basis of an immense commerce, which is now monopolized by England and the United States.

Whale Oil.—Under this name is comprised the liquid fatty matter obtained by melting the thick fat found under the skin of whales, cachalots, and other sea animals.

The whale oil, properly so called, is not very abundant in the subcutaneous fatty tissue; it is principally contained in large cavities, occupying the upper and anterior part of the head of the animal. This oil, which is in a liquid state in the living animal, solidifies by cooling, and takes the form of crystalline laminæ, held in suspension in an ambreous yellow oil.

The solid matter constitutes *spermaceti*, and the liquid part is *whale oil*.

There are three varieties of whale oil : the white, the yellow, and the black; but by their mixture a middling quality is made, which is the one generally sold.

Ordinary whale oil is more or less brown; filtered, it is reddish-yellow and transparent. Its odor of fish is very disagreeable. Sometimes it is thick and viscous, sometimes limpid. It solidifies at 32°. At the ordinary

temperature it is limpid, but it always deposits a certain quantity of spermaceti. Its sp. gr. at 68° = 0.9270. At a temperature near the freezing point it deposits a solid fatty matter. It is soluble in about its volume of alcohol at the temperature of 167°. By saponification it gives margaric and oleic acids, and several odoriferous fatty acids.

It is used in the preparation of soft soaps.

Cachalot Oil.—This oil is of a light orange-yellow color when in mass, and light yellow when in small quantity. It is transparent, and has an odor of fish. At 46.4° it deposits needles of a solid fatty matter. Its sp. gr. at 60°= 0.8840, and at 50°= 0.8680. Nitrous acid solidifies it.

Porpoise Oil (Delphinus globiceps), also called *dolphin oil*, is of a lemon-yellow color; it possesses a strong odor of fish. Its sp. gr. at 69° = 0.9178.

It is very soluble in alcohol; 100 parts of alcohol (sp. gr. 0.81) dissolve 110 parts at 158°; and 100 parts of anhydrous alcohol dissolve 123 parts at 69°.

The oil and its alcoholic solution have no action on litmus paper. The alcoholic solution becomes muddy at 125.6°. Exposed for some time at decreasing temperatures from 50° to 37.4°, it deposits crystals of spermaceti.

The oil deprived of spermaceti is of a darker color, with a stronger odor, and is more soluble in alcohol. 149 parts are dissolved by 100 parts of alcohol at 82° before ebullition. The alcoholic solution becomes muddy at 127.4°. It slightly reddens litmus.

By melting the fat of the *Delphinus phocæna*, an oil is also obtained which has a pale-yellow color, and a disagreeable odor, which disappears by the united action of light and air; its sp. gr. at 61.8°=0.9370. It does not redden litmus, but when exposed to the air it acquires

a brown color, which disappears in a few days. It has then the odor of the colewort oil, and reddens litmus paper. 100 parts of boiling alcohol at 81° dissolve 20 parts of this oil. The solution becomes muddy by cooling.

FISH OILS.

These oils are sometimes confounded with the above, and are often used to adulterate them. They are extracted by maceration and compression from the livers of several fishes. They are thick, have a strong odor and taste, and are differently colored according to their quality. They are distinguished as *brown*, *white*, and *fair*.

Commercial Fish Oil.—This oil has an orange-brown or yellow color. Its odor is that of fish; its sp. gr. at 69° = 0.9270. At 32° it remains limpid for several hours, but after an exposure of a few days to that temperature, it deposits a small quantity of fatty matter which may be separated by filtration.

Fresh, it does not affect litmus paper, but it is not the same when old; 100 parts of alcohol, at 0.795 of density, at the temperature of 167°, dissolve 122 parts of oil. The solution becomes muddy at 145.4°. It is not acid; 6½ ounces of oil are perfectly saponified by 4 ounces of potash, dissolved in 13½ ounces of water. The soapy mass is colored brown, and completely dissolves in water.

Cod-liver Oil.—There are three varieties of cod-liver oil: 1st. The *white oil* (about half of the weight of the liver) is that which separates first on the packing the livers in a vat, after they have received a certain degree of putrid fermentation. It is golden yellow.

Its odor is peculiar, and analogous to that of anchovies. Its taste at first is sweet, and afterwards more or less nauseating. Its sp. gr. at 63.5° = 0.9230.

2d. *The brown oil* separates later when the hepatic parenchyma begins to be broken down. This oil is the above one, altered only by a too long contact with the livers. Its color is analogous to Malaga wine; its odor is peculiar and disagreeable; it has a nauseating taste. Its sp. gr. at 63.5° = 0.9240.

3d. The *black oil* is obtained by boiling in water the substance which has furnished the two oils above named. This oil is of a dark brown color. Its odor is nauseous and empyreumatic. Its taste is bitter, empyreumatic, and nauseating. Its sp. gr. = from 0.9290 to 0.9300.

All these oils have a feeble action on litmus; they are soluble in alcohol, and in all proportions in ether.

CHAPTER XIX.

WAXES—RESINS—TURPENTINES.

Animal Wax.

Beeswax.—Wax is the substance secreted by the bee, an insect belonging to the family of the mellifera, order of the hymenoptera. As it exists in the combs and after purification, wax is a solid fatty body, compact, of a yellow color, more or less dark, insoluble in water, soluble in fixed oils, in 20 per cent. of boiling alcohol and ether, and in spirit of turpentine; it has no taste; its odor is aromatic and similar to that of honey.

Wax is dry, not greasy to the touch, tenacious, yet brittle. Yellow wax melts at 143.6° to 145.4°. Its sp. gr. =0.9750. It burns without leaving any residuum.

There are two kinds of wax, the *yellow wax*, the properties of which we have just described, and the *white wax*, which is the bleached yellow wax.

The white wax is obtained by melting the yellow wax and reducing it to thin plates, like ribbons, and exposing them to the sun and air for several days, until perfectly white.

It is white, slightly diaphanous when thin, without taste, nearly without odor, hard and brittle at 32°, and very malleable at 86°; it becomes softer when heated; at 149° it is completely liquid, but it cannot be boiled without decomposition.

Like yellow wax, it is insoluble in water, partly soluble in alcohol, but dissolves very well in ether and in fixed and essential oils. Its sp. gr. is from 0.960 to 0.966. Its fracture is slightly granular; it sticks to the fingers when kneaded; it is inflammable, and burns with a white flame without leaving a residuum.

Vegetable Waxes.

Palm-tree Wax.—Produced by the *ceroxylon audicola*, very abundant in New Granada.

It is obtained by scraping the epidermis of the tree.

The scrapings are then boiled in water, and the wax floats on the surface without melting.

In a crude state it has the form of a gray-white powder.

Purified by treatment with boiling water and alcohol, it is yellowish-white, but slightly soluble in boiling alcohol, and precipitates by cooling. It melts at 161.6°.

Carnauba Wax is produced by a palm tree which grows abundantly in the provinces of the north of Brazil. To obtain it, the leaves are cut and dried in the shade, and soon the wax is separated in the form of thin scales which are melted.

This wax is soluble in boiling alcohol and in ether; by cooling it crystallizes; it melts at 191.3°; it is very brittle, and is easily reduced to powder.

Myrtle Wax is obtained by boiling in water the berries of several species of *myrica*, especially the *myrica cerifera*, a tree very common in Louisiana. These berries give 25 per cent. of their weight of wax.

The crude wax is green and may be saponified.

Purified by treatment with boiling water and cold alcohol, this wax is greenish-yellow, and melts at 117.5°.

Ocuba Wax is obtained from a *myristica* in the province of Para, and in French Guiana.

This tree produces a fruit with a stone covered with a thick crimson pellicle, which colors water red.

To extract the wax, the stones are crushed, reduced to a pulp, and boiled for some time with water; the wax floats on the surface. This wax is yellowish-white, soluble in boiling alcohol, and fusible at 97.7°.

The wax of bicuida, obtained from the *myristica bicuyda*, is yellowish-white, soluble in boiling alcohol, and melts at 95°.

Resins.

Resins are natural products, which are elaborated in the organism of certain plants during their vegetation. Generally, they are obtained by a spontaneous exudation, or by making a longitudinal incision in the bark of the tree. These substances form a class as numerous as it is important, but in their ensemble they possess common

and distinct properties, such as insolubility in water, and solubility in pure alcohol, ether, acetic acid. Fixed oils, animal greases, and spirits of turpentine, dissolve many of them. With caustic alkalies, they form compounds soluble in water which are called *rosin soaps;* and it is on this property that depends their use in the fabrication of resinous soaps. Besides, resins have the remarkable property of rendering soaps more soluble, and of considerably increasing their detersive properties.

Nearly all natural resins are solid, not volatile, sometimes colorless, but most generally colored yellow or brown; their taste is generally acrid and hot; pure, they are nearly always translucent.

The principal resins employed in the preparation of soaps are extracted from the different species of pine tree, especially the *pinus maritima.* According to chemists, nearly all the resins are a mixture of different resins. Chemically pure, they are true carburetted hydrogens; they also contain variable proportions of oxygen. Some chemists believe, that resins are volatile oils saturated with oxygen.

Resins are generally denser than water, and melt at about 212°. Submitted to distillation, they set free the volatile oil which they contain, but after the separation of the oil, they cannot be distilled without decomposition; they then form very abundant gaseous products which burn with a bright flame. Some resins, and especially the turpentines, yield, in addition, essential and fixed oils, which have different applications in the arts.

To resume, among the immediate principles of vegetables, the resins form an important class. Many resins are found in commerce, and their names recall those of the vegetables from which they are derived. Considered in the ensemble of their chemical properties, they present

analogies and characteristics sensibly identical with those of the resins of turpentine. As for their color and odor, they are due to peculiar principles but little studied, and imperfectly defined.

Turpentines.

The substances, known in commerce by the generic name of turpentine, are the resinous juices which exude by excision, or spontaneously, from several trees of the family of the *conifera*, especially the pines, etc.

Generally, these products differ from each other in their color, odor, and consistency. Their color is ordinarily whitish, yellow, or greenish. In consistency they are sometimes viscous and unctuous, sometimes hard and brittle. In this state of solidity the product is specially known by the names of *white resin*, *resin gem*. It has the form of whitish translucent crusts of a lemon-yellow color; its odor is strong and penetrating. It is ordinarily mixed with many foreign substances. It is purified by melting it at a gentle heat and filtering it through a straw filter; it takes then the name of white pitch, or gem, which under different denominations indicate the same product.

Whatever is their place of production, natural turpentines are always a mixture, in variable proportions, of a fixed resinous substance and a volatile oil. In industry, the latter is separated by distillation, and the residuum constitutes rosin. These observations being made, we shall say a few words on the principal turpentines found in commerce, and which can be used in the fabrication of soaps.

Turpentine of Venice is obtained from the *pinus larix*. It is liquid and translucent, with a lemon-yellow color. It exhales a peculiar aromatic odor which is generally

pleasant. Its taste is acrid and slightly bitter. Distilled, it produces a very pure volatile oil. The residuum of the distillation is a very firm and slightly colored resin.

Switzerland turpentine is less pure, less transparent, and less limpid than the above one, and is extracted from the *pinus picea*. This turpentine is viscous, with a greenish-yellow color; its taste is acrid, and has a very characteristic bitterness. Its odor is less agreeable than the previous. It yields a volatile oil very much esteemed, and a yellow-brown rosin, very good for the manufacture of soaps.

Turpentine of Bordeaux.—Obtained from the *pinus maritima*.

To facilitate the exudation of the turpentine, deep longitudinal incisions are made in the tree; the resinous juice which exudes from these incisions solidifies. This turpentine is distinguished under two varieties: one which is impure and mixed with much foreign matter; the other, which has been carefully selected from the first. It is principally from this turpentine that the yellow rosin or colophony is extracted. The operation is conducted as follows: The turpentine is first melted and passed through a straw filter to separate the foreign matters. The melted substance is then introduced into a still and distilled by the naked fire. To avoid the alteration of the products by fire, a small but continuous stream of cold water flows into the still during the distillation; this water is instantaneously converted into vapor, which mixes with that of the oil, and both vapors condense in the receiver. By resting, the spirit of turpentine, which is lighter than water, separates from it, and is then decanted. The quantity of spirit obtained varies from 8 to 12 per cent. The residuum which remains in the still is run into

small cylindrical pits dug in the sand in which it solidifies. This substance is hard, brittle, very bright, and of a color varying from brown to black; it represents from 80 to 85 per cent. of the weight of the turpentine used. This substance is transformed into colophony by a very simple process; if 5 or 6 per cent. of water is incorporated with it while yet in a state of fusion, its color is immediately transformed from a dark brown to a yellow: it is then the substance known in commerce by the name of yellow rosin, and is used to prepare resinous soaps.

Boston Turpentine.—This is furnished by the resinous fluid substance which runs from the *pinus Australis* and *strobus*, a tree which grows abundantly in several countries of North America. This turpentine is generally fluid and viscous. Its name is improper, Boston being only one of the ports for the export of the rosins furnished by this continent.

Turpentine of Canada (Canada balsam) is obtained from the *pinus balsamea;* it is collected on the trunk of the tree. Its odor is balsamic and aromatic.

These turpentines like the above are essentially formed of solid resin and volatile oil, which is the principle which gives them their fluidity.

It is easy to ascertain whether the turpentines and ordinary resins are free from foreign substances by treating them with boiling alcohol. For this purpose, take half an ounce of the resin to be tested, and reduce it to an impalpable powder. After introducing this powder into a glass balloon, pour on it 5 ounces of pure alcohol and heat over a water-bath until it boils. If the resin is pure, it entirely dissolves in the alcohol; if, on the contrary, there remains any residuum, its weight indicates the quantity of foreign matter.

Preparation of a Purified Rosin for Soaps.—All rosins can be used in the preparation of yellow or brown soaps, but these rosins have generally the disadvantage of being too dry and too brittle, that is, if completely deprived of their essential oils. They saponify less readily than when they contain a small amount of oil, and it is better for the manufacturer to prepare his rosin himself.

In a copper kettle of a capacity of 50 gallons melt 200 pounds of turpentine; when melted, heat the substance to the boiling point and keep it thus for twenty minutes. During the ebullition a part of the oil volatilizes, but there yet remains a certain quantity in the rosin; then draw the melted substance and pass it through a hair sieve placed above a sheet iron box, and allow it to cool. By operating thus, a perfectly pure rosin is obtained, which is translucent and bright. To obtain it of a fine yellow color, incorporate into it 4 or 5 quarts of water, when in a state of fusion ; but water destroys the transparency and renders it opaque without adding to the quality.

Saponified with tallow or lard by caustic lyes of soda ash, the rosin thus prepared forms a remarkably fine yellow soap, the color of which may be brightened by the addition of 15 to 20 per cent. of palm oil. This soap, well refined, constitutes the marshmallow soap of first quality, and is also used to prepare the yellow transparent soap.

CHAPTER XX.

FALSIFICATIONS AND ASSAYS OF FATTY MATTERS.

Alterations.

In the general examination of the fatty bodies, we have seen that oils are altered by exposure to the air, become rancid, and that some dry into a varnish, while others become thick and unable to burn without smoke.

This alteration may be prevented, by keeping them in earthen vessels, in demijohns, or stone receivers, placed in a cool place, and protected from the contact of the air.

Oils may be altered by the presence of metallic substances, such as copper, or lead, due to the vessels in which they are stored. To detect the presence of copper, introduce a certain quantity of oil, with twice its weight of nitric acid, into a test tube and stir for some time; afterwards, separate the acid from the oil and pour ammonia into the acid; if copper be present, a fine blue color is developed.

To detect the presence of lead, take another portion of the acid liquor and pour into it a little sulphuric acid, or carbonate of soda, or a little caustic lye of soda; if lead be present, a white precipitate will be produced.

Falsifications.

Oils are often the object of numerous falsifications, which consist in mixing them either with oils of an inferior quality, or with greases or animal oils.

Our object here is not to enter into a general detail of the analysis of oils; we shall examine each one in particular, and indicate the adulterations to which they are liable.

Olive Oil.—Olive oil for the manufacture of soaps is ordinarily adulterated:—

1. With colewort oil;
2. With rapeseed oil;
3. With linseed oil.

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

Oil of Sweet Almonds.—The oil of sweet almonds is principally falsified with poppy oil, and in Marseilles with sesame oil.

Several processes have been proposed for detecting this falsification.

Oil of sweet almonds becomes muddy at 4° below 0°, and solidifies at 13° below 0°, while poppy oil begins to solidify between 39° and 42.8°.

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

Rapeseed Oil.—This oil is falsified with linseed, cameline, poppy, mustard, and whale oils, oleic acid, etc.

Ammonia with pure oil gives a milk-white soap; and a yellowish-white soap, when the oils of cameline, black poppy, mustard, and whale, are present.

Gaseous chlorine colors rapeseed oil brown, when it contains whale oil; if pure, it remains colorless.

Colewort Oil.—Colewort oil is adulterated with the oils of black poppy, cameline, fish, linseed, whale, and with oleic acid.

The most common adulteration is with whale oil.

The use of a current of chlorine in colewort oil, enables us to detect the smallest quantity of fish and whale oils; the oil becomes brown, then black.

Sesamum Oil.—This oil is ordinarily mixed with earth-nut oil.

Linseed Oil.—This oil is falsified with hempseed oil, and especially with fish oil.

Pure linseed oil treated by hyponitric acid becomes pale-pink; by ammonia, dark yellow, and gives a thick and homogeneous soap.

Black Poppy Oil.—This oil may be mixed only with sesamum and beech oils.

The pure oil is colored a light yellow with hyponitric acid, while beech oil acquires a pink color.

Ammonia colors it a light yellow; the consistency is slightly thick, and the soap is a little granular.

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

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

Neat's Foot Oil.—This oil is without doubt the most adulterated oil found is commerce; it is mixed with whale and black poppy oil.

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

Palm Oil.—This oil has been mixed with or manufactured entirely of yellow wax, lard, mutton suet, colored with turmeric, and aromatized with powdered orris root, without any genuine palm oil.

By treating the suspected oil with ether, all the fatty bodies are dissolved; the turmeric and orris root remain insoluble.

By saponification, the mixed or artificial oil takes a reddish shade due to the action of the alkali on turmeric. Sometimes powdered rosin has been mixed with it; this falsification is easily detected by treating the oil with alcohol; the rosin is dissolved while the oil remains insoluble.

Oil of Cacao.—The commercial oil is often adulterated with mutton suet, beef marrow, or other animal greases, sometimes also with the oil of sweet almonds and wax. The oil falsified by these substances does not completely dissolve in cold ether. The ethereal solution is muddy like that given by pure butter. The oil thus falsified has a taste and an odor less agreeable, a color rather grayish than yellowish, and has less consistency.

The melting point is the best method of ascertaining the purity.

Adulterated with greases or tallows the oil melts at 78.8° to 82.4°; with oil of sweet almonds, it melts at 73.4°.

Butter of Nutmegs.—Before introducing it into commerce, the falsifyers separate the butter from its volatile oil, which is substituted by a fatty body, the latter communicating a very different odor and taste.

Butter of nutmegs has been made entirely of yellow wax and tallow, colored with a little turmeric, and aromatized with volatile oil of nutmegs.

It is also imitated by melting tallow with powdered nutmegs, and coloring with a little annotto.

Sometimes it is made with spermaceti, aromatized with the volatile oil of nutmegs and colored with saffron.

All these manipulations are detected: 1. By the odor exhaled by the product when burned on a piece of red hot iron; 2. By the absence of the characteristics peculiar to the pure butter.

The presence of turmeric, annotto, and saffron is ascertained by the brown or red coloration these substances take with an alkali.

The third mixture is ascertained by its insolubility in four times its weight of boiling alcohol.

The fourth mixture is detected by its insolubility in cold rectified alcohol.

Assays of Oils.

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

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

By old oils, we understand those which, though prepared for some time, have been placed in good conditions of conservation. Olive oil, for example, placed for one or two years in a warm place, kept in a vessel half full, and exposed to the contact of the air, if tested in a certain manner, is colored like the oil of sesame. This discoloration indicates a decided alteration of the substance it holds in solution. This characteristic may be met with in the oil used in manufactures, never in that em-

ployed for food. The latter is generally colorless, or very little colored. By some other modes of testing, this oil behaves like one which has been well preserved, or has been recently obtained.

Several authors have spoken of coloration, but their processes to produce these colorations are difficult; besides, the colorations obtained are not characteristic enough to enable us to determine the purity of a commercial oil. We must understand by this denomination, the oil as it is usually prepared in the arts. The following processes are easy of employment: With the oil tried, a coloration ought to be produced similar to that assumed by the same kind of oil placed in similar conditions. If there is a mixture, the coloration obtained will be proportional to the volume of each oil in the mixture.

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

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

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

Fatty oils are imperfectly saponified in 30 seconds, at the ordinary temperature, by a solution of caustic potash.

If we treat a commercial oil at the ordinary temperature for thirty seconds, by a solution of potash, and after-

wards, if this mixture is acted upon by an alcoholic solution of bromine, this substance is absorbed by the fatty substance much quicker than if it had not been saponified. This absorption is helped by a more complete saponification, and it takes place with a production of heat which varies for every kind of oil.

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

Qualitative Assays.

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

At 44.6°, 46.4°, 48.2° F., the quantities to be taken are

1st. *Sulphuric acid sp. gr.* 1.80 *to* 1.84 (65° to 66° B.) 7 cub. cent.
2d. *Water* . . . . . 3 "
3d. *Oil* . . . . . 4 "
4th. *Nitric acid sp. gr.* 1.35 *to* 1.40 (35° to 40° B.) 3 "

At 50°, 51.8°, 53.6°, 55.4°, 57.2°, take

1st. *Sulphuric acid* . . . . . 6 cub. cent.
2d. *Water* . . . . . 3 "
3d. *Oil* . . . . . 4 "
4th. *Nitric acid* . . . . . 3 "

At 59°, 60.8°, 62.6°, 64.4°, 66.2°, take

1st. *Sulphuric acid* . . . . . 5 cub. cent.
2d. *Water* . . . . . 3 "
3d. *Oil* . . . . . 4 "
4th. *Nitric acid* . . . . . 3 "

At 68°, 69.8°, 71.6°, 73.4°, 75.2°, take

1st. *Sulphuric acid* . . . . . 4 cub. cent.
2d. *Water* . . . . . 3 "
3d. *Oil* . . . . . 4 "
4th. *Nitric acid* . . . . . 3 "

Measure in a graduated tube the sulphuric acid, which is introduced into a test tube closed at one end, 20 centimetres in height, and 18 millimetres diameter. Let the acid drain well, then in the same tube, measure the water which is poured upon the acid, and mix quickly by shaking the tube. The produced heat ought to range from 111.2°, to 118.4°. Into this warm mixture, pour the oil which has been measured in another graduated tube. Lastly, add the nitric acid carefully measured. Apply a sheet of India rubber to the opening of the tube and shake it strongly for 30 seconds, then dip it immediately into cold water where it is left for 5 minutes. The oil collects at the surface of the liquid and begins to be colored. After five minutes, remove the tube and keep it in a vertical position where it is left to rest. Fifteen minutes after observe the coloration.

When the acid mixture is not warm enough, the earth-nut oil blackens very little or not at all; if the tube is not dipped into cold water, the brown coloration easily disappears and becomes dark-red. The reaction of the warm acid mixture on the coloring matter ought to be suspended by an immersion of 5 minutes in cold water.*

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

Note.—It is important that the sulphuric acid should always be very concentrated. (Sp. gr. 1.8 to 8.4.)

* The temperature which succeeds the best is from 60.8° to 62 6°, in using 5 cub. cent. of sulphuric acid.

TABLE A.

Oils Used.	Temperature. 44.6°; 46.4°; 48.2°.		Temperature. 50°; 51.8°; 53.6°; 55.4°; 57.2°.		Temperature. 59°; 60.8°; 62.6°; 63.8°; 65 6°.		Temperature. 67.4°; 69.2°; 71°; 72.8°; 74.6°.	
	Oil.	Acid.	Oil.	Acid.	Oil.	Acid.	Oil.	Acid.
Virgin olive oil,	Dark nankin	Colorless	Pale nankin	.....	Pale straw	.....	Straw	.....
Ordinary " "	Dirty yellow	Greenish	Dark nankin	Colorless, or slightly greenish	Dark straw	Colorless, or slightly greenish	Straw	Colorless, or slightly greenish
Turning " "	Dirty yellow	.....	Nankin, a little yellowish	.....	Straw, yellowish shade the most often; dark straw	.....	.....	.....
Sesamum oil,	Red brown	Strongly colored orange	Red brown	Orange red	Dark orange	Yellow, infusion of saffron	Orange	Yellow, infusion of saffron
Earth-nut oil,	Soot, or infusion of coffee	Very little coloration.	Soot, or infusion of coffee	Very little coloration	Soot, or infusion of coffee	Slightly orange color, which disappears	Soot, or infusion of coffee	Slightly orange color, which disappears
Colewort oil, not refined,	Brown. In one quarter of an hour becomes red orange.	Very little coloration.	Red orange, or red currant	Colorless	Red orange, or red currant	Colorless	Red orange, or red currant	Colorless
Colewort oil, refined,	Red currant	Colorless	Red currant	Colorless	Red currant	Colorless	Red currant	Colorless
Neat's foot oil,	Dark brown	Very little coloration.	Dark brown	Very little coloration	Dark brown	Very little coloration	Dark brown	Very little coloration

Second Process (*temperature* 50° to 53.6°).—This process depends on the different colorations that fatty oils take under the influence of hyponitric acid dissolved in nitric acid, by operating at a temperature of from 50° to 53.6°, for olive, sesame, earth-nut, and neat's foot oils; and at from 60.8° to 67.4° for colewort oil.

The solution of hyponitric acid is used half an hour after it is prepared.

To prepare it, if there are many assays to make, take

Nitric acid, sp. gr. 1.40; 99 *c.c.—in weight*	138.6	*grammes.*
Mercury . . . 1 *c.c* . .	13.598	"

If there are few assays, take

Nitric acid	34.65 grammes to	35 grammes
Mercury	3.40 "	"

Introduce the acid and mercury into a glass stoppered bottle and close it immediately. The bottle must be three-quarters full; shake it from time to time. When the mercury is dissolved, the liquid is prepared; thus obtained it is colored a dark green. Before using it, its temperature must be at 50° to 53.6°, except for colewort oil. If the operation takes place in summer, the bottle is kept in cold water with a little ice, for about five minutes.

To try the oils by this process, they must be filtered, if not clear; for often they contain mucilage and parenchyma. When limpid, measure in a glass tube, 4 cub. cent. of oil, which is introduced into a bottle of a capacity of 15 cub. cent.; pour on the oil 3 cubic cent. of acid, cork the bottle and stir quickly for five minutes. A few minutes after the oil collects at the surface of the acid and colors.

If the acid liquor has not been recently prepared, the coloration is not apparent enough; in this case add 1 or

2 cubic centimetres of acid, and shake anew for a few seconds. It is necessary, after a second addition of liquor, to put the vial which contains the mixture into cold water, where it is left for about half a minute.

It is important not to color the oil too strongly, because the verdigris blue color that the olive oil takes would obscure the coloration of the oil mixed with it.

In summer, the temperature being at 59°, 60.8°, etc., the verdigris coloration of the olive oil changes very quickly. Then when this oil is tested, it must be previously cooled down. The colorations taken by the oils are indicated in the table B.

TABLE B.

Oils used.	Coloration at from 50° to 53.6°.
Virgin olive oil,	These three oils pass to a verdigris blue, more or less dark, which they retain for 20 to 25 minutes; solidified, they have a bluish-white color.
Ordinary " "	
Turning " "	
Sesame "	Orange or brick red; solidified, the oil is orange.
Earth-nut "	Yellow, capable of becoming orange; solidified, this oil is pale yellow.
Colewort "	Bistre, passing to minium; solidified, it has a lemon-yellow color.
Neat's foot "	Verdigris; solidified, it is bluish-white.

Third Process (*temperature* 59°).—This process consists in causing to react for 5 minutes at the temperature of boiling water, on 20 grammes of olive oil, the hyponitric acid produced by 10 drops of nitric acid, and 10 drops of sulphuric acid (sp. gr.) 1.84. If the oil is muddy, filter it; if mixed with a little water, add to it a small quantity of starch, and filter. Then take a glass tube about 10 centimetres high, and of a diameter of 20 to 22 millimetres, and introduce the olive oil into it. If the temperature is above 59°, cool the oil. Let fall on the oil 10 drops of sulphuric acid, and mix the oil and acid by shaking well; then introduce 10 drops of nitric

acid, and mix as previously. Place the tube in a small jar of cold water and raise the temperature rapidly to the boiling point. Boil five minutes and cool the tube in cold water.

Olive oil generally solidifies in 1 hour and 40 minutes after being taken from the boiling water. When out of this bath it has a yellowish-lemon color, or is a very slight orange-yellow. There are some olive oils which take more or less time to solidify; in this state, olive oil has the color of very pale fresh butter. When it contains 15 to 20 per cent. of sesamum oil, it solidifies and is yellow, like palm oil. Mixed with 15 to 20 per cent. of earth-nut oil, when out of the bath, it has a vinous red color; it does not solidify. Mixed with colewort oil, the solidification is very slow; one hour after, the oil is still liquid, and the color is orange-yellow.

If sesamum oil has to be solidified, it is necessary to use 10 drops of sulphuric acid, and 20 drops of nitric acid. To solidify earth-nut oil, it requires 15 drops of sulphuric acid, and 40 drops of nitric acid.

Pure colewort oil is not solidified by 10 drops sulphuric acid, and 10 drops nitric acid; 24 hours after, it is pasty. If the oil has not been purified it remains liquid, a black substance being deposited.

Fourth Process (*minimum of temperature* 53.6° *to* 59°).— Into a test glass of a capacity of 60 cubic centimetres, with an opening having a diameter of 5 centimetres, introduce 1 cub. cent. of quicksilver, 12 cub. cent. of nitric acid at 1.40, and 4 cub. cent. of oil. The mercury by dissolving in the acid disengages binoxide of nitrogen, which makes the oil foam and colors it. The colorations of the foam and the oil are indicated in the table C, after the complete solution of the mercury.

TABLE C.

Oil.	Coloration of the foam.	Coloration of the oil.
Virgin olive oil, Ordinary " " Turning " "	Foam very little voluminous; seen by transmitted light it is very pale, or straw color, with a greenish shade; seen vertically the surface has an unripe straw color.	Pale straw, or dark straw, or straw color, with a shade very slightly yellow.
Sesamum oil,	Voluminous orange foam.	Orange.
Earth-nut "	Lemon orange foam; more voluminous than olive oil, but less than sesamum and colewort.	Orange yellow.
Colewort oil,	Voluminous orange foam.	Red orange.
Neat's foot oil,	Very little voluminous foam, which has a straw color, slightly greenish.	Green olive.
Black poppy oil, Linseed " Whale "	Very voluminous foam which does not fall; dark orange color.	These oils do not reassemble and remain foamy.

Assay of the Oils for Manufactures.

These oils tried by the *first* process are colored in different manners, and these colorations enable us to divide them into four series, which are :—

1*st Series.*—*Olive*, is colored nankeen, pale straw, or dark straw.

2*d Series.*—*Mixture of oil and earth-nut*, is colored gray or brown.

3*d Series.*—*Earth-nut*, is colored a soot brown.

4*th Series.*—*Mixtures of olive and sesamum, olive and colewort, colewort and linseed.*—These mixtures are colored yellow-orange or red; the acid is colored yellow-orange or like an infusion of saffron, or is not colored.

Let us suppose that an oil is to be tested and its name ascertained.

If the oil is not clear, filter it; if it contains water, add to it a little starch, and filter; try it by the first process, operating at a temperature of 60.8° to 62.6°.

If the oil is colored a red-orange, and the acid has the

yellow tint of the infusion of saffron, we may attribute it to the presence of sesamum oil. If the oil tested by the second process passes to a verdigris blue; if tried by the third process it is colored lemon, or lemon with a slight orange shade; if it solidifies in 1 hour and 40 minutes and acquires the color of pale fresh butter; if tried by the fourth process, the foam seen by transmitted light is a pale straw, or greenish-straw color; we have an *olive oil* rarely met with in commerce. This oil has lost its light yellow or greenish shade to become nearly colorless.

If by the first process the oil takes a nankin color, a pale or dark straw, or straw with a very light yellow shade, and if the acid is not colored, or takes a very light-greenish shade; if by the second process the oil passes to the verdigris blue; if by the third process it solidifies, and passes to the color of pale fresh butter; if by the fourth process the foam seen by transmitted light is a pale straw, or greenish straw color, we have the *ordinary olive oil.*

If by the first process the oil becomes gray or brown; if by the second process it passes to the apple-green or yellow color; if by the third process, when out of the bath, it is colored a pale red, dark red, or vinous red; if the solidification does not take place, or is done with difficulty; if the solidified oil looks like yellow wax or palm oil; if by the fourth process the foam has a pale yellow color, we have a mixture of *olive and earth-nut.* (The foam is yellow when the proportion of earth-nut is from 40 to 50 per cent.).

If by the first process the oil passes to a brown soot color; if by the second process it is lemon, or lemon slightly orange; if by the third process when out of the bath it is vinous red, if it does not solidify, and forms an abundant brown deposit; if by the fourth process it gives a yellow lemon foam, we have *earth-nut oil.*

If by the first process the oil passes to a red-brown or orange-red, and if the acid is colored orange, or like a yellow infusion of saffron; if by the second process the oil becomes orange or brick-red; if by the third process the sulphuric acid does not sensibly alter the color; and, if after the addition of nitric acid it rapidly passes to a dark indigo, and afterwards to a dirty red; if when out of the bath, it is red or vinous red; and if the solidification does not take place with 10 drops of each acid; and if by the fourth process the foam is orange, and afterwards yellow-orange, we have *sesamum oil.*

If by the first process the oil passes to a dark red or orange, and if the acid is colored orange-yellow, or like the yellow infusion of saffron; if by the second process the oil is colored a more or less dark yellow; if by the third process the mixture of the two acids makes it rapidly pass to the indigo color, and afterwards to a dirty yellow, or dirty red; if when out of the bath it is red; if solidified it is yellow, like palm oil; if by the fourth process the foam is yellow, and the oil is orange-yellow, we have a mixture of *sesamum and olive oils.*

If by the first process the oil passes to a red-brown, and if the acid is colored orange, or like the infusion of saffron; if by the third process (10 drops sulphuric acid, and 20 drops nitric acid) it is not solidified in 2 hours and 30 minutes, or, if it solidifies with difficulty; if by the fourth process the foam is at first orange, and afterwards dark yellow, we have a mixture of *sesamum and earth-nut oils.*

If by the first process the oil becomes red orange or currant red; and if the acid is not colored orange, or like an infusion of saffron; if by the second process the oil takes a bistre, yellow, or minium color; if by the third process sulphuric acid alone colors it a very dark blue-

green; if when out of the bath it is orange or orange-brown; if after causing 10 drops of oil to fall upon a glass plate under which is a sheet of white paper, it is tried by 2 drops of sulphuric acid, and there forms around the acid a pale-blue aureola which disappears in 15 minutes, we have *colewort oil.*

If by the first process the oil passes to an orange-yellow, and if the acid is not colored yellow; if by the second process the oil is colored apple-green, or pale yellow; if by the third process sulphuric acid alone makes it pass to a very dark blue-green; if when out of the bath the oil is orange and remains liquid; if in trying 10 drops of oil by 2 drops of sulphuric acid, it forms a pale blue aureola, which easily disappears; if by the fourth process the foam is lemon-yellow, we have a mixture of *olive and colewort oils.*

If by the first process the oil is colored a dark-red or brown-red, at a temperature of from 60.8° to 67.4°; if tried by the second process the oil effervesces, becomes brown, and a certain quantity of oil is deposited; if by the fourth process the foam is orange-yellow, and very voluminous, we have a mixture of *colewort and linseed oils.*

If tried by the second process at a temperature of 60.8° to 67°, the oil effervesces, passes to a brown without depositing oil, we have a mixture of *colewort and whale oils.*

Such are the qualitative assays by which the purity of oils used in manufactures can be determined. The composition of the mixtures may be ascertained as follows:—

OLEOMETRY.

Assay by Volumes.

Mixture of Olive and Earth-nut.—It is more easy to analyze a mixture of olive and earth-nut oils by the first than by the second process.

Fill a bottle of a capacity of 15 cubic centimetres with earth-nut oil, then let fall drop by drop, into a graduated tube, a sufficient quantity of earth-nut oil to measure 4 cubic centimetres. By this process, the number of drops necessary to represent this volume is ascertained. Empty the graduated tube and dry it. We suppose that 90 drops of earth-nut oil are required to measure 4 cubic centimetres. Fill half the graduated tube with olive oil, then introduce 9 drops of earth-nut oil, and complete the 4 cub. cent. with a sufficient quantity of olive oil. Shake well to mix the oils. In this manner, we have a mixture A which contains the tenth of its volume of earth-nut oil.

Try this mixture by the first process. Make a second mixture B, with 18 drops of earth-nut oil; a third mixture C, with 27 drops; a fourth mixture D, with 36 drops; a fifth E, with 45 drops. Try these different mixtures in the same manner as mixture A.

Lastly, try 4 cub. cent. of the oil, the composition of which has to be ascertained.

The mixtures A, B, C, D, E, give brown shades, more or less dark, constituting a scale. The tested oil generally places itself in the scale between two of the former mixtures, the proportions of which are known, unless it contains more than 50 per cent. of earth-nut oil. If the oil to be examined is more colored than the mixture B,

and less than C, it contains about $\frac{25}{100}$ of its volume of earth-nut oil.

Mixture of Olive and Sesamum Oils.—It is easy to operate by the first and second process.

Let us suppose that at a temperature of 59° to 60° it requires 100 drops of sesamum oil to measure 4 cubic cent. With the two oils make a mixture A, which contains 10 drops of sesamum, and try it by the first process; mixtures B, C, D, E, made with 20, 30, 40, 50 drops of sesamum oil, are tried in the same manner as mixture A. We have mixtures which contain 10, 20, 30, 40, 50 per cent. of their volume of sesamum oil, and which form two scales colored by the oil and the acid.

Try the oil, the composition of which is to be determined. If it becomes yellow or orange, the acid is colored like a yellow infusion of saffron.

By observing the coloration of the oil and the acid, and comparing with the scale, it is easy to determine the proportions in which the two oils are mixed.

Mixture of Olive and Colewort Oils.—The process which succeeds best is the second, by operating at temperature of 40° to 43.6°.

Mixture of Sesamum and Earth-nut Oils.—The process which succeeds best is the first, operating at a temperature of 40° to 57.2°, with 6 cub. cent. of sulphuric acid.

Mixtures of Colewort and Linseed Oils—of Colewort and Whale Oils.—The first process is the only one which can be used.

Assays by Weights.

Prepare an aqueous solution of potash, an alcoholic solution of spirit of turpentine, and lastly, an alcoholic solution of bromine.

FIRST SOLUTION.

Pure caustic potash	5 grammes.
Distilled water	95 "
	100

Solution of potash at 5 per cent.

SECOND SOLUTION.

Rectified spirit of turpentine . . .	2 grammes.
Alcohol at 0.86	98 "
	100

Solution of spirits of turpentine at 2 per cent.

THIRD SOLUTION.

Pure bromine	20 grammes.
Alcohol at 0.50	40 "
	60

Solution of bromine

The first two solutions must be prepared beforehand and kept in glass stoppered bottles. The solution of bromine is prepared only when wanted.

Let us suppose now that the composition by weight of a mixture of olive and sesamum oils has to be determined.

Take 3 tubes of 50 cub. cent. capacity, close each tube with a cork. On the plate A of a scale, place one tube; on the other plate B place the two other tubes. Balance them by weights placed on the plate A. In the tube of the plate A, weigh 5 grammes of olive oil; in one of the tubes of the plate B, weigh 5 grammes oil of sesamum; in the last tube, weigh 5 grammes of the oil to be tested.

In each tube introduce 5 grammes of the solution of potash. Stir each tube for half a minute and open them carefully. In each tube introduce 16 grammes of solution of bromine well cooled; shake them well for one

minute. After shaking the tubes let them rest. If after 15 minutes they are yet a little warm, dip them into cold water until cold. All the fatty matter has deposited in combination with bromine. This compound of bromine and oil is thick and viscous; it is covered by a liquor which is red, orange, or yellow. In a bottle of a capacity of 60 cub. cent., weigh 10 grammes of this liquor taken from one of the three tubes and pour into it drop by drop, a sufficient quantity of the solution of turpentine, stirring all the time. The liquor successively passes from the red to orange, and to yellow; and when the last drop has decolorized it, it becomes as white as milk diluted with water. When the liquor has lost its yellowish shade, weigh it, so as to ascertain the weight of the solution of turpentine used. Decolorize in the same manner 10 grammes of liquor from the two other tubes; and weigh anew to ascertain the weights of turpentine liquor by which the two liquors have been decolorized.

We suppose that the weight of the solution of turpentine necessary to decolorize the 10 grammes of brominated liquor for the olive oil is 10.7 grammes; for the sesamum oil 4.03 grammes; for the mixed oil 7 grammes. Proceed in the following manner to ascertain the composition of 100 grammes of the mixture.

We have a simple rule of mixture to proportionally divide 10.7 and 4.03 to give 7.

We say :—

1*st. The difference of* 4.03 *to give* 7 *is* . . 2.97
2*d. The difference of* 10.7 *to give* 7 *is* . . 3.70

Which made

Increase 2.97
Loss . . . . . 3.70 } = 6.67

We have to form 7 proportionally.

1*st*. *The* $\frac{2.97}{6.67}$ *of* 10.7 *corresponding to* $\frac{2.97}{6.67}$ *of* 100 *grammes of olive oil.*

2*d*. *The* $\frac{3.70}{6.67}$ *of* 4.03, *corresponding to* $\frac{3.70}{6.87}$ *of* 100 *grammes of sesamum oil.*

We have :—

		Grammes.
1*st*.	$\frac{10.7 \times 2.97}{6.67}$ $x=4.76446$, *corresponding to olive oil*	44.5277
2*d*.	$\frac{4.03 \times 3.70}{6.67}$ $y=2.23553$, *corresp'g to sesamum oil*	55.4722
	6.99999 *mixed oils*	99.9999

There is an easier method for finding these weights. Thus 6.67 being the total of the differences of 7—4.03 and 10.7—7, we can find the quantities represented by these differences, as the weights of corresponding liquors, with the aid of the following proportions :—

1*st*.	10.7—4.03 : 7—4.03 :: 100 : x=olive .	44.5277
2*d*.	10.7—4.03 : 10.7—7 :: 100 : y=sesamum .	55.4722
		99.9999

The above mixture will then be formed of

Olive	44.5277
Sesamum	55.4722

If a mixture of oil was composed of olive, sesamum, and earth-nut oils, it would be undetermined and be resolved only by probabilities. To find the composition of this mixture, we shall give three different combinations.

At 59°	*the olive oil would be represented by a weight of turpentine liquor*	10.7
"	*Earth-nut oil by*	9.2
"	*Sesamum oil by*	4.03
"	*The mixture of the three by*	8.00

First Combination.

$$1st.\ 10.7.\quad 2d.\ 9.2+4.03=\frac{13.23}{2}=6.615.$$

Which would give

10.7—6.615 : 8—6.615 :: 100 :	x=olive	33.90	p. liq. turp.	3.6273
10.7—6.615 : 16.7—8 :: 100 :	y=earth-nut	33.05	"	3.0406
	z=sesamum	33.05	"	1.3319
	oils	100.00		8 gram.

Second Combination.

$$1st.\ 10.7.\quad 2d.\ 9.2+2(4.03)=\frac{17.26}{3}=5.753.$$

Which would give

10.7—5.753 : 8—5.753 :: 100 :	x=olive	45.40	liq. turp.	4.8578
10.7—5.753 : 10.7—8 :: 100 :	y=sesamum	36.40	"	1.4667
	z=earth-nut	18.20	"	1.6744
	oils	100.00		8 gram.

Third Combination.

$$1st.\ 10.7\quad 2d.\ 9.2+3\ (4.03)=\frac{21.29}{4}=5.3225.$$

Which would give

10.7—5.3225 : 8—5.3225 :: 100 :	x=olive	49.79	liq. turp.	5.32753
10.7—5.3225 : 10.7—8 :: 100 :	y=sesamum	37.66	"	1.51769
	z=earth-nut	12.55	"	1.15460
	oils	100.00		8 gram.

If the operator thinks that the process by bromine is too difficult, and if he wishes to know the weight of each oil contained in a binary mixture, he will multiply the volume of these oils by their specific gravity; that is, if a mixture is composed of 30 litres of sesamum oil and 70 of olive oil, he will have

Sesamum	30 litres	×	0.9235	=	27 kilog.	705	grammes.
Olive	70 "	×	0.917	=	64 "	190	"
Oils	100 litres at 59°			weighing	91 "	895	"

Then it is possible, under all circumstances, to determine the purity of industrial oils, and to give very nearly their volume and their weight, when they have been mixed two by two.

Falsifications of Lard.

Alterations.—Lard exposed to the air in jars not well closed becomes rancid and turns yellow.

If kept in copper vessels, or in earthen jars glazed with sulphide of lead, it may, by contact with the air, attack the copper or the glazing, and then contain stearate and oleate of copper or lead. The copper is detected by pouring on the grease a few drops of ammonia, which immediately becomes blue; a red coloration is given by a solution of yellow prussiate of potash.

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

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

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

The addition of salt is easily detected by digesting the lard with hot distilled water. The water abundantly precipitates with nitrate of silver. The precipitate is

white, soluble in ammonia, and insoluble in nitric acid; it becomes black when exposed to the light.

Plaster of Paris is detected by melting in warm water the suspected lard. If it contains plaster, this falls to the bottom in the form of a white powder.

The inferior greases are often very difficult of detection; they are ascertained by the less white color of the lard and by a taste entirely different.

The greases from the cooking of pork meat give to the lard a grayish color, a soft consistency, a salted and disagreeable taste.

Falsifications of Tallows.—Tallows are generally adulterated with greases of inferior quality. Water is also incorporated in them by a long beating. Cooked and mashed potatoes have been also introduced into them.

Fecula, kaolin, white marble, sulphate of baryta, are also added to tallows. The principal adulteration is the addition of bone tallow; properly speaking, it is not a falsification, it is only a change in the quality of the product.

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

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

For the mineral substances there is a process as simple as the above to ascertain their presence in tallow; it is to melt the tallow with twice its weight of water. The

foreign substances are precipitated and the grease floats on the surface.

Instead of using ordinary water, the tallow may also be boiled for a few minutes with 2 parts of acidulated water for one part of tallow. The whole is allowed to rest in a test glass, or in a funnel placed over a water-bath, kept at a temperature of about 104°, so as to prevent the too rapid cooling of the tallow, and to give time to the impurities to separate and deposit.

Iodine added in this last treatment will disclose the presence of fecula or starch.

To ascertain the presence of water, knead dried powdered sulphate of copper with the tallow (half its volume of the powder). If there is much water, the mixture will take a blue color, if the tallow is white; and greenish, if the grease is yellowish.

As for the quantity of water added, the only way to ascertain it is by drying a sample in an oven.

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

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

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

melting the wax in water, it may be dissolved in spirits of turpentine, ether, or benzine; the wax alone will be dissolved.

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

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

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

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

3. Treated by 3 or 4 drops of sulphuric acid, it gives, by operating on the liquefied wax, a red coloration; the wax in solidifying takes a violaceous shade. This reaction is very precise, and enables us to detect 1 per cent. of resin; however, in this last case, the resin has a greenish shade.

Wax and Starch, or other Amylaceous Substances.—The presence of starch is ascertained by Delpech's process, by dissolving the wax in spirits of turpentine, which does not dissolve the starch or other amylaceous substances.

To detect starch, boil the wax with water, and test by

an alcoholic tincture of iodine, the cold and clear liquor. A blue color indicates the presence of starch. The wax may also be treated by warm water acidulated with 2 per cent. of sulphuric acid.

The starch is transformed into dextrine and remains in solution, leaving the wax to cool and solidify. By weighing the latter, the difference in weight gives the proportion of starch.

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

The introduction of flour into wax is also practised; some samples contain as much as 68 per cent.

A wax containing 10 per cent. of flour takes a bluish shade by standing in iodine water.

A wax adulterated by 23 per cent. of flour falls to the bottom of the water; pure wax floats on the surface of this liquid.

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

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

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

	Melting Point.
White wax,	156.2° to 158°
White wax containing its own w't of tallow,	147.2°
$\frac{1}{3}$	149.0°
$\frac{1}{4}$	150.8°
$\frac{1}{6}$	152.6°
$\frac{1}{8}$	154.4°
$\frac{1}{10}$	156 2°
$\frac{1}{12}$	156.2° to 158°
$\frac{1}{16}$	156.2° to 158°
$\frac{1}{20}$	156.2° to 158°

	Melting Point.
Yellow wax,	147.2°
Yellow wax containing its own w't of tallow,	138.2° to 140°
$\frac{1}{3}$	140°
$\frac{1}{4}$	141.8°
$\frac{1}{6}$	143 6°
$\frac{1}{8}$	145.4°
$\frac{1}{10}$	145.4° to 147.2°
$\frac{1}{12}$	147.2°
$\frac{1}{16}$	147.2°
$\frac{1}{20}$	147.2°

The sp. gr. may also be used to ascertain the mixture of wax and tallow.

The sp. gr. of yellow and white wax is 0.962; that of tallow is 0.881. Prepare at 59° two cerometric liquors: one, the weight of a volume of which is equal to the weight of a similar volume of wax free from tallow, and marking 29° (Gay-Lussac's alcohometer;) the other, a volume of which is equal in weight to a volume of tallow free from wax and marking 46° on the alcohometer.

All mixtures of these two liquors in any proportion will represent a corresponding mixture of wax and tallow; thus, a mixture of equal parts of the two liquors represents a mixture of 50 parts of wax and 50 parts of tallow.

Take, also, a specimen of the wax to be examined and dip it at 59° in a cerometric liquor prepared with such proportions of water and alcohol that the specimen will remain suspended in the middle of the liquid, without either going to the bottom or ascending to the surface.

The specimen of wax being removed, dip the alcohometer into the liquor, and the degree marked by this latter being always between 29 and 46, indicates the richness in wax of the specimen; and consequently the difference indicates the quantity of tallow added. According to M. Legripp, the cerometric liquor marking 29° of the alcohometer will represent:—

Wax	. 100	Tallow	. 00	29°
Wax	. 75	Tallow	. 25	33.3°
Wax	. 50	Tallow	. 50	37.5°
Wax	. 25	Tallow	. 75	41.7°
Wax	. 0	Tallow	. 100	46°

It is clear that a cerometer may be constructed with a centesimal scale. The lowest point, wax 100, corresponds to 29° of the alcohometer, and the upper point, tallow, to 46°.

The following very simple method, which has been recommended by Vogel, enables us to ascertain the falsification of white wax by tallow. The process is based on the dissolving action of chloroform: thus, 1 part of pure wax treated by 6 to 8 parts in weight of chloroform at the ordinary temperature, leaves 75 per cent. of residuum; the chloroform dissolves 25 per cent.

Consequently, a wax which, submitted to the same treatment experiences a loss exceeding the one-fourth of its weight, must be considered as adulterated.

Wax and Stearin.—The following process described by Lebel, is very sensitive, and enables us to detect $\frac{1}{20}$th of stearin. It consists in melting one part of the suspected wax in two parts of olive oil, and boiling the whole with its weight of water, and adding to it a few drops of subacetate of lead. There is an instantaneous decomposition and formation of a stearate of lead.

Wax and Stearic Acid.—Stearic acid introduced into wax may be detected by lime-water or ammonia; the first reagent is better than the second. The wax previously cut up into very thin shavings, is heated with lime-water. If the wax is pure, the lime-water remains clear; if it is adulterated, it loses its transparency, and a very perceptible deposit of a white substance is formed, which is an insoluble stearate of lime.

If the operation is performed with ammonia, and the wax is triturated in moist air with this liquid, the latter becomes muddy if the wax contains stearic acid; this is due to the formation of a stearate of ammonia.

Wax and Water.—Water is incorporated into wax by agitation after fusion; the following process for detecting it is the best. The wax is ground with the powder of dried sulphate of copper. If the wax contains water, the sulphate becomes blue or bluish with white wax, and greenish with yellow wax. There is an empirical process which enables us to ascertain, in a general manner, if wax is adulterated. Pour a few drops of wax on a cloth, and try to remove it by alcohol. When the wax is pure, the alcohol renders it granular; when impure, it remains adherent, and makes a stain.

Falsifications of Spermaceti.—Spermaceti is often adulterated with greasy matters, obtained by a long maceration of meat in water; it is also falsified with wax, tallow, and margaric acid.

The adulteration by wax is rare, and is ascertained by ether, which gives a muddy and milky solution. Besides, spermaceti thus adulterated is of an unpolished white color; it is also less lamellar and friable.

The falsification by greasy matters is ascertained by the melting point, which varies then from 82.4° to 86°, and by triturating the suspected substance with caustic potash or lime which gives a disengagement of ammonia easy to determine by the white vapors produced by the contact of a glass rod moistened with hydrochloric acid.

The mixture of tallow is easily ascertained by the known and special odor that grease communicates to spermaceti. The adulteration by margaric acid is ascertained by the alcoholic solution, which is very acid, and by the saponification of the mixture by an alkali. Saponification does not occur with pure spermaceti.

CHAPTER XXI.

VOLATILE OILS—RESIN.

The only use the soap maker has for volatile oil is to perfume soaps. We think it will interest the reader to have some general notions on their composition, and especially their adulterations, as it is necessary for the manufacturer to use a pure product.

The essential oils are the odorous principle of plants; in most plants, they exist already formed as a normal secrétion, 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 orange and the lemon, 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 essential 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 exception 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 coriander, and the second that of oil of sassafras. Most of them congeal at different temperatures; some acquire viscidity 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. Although 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 temperatures, their boiling point usually is not less than 316° to 320° F. In contact with air or oxygen, they acquire thickness, and are eventually converted into a resin by the absorption of this gas. This absorption varies with different 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 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 *séreusine* 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 essential oils containing oxygen, into an acid and a non-nitrogenized 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 saponaceous properties.* The 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	"	roots, 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 fœniculum	white	seeds	0.997
" galangal	Maranta galanga	yellow	root	
" genista	Genista canariensis	"	"	
" juniper	Juniperis communis	green	seeds	0.911
" ginger	Amomum zingiber	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
" marjorum	Organum 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 essential 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, be-

neath 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 unequal 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 rosin, 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 Rosin.—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 rosin 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 rosin for several hours to a dry steam heat, which does not change genuine yellow rosin, 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. Rosin 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 composition is, according to Tromsdorff, $C^{40}H^{30}O^4$, which makes it isomeric with pinic acid.

The formation of yellow soap from rosin 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 rosin, 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 rosin generated during distillation of the turpentine from it. Pinic and sylvic acids being colorless when pure, the brown shade of rosin is therefore due to action of the fire.

SECTION IV.

ESTABLISHMENT OF A SOAP FACTORY.

In the preceding sections of this work, we have treated of the alkalies, acids, and of the fatty matters used in the fabrication of soaps; in this section, we shall treat of the different apparatus which compose the material of a manufactory of soap, and shall give the plan of two factories: one for the fabrication of marbled soap, the other for different kinds of soaps, and especially for that of oleic acid soap. But before entering into these descriptions a few general considerations are necessary.

The fabrication of soaps requiring substances of different origin, the manufacturer must prefer that locality where the crude materials which furnish the basis of the fabrication are abundant and easy to be obtained. It is thus that a manufactory of soap with olive oil for its base, will be in better condition of success in a seaport, or in its neighborhood, than in an inland city, because the oil being imported, the manufacturers of soap of the other localities would obtain those oils from second hand, with much expense, and could not compete with the manufactories of the sea-ports.

For the fabrication of the other kinds of soaps, such as those of tallow, greases, animal oils, oleic acid, etc., experience proves that this fabrication succeeds, in general, better in the inland cities, and particularly in the northern than in southern localities. It is then import-

ant in the establishment of a soap manufactory, to make products similar to those employed in the locality. For example: a manufacturer of oleic soap will realize fine profits in New York, Philadelphia, Cincinnati, etc., and may experience a loss in New Orleans, and other cities of the south.

As for the other conditions which have to be observed in establishing a manufactory of soap, it must, if possible, be established in a locality where the supplies are convenient and can be obtained with little expense. It is thus we see in France, that the principal manufactories of oleic acid soaps surround the manufactories of stearic acid, which furnish them with the oleic acid; they thus save the expenses of transportation. In industry, a useful economy is one of the most essential elements of success.

In regard to the working material, it is about the same in all manufactories; however, there exist some modifications, but these modifications are only in the apparatus used to prepare the lyes. Thus, in all the manufactories where crude soda is employed to prepare the lye, to wash the soda and extract its alkali, they use vats built of masonry, or large cylindrical tanks made of sheet-iron; whilst, if salts of soda or potash are employed, their solution is effected by means of boiling water in cast-iron or sheet-iron kettles. Necessarily, these different methods of operating cause modifications in the apparatus for preparing the lyes.

There exist also some differences in the construction of the frames according to the kind of soap which is manufactured. Thus, at Marseilles, the frames in which the soap is run are always made of stone, while in other localities they are generally of wood. As for the kettles, those of Marseilles are of stone, elsewhere they are of

cast iron, sheet iron, or wood. Their shape is generally the same in all manufactories; it is a truncated cone.

The manner of heating is improving every day. Heating by steam is now employed in all large factories.

Generally, the fabrication of soaps is a productive industry, but the advantages it presents are very variable. They essentially depend on the quality of the raw materials employed, on their prices, and the sale of the products; they also depend on the greater or less economy brought to bear in the expenses of the establishment, the fabrication and administration. But we presume that soap manufacturers possess that knowledge and skill which are necessary for their business, for without these qualities it will be very difficult to bring into their operations the regularity, economy, and the improvements which will lead to happy results.

We shall not here treat of the expenses necessary to the formation of a soap factory, for all the documents which can be produced on this subject would be wanting in exactness; for the same reason, we shall not speak of the necessary working capital, as this itself varies, according to the nature of the materials and the importance of the fabrication.

CHAPTER XXII.

KETTLES.

Kettles in Masonry—In Cast Iron, in Sheet Iron—Heating of the Kettles by open Fire and by Steam—Different Apparatus.

KETTLES are vessels in which, by means of heat, the manufacturer combines fatty bodies with lyes of potash or soda to form soap. Their dimensions vary according to the importance of the fabrication. Their capacity varies from 250 to 3750 gallons and more. It is always advantageous to operate in large kettles, because they present a greater economy of labor, fuel, and lyes than the small ones.

As for the capacity, we have ascertained that, for the treatment of every 100 pounds of fatty matter, we require a capacity of about 37½ gallons, thus: to saponify 1000 pounds, a kettle of a capacity of 375 gallons; of 750 gallons for 2000 pounds; and from 1000 to 1125 gallons for 3000 pounds, which represents the ordinary size of the kettles of Marseilles.

Whatever are their dimensions, these kettles have always a circular form, and gradually widen up to the top, so as to form a cone. Some have flat bottoms, others have a convex or concave bottom. Experience has shown that the latter arrangement is the best, and the most convenient for the work. Whatever is their capacity, they are always provided at their lower part with a long hollow pipe, used to draw off, after each operation,

the old lyes collected under the soap. Formerly this pipe was fitted with a kind of movable bung, packed with tan, and was put in motion by a long iron bar; it was used to open or shut, at will, the pipe to empty the kettle; now this bung is generally substituted by a cast-iron, iron, or copper cock, which fulfils the same conditions.

Masonry Kettles.—At Marseilles nearly all the kettles of soap manufacturers are made of masonry, except the bottom which is of copper or sheet iron.

The most essential condition for the good construction of such a kettle is to establish it on a solid foundation. This foundation is covered with a thick mass of masonry, constructed of good materials, which is rendered tight with hydraulic mortar, a little soft, so that it may penetrate into all the interstices of the mass; thus, the infiltrations of liquid are rendered impossible. Afterwards the kettle is built on this mass, beginning at the hearth and the surrounding walls, to which a thickness is given proportioned to the capacity of the kettle.

When the level is reached on which the bottom of the kettle has to rest, it is important to employ materials of the best quality, and the least apt to be destroyed by the action of heat and lyes. Some stones are not good for these kinds of construction, because the heat quickly injures them. Good stone must be used for the outside walls. As for the inside of the kettle, it is always formed of a thick counter wall, of hard and well-burned bricks, and of pouzzolane cement, employed with a certain quantity of fine sand. It is very important to fill exactly all the interstices, for, independently of the loss of material, they would have the effect of accelerating the destruction of the masonry. To preserve the kettle, it is surrounded outside with hoops of very thick iron.

It is by these precautions that great solidity is given to these kettles. It is true, their construction is costly, and they require frequent repairs, but these inconveniences are well repaid by the advantages they present.

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

Cast iron Kettles.—Cast-iron kettles are not much used in soap manufactories, because they are more costly than those of sheet iron, and also, because it is very difficult to have them of a large capacity, made of a single piece. In France, they are used only in small manufactories, but in Belgium and England their use is more general.

The first care to be taken in purchasing such a kettle, is to choose it without defects, and as thin as possible, for experience has shown that in this state it better resists the action of fire than when thicker. For the same reason soft cast iron must be preferred to the brittle; the

first has a fine and soft grain, and can be more easily filed; it presents less inconvenience than the brittle cast iron, and is capable of lasting much longer than the latter.

Indeed, a soft cast-iron kettle may last a very long time when well managed, besides, when warm, it requires very little fuel to keep up the heat.

Sheet-iron Kettles.—These kettles are generally used now in nearly all the soap manufactories. For a long time it was difficult to construct them, but since the progress in mechanical arts, they have been constructed with great perfection. When a sheet-iron kettle is constructed, the dimensions must be calculated according to the quantity of soap to be manufactured. As we have said before, for every 100 lbs. of fatty matter, it requires a capacity of 37½ gallons; starting from this base, the maker will always succeed in giving to the kettle the capacity necessary for the work for which it is intended.

As for the thickness of the metal, it varies, according to the capacity of the kettle. For a kettle of 750 to 1000 gallons, the iron should have 3 millimetres of thickness for the lateral sides, and 4 to 5 millimetres for the bottom. All the solidity of such a kettle depends entirely on the riveting; however, as well riveted as a kettle may be, it often happens that the first time it is used it allows a little liquid to escape, but soon, the soap by stopping all the crevices, completely prevents the leaking.

A sheet-iron kettle, well heated and carefully cleansed, after each operation, may stand five or six years, and sometimes longer without any repairs; from this we can calculate how advantageous these kettles are compared with those of Marseilles, the construction of which is so costly and which require such frequent repairs.

Heating of Kettles by Fire.—In the heating of ordinary kettles by fire, the furnaces are constructed so as to absorb the most of the heat produced by the fuel, by applying at first, the heat under the bottom of the kettle and directing it afterwards around the sides, before loosing it in the chimney. In soap kettles, on the contrary, a great part of the heat developed by the fuel is lost, because these kettles can be heated only by the bottom, so as not to burn the soap, which would be the case if the heat circulated around the sides.

Notwithstanding the imperfection of this kind of construction, and the enormous loss of fuel, experience has demonstrated that it cannot be modified without great inconvenience. To diminish as much as possible the loss of heat, it is necessary—

1. That the fireplace should be right in the central axis of the kettle.

2. That the lining of the hearth should be of refractory brick, in order that the heat may be thrown back below the bottom of the kettle.

3. That the fuel which produces the most intense heat with the least flame should be used; hence hard coal should be selected.

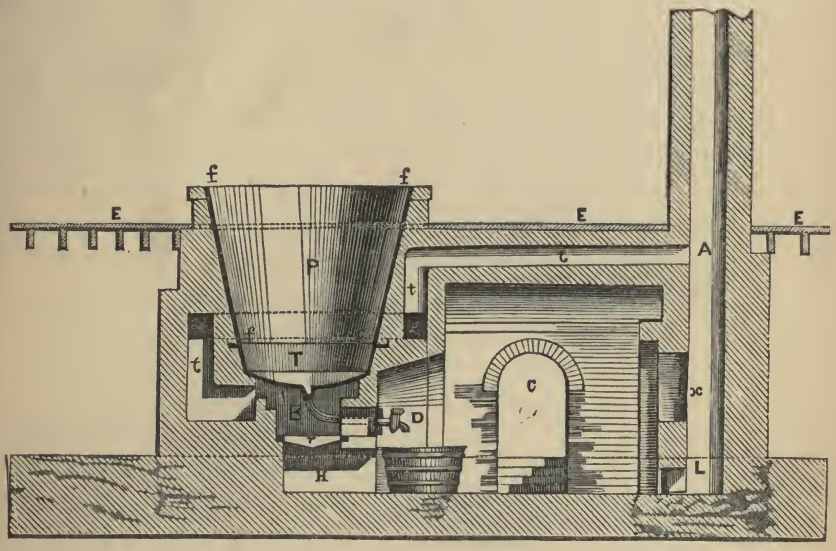
4. That the openings through which the products of the combustion enter the chimney should possess together the same surface as the grate, experience having shown that this is the best arrangement for obtaining a good draft and effecting a complete combustion of the fuel.

It is by fulfilling these conditions that the greatest amount of coal is utilized in heating the kettles. But to obtain this result, it is essential to have a well-constructed furnace, with all the recent improvements. The furnace must be very dry before using it.

The following figure (Fig. 17) represents a kettle heated by an open fire.

"The sides are composed of brickwork erected and lined with cement (mortar resisting the action of water). The

Fig. 17.



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

brickwork of the upper part projects to about three feet above the floor."*

Heating of the Kettles by Steam.—The most important invention introduced into the heating of the kettles, is incontestably the heating by steam. For a long time numerous experiments were made, but it is only within about thirty years that this new system has been advantageously applied. The first manufacturers who used steam, discharged it directly into the mass of the soap; the result was that the water produced by the condensation of steam considerably lowered the degree of the lyes used to saponify the fatty bodies. They were then under the necessity of using more concentrated lyes.

Soon after, other manufacturers—to obviate the above inconveniences—conceived the idea of making the steam circulate in the kettle, within a double casing, in such a manner that water produced by the condensation of steam should not mix with the lyes, and weaken their degree. This system is still followed in some manufactories, but it has the inconvenience of heating too much the sides of the pan, and not enough the bottom; it results that the ebullition is never very regular, and is more pronounced on the sides than in the centre. Now, in new manufactories, pans with double casing are suppressed, and the soap is heated directly by means of a flat worm of strong wrought iron, placed at about 3 to 4 inches from the bottom, and in which the steam circulates. This arrangement—as simple as it is ingenious, produces the best results, and the heating is so rapid that it requires only half an hour to boil a kettle containing 1000 pounds of soap, while the heating by an open fire will require from 3 to 4 hours. This advan-

* "The Art of Manufacturing Soap and Candles." By Adolph Olt, Ph. D. Philadelphia: Lindsay & Blakiston, 1867.

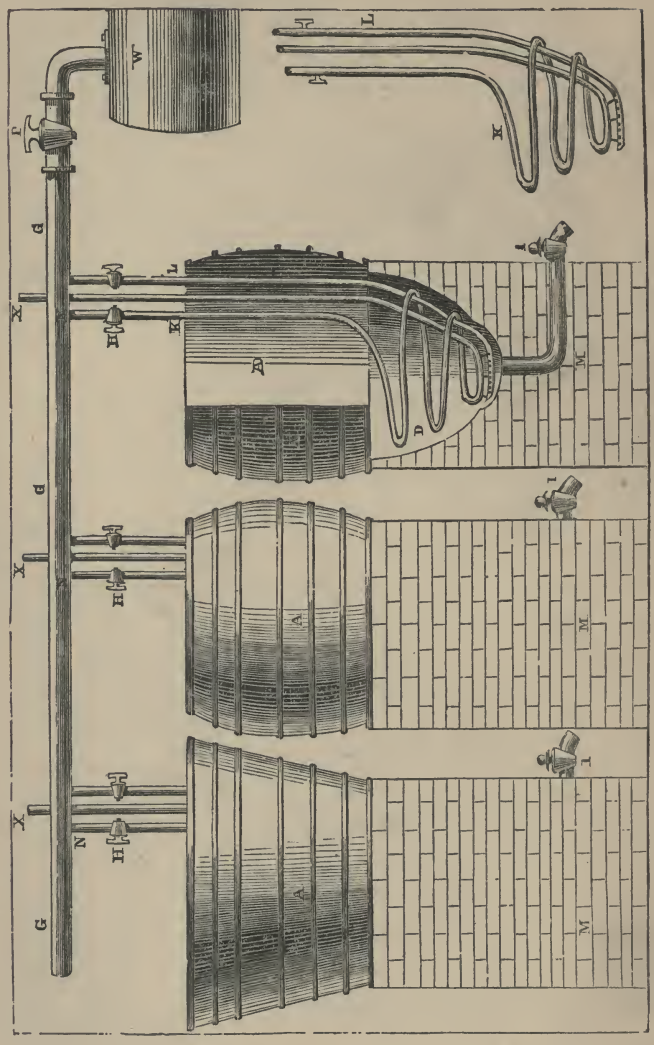
tage is not the only one this system presents; it enables us to heat with a single boiler, and consequently with the same furnace, several pans at a time, which presents a notable economy in fuel, time, and labor. There is no chance to burn the soap, as in heating with an open fire.

The use of superheated steam presents greater advantages than those obtained by ordinary steam. Experience has shown that, by the use of superheated steam, the operation was more rapid, and the expense in fuel greatly diminished.

STEAM SERIES—MORFIT'S SYSTEM.

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

Fig. 18.



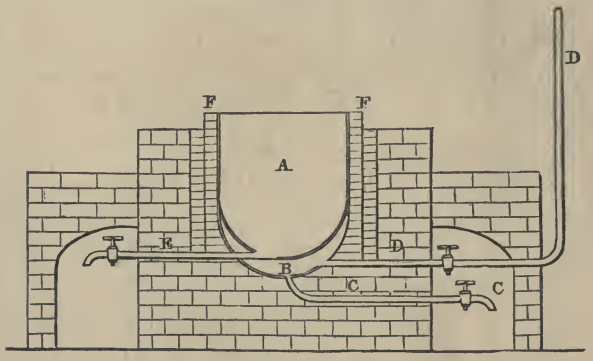
hooped round by iron rings, and the lower portion D of cast iron, and so shaped that the worm may hug closely to the sides without loss of room, and the "blowpipe" fit

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 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 A D, 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. 19.

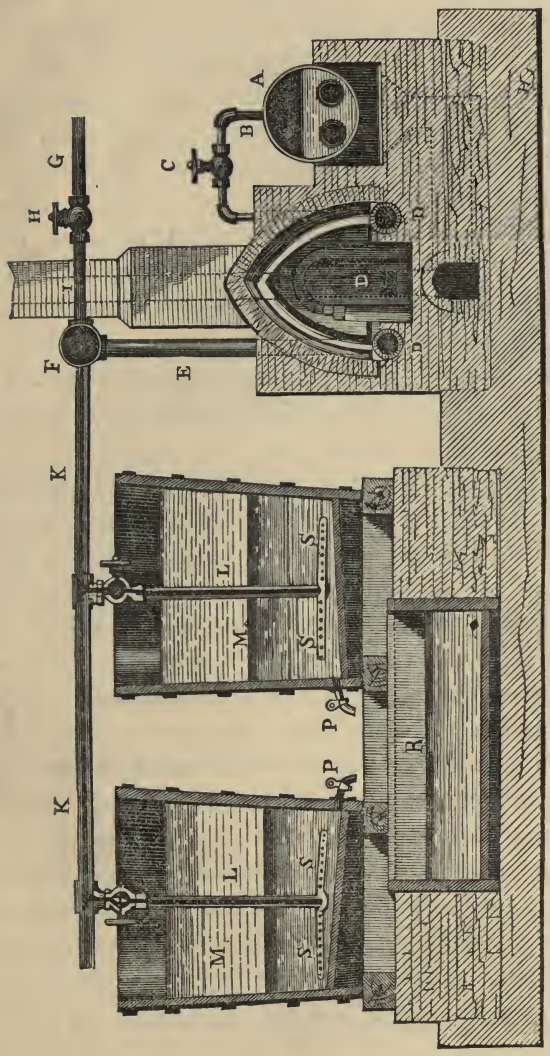


A is the interior of the cast iron kettle, surrounded by brickwork. B is the outer cast-iron caldron, which should fit to the inner kettle tightly, so as to prevent any escape of steam. D D is the tube leading from the steam boiler, and conveying the steam to the kettles. It is fitted with a cock, which is opened or shut, according as the steam is to be let on or off, for accelerating or retarding the boiling of the soap. C C is the tube by which the condensed vapor is discharged. The cock in this tube can be left slightly open so as to operate as a safety-valve, when one of these necessary appendages is not affixed to the apparatus. The tube E is the discharge-pipe of the caldron.

The brick work F F is similar to that for other furnaces.

"*Hubert's Apparatus for Boiling Soap.*—This new appa-

Fig. 20.



ratus, represented in Fig. 20, was patented by Mr. H. G. Hubert, 309 Broadway, New York.

"A is a steam boiler of ordinary construction. B is a steam pipe provided with a stopcock C. D is a steam superheater. E is a pipe leading from the superheater D to the receiver F. G is a pipe supplying air from a force pump. H is a valve for regulating the introduction of air into the apparatus through the pipe I. F is a receiver, where the steam and air are mixed together. K is a pipe conveying the mixed air and steam to any number of soap boiling apparatus. L L are pipes conveying the steam and air to the bottom of the vats M M; S, S, S, S, are radiating pipes perforated with holes, turned in opposite directions, so that when the air and steam issue from them, they will cause a rotating motion of the whole mass of supernatant liquid in the vats MM. R is the tank for receiving the lye drained by the cocks P P.

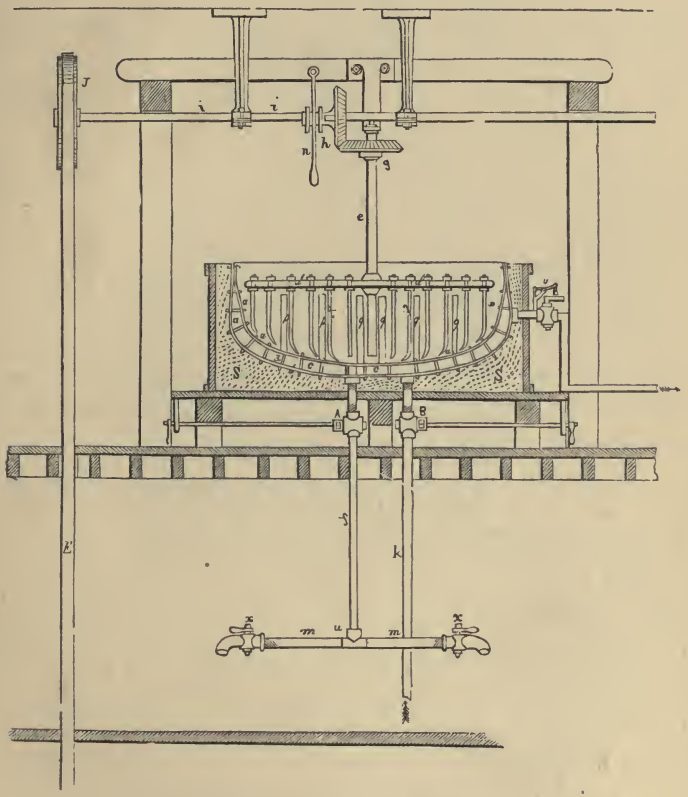
"The operation of this apparatus is easily understood. The lye and fats being introduced into the vats M M, steam is allowed to escape gradually into the apparatus D, where it becomes superheated, and is carried over and injected through the mass in the tanks M M. When it is required that the mass be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

St. John's Steam Jacket.—This apparatus, patented 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

* "The Art of Manufacturing Soap and Candles;" by A. Ott, Ph. D., Philadelphia, 1867.

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. 21. The boiling pan *a a*, is enveloped by a

Fig. 21.



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.

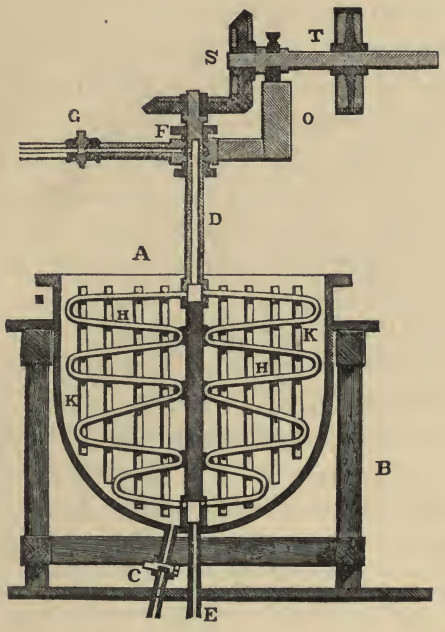
A is a cock for letting the charge into the branch pipes *m m*. Another cock, *B*, is for regulating the admission of steam to the chamber *c*, and the tubes *p p*. The clutch lever *D* is for adjusting the cog-wheel *h* with the cog-wheel *g*, when the stirrers are to be put in motion. *E* is a driving-band, connected with the pulley *j* on the shaft *i*. *F F* are stay bolts for coupling the kettle and jacket.

Morfit's Steam Jacket.—This jacket produces the same effects as the above. The following figure represents a vertical section of it.

"A is the soap kettle, which may be made of any shape

and of any material, having a waste cock C, and mounted upon a frame B. D is an upright shaft, hollow both in

Fig. 22.



its upper and lower parts, but solid in the middle. F is a stuffing box in which the shaft D runs, and is provided with suitable packing and a circular chamber, so that steam from the pipe G may be admitted through openings in the hollow top part of the shaft D. The lower end of the shaft D runs through the bottom of the kettle A, fitting sufficiently tight to prevent the soap and lye from escaping, yet loose enough to be easily turned. Two, three, or four pipes H, so bent as to take the configuration of the kettle A, are connected at both ends with the hollow part of the shaft D. K K K are a num-

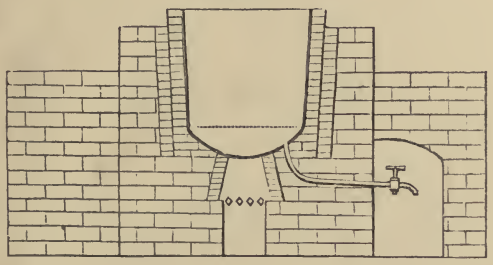
ber of slats fastened to the pipes H H, to strengthen them, and at the same time offer more resistance to the materials to be stirred. A set of gearing S, and a shaft T, mounted on the beam O, are so arranged as to give motion to the shaft D. The advantage derived from this arrangement is obvious, as the steam entering the pipe D finds no other outlet than the pipes H H, through which it rushes, following their sinuosities, till it reaches the bottom of the shaft D, where the condensed water is drawn off at E. The heat thus conveyed into the pipes H H, is communicated to the materials contained in the kettle A, which being continually stirred, have the heat more uniformly distributed throughout their mass than could be effected by the ordinary methods."*

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 soap by the naked fire may be employed, and we proceed to give a description and drawing of the kind of kettles most advantageous for the purpose. The size of the caldrons should be proportioned to the amount of soap intended to be made at each boiling. The bottom pan may be of cast iron, but in England they prefer Swedish wrought iron plate. This bottom pan is consolidated in brick masonry, and is so built around, that the heat acts solely upon its bottom. Fig. 23 shows one of these caldrons. Should there be several, they are placed on a line with each other, and over a furnace beneath. To the caldron a tube of about two inches diameter is adapted, which serves as an outlet for the 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 cal-

* "The Art of Manufacturing Soap and Candles;" by P. Ott, Ph. D.

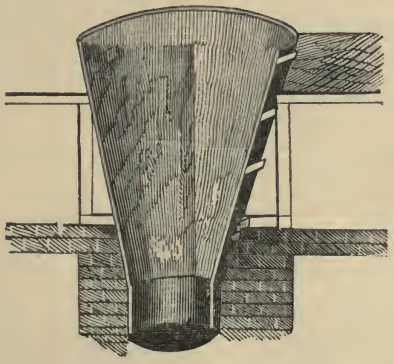
dron. The arrangement of the mason work is generally, however, left to the skill and ingenuity of the bricklayer. These soap pans or caldrons are cast with a flange at

Fig. 23.



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. 24, or upper part of the caldron. It is nothing more than a hollow cone of iron-

Fig. 24.



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

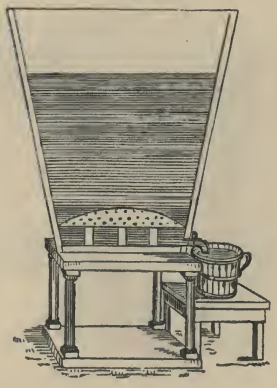
the lower pan. In this way a pan may be enlarged, at much less cost than for a caldron wholly of iron requiring to be entirely enclosed within mason work.

CHAPTER XXIII.

LYE VATS.

The lye vats, in very extensive factories, are made of brickwork, smoothly cemented within; but much the better material would be lead; for then one set of vats would answer for all kinds of soaps, as the lye prepared in them, not being acted upon by the metal, will be perfectly clean. Large tuns lined with sheet lead, and with a cullendered false bottom, Fig. 25, are perhaps the best

Fig. 25.

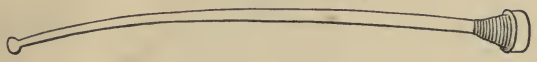


and most durable fixture of this kind that could be put up. In this case there is a cock fitted near the bottom of each tun, and through it the clear lye collecting in the lower part of the hogshead, between the diaphragm

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. 26. Its conical tip must be

Fig. 26.



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 advance, and, therefore, containing *weaker* liquor;

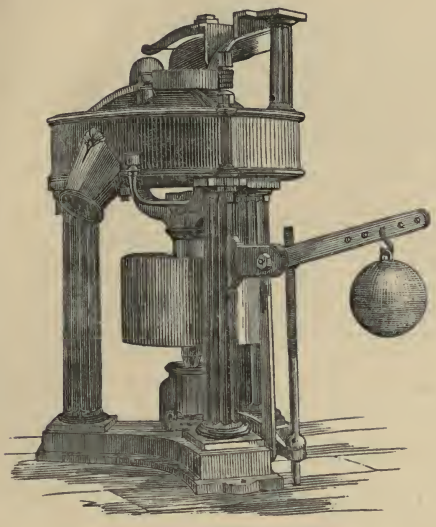
and No. 4 is the *water*-vat, because into that the water is directly introduced. Into No. 3, the moderately exhausted or somewhat spent lyes are thrown. From No. 3 the lye is pumped into No. 2, to be strengthened, and in like manner from No. 2 into No. 1. Upon the lime paste, in No. 4, which has been 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' eccentric mill, Fig. 27; 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

Fig. 27.

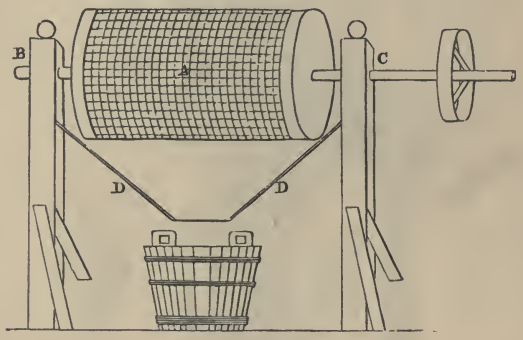


speed) on centres, which are apart from each other one inch more or less. The centre of the one, or axis thereto affixed, rests and revolves upon a stationary point; whilst the prime mover, by means of a belt or gearing, communicates motion to the other plate. The circles which are cut in the plate,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

der 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

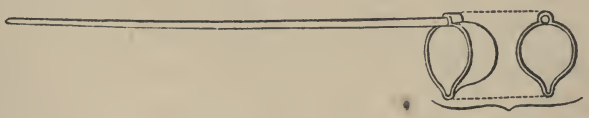
Fig. 28.



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

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

Fig. 29.



29, an iron spade, and large wooden shovels are also necessary implements for the lye department.

CHAPTER XXIV.

SOAP FRAMES.

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

Frames of Masonry.—The first thing to do when building a masonry frame is to carefully level the ground on which it has to be established. This done, a platform of good masonry is constructed on it, at about four or five inches above the level of the ground, and the dimensions of which exceed, in every direction, from seven to eight inches the outside line of the walls of the frame.

To build the walls, employ well-burned and very smooth bricks. For large frames, the walls have generally from twelve to fourteen inches of thickness, their height varies between twenty-four to twenty-six inches above the level of the platform. In the front of the frame leave a lateral opening of about two feet, in which is fixed a kind of movable door, which is used for removing the soap after its cooling.

The mortar used in the construction consists of three parts by weight of good cement, and one of fine sand. When the walls are raised to the proper height, and have stood for two or three days, the joints are cut down smooth, and the walls are thoroughly washed with a broom. The next day they receive a perfectly smooth coat of cement, about one inch in thickness.

As for the bottom of the frame, a coating of cement is

applied about one or two inches thick; it is then suffered to dry for a few days; on this coating of cement a floor of hard bricks is laid; these bricks are laid flat, and well cemented with mortar. It is proper to give a slight inclination to the bottom of the frames in the direction of the door, so as to permit the lye to run off into a small tank, also built of masonry, and sunk in the ground below the door of the frame.

The dimensions of a frame are generally regulated by the capacity of the kettle for which it is destined. It has been ascertained that for a regular and continued work, three frames are required for the service of each kettle, so as to have no interruption in the different operations.

Frames of masonry are completely water-proof, and do not allow the escape of any liquid, when properly prepared. Good frames last very long; they are used principally in the manufacture of marbled soaps; their employment is general at Marseilles.

Frames of Iron.—These frames have nothing remarkable in their construction. They ordinarily have the form of a parallelogram; their dimensions vary according to the quantity of soap to be run into. They are formed of strong iron plates, so firmly riveted together as to render impossible the loss of liquid.

These frames have on one of their sides a vertical opening from top to bottom, the width of which is from 16 to 20 inches; this opening is closed by a sheet of iron and is used as a door to the frame. It is by this opening that the soap is taken out after its cooling.

The construction of these frames is costly, but they have the advantage of being perfectly tight, and of not allowing any leakage of soap or lye.

Frames of Wood.—These frames are made of oak or pine. Those of oak are costly, and have the disadvantage

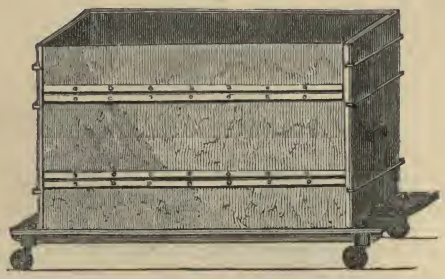
of coloring the soap; the others do not present this inconvenience, and are to be preferred.

Nearly all the frames are constructed of four movable parts, which are made of boards of pine wood, about two to three inches thick. To preserve the wood from alteration the inside is lined with very thin sheet iron, fixed to the wood with tacks about half an inch long. By this means these frames may be used five or six years without repairs. The floor is of wood or brick.

When the soap is cold and ready to be taken off, the sides of the frames are removed, and the cake of soap remains standing on the bottom.

In this country, frames are made of pine wood, for light-colored and fine soaps; and of cast iron for common yellow soap. The iron frames need not exceed half an inch in thickness; but those of wood should be made of 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. 34), they may form a water-

Fig. 30.



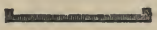
tight well, which will hold the hot paste without leaking. The iron are of the same form as the wooden frames;

but differ in size. The sides are of wrought iron plate, and the remaining portions of cast iron. Fig. 30 presents a side view, Fig. 32 the bottom, and Fig. 31 a top view of them, as made by Poole & Hunt, engineers and ma-

Fig. 31.

Fig. 32.

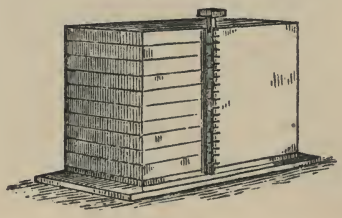
a



chinists, Baltimore; and the clamp, which fits on the ends, and which holds them together, is shown by *a*. They are drawn to a scale of three-eighths of an inch to a foot. Being mounted on wheels, these frames can readily be moved from place to place. The good conducting power of the metal promotes the cooling and solidifying of the soap paste.

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

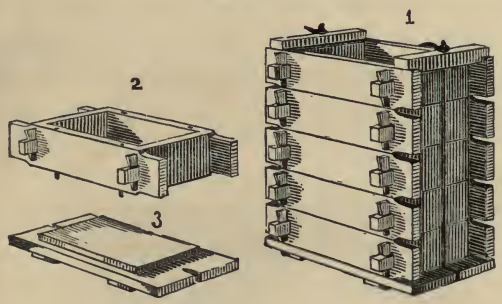
Fig. 33.



the soap remains upon the movable bottom ready to be divided into bars, as shown by Fig. 34. Fig. 34, 1, shows

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. 34, 3 and 2.

Fig. 34.



The German frames, like those of this country, are also constructed so that they may easily be separated into pieces, being set up by nuts and screws, as shown in Figs. 35 and 36. Their floor is also movable; and is

Fig. 35.

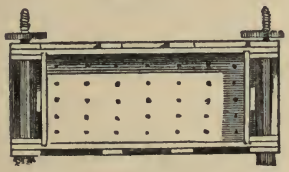
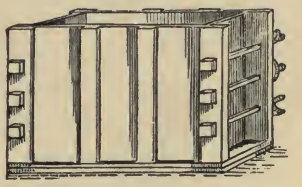


Fig. 36.



shown in longitudinal section by Fig. 37, and in breadth by Fig. 38. It consists of two layers of deal boards, in the upper of which are four grooves, fitting with the projections in the sides. The two narrow sides are also sup-

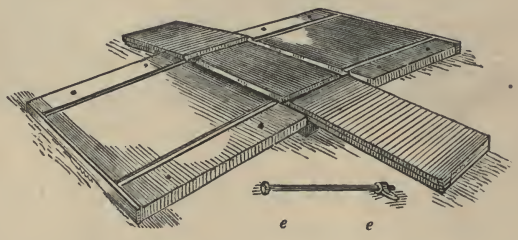
Fig. 37.

Fig. 38.

ported on the inside by cross-pieces. All the sides are strengthened by supports. When the several parts are

put together, the bolts, screw cut at the other end, 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. 39. By the side of it is

Fig. 39.



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

CHAPTER XXV.

DRYING-ROOMS.

It is not necessary to dry all kinds of soap before introducing them in commerce; ordinarily we dry only those soaps which are to be stamped in a copper mould. Nevertheless, as drying-rooms constitute an important part of the outfit in the French manufactories, we must not omit a notice of them.

There are two kinds of drying-rooms, one by free access of the air, the other with hot air. The first does

not require any heating apparatus, but it is used only in fine weather. It is generally established in the upper story of the building, where the air circulates freely. Shelves, on which are placed the pieces of soap to be dried, are fixed in the room eight or ten inches apart, one above the other; this separation has the advantage of accelerating the drying of the soap, by putting it in contact with a greater mass of air; the desiccation is more rapid when the temperature of the air is elevated.

This mode of drying is incontestably the most economical, because it does not require either apparatus or fuel; it is also the most regular and the best for the drying of soaps, and it may be used whenever circumstances will permit; unhappily it is subject to the variations of season and weather so frequent in our climate.

The drying-rooms with warm air have the advantage of being used at all seasons. In many manufactories, the drying-room consists of more or less large rooms around which shelves, provided with trays are disposed, and upon which are placed the pieces of soap to be dried. In the middle of the room is a stove heated with wood or coal. The temperature must not be above 80°; openings must be made in different parts of the room to permit the air, saturated with moisture, to escape freely This arrangement quickly hastens the drying of the soap.

A temperature of 80° is sufficient to dry in fifteen or twenty hours pieces of olein soaps destined to be moulded.

Drying Room with Warm Air.—We have seen that the drying of soaps in the free air cannot be practised in all seasons, and has to be stopped in rainy or damp weather. As for the drying in a room heated by a stove—while this mode is generally employed, it presents the

inconvenience of localizing, and causing an unequal distribution of the heat; some shelves are remote from the source of heat—being *but little affected by it*—from which it results that the soap does not dry equally in all the parts of the drying-room. This is not the only inconvenience; stoves often smoke, especially when first lighted, and the smoke stains and blackens the pieces of soap.

These different inconveniences, and particularly that of the smoke, have obliged some manufacturers to use drying-rooms heated by hot air. By this system, they completely utilize the heat produced by the fuel, and the hot air which flows into the room is always pure, without either odor or smoke.

What distinguishes this system from all the others is, that the desiccation of the soap is rather produced by an energetic ventilation, occasioned by the abundance of the hot air continually renewed in the room, than by a high temperature; and experience proves that, in rooms heated by a good stove, it requires twenty-five to thirty hours to dry the soap, while with a much smaller expense of fuel a treble quantity of soap can be dried in eight or ten hours in a room heated by hot air.

The following, Fig. 40, presents a longitudinal section of a drying-room with hot air.

A. Furnace in which the fuel is burned.

B. Grate.

C. Ash pan.

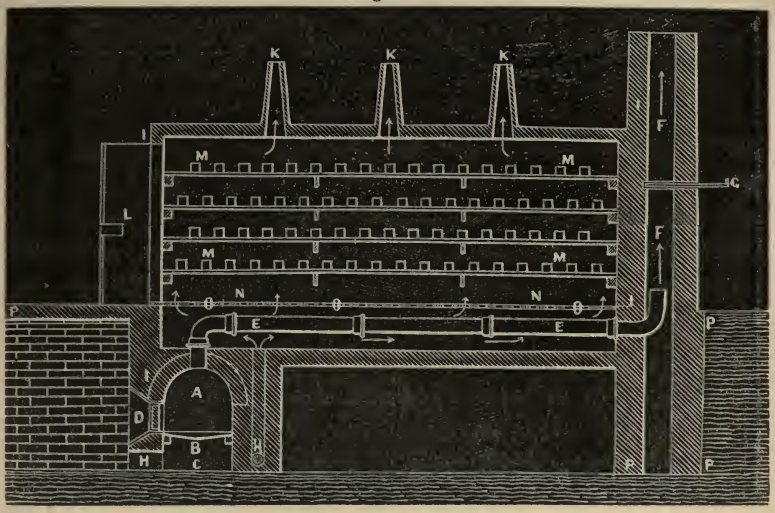
D. Door of the fireplace.

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

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

G. Register in the chimney, used to regulate the draft

Fig. 40.



of the fire, and thus control the temperature of the hot air in the room.

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

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

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

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

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

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

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

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

The manner of using this apparatus is very simple. After filling the trays with pieces of soap, they are introduced into the room by the door L; the door is closed, and the fire lighted. The cold air enters by the openings H H, grows warm by circulating around the furnace, and flows continually into the room by the openings O O O. The temperature must not be too high, but must be kept between 80° and 86°.

With an ordinary room, it is possible to dry 20,000 pounds of soap in a day.

CHAPTER XXVI.

DIVIDER—MOULDING MACHINE, AND MINOR IMPLEMENTS.

Divider.

This apparatus is very simple. It consists of a wood platform 3 feet high, 4 feet long, and inclined in the direction of its height at an angle of about 50°. This platform is formed by a certain number of boards having the same length and width, and held together by the ends only in a kind of frame, but in such a manner that they do not come in actual contact, but leave between them a space in all their length. It is essential that the width of the boards should correspond very exactly with the thickness to be given to the cakes of soap.

This apparatus is completed by a wooden frame of the same dimensions as the platform. It is traversed in the

direction of its height, by iron wires placed at about 3 inches from each other; each of these wires enters between the joints of the boards which form the platform.

All being ready, if a block of soap is placed on the platform of the apparatus, and the frame lowered ; the iron wires follow the motion of the frame, they traverse the plate of soap and divide it into as many cakes as there are iron wires (and one more).

This apparatus, very cheap and yet little known, has the advantage of cutting the soap with great regularity. It works very well and very quickly, for a single man can cut 150 cakes in one hour.

Moulding Machine.

There are found in commerce cakes of soap weighing one pound, which have on all their surfaces, marks traced in relief, or sunk in.

To mould these soaps, they are at first cut into pieces of the required weight, and are then dried. Afterwards, they are pressed in a cast-iron or copper matrix.

To reproduce on the soap the marks or inscriptions engraved in the matrix, a screw press is generally used, but this machine has been substituted by another called a ram. To use this apparatus, employ a movable matrix, which slides in a cast-iron frame, and which can be raised or lowered at will. This matrix opens in four parts to receive the piece of soap to be moulded. The upper plate is firmly fixed to a piece of wood about 3 to 4 inches long, which enables it to be drawn from the matrix after each stroke of the hammer.

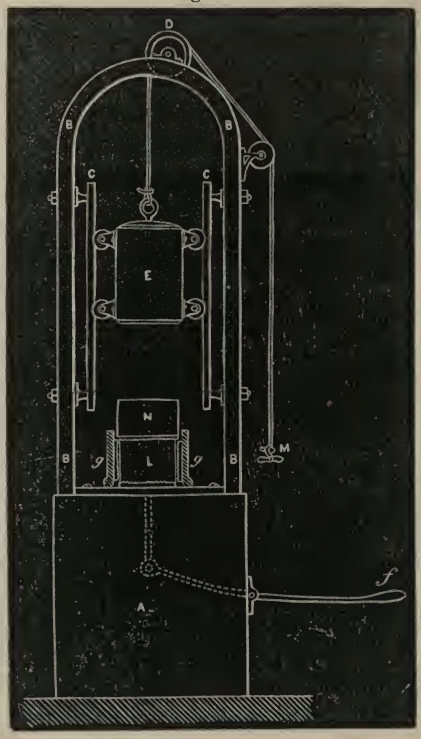
All being ready, the ram is raised by means of a long cord; on allowing it to fall, it strikes directly on the piece of wood to which is fixed the top plate of the ma-

trix. By the shock, the matrix enters the cast-iron frame, and strongly impresses on the soap the marks engraved on the matrix.

After the percussion, raise the ram and press on the lever to raise the matrix from the cast-iron frame, remove the piece of soap and substitute it by another.

With this apparatus, two men can mould 6000 pieces of soap in a day. The figure represents the elevation of the moulding machine.

Fig. 41.



A. Table of oak, on the platform of which rests the machine.

B B B B. Side beams of oak firmly fixed to the table.

C C. Iron guides, fixed by means of screws to the side beams B B B B.

D. Pulley, in which runs the cord M, used to raise the ram.

E. Cast-iron ram put in motion by the rope M.

f. Lever to raise or lower at will the matrix L, in the cast-iron frame G G.

g g. Cast-iron frame, fixed on the table A, and used as an envelope to the matrix L.

L. Cast-iron or copper matrix, destined to reproduce, on the pieces of soap, the form of the impressions which have been engraved on it.

N. Piece of wood, to which is attached the top plate of the matrix; it directly receives the blow of the ram.

Minor Implements.—The minor implements of the soap laboratory are, a crutch, Fig. 42, composed of a long wooden handle adjusted, at the end, to a board, and used

Fig. 42.

for stirring the soap paste in the operation of "*mottling;*" large, cullendered, iron ladles, with long, wooden han-

Fig. 43.

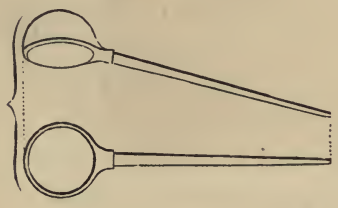
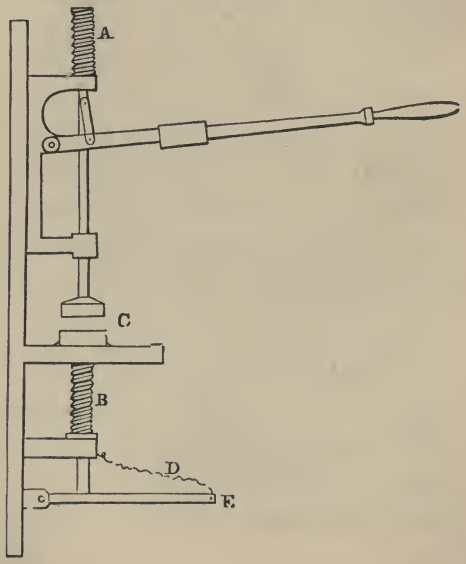


Fig. 44.

dles (Fig. 43) for dipping out the hot paste from the kettles, and copper buckets, Fig. 44, 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. 45, 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

Fig. 45.



tablets may be varied by merely changing the box. The die from which the tablet is to receive a device, or the

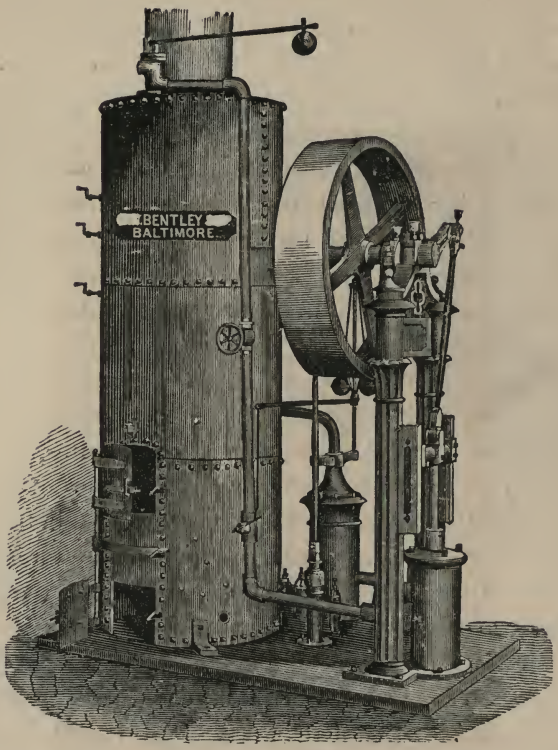
impress of the manufacturer's name, is screwed to the top of the box C, and may also be changed, as fashion, or caprice, or taste shall dictate.

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 factory. 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. 46 shows a very compact 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.

Fig. 46.



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

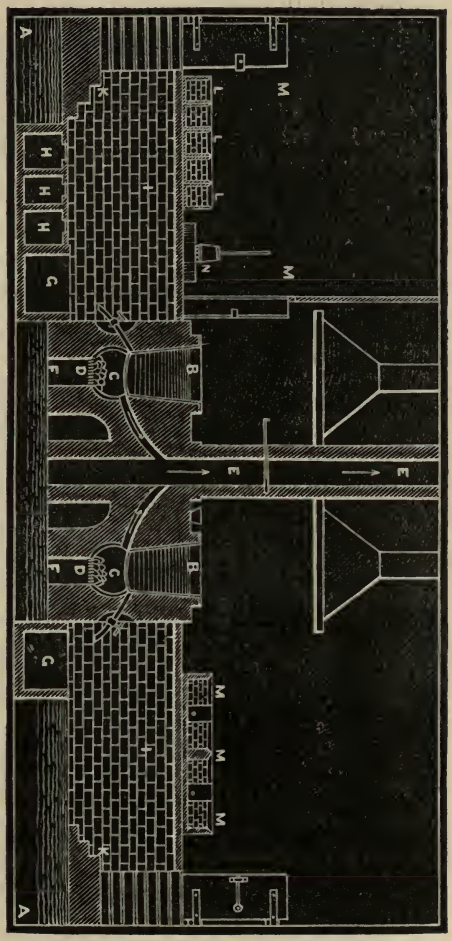
CHAPTER XXVII.

PLAN AND DESCRIPTION OF A SOAP FACTORY.

Establishment and General Arrangement of a Marbled Soap Factory.—We have said before, that the establishment of a marbled soap factory was not the same as

that for other kinds of soap; the following figure represents the general arrangement of an establishment of the kind.

Fig. 47.



A A A A. *Factory Building.*—This building has the form of a parallelogram, the dimensions of which vary according to the importance of the manufacture. It is

divided into three compartments; the middle one is occupied by the kettles, frames, and lye vats. That on the left contains the lixiviating apparatus. That on the right is employed as a store-room.

A basement about 9 feet below the first floor, forms passages and cellars, a part of which is occupied by the furnaces and reservoirs of masonry to receive the waste lyes drawn from the kettles during the boiling of the soaps. The communication with the first floor is by the stairway K K.

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

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

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

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

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

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

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

I I. *Cellars* below the first floor.

L L L. *Basins* of bricks or stones. They are used to lixiviate the crude soda for the preparation of caustic lyes. Their number, like their capacity, varies according to the importance of the manufacture. They are established on the first floor, and parallel with the kettles; immediately below, large cisterns are constructed,

from six to nine feet deep, specially destined to be used as receivers for the different lyes obtained by the lixiviation of the crude soda.

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

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

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

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

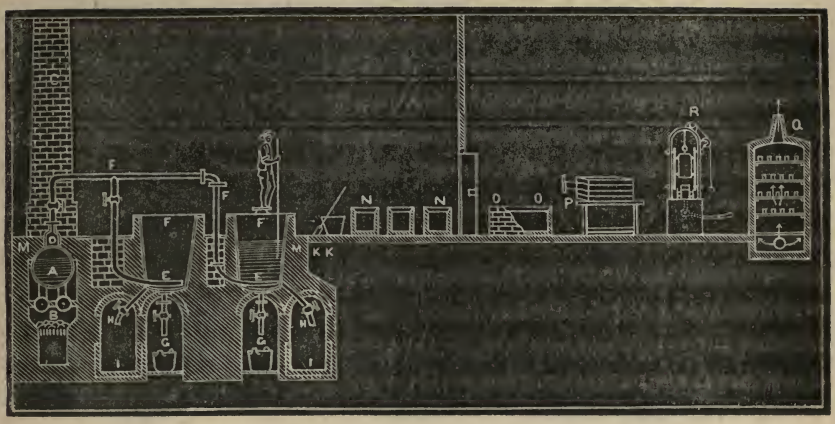
A. *Boiler* to produce steam.

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

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

D. *Dome* from which the steam is discharged by means of the pipe F F, into flat coils, placed at about one inch

Fig. 48.



from the bottom of the kettle. This dome is necessary to prevent the boiling water from entering the pipe, and thence passing into the coil.

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

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

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

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

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

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

O O. *Frames*, into which the soap, when finished, is drawn. These frames are of wood, and open in four parts.

P. *Table* on which the soap is divided into bars and cakes.

Q. *Drying-room*, using hot air in which the soap is dried.

R. *Ram*. This machine is used to mould the soap by means of a copper matrix.

The advantages of the system by steam may be summed up in the following points :—

1. Economy in fuel, since several kettles can be heated by the same fire.
2. Facility and rapidity in the work.
3. Products of a quality superior to those obtained by heating with an open fire.
4. Economy of labor.

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

SECTION V.

FABRICATION OF SOAPS.

Soaps are saline compounds, resulting from the chemical union of fatty acids with alkaline oxides. When the bases are potash or soda, the soaps are soluble in water. It is on this important property that depend their detersive action and their uses in domestic economy. These two alkalies, and also ammonia, are the only ones which form soluble soaps. The insoluble soaps, are those obtained by the saponification of fatty matters with lime or metallic oxides; they are generally prepared by decomposing a soluble soap of potash or soda in solution in water, by an earthy or metallic salt, also in solution in water. The alkali of the soap combines with the acid of the salt, whilst the oxide of this salt by uniting with the fatty acid forms an insoluble soap which is precipitated.

Soaps of potash and soda only being used in industry, or domestic economy, will be studied with details.

We divide the soaps into two classes: 1st. Hard soaps; 2d. Soft soaps.

The first always have soda for their basis, and are generally solid. The second have potash for a basis, and are always soft, whatever is the nature of the fatty substance used.

The preponderance of concrete fatty acids in vegetable oils and animal fats, gives them a greater value in the fabrication of solid soaps. The soaps resulting from

the saponification of substances rich in stearin and margarin, have always a firmer and more solid consistency than those obtained from fatty substances in which olein predominates. Example: the soap made with olive oil or with tallow and soda is always very hard. Earth-nut oil, sesame oil, etc., treated exactly in the same manner and by the same alkali, give an unctuous and soft soap which never acquires a solid consistency. In what exists the difference producing such an anomaly? It is evidently due to this, that in the first fatty matters stearin exists in large proportions, while olein predominates in the latter. It results that the first soaps owe their firm consistency to the large proportion of stearate of soda they contain, and the second their less consistency to the presence of a larger quantity of oleate of soda.

Thus, soaps having soda for basis will be as much harder as the fatty substances used to make them are more abundant in solid principles; but they always differ from one another in consistency and odor, according to the nature of the oils or fatty matters which enter into their composition.

It is then very important for the manufacturer to know the nature of the fatty substances he employs in the preparation of solid soaps, since each one produces a different soap with the same alkali. But as we have seen, if there exist some vegetable oils poorer in solid principles, and consequently but little suited for making hard soaps when used alone, nevertheless they may be advantageously employed, by mixing them with some other rich in stearin. Thus by mixing nut oil, sesame oil, etc., with olive oil or tallow, soaps of a very firm consistency will be obtained. These mixtures have the advantage of rendering the soap more unctuous and more

detersive. We must remark that soaps made only with olive oil are brittle, and fall to pieces when cut; to prevent this inconvenience some persons formerly added a certain quantity of potash which lessened its hardness and rendered it softer and more soluble in water. But for many years, the potash has been substituted by adding to the olive oil a certain proportion of vegetable oils poor in stearin; the result is the same as with potash. Besides there is the double advantage, of rendering the soap less costly and more soluble.

The theory of the formation of soap, which we present in the next chapter, is generally adopted by chemists, and explains the differences that are presented by soaps in relation to their solidity, according to their bases, potash or soda; the first forms always with any fatty matter, stearates, margarates, and oleates, which are deliquescents and very soluble in water. This is the reason why these soaps have always a soft consistency.

Toilet soaps have the same composition as ordinary soaps; they are all manufactured with the same fatty matters as the first. These substances are tallow, lard, palm and coco oils, which are saponified with potash or soda, according to the kind of soap to be obtained. The essential condition to obtain fine products, is to use substances of first quality, and to refine the soaps carefully. Their purity constitutes their principal merit.

Independently of the soaps obtained by the saponification of vegetable oils and animal greases, we have also the resinous soaps. The so-called resinous soaps are obtained by the saponification, under the action of heat, of rosin, by lyes of potash or soda. Whatever is the base used these soaps are always soft, and are never used alone. In industry the resinous soap is a mixture, in variable proportions, of tallow soap and saponified

rosin. It is always necessary to combine the tallow soap with the resinous soap to give this compound the consistency which renders it fit to be employed in manufactures and domestic economy.

Generally, the good composition of soaps depends on the complete union of the fatty matters with the alkali which saturates them. To obtain a quicker effect, alkalies deprived of their carbonic acid are employed; ordinarily the saponification is effected by the aid of heat, by boiling the fatty substances with more or less concentrated lyes of potash or soda. This operation is conducted in kettles which have been described before.

From experiments carefully made, it has been demonstrated that carbonates of potash or soda are insufficient to completely saturate fatty substances, and consequently to form real soaps.

Then the saponification of fatty bodies requires the use of caustic alkalies, and the more caustic they are the quicker their action.

Investigators have sought to discover the causes which may have a greater or less influence on the specific gravity of soaps. Some have indicated the sp. gr. of the fatty matters used in the saponification; but this is a mistake, for all fatty substances are lighter than water, and nearly all the soaps are heavier than this liquid.

Experience evidently proves that the sp. gr. of a soap depends upon the concentration of the lyes used to boil it. When these lyes are at a weak or average degree, the soaps are generally lighter than water, whilst if the lyes are of a high degree of concentration—from 25° to 30°—the soaps are heavier than water.

Thus—and it is an important fact—in operating in the same manner with the same alkali, light or heavy soaps will be obtained, according to the degree of concentra-

tion of the lyes of coction; but to obtain soaps well filled with alkali, of a firm consistency, and heavier than water, the use of concentrated lyes is absolutely necessary during all the periods of the coction, and especially during the last. This is not the only advantage of the use of strong lyes. They also accelerate the operation, and furnish a product more abundant in soap; and as these lyes have a more energetic action on the fatty substances, they deprive them more completely of all foreign odor.

As for the soaps prepared by the cold process, their fabrication is based on the use of concentrated lyes which are combined with fatty substances, previously melted. An important condition is to make the mixture at the lowest possible temperature; for, it has been remarked that, if the temperature is above 59° or 68°, the fatty substances combine with difficulty. We do not consider this process an improvement in the art of soap-making. It is true that modifications and improvements have been made; and in soaps well prepared, the alkali is combined in proportions exact enough to have no noxious action on the skin. But, at all events, these soaps are always less neutral and less pure than those prepared by the hot process.

CHAPTER XXVIII.

THE THEORY OF SAPONIFICATION.

As the decomposition of the natural fats into their constituent acids and base is necessarily preliminary to the production of soaps, the process employed to effect it is comprised under the technical term *saponification*, from the 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.

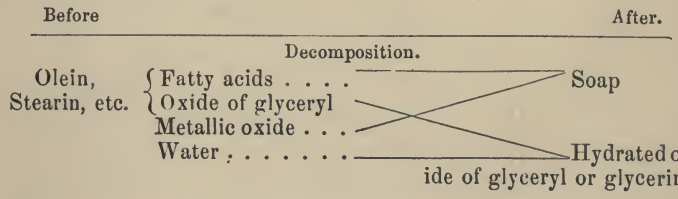
A clear idea of the formation of soap, and a correct explanation of this remarkable process, can only be obtained from a thorough knowledge of the constituents of fats, as well as of their mode of combination. The question respecting the theory of the formation of soap, and the question concerning the constitution of fats, have reference, therefore, to one and the same thing. All that is known concerning these bodies at present, has been furnished by the extensive and careful researches of M. Chevreul, dating from the year 1813 to 1823, the results of which were published by their author.* More recent researches upon the subject have seldom found anything to correct, but have adduced more facts, and given rise to explanations of those already known, which are more in accordance with the advanced state of science. These researches, conjointly, have proved that the fats—such as tallow, lard, olive oil, etc.—are mixtures of two kinds of fatty matters, which, taken singly, possess all the properties of the fats themselves. They are chiefly distinguished from each other by their state of aggregation at ordinary temperatures. Those which appear solid and hard have been called *stearin* by Chevreul; the fluid kinds he called *olein*. The consistency of the fat, therefore, depends upon the predominance of one or other of these constituents; so that the fluidity of the oils is due to a preponderance of olein, the solidity of the varieties of tallow, to that of stearin or margarin. Pelouze and Boudet have observed that the olein of olive oil, hazelnut oil, human and swine fat, is very different in solubility, and in its action with nitrous acid, from the olein

* Recherches Chimiques sur les Corps Gras, etc. Paris, 1823.

from linseed, nut, poppy, hempseed oils, and coco butter. There are, consequently, several distinct substances included under the name of olein, which in the above-mentioned fats hold margarin and stearin in solution. The same chemists have shown that those substances which were supposed to be different varieties of margarin and stearin are rather combinations, in definite proportions, of olein with margarin and stearin, as in the butter of coco, and in olive oil. With reference to the fats of coco-nut and palm, it has already been stated that the varieties of stearin which they contain, in consequence of a difference in their chemical constitution, have been called *cocine* and *palmitin*, respectively.

These proximate principles, stearin, margarin, and olein, which either merely commingled, or in chemical combination constitute fats, are considered as true salts, or as a combination of a base with an acid, and this view has been arrived at by the appearances observed during their decomposition, and the similarity of their action to other well-known combinations. The base is the same in the greater number of fats; it is the oxide of a compound radical *glyceryl* $C^6H^{14}O^5$ or $2C^3H^4O+3H^2O$; the acids in combination with it, however, are of various kinds. Oxide of glyceryl is a substance soluble in water; it is colorless, and has a sweet taste (sweet principle of oils), and possesses none of the properties of fats, which are, on the contrary, retained by the so-called fatty acids. These bodies are fluid at the ordinary temperature, when derived from a fluid constituent (for instance, olein), but are solid, when obtained from a solid ingredient (as stearin). Thus, oxide of glyceryl, in combination with stearic acid, forms stearin; with margaric acid, margarin; with oleic acid, olein; with palmitic acid, palmitin, etc; combinations, which have

always the characters of a fat, but not those of the oxide of glyceryl. The basic metallic oxides, the earths, etc., speedily decompose these compounds in the presence of water, uniting with the acid, whilst the oxide of glyceryl dissolves in the water. The salt produced by the union of the fatty acid with the metallic oxide, is a soap in the extended scientific signification of the word. When a natural fat is treated in the same manner, the same decomposition of its constituents occurs as if they had been taken separately; the same number of salts of the metallic oxide are produced, as there are fatty acids present, and these together, form a mixture. A mixture of this kind is obtained on a large scale, when fats are treated with potash, or soda, or lime, and this is then called soap in a limited practical sense of the word. The process concerned in the saponification of a fat is therefore, the following :—



When, therefore, olive oil is boiled sufficiently long with water and oxide of lead, a lead soap (lead plaster) is obtained, which is insoluble in water, and floats upon the surface of a solution of glycerine in water. Indeed, the existence of glycerine was first observed in preparing this plaster, as no other substance soluble in water occurs in the process to mark its presence. Some of the fatty acids are volatile, as was observed by Chevreul, in the case of butter and train oil. Such acids are the cause of the smell in some kinds of soap; during the gradual decomposition of the salts, some of the acids are vola-

tilized. The same chemist has proved, that the formation of soap is entirely independent of the access of air, and that the weight of the products of saponification always slightly exceeds that of the fat employed. Thus, he obtained from 100 parts

	Stearin.	Olein.
Margaric acid	78.00	20.08
Oleic acid	18.40	75.92
Glycerine	8.50	9.80
	104.90	105.80

This increase of 4.9 and 5.8 per cent. traced back to the elementary constituents of the products of saponification, is found to be oxygen and hydrogen in the same proportions as those in which they combine to form water. In fact, the fatty acids, and oxide of glyceryl, which are anhydrous in the fats, are obtained after decomposition in the state of hydrate. In palm oil and coco butter, the greater part of fatty acids have separated from the oxide of glyceryl during the process of spontaneous decomposition (by becoming rancid); the saponification has, therefore, in this case, obtained a start, and the alkalies are not obliged, in the first instance, to decompose a combination of oxide of glyceryl, but have simply to enter into combination with the existing free acids to form soap. The small proportion of undecomposed palmitin and coccine, is all that remains to be decomposed by the alkali. Thus, it is easily explained why the saponification of palm and coco fats is so much more rapid than is the case with a great number of the other fats. Rosin (colophony), on the contrary, is very differently affected, inasmuch as its constitution is very different from that of the fats.

Commercial colophony is a mixture of a large quantity of pinic acid with a little sylvic and colophonic acids, a mixture which, from the nature of its ingredients,

possesses the properties of a weak acid. In this case, therefore, no real saponification ensues, but the alkali is simply saturated with the resinous acids, and a substance is obtained which, in a commercial point of view, is equivalent to soap. The production of this substance is still simpler and easier than the saponification of the acid vegetable fats.

Thus far, in speaking of alkalies, reference has been made only to caustic soda and potash. It is, however, well known that soap can be prepared with the carbonates and even the bicarbonates of the alkalies; but the process is then so tedious and imperfect that it is never practised on a large scale. A solution of carbonate of potash, when boiled with fats, parts with one half of its potash to form soap, whilst the other half becomes a bicarbonate. The decomposition of this latter continues with the evolution of carbonic acid as long as the boiling lasts, provided sufficient fat is present; but the process is so long, that a perfect soap is hardly attainable in this manner. For saponifying rosins upon a large scale, the alkaline carbonate is quite as applicable as caustic lye. An excess of alkali is requisite for saponification, and is so much the more willingly employed, that it can be recovered without difficulty. It must not be supposed that the production of soap is a momentary process, or that it may be accomplished with the same exactness and rapidity as the decomposition of an ordinary soap. On the contrary, the production of soap passes through a number of stages, and these occupy a considerable length of time, from the first mixing of the fat with the alkali—when a milky turbid mixture is produced—to the formation of soap ready for use, or to that point when the whole of the alkali is saturated with fatty acids. Acid salts are first produced with the fatty acids, and these hold the remainder of

the fat in a state of solution and division until it also is enabled to combine with the alkali, and transform the acid into neutral salts and into soap ready for use. This reaction may easily be observed if the fat is boiled with one-half the requisite quantity of alkali; the whole of the oil is at length dissolved, but the solution becomes troubled on cooling, and when diluted with water and boiled, unsaponified fat separates, and this has only been retained in the fluid soap by the stearate (or margarate) of the alkali that had been formed. From what has been stated, it appears that ordinary soap is a mixture of the compounds of the fatty and resinous acids with potash or soda. The choice of the base is, however, by no means a matter of indifference. The potash soaps are of that nature, which in certain salts is termed deliquescence, *i. e.*, they do not dry up when exposed in solution to the air, but retain as much water as will form them into a soft slimy jelly. On the other hand, artificially dried potash soaps absorb a large quantity of moisture and become converted into a soft jelly. This is called *soft soap* by the soap-maker, in contradistinction to the soda, or *hard soap*. The latter neither retains so much water nor does it absorb so much as to render it soft, but hardens when exposed to the air, and with a certain amount of matter forms a perfectly solid mass on which it is difficult to make impression with the fingers. The deliquescence of the former kind of soap is derived from the stearate, margarate, and oleate of potash, whilst the properties of the latter are due to the corresponding salts of soda.* Rosin in combination with either soda or potash forms by itself a soft soap. Soft

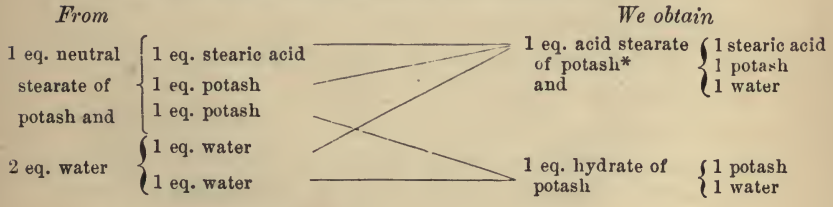
* 100 parts of dry oleate of potash, absorb from the air 162 of water.

100	"	margarate	"	"	55	"
100	"	stearate	"	"	10	"
100	"	stearate of soda,		"	$7\frac{1}{2}$	"

soap is made from train oil and the drying vegetable oils; hard soaps from the vegetable fats and oils which do not dry, or from tallow. Every kind of soap found in commerce contains a variable quantity of water depending upon the state of humidity of the air; part of this is in chemical combination, but by far the greater portion is only imbibed from the atmosphere. Hard soap becomes harder by drying, so that at last it may be pulverized. Potash soap decomposes the salts of soda, that is common salt, sulphate of soda, etc.: the potash, or the stronger base, unites with the more powerful (mineral) acid, and the fatty acid combines with the soda. There results, therefore, chloride of potassium or sulphate of potash, and a soda soap. It is, indeed, in this indirect manner that hard soap is manufactured in Germany. The action of solvents upon soaps is particularly interesting, and of the greatest importance for the purposes for which it is employed. In alcohol and hot water, soap is perfectly soluble. The aqueous solution is more thickly fluid and slimy than the alcoholic solution, but both solidify to a jelly at a certain stage of concentration; opodeldoc is soap dissolved in alcohol in a state of concentration. It has constantly been found that potash soap is more readily soluble in water than soda soap. This can be better seen with the salts of the pure fatty acids than with ordinary *soap.* Stearate of soda undergoes hardly any change when brought in contact with ten parts of water, whilst stearate of potash is transformed by it into a thick jelly. Oleate of soda is soluble in ten parts of water, oleate of potash in four parts, and forms a jelly even with two parts of water; margarate of potash is converted by ten parts of water into a transparent stiff jelly. From this it will also be seen that the salts of oleic acid are more soluble than those of stearic or margaric acid with the same basis, so that

the softness or hardness of the soap is not solely dependent upon the base that is used, but also upon the relative quantities of oleic and stearic acids which it contains. The fats mentioned as serving for the production of soft soap are remarkable for the large proportion of oleic acid which they contain.

Cold water never entirely dissolves the oleate, margarate, or stearate of an alkali—the soap of commerce—without *decomposition*. The neutral salts are resolved into an alkali which dissolves, and into an acid salt which is precipitated. The same decomposition occurs, when hot solutions of soap, particularly weak solutions, are cooled. M. Chevreul investigated this decomposition in the case of stearate of potash, with the greatest accuracy, and the results of his examination are well suited to illustrate the action of soaps in general. When a solution of neutral stearate of potash ($\overline{St}+2KO$) is cooled, one-fourth of its potash remains in solution and a mixture of neutral with acid stearate of potash is separated. If the same salt is allowed to dissolve in 5000 parts of cold water, the acid stearate ($\overline{St},KO$) is alone precipitated, in the form of scales, possessing the lustre of mother-of-pearl, and the half of the potash remains in solution, for



* The acid salt $= \overline{St}KO,Aq$, when separated from the liquid is again decomposed by a large quantity (1000 parts) of hot, but not of cold water, when

1 eq. neutral stearate of potash $= \overline{St} + 2KO$ and 1 *eq. of a still more acid salt* $= 2\overline{St} + KO + 3Aq$ are produced from every 3 eq. of the acid salt $= 3\ \overline{St} + 3KO + Aq$.

This behavior is common to the neutral margarates, and oleates of potash, and soda, and it explains why, in using soap, even with the purest water, a whitish turbidness—*soapsuds*—is always obtained. The alkaline property of soapsuds is solely due to the liberation of a portion of caustic potash or soda, and this it is that affords the possibility of removing fatty impurities in water, which is the sole object of washing with soap.

Every kind of soap, when it leaves the pan, and is afterwards sold, is a more or less concentrated solution of soap in water, which, when it has cooled, and becomes firm, is subject to the same phenomena of decomposition. In fact, common soap shows a number of extremely slender crystalline fibres, but slightly transparent, and having a silky lustre, which are surrounded by a more translucent matrix.

The physical reaction of soaps with different saline solutions, as that of common salt, carbonate of soda, the corresponding potash compounds, sal ammoniac, etc., is of the utmost importance to the soap-maker, because, although it may not be instrumental in the formation, it is very much concerned in the separation of the foreign matters which render hard soap impure, and is also influential in imparting to it the proper amount of water. In practice, a *solution of common salt* is always employed for this purpose.

When soap, cut up into small pieces, is placed in a solution of common salt, saturated at the ordinary temperature, no action whatever takes place; the pieces of soap, instead of being dissolved or softened, swim on the surface of the solution without even being melted by it; the solution of salt flows from their surface as oil from ice. Even after long immersion, no other result ensues than would occur if the soap were plunged into mercury;

instead of softening, its hardness is rather increased. If the solution of salt is boiled, the soap is softened by the heat and assumes the form of a gelatinous, or, rather thick and doughy mass, which is equally insoluble in the saline solution, keeping perfectly distinct from it, or, at most, separating into curds which swim upon the surface. These curds harden when taken out and cool down to a hard soap. If the solution of salt is not saturated, but diluted to a certain extent, the salt and soap contend for the water after such a fashion, that neither positively gets possession of it. The water is partly imbibed by the soap, but a part remains with the salt, so that a solution of soap is seen swimming upon the saline solution, which is now saturated, without mixing with it or dissolving, but still forming a distinct layer. It is only when the salt in solution is below the $\frac{1}{400}$th of the liquid, that the soap is not prevented by it from dissolving. If a solution of this kind is boiled for a length of time, the following appearances will be observed as the water gradually evaporates.

The fluid when steadily boiled, assumes in the beginning, a thin, frothy character. The mass of soap and the froth becomes gradually thicker, until on allowing a sample to run down the stirring rod, it is observed by the manner of its descent, that the solution of soap, although still very soft and liquid, is nevertheless separated from the saline solution. At this period of the process the solution of salt is so far concentrated that the soap cannot remain any longer dissolved. It can easily be observed in what manner the stirring rod is wetted by a liquid (solution of salt), above, or on the surface of which the solution of soap slides down in flat lumps or curds, without attaching itself, or partially sticking to the rod. From this time, the solution of soap becomes constantly

thicker, for the solution of salt takes water from it, in proportion as its own water is diminished by evaporation. The solution of salt collects more and more in the lower part of the vessel; the soap swimming on the top boils, and throws up larger and larger froth-bubbles, until it becomes at length so tough and thick as to obstruct the passage of the vapors arising from below. The surface now splits up into several fields, separated from each other by deep furrows; these have not the fresh and soft appearance of the froth in the furrows, but present the appearance of dry slabs, which being forced from side to side by the escaping vapor, slowly arrange themselves one above the other. The escape of the steam soon becomes so retarded by the thick mass, that it forces its way, as it were, through craters, and gives rise (particularly in covered boilers) to a peculiar sound. At length the period arrives when the attraction of the soap to the remainder of the water is so great, that it completely resists every endeavor of the salt to remove it. Soap and salt, therefore, balance each other with reference to their affinity for water. This state is attained when the soap which, previous to this, was always covered with froth and bubbles, suddenly sinks, and the froth breaks up into roundish massive grains, distinctly separated from each other, and from the saline solution. In this state, the mass no longer rises, even when a greater amount of heat is applied; but the saline solution is thrown up from time to time with much force from below, breaking through the granular mass (*curd*) on the surface, and then sinking down again. If soap is taken out during the boiling process and allowed to cool, it solidifies to a more or less firm mass, depending upon the quantity of water it has retained; when it is removed in the gran-

ular state, it has the consistency and hardness of commercial soap.

Soap that contains a larger amount of water than curd soap is called *watered*,* when water or weak lye is added and mixed with the curd in the boiler itself, or when the curd is treated subsequently with water whilst still in contact with the brine; it is called, on the contrary, *filled*, when the water is added and stirred into the curd after its removal from the boiler and immediately before it solidifies.

All varieties of soap are not separated with the same ease from their solution by means of salt. Thus, soap made from coco oil requires a much larger quantity of salt to separate it from solution than soap made from tallow; the former being soluble in saline solutions, in which the latter is perfectly insoluble. Rosin soap is affected by common salt in the same manner as the soap from fat.

The same results as those obtained by the use of common salt are also produced, although in a less energetic manner, by chloride of potassium, which acts but slightly, by the carbonates of the alkalies, sulphate of soda, acetate of potash and sal ammoniac. In weak caustic lye, soap is perfectly soluble; in strong lye, on the contrary, or when the concentration of the lye is increased by boiling, the soap separates in the same manner as from a solution of common salt. For this reason, the soap-makers are in the habit of using weak lyes, particularly in the beginning of their operation, as stronger lyes, in separating the soap, would prevent the necessary amount of contact

* These terms *watered* and *filled*, as applied to soap, will, perhaps, appear strange, but it is obvious that they are both applied to soap watered in a peculiar manner, and for which there is no corresponding technical terms in English.

among the ingredients, and very much retard the process of saponification.

As glycerine has no kind of resemblance to soap, as regards its reaction with saline solutions and caustic lye, but dissolves in them all with perfect ease, the use of common salt affords a ready means of separating this and other foreign matters from the soap.

In the process of saponification, the aggregate weight of the product 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 of glycerine. This excess is due to the assimilation of equivalent proportions of water by both the fatty acid and the glycerin at the moment of the decomposition of the stearin. In other words, the stearic acid and the 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.

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 spontaneous 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 XXIX.

THE PREPARATORY MANIPULATIONS IN THE PROCESS OF MAKING SOAP.

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

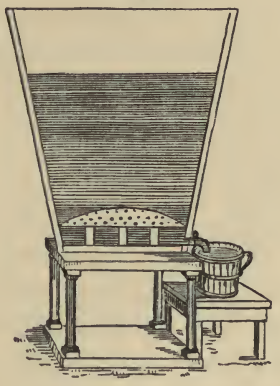
decomposition of the fat and its conversion into soap are effected.

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; premising 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. 28, to separate coal and other rough matters that might injure the color of the soap. The sifted ash is then heaped upon 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 it must be thoroughly mixed with the ashes. In the mean time, the vat, Fig. 49, 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 from 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 displaced by the force of atmo-

Fig. 49.



spheric 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

necessary 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 potash, 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 to-

gether 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 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.

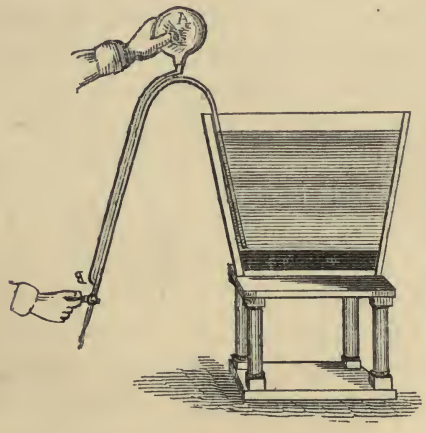
There are other disadvantages in this mode of preparing lyes, one of which is the impossibility of obtaining the alkaline solution beyond a certain strength, thus exacting subsequent concentration, by evaporation, when a greater density is needed. Moreover, it is an established fact that less than ten 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 potash lye. In making the first, however, fifty pounds of lime are required to the hundred of soda; whereas, for the same quantity of potash, 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, 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. 50, and consists of

Fig. 50.



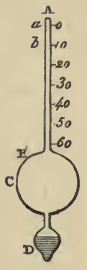
a bent tube, one leg of which is longer than the other, and a smaller lateral tube B, capped with a large, hollow

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 removed from the ball, the outward pressure of the air drives the liquid up to the highest point of the bend, whence it drops, by the force of gravitation, on the opening of the cock, and flows out in a continuous stream, as long as the mouth of the short leg is covered by it.

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

Fig. 51.



of a little glass instrument called Baumé's hydrometer, Fig. 51. Therefore, begin by filling the kettle to one-third its capacity with a lye marking 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 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, 1600 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 consistency, 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 into 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 overheated 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 kettle separates 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 into 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 coco 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, the latter 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 impurities; and an insoluble, dark-colored, *alumino-ferruginous soap* diffuses itself throughout the mass, along with precipitated black sulphuret of iron. Being held in intimate suspension by the thick paste, it form bluish veins in the white ground, and thus gives to the soap the appearance of marble. 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 characteristic effect of proto, and brown that of persalts of iron. When the lyes contain

a large quantity of these impurities, the mottling is produced without any further addition. 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 commence, 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; because 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. 52), 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.

Fig. 52.

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

7. *Cutting Operation.*—When the soap sets firmly, the frames, according to their construction, are either lifted off

or unbound, by loosening the clamps, and removed, so as to leave resting on the bottom a solid mass of soap, corresponding in size with the interior of the wells, as shown in Fig. 53. It is then divisioned off on the sides by means of a scribe, Fig. 54, which is a

Fig. 53.

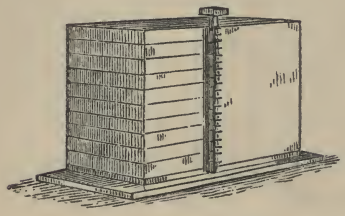
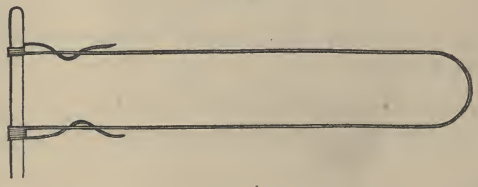


Fig. 54.

wooden slat, carrying on its smooth side a number of slender iron teeth. The workman, then taking a brass wire, Fig. 55, directs it in the track of the teeth, and

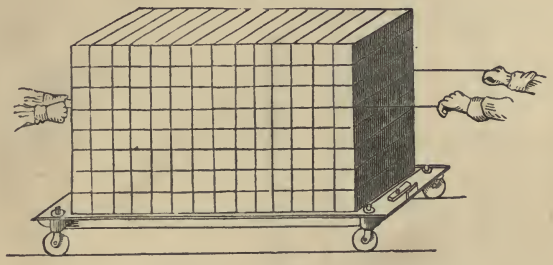
Fig. 55.



thus cuts off one slab of the pre-arranged thickness, as shown by Fig. 56. When the whole block is thus divided into slabs, the latter are in their turn reduced to bars and lumps of smaller dimensions, the usual size of the bars being 12 to 14 inches long, by 3 inches every other way. The pound lumps are about 5 or 6 inches long, 3 inches deep, and the same width. The size of the slabs must, therefore, be regulated accordingly; and, therefore, it is convenient to have a scribe with several sets of teeth, as shown in Fig. 53. 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

Fig. 56.

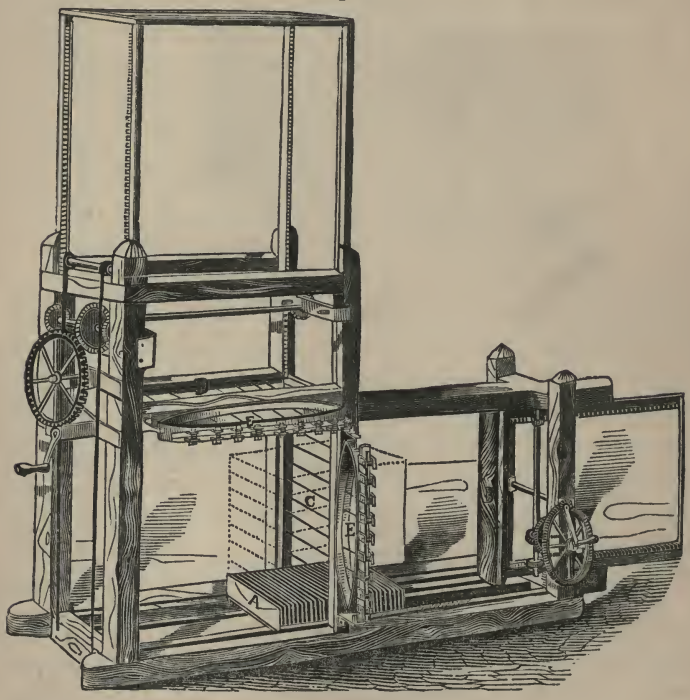


four sides smoothly planed, and bearing slender teeth. On one side they may be set 1 inch apart from each other; on the second, 2 inches; on the third, 2½ inches; and on the fourth, 3½ inches; care being taken, however, that the distance between the teeth of the respective sides is uniform. In this manner, slabs and bars may be smoothly and accurately cut, according to the size traced out upon the block by the teeth of the scribe.

A much more rapid method of dividing the blocks into bars, is that invented by Van Haagen, of Cincinnati, and which requires the use of two pieces of machinery, as shown by Figs. 57 and 58. The first is called 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. 56, 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, there-

Fig. 57.



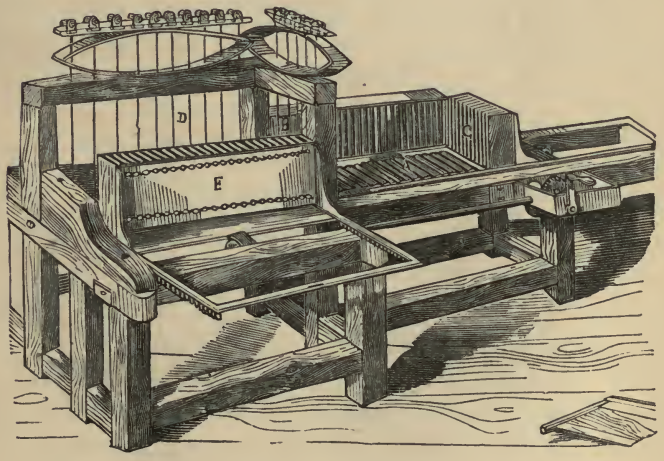
upon placed. All this is done with great ease and despatch, and by the same power.

" 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

Fig. 58.



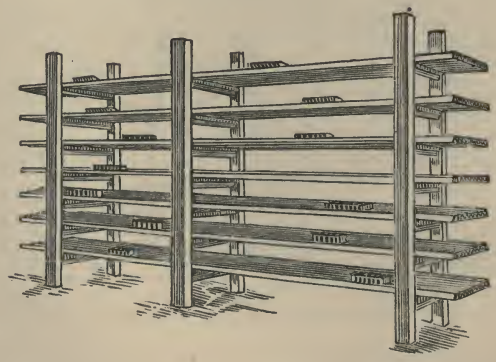
bars as long as its width. To make pound lumps or small cakes and tablets, the slabs must be transferred to the second, or *caking machine*, Fig. 58.

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

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. 59. The openings between the slats

Fig. 59.



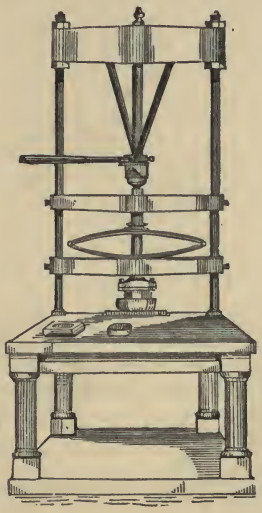
permit the free access of air, and thus promote the drying. Sometimes the bars of commoner soaps are placed

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.

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. 60, with a suitable box and die

Fig. 60.



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

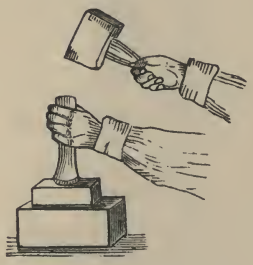
by B, Fig. 61, and consists of a stereotype plate, bearing the inscription, and screwed to the face of a wooden handle. It is used as represented in Fig. 62, by holding it on the soap, and giving a gentle tap to the upper end with a mallet, which sinks a clear impression of the lettering, as shown by the lump of soap, A, Fig. 60. Box-

Fig. 61.

A B

ing is the final operation; and the boxes, made of wood for common and of fancy paper for toilet soaps, differ in proportion with the size and number of bars, lumps, or tablets which are to be packed in them. The present

Fig. 62.



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

CHAPTER XXX.

FABRICATION OF MARBLED SOAP.

Preparation of the Lyes—Paste Operation—Separation—Coction—Causes which produce the Mottling—Cooling—Remelting of the Soap—Quantities of Soap Obtained—Regeneration of Old Lyes.

Olive oil is the basis of marbled soaps of good quality. The best oils for this fabrication come from Naples; the Spanish oils are very highly esteemed; the soap they furnish is whiter and firmer. The oils from the East produce less advantageous results; they are not so rich in stearin, and are more or less colored greenish-yellow, a circumstance due to the presence of a foreign substance designated by chemists under the name of *Viridine*.

As the oils colored green or yellow communicate their color to the soap, it is necessary, if possible, to use oils perfectly clear and limpid, and without any other color than the natural color of that liquid. This last condition is essential in the fabrication of the liquid white soaps.

Numerous experiments have demonstrated that 100 pounds of olive oil, of good quality, will yield 170, and even 175 pounds of excellent marbled soap; but to obtain such an amount, the oils must be very pure, for, if they are adulterated, or of impure quality, the results will not be so advantageous. Besides olive oil, the earth-

nut, sesame, linseed, coleseed, and black garden poppy oils, greases, tallows, etc., are also used in the fabrication of marbled soap; but the soaps resulting from these different combinations of oily and fatty substances, while being of good quality, cannot be compared to those obtained by the direct saponification of olive oil. The latter are always denser, firmer, and finer.

However, we may remark that the mixture of olive oils with other oils containing less stearin, gives, if not the best, at least the finest kinds of marbled soaps. They are also more unctuous, and their cut is softer and smoother, as they contain less stearate of soda than those prepared with olive oil, they are more detersive, and more advantageous for use.

The sodas employed for these soaps are of two kinds, one called *soft soda* is the most alkaline; the other called *salted soda*, is composed of soft soda and common salt.

Well-prepared soft soda ought to be free from common salt; it is employed to produce the pasting (1st period of the operation). Being purer and more alkaline than the salted soda, it has more affinity for fatty matters, and forms more lasting combinations.

Recently prepared, good crude soft soda is in very hard and compact masses of an ash-gray color. Its alkalimetric degree varies according to its richness in pure alkali. Good soda marks generally from 34 to 38 degrees.

The salted sodas are a mixture of soft soda and salt. The proportions of salt are from 30 to 40 per cent. of the weight of the soda. Their alkalimetric degree is from 18 to 22 per cent. of pure alkali. Mixed with the soft soda, they are employed in the different periods of the *coction*, but very seldom in the pasting. The characteristic property of salted soda is to prevent the *invisca-*

tion of the paste, to render quicker and easier the action of the lyes, and to give hardness and consistency to the soap.

In certain circumstances, salted soda can be substituted by common salt. Nevertheless, it ought to be remarked that an excess of salt is injurious in the marbling of the soap, and salted soda must be used whenever it is possible to obtain it.

Salt in solution in water, or in lyes of coction, can be employed to effect the separation of the soap from the weak and exhausted lyes after the pasting operation. The action which takes place in these circumstances is due to the property that salt possesses, of separating soap from its aqueous solution.

Lime is useful, even necessary, in the preparation of marbled soaps, not as an element and constituent part of the soap, but to deprive the sodas of their carbonic acid. To obtain this result, lime recently burned, and perfectly caustic, must be used.

Soda ash is sometimes employed with artificial crude soda (black ash), to prepare the lyes for the pasting and boiling operations. In this case, the soda ash—the richest in alkali—is to be preferred.

Soda ash is not so suitable for the fabrication of marbled soaps as crude soda. Being entirely deprived of coloring matter and of sulphurets, when it enters in too large a proportion into the preparation of the lyes, it lessens the beauty and intensity of the marbling.

The fabrication of marbled soaps requires several distinct operations which may be thus summed up:—

1. *Preparation of the lyes.*

2. *Pasting or saponification of the oils and fatty substances.*

3. *The separation of the saponified paste from the weak lyes it contains.*
4. *The coction.*
5. *The mottling or marbling.*
6. *Running of the soap into the frames.*
7. *Division of the soap.*
8. *Packing.*

§ 1. Preparation of the Lyes.

We have said before that two kinds of soda are used to prepare the lyes; the soft soda (or alkali without salt) is the only one used for the pasting. This lye is prepared as follows:—

Crude soft soda (black ash) at 34° to 38°	2250 lbs.
Lime recently calcined . . .	450 "

If the soda is in a hard and compact mass, it is broken or crushed.

This operation is generally performed on a strong and hard stone fixed level with the floor, upon which the soda is spread, and the pulverization is effected by means of beetles or iron hammers. The powder must not be too fine, for in that state the lixiviation would be very difficult; it is sufficient to break the black ash in pieces of the size of an ordinary musket-ball. By this means spaces are left which facilitate the penetration of the liquid used for the washing of the soda, and allow the extraction of the soluble parts more rapidly and more completely.

The soda being broken up, the lime is slacked by immersing it for one or two minutes in warm water; with warm water, the penetration of the liquid is quicker and more complete; after one or two minutes of immersion, the lime is quickly taken out and spread on a hard,

smooth and dry floor; if the lime is of good quality, it soon grows warm, and falls into powder; this powder is then thoroughly mixed with the soda, by means of large iron shovels. We ascertain that the mixture is well done, when the mass is of gray color, perfectly uniform in all its parts.

The mixture is conveyed to filters made of masonry or sheet iron, of a capacity of about 125 to 150 gallons, and each filter is provided with a double bottom, pierced with holes, supported on three or four little pieces of wood which keep it at about two inches from the bottom. A bed of straw, two or three inches thick, is spread on this double bottom; its object is to prevent the mixture from passing through the holes of the double bottom, besides it acts as a filter, and the lyes obtained are always limpid. A cork placed in the space between the two bottoms is used to draw the lye.

The mixture of soda and lime occupies about the four-fifths of the capacity of the filters, and the remaining space is used to receive the water destined for washing the soda.

The whole being ready, pour on each filter a sufficient quantity of cold or warm water, in such a way that the material may be entirely covered with the liquid. The water penetrates by degrees through the mixture; water must be added until the mass is entirely impregnated and cannot absorb any more.

Under the dissolving influence of the water, the mixture swells, and grows warm, the soluble salts of the soda are dissolved and carried off by the liquid. After a contact of 20 to 24 hours, the cocks are opened, and the lye obtained represents about 60 per cent. of the water used. The areometric titer of the lye varies from 22° to 25° Baumé.

This lye is used at the end of the first operation, to give more consistency to the paste; it is also successfully used to give the first *service* after the separation.—

The first lye being drawn off, the cocks are shut, and the washing of the soda continued by pouring upon the mixture a quantity of cold water equivalent to that of the lye obtained; after a contact of 15 to 18 hours, the cocks are again opened to run off the second lye, which must not be mixed with the first. This lye marks from 14° to 18°, and is used in the middle of the first operation.

Lastly, a third washing with the same quantity of cold water dissolves nearly the whole of the soluble salts contained in the soda. During this third washing, the water is left in contact with the mixture for about 25 to 30 hours; after this time the lye is drawn off, and marks from 8° to 10°; it is used for the first operation.

After this third washing, the residuum left in the filters is not entirely deprived of alkali. To separate, as completely as possible, the soluble parts it contains, the mass is allowed to dry by keeping the cocks open. When all the lye is run out, which requires a few days, the mass is divided with an iron shovel, so as to disaggregate the portions of soda imperfectly washed in the preceding operations, and render the following washings more easy and more complete.

All the filters being thus ready, the cocks are shut, and a sufficient quantity of water is poured on the residuum, so as to cover it entirely. The mixture is left to rest for 30 to 40 hours, and during this time the dissolution of the soluble substances takes place.

The lye is drawn off by opening the cocks; then, if found convenient, a last washing may be made, after

which, the residuum entirely exhausted of alkali, is thrown away.

These last lyes are not mixed with the other weak lyes, they are used instead of cold water in new operations, and thus the very small quantity of alkali they contain is not lost.

§ 2. Preparation of Salted Lyes.

What we have said above is applicable only to the preparation of soft or purely alkaline lyes, used for the pasting and the first cold service after the separation. They do not contain salt enough to be used in the coction; the soaps produced would be wanting in consistency and hardness. The lyes of coction are a mixture of soft and salted sodas rendered caustic by lime. The respective proportions of these two salts in the preparation of the lyes, depend on the nature of the fat to be saponified, and on the consistency to be given the soap. As a general rule, the fatty or oily matters in which stearin exists in a large proportion, require for their coction lyes less charged with salted soda than those in which olein predominates. This difference is very easily explained by the well-known property that olein possesses, of forming soaps less solid and less hard than the oils richer in stearin. However, a few trials made on a small scale will readily establish the proportions to be employed.

Generally, for marbled soaps having for a basis 50 parts of olive oil, 40 of earth-nut oil, and 10 of black garden poppy oil, the proportions for the preparation of lyes of coction, are 25 of salted soda, and 75 of soft soda, but there are no fixed and precise rules. The nature of the fatty bodies, the consistency to be given to the soap, are the best and surest indications to be consulted. It has

been ascertained that the proportions of oils indicated above, give a very white and firm soap, with a pleasant odor, and having all the qualities of the genuine Marseilles soap.

The salted lye is prepared as follows :—

Crude soft soda at 33° to 38° . .	3375 lbs.
" salted soda at 18° to 20° .	1025 "
Lime recently burned . . .	900 "

The sodas are crushed and mixed with the lime. The filters are filled, and the washing conducted exactly in the same manner as indicated for the soft lye.

§ 3. First Operation.—Pasting.

The name of *pasting* is given to the first stage of the union of the fatty substances with the alkali. This operation has always been considered as the most important, the most difficult and delicate of the fabrication. On its success depends the amount of soap obtained, and its good quality. It is conducted as follows:—

Take

Olive oil	1125 lbs.
Earth-nut oil	900 "
Black garden poppy oil . . .	225 "
	2250 "

The saponification is effected in a sheet-iron kettle of a capacity of 875 to 1000 gallons, into which from 125 to 150 gallons of soft lye at 10° or 12° are poured. This is heated, and when the lye begins to boil, the oils are added by degrees, being careful to stir all the time. Three-quarters of an hour after the introduction of the oils, the ebullition begins to be manifested by a tumultuous agitation in the mass, and the formation of a very

abundant white foam. The mixture swells considerably, the action of the heat must then be moderated, for without this precaution, the soap would soon run over.

When this first and rapid effervescence has ceased, the foam diminishes, and finally disappears entirely. The perfectly homogeneous paste has a dead white appearance. Continue to boil for four or five hours; by the ebullition, the mixture of the materials becomes more and more intimate; it acquires also more consistency and strength by the evaporation of the water which separates from the lye; then add 25 to 30 gallons of lye at 15° or 18°, which is incorporated by stirring for about 10 minutes. Boil a few hours, and when the mixture has acquired a thicker consistency, add to it one pound of green vitriol (sulphate of iron), previously dissolved in a few quarts of boiling water. By this addition, the paste, which was of a reddish-white, assumes instantaneously a greenish color, the intensity of which depends on the degree of sulphuration of the lye. To combine the sulphate of iron with the paste, the mixture is well-stirred for a few minutes; under the influence of the soda, the sulphate of iron is decomposed, and produces an oxide of iron. The chemical union of this oxide with the sulphuret of sodium which always exists in the lyes of crude soda, produces the coloring principle of the marbling of the soaps.

To obtain a more intimate combination of the fatty acids with the lyes, and to give more consistency to the paste, conditions which are essential to prevent the separation of the oils when in contact with salted lyes, add little by little, stirring continually, from 25 to 30 gallons of soft lye at 25°, and continue the boiling for a few hours. During this time, the aqueous part of the lyes evaporates, and the paste becomes firmer. The pasting

operation lasts about 15 hours, and produces a soap imperfectly saturated with alkali. To continue the coction, the lyes of the first operation have to be separated.

Observations on the above Operation.—Whatever may be the pains taken during this operation, it may, and, indeed, it does sometimes happen that a portion of the oils will float on the surface of the paste. When this effect is produced, a certain quantity of weak lye, or even cold water must be thrown into the kettle. If this does not succeed in incorporating the oils in the saponified mass, we may then add from five to six per cent. of the weight of the fatty matters, of pieces of soap, and continue the saponification by boiling the mixture gently until the combination is effected.

By these means—employed separately, or together—the oils which have separated may be always incorporated and combined in the saponified paste. We must remark that this incorporation would be much more difficult, if salted lye had been used, for the presence of salt considerably diminishes the affinity of fatty matters for the alkali. But these inconveniences are very rare, where the pasting is done with very pure and caustic lyes, and the operation is conducted according to the above rules.

§ 4. Second Operation.—Separation.

This operation, the object of which is to render the soap more alkaline and less watery, is based on the remarkable property that salt possesses of separating completely the soap from all its aqueous solutions. There are, it is true, some exceptions, but they are few.

The separation can and ought to be effected only when there is a positive certainty that all the fatty and

oily substances are completely combined with the lyes; if it should be otherwise, and if the combination be not perfect, the oils, after the separation, would be seen to float on the surface of the soap; then their incorporation in the saponified mass would be—if not impossible—at least very difficult. Indeed, the salt which impregnates the mass would be an obstacle to the combination of the oil with the lye.

In soap factories to accomplish the separation, they throw, by small portions on the soapy mass, clear and limpid regenerated lyes, at 25° to 30°. When these lyes cannot be had, new salted lyes, at 20° to 25°, can be used, or an aqueous solution of salt at 20°. To obtain 25 gallons of salted solution at 20°, 40½ pounds of salt are employed. The separation of the paste is managed as follows: When the saponification is finished, and the paste has the required consistency, it is watered with a sufficient quantity of old and salted lye of coction marking 25° to 30°. To render the action of the lyes more thorough upon all the molecules of the soap, a large board is placed over the kettle, on which a man—provided with a beater or crutch—stands to stir the mass continually, from bottom to top, in such a manner that the lye brought to the surface of the kettle penetrates every portion of the soap.

When the paste—until now homogeneous and viscous—is transformed into clots, and when the lye separates abundantly, it is a proof that the mass has absorbed enough of it; at this point, the operation is finished. By settling, the lye separates slowly from the clots of soap, between which it is interposed, and occupies the lower part of the kettle, while the soap specifically lighter floats on the lye.

Allow the whole to rest at least four hours; this is necessary, to give time to the soap to separate from the

aqueous liquors, then open the cock to draw off the lye. The operator must be careful that the lyes are clear and limpid; if soap flows out with them it will be easily detected by the viscous and whitish appearance of the liquors.

When the first two operations have been carefully conducted, and the quantities of lye indicated above have been used, from 175 to 188 gallons of a limpid lye at 17° or 18°, are drawn off from the kettle; this lye passed over an old residuum of soda exhausted by water, is used for the mottling.

Experience proves that 100 gallons of lye at 25° to 30° are sufficient to effect the entire separation of a batch formed of the quantities of oil indicated above.

The paste being deprived of the surplus of the weak lye it contained, is ready for the coction.

§ 5. Third Operation.—Coction.

It is by this operation that the entire and perfect combination of the oils or fatty substances with the pure alkali is determined and completed. The coction is necessary to give hardness and consistency to the soap; it increases its weight, deprives it of all disagreeable odor, renders it more detersive, prevents its decomposition, and permits it to be kept for any length of time without alteration.

As we have said before, the coction of marbled soaps is conducted with salted lyes, resulting from the mixture of *soft* soda and artificial *salted* sodas, rendered caustic by lime. The number of *services* varies according to the nature of the oils or fatty substances which are saponified, and particularly with the degree of concentration of the lyes, and their richness in alkali. Three services of

lyes are generally sufficient to bring the soap to its proper point; but if the soap is manufactured for exportation, one service more is given; this excess of coction is necessary to prevent its decomposition in warm climates.

1. *First Service with Cold Soft Lye.*—The lyes of the pasting being entirely drawn off, the cock is closed, and about 88 gallons of soft lye at 20° to 25° are poured on the pasty soap. Heat is not used for this first service, the mass is sufficiently warm to keep the paste in a fluid state, only a man provided with a mottler stirs the mass all over, so as to bring all the molecules of the soap into contact with the new lye. The paste, which during the pasting was homogeneous, is transformed into soft and voluminous flakes which float in the lye. The mixture is stirred for about half an hour; the stirring finished, the kettle is covered to keep the heat in the mass. When the lye has separated from the soap, which takes from three to four hours, it is drawn off by the cock.

Observations.—Some manufacturers for the first service use salted lyes, but in our judgment soft lyes are to be preferred. Indeed, there is already in the paste an excess of salt, due to the lyes employed for the separation, and as too large a quantity of salt interferes with the useful action of new lyes on the molecules of soap, it is proper and rational to eliminate it from the paste as much as possible. The soft lyes contribute to this result. This advantage is not the only one; the lyes of coction used in considerable quantities in the separation, have set free some fatty matters imperfectly combined; thus the soft lyes while purifying the paste from the excess of salt it contains, determine the incorporation with the mass already saponified, of the oily or fatty substances which had not been combined before, and could not be, if salted lyes had been used.

Moreover, the fire is not kept up under the kettle during this first service, not only because it would be a useless expense of fuel, but a pure loss, the heat of the mass rendering it superfluous, and besides, too great a heat at this stage of the operation would cause the mass to expand considerably, and may even sometimes cause the soap to become incorporated with the lye.

2. *First Service with Salted Lye.*—The second service is given with salted lyes. Proceed as follows: After drawing off the lye of the first service, the waste cock is closed, and from 100 to 115 gallons of salted lye at 25° are poured on the paste, heat is applied, and when the ebullition begins, the mass is stirred for ten minutes. Boil gently until the lye loses its sharp and caustic taste, which takes place generally after seven or eight hours of ebullition; a very abundant black foam is produced on the surface of the paste, which continues during the whole time of the coction, and only disappears entirely when the soap is properly saturated with alkali.

The heat being checked, allow a rest of three to four hours, and draw off the lye.

3. *Second Service with Salted Lye.*—After the second service of strong lyes, the soap has already acquired much consistency, but it is yet viscous and greasy. To bring it to the proper point, pour into the kettle from 115 to 125 gallons of salted lye at 25° to 30°, boil for 12 to 15 hours, stirring the paste from time to time, and adding every hour, for eight or ten hours, about 5 gallons of lye of coction at 28° to 30° to take the place of the evaporated water, and complete the saturation of the soap.

It is generally towards the end of this service that the soap is boiled or nearly so. At this point, the foam which covered it has disappeared, the paste is furrowed

by deep channels, and the batch is stiff, clean and dry; the lye is clear and limpid, but colored; it ought to be slightly pungent and alkaline to the taste.

In conclusion, the coction of the soap may be ascertained by the following indications:—

1. When a few grains of the soap separated from the lye, and while warm, pressed between the fingers, form thin, hard, dry, and friable scales, easily reduced to powder when rubbed in the hand, it is a certain indication that the soap is perfectly boiled. If on the contrary, it forms soft, greasy, unctuous scales, adhering to the finger after cooling, it is a proof that it is not completely saturated with alkali.

2. The lye brought by the ebullition to the surface of the soap, ought to be alkaline and caustic; if on the other hand it is only salted, it is a sign that the soap is not sufficiently saturated with alkali.

If the indications show that the soap is not entirely saturated, allow it to cool and rest for two hours, draw off the lye, and complete the coction by boiling the soap seven or eight hours with 75 gallons of salted lye at 28° or 30°.

When perfectly boiled, allow it to rest three hours, draw off the lye and proceed to the mottling.

All the lyes used in the above operation are called lyes of coction. They are passed through the spent material of the lye vats, and are employed in the separation; in many manufactories these lyes are repeatedly used, and for this purpose they are purified as indicated, that is, by passing them through a residuum of soda in the leaching tubs. This first filtration separates the fatty matters they contain, and renders them clear and limpid. Afterwards, they are successively passed through filters richer in new soda, and they acquire more strength

by their progressive saturation with alkali. This method, which is generally used, is rational and very economical, besides, it has the advantage of utilizing the lyes of coction.

Observations on the Coction.—We have said that for the above quantities of oil, three services of new lyes are generally sufficient to bring the soap to the proper point of saturation; but if the operation is performed with lyes prepared with lyes of coction and consequently less pure and not so rich in alkali as those obtained by washing sodas with water, it is necessary, in this last case, to give five or six services to perfect the soap.

But, whatever is the purity of the lyes, and their richness in alkali, the essential and distinctive characteristics which indicate the termination of the coction, are always the same, and are identical in both cases. These characteristics, well understood and well applied, always enable the manufacturer to watch and direct a coction of soap in a proper manner, for, we repeat it, these characteristics are very evident only when the soap is entirely boiled.

§ 6. Fourth Operation.—Mottling.

When the soap is completely boiled, the heat is reduced and the kettle covered; after one or two hours' rest the lye is drawn off; this lye should mark from 28° to 30°. The more concentrated the lye, the denser is the soap, and the easier the mottling.

A man throws little by little, on the surface of the soap a pure lye, marking 12° to 15°, and another spreads it all over the mass with a mottler. When the paste has been sufficiently sprinkled with this first lye, and begins to become soft, the same lye at 8° to 10° is added, and

the stirring continued; a progressive change then takes place in the condition of the paste. Until now the soap has been in hard and concrete grains, very little adherent to each other, but under the influence of lyes successively weaker, and of the continual stirring of the mass, the grains of soap become softer, more pliable and more viscous; at this point the operation is finished by using lyes at 5° or 6°. These lyes must be employed gradually, so as to retain the adhesiveness of the paste, which would be destroyed by the introduction at one time of a too large quantity of lyes of a feeble degree. It is ascertained that the paste is ready to be run into the frames when the soap, half fluid and melted, is seen to float in the lye in large flakes of a greenish color. The fluidity of the mass must not be pushed too far, for in that case, the marbling would be defective, and even it might happen that it would fail altogether, if the soap be too much diluted by weak lyes, and especially if it is run while too hot into the frames.

The degree of the lye is also a sign which can be used under some circumstances, to ascertain the moment the soap can be run into the frames, but this sign is neither exact nor certain, besides, it varies according to the way in which the coction has been conducted, and also to the nature and proportions of oils or fatty matters entering into the composition of the soap. When the soap is made with a mixture of equal parts of olive and earth-nut oils, the lye left in the kettle marks from 15° to 16°.

When the operation is conducted under favorable circumstances it lasts from two to three hours.

Nevertheless, if in spite of all the precautions taken, the operation presents some difficulties, these difficulties are due to two different causes: or the mixture has been

cooled too much by the introduction of the cold lyes used for mottling; or the soap contains too large an excess of saline substances. In the first case, heat the mixture gently, and when the lye is sufficiently warm, stir the mass; after a stirring of about half an hour, the paste acquires some viscosity, the soap forms large flakes floating in the lye, and at this point the operation is finished. In the second case, it is an excess of saline substances, incorporated with the soap or in solution in the lyes, which are an obstacle to the fluidity; consequently it is very important to separate them as completely as possible; the best way would be to separate the soap from the lyes and transfer it to another kettle, and then to mottle it with pure lyes.

But this change of kettles is a long and difficult operation, and must be avoided if possible. If the paste should not be right, and if the grains of soap are dry and hard, as if their surface were covered with a whitish crystallization, the kettle is gently heated for one or one and a half hours, when the heat is checked. In this condition, let it rest a few hours, to permit the soap to separate from the lyes, which are drawn off. The paste, thus deprived of the excess of strong lyes and salt, which were an obstacle to its softening, is treated by fresh and purer lyes marking from 10° to 12°. The action of the lyes is accelerated by heating a little and stirring.

Under the influence of a gentle heat, of purer lyes at a proper degree, and a continual stirring, the paste assumes another appearance and becomes opened, the soap is transformed into lumps, and whilst they are entirely separated from each other, these lumps are soft and voluminous, and have a tendency to unite; they have a gelatinous appearance.

When in this state the soap is ready to be run into the frames.

The frames into which the soap is introduced must contain a certain quantity of warm lye of the same degree as that in the kettle at the time it is drawn off; this addition of warm lye has for its object to prevent the soap from adhering to the bottom of the frame. The reason is, that the first parts of soap coming into the frames are quickly cooled, stick to the bottom, while the cold lye which separates rises to the surface; thus in continuing to fill the frames, the lye will be interposed between the layers of soap. The warm lye remedies this inconvenience.

§ 7. Observations on the Causes which produce the Mottling.

The soap when properly boiled has the form of separated and hard grains, the agglomeration of which has the aspect of a bluish-black colored mass; the intensity of the color varies according to the quantity of the soaps of alumina and protoxide of iron, contained in the mass, and also according to the degree of sulphuration of the lyes of coction. The mottling has for its object to disseminate the soaps of alumina and iron through the mass of white soap. To obtain this result, cold lyes of a feeble degree are used, and a gentle heat is applied, under the influence of which the metallic soaps by separating and distributing themselves in the mass of white soap, combine with it very uniformly and produce small veins of a fine, intense, and bright blue color.

The success of the operation depends entirely on the skill and experience of the operator; the most enlightened theory in this case is often entirely at fault.

The essential point is to run the soap into the frames as soon as it presents the characteristics which experience has shown to be necessary for producing a good mottling. The eye is the best guide, for there are no fixed and precise rules to direct this operation, always delicate and difficult even for the skilled workman.

As for the use of the lyes, which are the most suitable for mottling, those resulting from the separation, as being entirely deprived of caustic alkali, are to be preferred. These lyes are always soapy, and must be purified; for this purpose they are cooled and passed through cold residues of soda exhausted by water, when they are obtained clear and limpid and in the most favorable state for mottling.

This is not all, these lyes have over the salted lyes, generally used for mottling, the advantage of not superoxidizing the iron of the mottling, and the result is that the blue will be preserved a much longer time, and, moreover, as these lyes are deprived of caustic alkali, the soap is purer and more neutral.

In general, the mottling of a soap, made with the quantities named above, requires 150 gallons of lyes of different degrees, the mean of which corresponds to 12° or 13°. For example, there may be used 50 gallons at 8° to 10°, 50 gallons at 12°, and 50 gallons at 15°.

To mottle the soap, the strongest lye is first poured into the kettle, then the medium, and lastly the weakest.

In conclusion, the mottling can only be obtained :—

1. By the introduction into the paste of a sufficient quantity of lyes of a feeble degree.

2. By the influence of a gentle heat, so as to keep the paste in a fluid state.

3. By a continual agitation of the paste during the operation.

There are many precautions to be observed to attain success in this operation:—

The first, is not to add more lyes than may be necessary, so that the soaps of alumina and iron, which are the coloring principles of the mottling, may be distributed in the mass of white soap and form by depositing those little blue veins which constitute the marbling. The temperature of the mixture must not be too high.

Indeed, if the quantity of lye introduced into the soap be too considerable and of too feeble a degree, and if, at the same time, the temperature is too high, the result will be, that instead of disseminating the metallic soaps through the mass, they will be carried off in the lyes; then the soap deprived of the metallic soaps will be white or nearly so.

If, on the contrary, too strong lyes are used, not only will the metallic soaps not separate, but the soap will also not contain all the water of composition it should, which will occasion a real loss to the manufacturer without adding to the quality of the soap.

Nevertheless, it is ascertained that the soap is sufficiently macerated when, after the introduction of the lyes, the paste presents the following characteristics: When the flakes of soap are separated one from the other, and float in the lye; whilst separated, these flakes must be soft and *voluminous*, and of a fine dark green color; they must have a sort of viscosity which brings them together but without uniting them. Lastly, when the paste is ready to be run into the frames, the grains are pliant and elastic and have a tremulous and gelatinous appearance.

The temperature of the mass, when the soap is ready to be run into the frames, must be moderate; too strong a heat dilates the soap and lets it precipitate almost the

whole of the mottling. For the above quantities the temperature may vary between 158° and 167°. Below 140° the operation is imperfect; above 176° a part of the mottling precipitates in the lyes.

§ 8. Cutting of the Soap.

When the soap has acquired the proper consistency, which generally requires ten or twelve days, it is cut into large blocks having the form of an oblong square, and weighing about 200 pounds. The division of the cakes of soap is effected by stout iron wires properly arranged at the bottom of the frames before running the soap into them. When it has the required hardness each wire is drawn in the direction of lines previously traced on the surface of the soap.

Experience has proved that it is advantageous to leave the soap in the frames for eight or ten days, after it has been divided, in contact with clear lyes of coction at 18° to 20°. By this immersion, the soap becomes firmer and finer, and increases sensibly in weight. The increase is from one and a half to two per cent.

When the soap is to be removed from the frames, the lyes are first drawn off, the door of the frame is opened, and the large cakes are carried to a long table on which they are divided into small bars. These bars are placed in boxes, the dimensions of which are determined by the number of bars they contain; generally each box contains 40 bars, the total weight of which is between 210 and 220 pounds.

Immediately after boxing, the bars have not that white coat designated by the name of *robe*. This effect is produced when the soap has been put up in the boxes for four or five weeks.

All the small pieces of soap are used in a new operation, and it is generally at the end of the coction that they are added.

§ 9. Remelting of the Soap.

The difficulties presented by the operation of mottling, and the numerous circumstances which may lead to a failure, sometimes oblige the manufacturer to remelt entire batches of soap. This operation, always costly, is effected in the following manner: The soap is at first cut into large pieces and melted in a kettle of a suitable capacity, with a sufficient quantity of a limpid lye of coction at 20° to 22°, and boiled a few hours. The object of this first treatment is to separate the soap from the excess of weak lye it contains. After two hours' rest, draw off the lye. For the second treatment, pour into the kettle new salted lye, at 25°, and boil five or six hours. In this operation the grain of the soap is formed again, and acquires consistency. Draw off the lye after an hour of rest.

Then for the third and last treatment, boil the soap in an excess of new salted lye, at 28° to 30°; keep the mixture boiling until the grain of the soap is well formed, hard, and becomes scaly when pressed warm between the fingers; cut off the heat, let the mixture rest one hour, and draw off the lye, which ought to be slightly pungent and caustic.

The mottling is conducted in the same manner as we have indicated above.

Independently of the expense of remelting, the soap by this operation experiences a loss varying from four to six per cent., and sometimes more. We see how important it is, then, to be careful in the first operation, since

its failure causes a considerable expense. However, with all possible care, the manufacturer is not always successful. The remelted soap has never the whiteness and brightness of that which has not been subjected to this operation.

§ 10. Quantities of Soap furnished by Oils.

The quantity depends essentially on the nature of the oils, and their state of purity; it depends, also, on the care taken during the fabrication.

To be assured of a large amount of soap, the oils must be of good quality, limpid, and free from adulteration; the black ash must be of the best quality, and rich in caustic alkali; the lyes must be perfectly caustic, and as free as possible from carbonate; the lime must be recently burned, and fall into powder, when moistened with water.

It is indeed demonstrated that perfectly caustic lyes have a greater affinity for fatty matters than those in which there is a large amount of carbonate. By using the first, a more perfect and complete saturation of the fatty acids is obtained, and consequently the amount of soap is much larger.

By operating under favorable conditions, and using the best olive oil, 100 pounds of oil yield from 172 to 175 pounds of marbled soap, of the first quality. But on a large scale, it is not often that these results are obtained; they generally vary from 165 to 170 pounds for 100 of oil.

When olive oil is mixed with some other oils, the amount varies, according to the relative proportions of each—from 155 to 165 per cent. of the weight of the oils. However, we have remarked that the mixture, in

different proportions, of earth-nut oil with olive oil gives as much soap as where olive oil is employed alone.

The quantity of crude soda to be used is from 80 to 85 per cent. of the weight of the oils.

The fuel for treating 2250 pounds of oil is from 560 to 675 pounds of coal.

As to the composition, this soap offers less variations than other kinds. It is less susceptible of alteration and adulteration than the white soap. A marbled soap, well prepared, should not contain more than 30 to 35 per cent. of water, whilst pure white soap generally contains 50 per cent. of water, and sometimes more.

Marbled soap has the following composition :—

Pure soda	6
Fatty matter	64
Water	30
	100

This soap is less neutral and less pure than fine white soap ; unlike the latter, it cannot be used for the cleansing and bleaching of silks, because the free alkali it contains would act on the fibre. But for ordinary uses it is to be preferred. In using it, the consumer is assured of getting an article always the same in quality, which, in many cases, is a great advantage.

As the fabrication of marbled soap is no longer confined to the city of Marseilles, and as it is manufactured in many other localities, we think it will interest the reader to know the formulæ of fatty matters, which answer as well as the one given above.

The following proportions give a soap of good quality, which is white, without odor, and has a great similarity to the Marseilles soap.

Olive oil	675 pounds.
Earth-nut oil	675 "
Lard	900 "
	2250 "

Another—

Bleached palm oil	1575 pounds.
Sesame	450 "
White tallow	225 "
	"
	2250 "

This soap is very hard, and of good quality; it is not so white as the above, and becomes slightly yellowish by growing old.

Another—

Olive oil	450 pounds.
White tallow	1350 "
Earth-nut oil	450 "
	2250 "

This mixture constitutes one of the best soaps. It is very white and firm, and is better for use than that of Marseilles. Unfortunately, it has a faint smell of tallow, which restricts its use in domestic economy.

Another—

Olive oil	675 pounds.
Coco oil	225 "
Lard	675 "
Tallow	675 "
	2250 "

The soap resulting from this mixture is of a fine white color, very consistent; its odor is not unpleasant. The addition of coco oil renders it more detersive, and more lathering than those above.

In some manufactories, marbled soap, having all the

appearances of the Marseilles, is manufactured with the following mixture :—

Olive oil	675 pounds.
Sesame, or earth-nut oil . .	1575 "
	2250

The coction of the soap is effected with salted lyes resulting from a mixture of 60 parts of soft soda, and 40 parts of salted soda. It is of good quality, and becomes yellow by age, when sesame oil has been used.

§ 11. Regeneration of Old Lyes.

When the lyes have become very greasy, and have contracted a strong and disagreeable odor, it is customary for some manufacturers to throw them away, which is evidently a loss, for they contain large quantities of alkali in the carbonated state. They may be regenerated and employed, either singly in the separation of the soap, or mixed with new lyes in the first services of the coction.

To separate the excess of fatty and gelatinous matters they contain, the lyes are passed through the residuum of soda and lime exhausted by water; they may also be filtered through sand, and this is the best method.

The lyes being filtered, pour 500 gallons, into a sheet-iron kettle of a capacity of 750 to 875 gallons, heat, and when the liquid begins to boil, add from six to nine pounds of lime for every 25 gallons of lye. The lime must be slacked in a sufficient quantity of water to form a thick milk.

After the introduction of the lime, add 50 lbs. of bone black, boil the mixture for a few hours, being careful to stir from time to time. Under the influence of an

elevated temperature, the fatty and gelatinous matters, held in suspension or in solution in the lye, combine with a part of the lime, and form an insoluble calcareous soap which is precipitated; the other part of the lime transforms the carbonate of soda into caustic soda, while the carbonate of lime is precipitated. Lastly, the bone black acts as a deodorizer and decolorizer.

After an ebullition of three to four hours, remove the fire, cover the kettle, and let the contents rest from 24 to 30 hours, to allow the lye to become clear; but if it should be wanted immediately, filter the boiling liquor through sand.

This process may be applied to all kinds of lyes.

CHAPTER XXXI.

WHITE SOAP FROM OLIVE OIL.

Pasting—Separation—Coction—Fitting.

This soap is the purest to be found in commerce, when it has been prepared and purified according to the rules of the art. It is very much used in industry, particularly in the bleaching of raw silk. By its extreme purity and its nearly absolute neutrality, it does not alter the brilliancy and elasticity of the silk, which renders it superior to all the other kinds of soaps.

When prepared in all its purity, it has for its basis pure olive oil saponified by caustic lyes of artificial soft soda. These lyes are prepared in the same manner as indicated for marbled soap; but as the presence of salt would render this soap less soluble in water, the lyes

must be prepared only with soft soda free from salt and containing as little as possible of sulphuret of sodium; by this precaution too much coloration of the paste is avoided, and the operation is much more easy and shorter.

In Belgium, they substitute soda ash for crude soda in the preparation of the lyes. The soap thus made is of a fine pure white color. Thus by using a colorless and purer alkali, the refining of the soap is easier, and the amount obtained much larger than with lyes made from crude sodas. This is rational, and we have seen soaps of olive oil thus prepared, which were perfectly white and as pure as the best Marseilles soap.

Independently of the purity of the alkali, the nature of the oil employed to prepare this soap exercises a remarkable influence on its consistency and whiteness. To obtain good results, the whitest and most limpid oil must be used.

Experience proves that oils much colored have the property of communicating their shade to the soap; sometimes a proportion more or less considerable of another oil is mixed with the olive oil, especially earth-nut oil; this oil being white, has no influence on the color of the soap, but it changes its consistency and renders it more soluble and lathering. Whilst this mixture is often employed, we shall speak only of the fabrication of the white soap prepared with pure olive oil and caustic lyes made with crude soda.

§ 1. Pasting.

We suppose a saponification made with 2250 pounds of oil. For this quantity use a kettle of a capacity of from 1000 to 1250 gallons. Pour into the kettle from 175 to 200 gallons of caustic lye of soft soda at 8° to 10°

which is heated. When the lye begins to boil, pour on the oil, and to facilitate its combination with the lye, stir the mixture all the time; the stirring may be continued for half an hour after the last portion of oil has been introduced.

This being done, boil the mixture; the ebullition must be very gentle to prevent the formation of too much foam at the surface. If, notwithstanding this precaution, the mixture rises, the heat is to be slackened, then the ebullition becomes less rapid, the foam diminishes and falls down, and the mixture boils regularly; but it is essential to watch the operation, for in the state of dilatation the paste is, it would soon boil over.

A gentle ebullition has also for its object to facilitate the combination of the oil with the lye. It is known that the paste is quite homogeneous, when neither oil nor lye is seen at the surface.

This result being obtained, pour into the kettle lyes at a higher degree than the first, at 12° to 15°, for example. The quantity of lye to be added is not well determined, but from six to eight gallons may be added without inconvenience every half hour, to take the place of the evaporated water. A slight excess of weak lye in the pasting is not injurious, and has the only inconvenience of making the operation a little longer and more expensive; but as a compensation, the oil is better saponified, and more completely deprived of its coloring and mucilaginous matters, and the soap is finer and better.

After a gentle ebullition of eight or ten hours, the paste becomes thicker, and more homogeneous. To finish, introduce 25 to 50 gallons of lye at 5°, and after stirring for half an hour, stop off the heat, and proceed to the separation.

§ 2. Separation.

This operation is conducted in the same manner as indicated for marbled soap, that is, by pouring little by little in the kettle perfectly limpid lyes of coction at 20° to 25°. During the introduction of the lye, a man stirs the mass all the time. It is known that the quantity of lye is sufficient, when the soap separates from the lye, and acquires a clotted appearance. The more concentrated the lye, the less the quantity to be used to effect the separation.

The operation being finished, cover the kettle, let it rest five or six hours, then draw off the exhausted lye, and proceed to the coction.

§ 3. Coction.

1. *First Service of Lye.*—To begin the operation, pour at first into the kettle from 125 to 150 gallons of soft lye, at 15° to 18°; heat gently, and when the soap is very warm, stop off the heat. This done, the soap is briskly stirred for three-quarters of an hour or an hour. By stirring thus, the soap is brought into contact with the lye, and by combining with the alkali it acquires more consistency, at the same time that it is deprived of the larger portion of the foreign salts that it has absorbed during the saponification and separation.

Rendered purer by this first washing, the soap is more fit to combine with the concentrated lyes which bring it to the proper point to be purified. After a settling of a few hours the lye is drawn off.

2. *Second Service of Lye.*—For this second service, pour into the kettle 100 gallons of caustic and concentrated lye, at 22° to 25°. Boil the mixture gently for eight or ten hours, adding every hour six gallons of pure lye to take the place of the evaporated water.

During the ebullition, a very abundant foam is formed on the surface of the soap, but its development is moderated by slacking the heat. When during the ebullition the soap becomes apparent, it is entirely granulated, and floats in the lye. By pressing it between the fingers, it is found to have more consistency, but it is greasy, because it is not yet completely saturated with alkali. To bring it to the state of saturation, the heat is stopped off, and the mixture left to settle for a few hours; then a third and last service of new lye is given.

3. *Third Service of Lye.*—For this service, use a new lye marking 28° or 30°. Pour into the kettle 110 gallons of the lye and heat. After an ebullition of five or six hours, the grain of the soap is well developed, and forms hard and dry scales, when pressed between the fingers. Continue the ebullition for a few hours, and when the soap is saturated, the foam which covered it disappears entirely, and that which is left is very light and white. If the oil used is of a good quality, the kettle emits an odor somewhat similar to that of the violet; the heat is stopped off, and after resting for a few hours, the lye is drawn off. This lye by being passed over a mixture of soda and lime half exhausted, becomes clear, limpid, and caustic, and may be used anew to separate the soap in a subsequent operation.

When thus saturated, this soap contains only 16 per cent. of water, and is very alkaline and caustic. Its coloration is due to the use of crude sodas and especially to the presence of the sulphuret of sodium, always existing in these sodas, which combine with the oxide of iron, also existing in the sodas, and gives rise to a sulphuret of iron which colors the soap. To refine it, it is necessary to submit it to a last operation called fitting, and *liquidation* by the French soap-makers.

§ 4. Fitting.

To transform into a pure white soap the mass of soap which has a bluish-gray color, it has to be dissolved by degrees in weak lyes with the aid of heat. To begin, pour into the kettle from 125 to 150 gallons of soft lye at 8° to 10° and apply heat. When the soap is very warm, stir it briskly. Under the influence of heat, of the lyes and the stirring, the grain dilates, softens, and looks as if half melted in the lye. When in this state slacken the heat, and after a few hours' rest, draw off the lye.

By this first operation, the paste begins to be deprived of the coloring matter and the excess of alkali it contains, but it is still caustic. To complete its refining, pour into the kettle from 50 to 60 gallons of soft lye at 5° or 6° and heat gently, stirring the paste all the time from the bottom to the surface. By agitation and heat, the paste becomes more and more fluid, but is yet separate from the lye. As its refining can take place only when completely liquefied, to obtain this result, add from time to time a few pailfuls of lye at 2° or 3°, continuing the heat and the stirring. When it has become fluid, and the liquid, brought to the surface by the stirring has a blackish color and is viscous, the operation is finished, because the coloration is due to the precipitation of the alumino-ferruginous soap—and the viscosity to the complete liquefaction of all the parts of the paste.

When in this state, stop off the heat, cover the kettle and surround it with woollen blankets, so as to retain the heat as long as possible. By resting and the heat of the mixture, the metallic soaps and the excess of alkali precipitate to the bottom of the kettle, with the

fat of the soap and the excess of weak lyes used in this operation.

After a rest of 36 to 40 hours, uncover the kettle, and take off carefully the skum formed on the surface. Decant the soap with large iron ladles, and pour it into wooden frames. When the black soap begins to be seen the operator must be careful not to disturb it, since its mixture with the white soap would render it less neutral and less pure. When all the soap is in the frames it is well stirred so as to have it perfectly homogeneous; if not stirred, it would present veins and even spots of lye.

When the soap is completely solidified in the frames, it is flattened by beating it with large wooden beaters. This operation renders the soap more compact and heavier, it is useful also to fill the vacant spaces due to the air interposed in the soap. In conclusion, the beating of the soap fulfils two essential conditions: 1. It increases its specific gravity; 2. It destroys its porosity.

A few days after, the frames are opened. The block of soap is divided into cakes by the usual methods.

Recently manufactured, this soap is always a little soft. To give it the firm consistency required in commerce, it is exposed for a few days to the air in the drying-room, then it becomes solid enough to be packed in boxes. Exposure to the sun, or too elevated a temperature must be avoided, for heat always communicates to it a more or less yellow shade.

When the soap is not to be sold immediately, the boxes containing it are stored in a cellar. A few weeks after it has acquired the whiteness and solidity which distinguish fine Marseilles soap.

Well-prepared white soap from olive oil constitutes, as

we have before said, the purest soap of commerce. One hundred parts of this soap are thus formed:—

Fatty acids	50.20
Pure soda	4.60
Water	45.20
	100.00

By operating under favorable circumstances, that is, using the purest and whitest olive oil, and the best quality of artificial soda, the 2250 pounds of oil will give:—

Soap of skum	157 to 225
Pure white soap	2925 to 3040
Black soap	675 to 790

We see by these numbers that 2250 pounds of oil give as a maximum 3040 pounds of soap, or 135 pounds of soap for every 100 pounds of oil.

The black soap left in the kettle as a residuum of the operation is separated, while warm, from the weak lyes with which it is combined, by means of lyes of coction at 20° to 25°. It is then run into a frame and allowed to cool.

In a regular mode of working, this black soap is introduced into a new operation, and gives by refining a new quantity of pure soap by the precipitation of the coloring matters it contains.

This method is not without inconveniences, because this mass of black soap introduced into each new coction impairs the whiteness and purity of the soap. It would be more rational to use this residue in the fabrication of marbled soaps.

CHAPTER XXXII.

SOAP MADE WITH BONE TALLOW.

Pasting—Separation—Coction—Fitting.

§ 1. Pasting and Separation.

To prepare this soap, introduce 1100 lbs. of bone tallow of good quality, into a sheet-iron kettle of a capacity of from 450 to 500 gallons. Melt the tallow by a gentle heat, and when melted pour into the kettle from 75 to 90 gallons of lye of soda ash at 10° to 12°. Stir the mixture well to render the combination more intimate.

Continue to heat gently, and when the mixture begins to boil, an abundant skum is formed which disappears in a short time. By the ebullition, the paste becomes more and more concrete, and by stirring it produces a noise similar to the rattling of scales. This operation often presents some difficulties; it happens ordinarily, that after a few hours' of ebullition a part of the tallow separates and floats on the surface; this inconvenience is remedied, by pouring little by little into the kettle from 35 to 50 gallons of soft lye at 15° to 18°. By this addition of lye which is incorporated in the mass by stirring, the oily part which swims, and which is almost entirely formed of the olein of the tallow, saponifies easily, and the mixture has then the appearance of a homogeneous mass of a grayish-white color.

To give the paste all the proper consistency, boil it for a few hours, adding every hour from six to eight gal-

lons of sweet lye at 20°. This first operation lasts from 10 to 12 hours. The lyes must be as caustic as possible, especially those used in the first operation. It will be very difficult to prepare a good soap with tallow, if the lyes are not entirely decarbonated.

The pasting being finished, turn off the heat and proceed to the separation of the aqueous lyes. This operation is conducted in the same manner as for the other soaps, by pouring into the kettle lyes of coction at 20° to 25°. To avoid coloring the paste, lyes from white soap must be used; if none can be had, new lyes at 15°, in which 12 lbs. of salt are dissolved for every 25 gallons, are employed.

Soon, the soap becomes granular, it contracts and abandons the old lye with which it was mixed. To render the operation quicker, stir the mixture all the time the lye is being added. The quantity of lye necessary to effect the separation, is from 75 to 80 gallons at 25°.

The separation being terminated, let the whole settle a few hours, and then draw off the lye, which is colored and marks when cold from 14° to 15°.

§ 2. Coction.

Pour into the kettle 100 gallons of lye of soda ash at 25°, and heat briskly, for there is no fear of burning the soap which remains on the surface on account of the greater specific gravity of the lye. Boil thus for ten or twelve hours, adding every hour 6 gallons of lye at 25°. After an ebullition of five or six hours, the soap begins to acquire a firm consistency, but the coction is finished only when the soap forms thin scales when pressed between the fingers, without leaving a greasy feel, which is a sign that it is not entirely boiled. If this be the case,

continue the ebullition for a few hours, after pouring into the kettle from 12 to 20 gallons of lye at 25°.

The coction may be completed in two services, by using in the first, lyes at 15° or 20°, and for the second, that at 25°.

When the soap has boiled long enough, turn off the heat, let it settle two or three hours and draw off the lye. About half of the lye used is recovered; it marks from 28° to 30°.

§ 3. Fitting.

For domestic uses, this soap is liquefied with lyes of soda ash at 4°. To begin the operation pour into the kettle 62 gallons of lye at the degree indicated. Boil gently for 1½ to 2 hours, stirring from time to time. The liquefaction is carried so far only for refined soaps used to make fancy soaps. It is ascertained that the operation is finished when the grains of the soap have become soft, flat, and are very little separated from the lye. If the quantity of lye indicated above is not sufficient to bring the soap to this state, new portions may be added of the same degree, or even pure water, but weak lye is to be preferred. At this point turn off the heat and cover the kettle carefully.

By resting, the soap separates from the lye which remains at the bottom. After five or six hours, and while the soap is yet warm and fluid, it is run into wooden frames, being careful not to mix it with lye. It is stirred for some time in the frame so as to have it free from spots and veins. The lye left in the kettle after the extraction of the soap, marks from 10° to 12°.

After seven or eight days, the soap has acquired the proper consistency to be divided; the frame is opened and

the block of soap is divided into cakes in the usual manner.

Bone tallow gives a soap of good quality, and of a firm consistency; but like all soaps made with animal greases, it has a peculiar odor which recalls its origin. This odor may be modified by different perfumes more agreeable, such as the common oils of thyme, lavender, etc. It is sufficient to add two ounces of one of these oils to every 100 lbs. of soap, to mask the odor. This addition is made a short time after the soap has been introduced into the frame, and while it is still fluid.

Prepared by this process, this soap has a white color, slightly grayish; but the whiter the tallow used, the whiter the soap.

One hundred pounds of tallow yield 165 lbs. of good soap, and if the tallow is of the first quality, the amount obtained is 170 lbs., and sometimes more.

We recommend the use of lyes of soda ash to prepare this soap. Lyes made from crude sodas can also be employed, but then the soap is not so white, and requires for its purification a more complete liquefaction, by which about one-fifth of its weight will be a black and soft soap, which has very little value. By using lyes of soda ash, the whole of the soap is white, and there is no loss.

The process is the same if horse grease, old tallow, etc., are used; the only condition to be observed is to proportion the quantity of lyes to the quantity of fatty matter to be saponified.

CHAPTER XXXIII.

SOAPS MADE WITH OLEIC ACID.

Preparation of the Lyes.—First Process—*Pasting—Separation—Coction—Fitting—Drawing off—Amount of Soap obtained.*—Second Process—*Pasting—Coction—Fitting—Agitation.*—Third Process—*Fitting.*

Soaps obtained by the saponification of the oil of tallow, and other animal greases, are called oleic-acid soaps. We have thought that it will interest many to read a summary exposition of the different processes used for separating the immediate principles which constitute fatty bodies.

For a long time chemists had supposed that the composition of fatty substances was very complex; but the imperfection of the analytical processes then in use had not yet enabled them to make an exact analysis. Braconnot succeeded in separating the liquid part of vegetable oils and animal greases by simple pressure in blotting paper. This process—as simple as ingenious—by indicating that these substances were composed of several immediate principles, was a step towards the truth. But it was only after the beautiful experiments of M. Chevreul that the composition of the fatty bodies was well determined.

But these experiments—whilst very interesting in a scientific point of view—would have been useless for the arts, if practical processes had not been discovered for preparing stearin and oleic acid.

The first important improvement was the substitution of lime for potash or soda, in the saponification of fatty bodies. A calcareous soap is thus obtained, which is decomposed by sulphuric acid, in wooden vats lined with lead, and heated with steam. In this reaction the acid combines with the lime to form a sulphate of lime; while the fatty acids, set free, form an oily layer on the surface of the acid liquid. The fatty acids are decanted and washed at first with water containing a little sulphuric acid, so as to separate the lime they may yet contain; afterwards they are washed two or three times with boiling water.

After resting a few hours, the fatty acids are decanted into sheet-iron moulds, capable of containing from 10 to 12 pounds of material. The mass becomes solid in 15 to 18 hours, according to the season; it is a mixture of stearic, margaric, and oleic acids.

To separate the oleic acid from the stearic and margaric acids, which are the solid principles, the mixture is submitted to two successive pressures, the one without, the other with the aid of heat. By pressure oleic acid separates from the concrete acids which remain in the cotton-bags, in the form of cakes; these acids, purified by different processes, are used to make candles.

The principal residuum of this operation is the oleic acid, and it is the only product which interests us at present. As it comes from the press, this acid is strongly colored brown; it contains a little water, and a small quantity of stearic acid. By cooling and resting, the margaric and stearic acids separate in part from the oleic acid, and it is in this state that it is sold to soap manufacturers. When the temperature is at 40°, or above, this acid is limpid; its color is a reddish-brown; it has

very little odor. Its specific gravity varies between 0.920 to 0.940.

It combines very readily with potash and soda, and forms with the latter soaps as much harder as the quantity of stearic and margaric acids it contains, is greater. It is well ascertained now that oleic acid forms soaps of first quality, not inferior to the best Marseilles soap.

Oleic acid obtained by the saponification of tallows by lime is not the only one found in commerce; there is also the distilled acid. This latter is obtained by a very ingenious process, of English origin, but which is extensively practised in other countries. This process—known by the name of *sulphuric saponification*—consists in heating tallow to a temperature of 122° to 140°, and treating it by its weight of sulphuric acid at 66°. By using so much acid, the saponification is nearly instantaneous, and when the reaction is finished, the fatty acids are decanted and washed with boiling water. These acids are distilled in a suitable apparatus, placed in a metallic bath, with the aid of super-heated steam.

After the distillation, the acids are run into sheet-iron moulds, and after cooling, are submitted to the action of the press in the same manner as in the process of saponification by lime.

Oleic acid obtained by the two processes as above, has very different properties, and it is essential for the manufacturer to know how to distinguish them. Distilled oleic acid has generally a more intense coloration than that obtained by the other process. Besides, it has a decided empyreumatic odor, while the other is nearly odorless.

But there is a method of ascertaining its nature, which is more exact, and more certain; it consists in treating one pound of the acid to be tested by one pint of a caus-

tic lye of soda ash, at 30°, and in boiling gently the mixture for three or four hours; after turning off the heat, the soap is separated from the excess of lye, and is melted in another kettle with two or three ounces of water. When homogeneous, it is run into a frame, in which it is left for 25 or 30 hours. By examination it is ascertained if the soap is made with pure or distilled acid—in the first case the soap is hard, and without odor; its cut is smooth and homogeneous.

The distilled acid, on the contrary, produces soaps wanting in cohesiveness and aggregation; they never acquire any consistency, and they have an odor of empyreumatic oil so pronounced that this odor alone is sufficient for its recognition.

The manufacture of oleic acid soaps requires several operations, which are the preparation of the lyes, the pasting, the coction, the fitting, the running and stirring of the soap in the frames. We shall describe each one with all the developments necessary for such an important industry.

Preparation of a Lye at 28°.—The lyes used for the saponification of oleic acid are generally prepared with the qualities of soda ash that are richest in alkali, and which are decomposed by lime. Insoluble carbonate of lime is formed and the clear liquid constitutes the hydrated soda or caustic lye. To prepare a lye at 28°, heat in a sheet-iron kettle, of a capacity of 450 to 500 gallons, 250 gallons of water. When sufficiently warm, dissolve in it 790 pounds of soda ash at 80° or 85°. When the alkali is dissolved, add to the liquor in several portions, 260 pounds of recently burned lime well slacked, and stir well to facilitate the mixture. When all the lime has been introduced, check the heat, and let the liquid clarify of itself. To avoid the absorption of the car-

bonic acid from the air, the kettle is to be closely covered.

After twenty-four hours, decant the clear liquor, which constitutes the soap-maker's lye. The residuum of lime is deprived of the alkali it contains by several washings with water.

To ascertain if the lime is well burned, dip a piece into water, and after an immersion of one or two minutes expose it to the air; if of a good quality it falls into a powder in a few minutes. This is the method most generally employed in soap factories, but some manufacturers have ascertained that lyes made without heating are preferable.

In this case the operation is conducted as follows:—

1. Several filters of strong sheet iron and about four feet dimension in all directions, are each placed above a special receiver or cistern destined to receive the lyes. This receiver is made of good bricks, and lined inside with a thick coat of cement.

2. Each filter is provided with a false bottom of sheet iron pierced with holes, which is supported on small blocks at about three inches from the bottom of the filters. These filters, however, are similar to those we have described for preparing the lyes of crude soda. The lyes are prepared by decomposing the carbonate of soda (soda ash) by hydrated lime (slacked lime).

For 1000 pounds of soda ash at 80° to 85° use 380 pounds of lime, that is 38 per cent. of the weight of the soda.

It is very important to have the lime as pure as possible and completely caustic.

To slack the lime, it is sprinkled with a sufficient quantity of tepid water; this liquid unites with the lime, the mixture grows warm, dilates and increases in

volume. When the reaction is finished, there remains a light white powder of hydrated lime.

When the lime is thus prepared, it is thoroughly mixed with the soda ash and the mixture is put in heaps and allowed to stand so as to have it grow warm; after a contact of two hours the mixture is introduced into the filters, on the bottom of which a bed of straw has been spread.

All the filters being thus charged, the mixture is watered at first with very weak lyes which have passed through old residues to exhaust them. When the mass is well soaked, it is then covered with the same liquid.

After 18 to 20 hours, the liquid which has filtered through the mixture, is then drawn off into the receivers placed under the filters. If the mass has grown very warm, these first lyes must mark from 33° to 34°. By drawing off all the liquid, the lye marks from 27° to 28°.

The quantity of liquid drawn off is substituted by the same quantity of weak lyes or fresh water. After 12 hours, the lye is drawn off; a new addition of water equivalent to the quantity of lye obtained, gives a third lye, but of a feebler degree than the first two. By continuing to wash the filters with water, until all the alkali is completely dissolved, very weak lyes are obtained, which are generally used to lixiviate new materials.

When the residue is completely exhausted by water, lyes of coction may be filtered through it, and they become perfectly limpid. The residue is then thrown away.

Fabrication of Oleic Acid Soaps.—The time required for effecting the saponification of oleic acid varies according to the season, the mass operated upon, and the degree of causticity and concentration of the lye used. In

operations made under good conditions, the time for saponifying 2250 pounds of oleic acid is from three to four days.

The manufacturers of soap often mix oleic acid with common tallow or animal greases. The proportions of these two substances are generally from 30 to 40 per cent. of the weight of the oleic acid. The soap is firmer, whiter and finer, and is generally preferred to that made with oleic acid alone.

FIRST PROCESS OF FABRICATION OF OLEIC ACID SOAP.

§ 1. Pasting.

We suppose an operation made on 2250 pounds of material, composed in the following manner:—

Oleic acid	1350 pounds
Common tallow	900 "

To begin the operation introduce the oleic acid into a sheet-iron kettle of a capacity of from 700 to 750 gallons. Heat, and when the oleic acid is liquefied and melted, pour, little by little, into the kettle, about 100 gallons of lye of coction at 22° to 25°. The addition of 20 to 25 gallons of new and caustic lye at 28° renders the operation easier and quicker.

When the lye falls on the oil, it is transformed into a compact mass of a spongy appearance. According to chemists, this effect is due to the spontaneous saponification of the margaric and stearic acids held in solution in the oil, and to the formation of margarate and stearate of soda; the oleic acid is the last to saponify.

Heat gently for five or six hours, stirring from time to time, so as to facilitate the solution of the grains of soap;

this result is more easily obtained by adding to the mass lyes of coction in small portions. When the whole is well melted, boil gently, until an abundant foam is produced on the surface; moderate this effervescence by a continual stirring, and if necessary by a new addition of 12 to 15 gallons of cold lye at 20° to 25°. Care must be taken that the material does not swell too much, for it would be difficult to stop the ascensional movement of the mass, except by adding new lyes, which in this case would be a useless expense.

In boiling, the paste must separate from the lyes, and form small grains; when in this state, boil again for two hours, and the first stage of the operation is completed.

This operation finished, turn off the heat, and give a rest of eight or ten hours, to obtain the separation of the lyes which are drawn off.

The pasting of the oleic acid being complete, proceed to that of the tallow: For this purpose, after the lyes have been drawn off, introduce into the kettle the 900 lbs. of tallow which are saponified with 75 gallons of good new lye at 20° to 28°, stir for some time to facilitate the combination of the lyes with the tallow and let the whole rest all night. On the next day heat the mixture. Under the influence of heat, the last grains which were formed during the pasting of the oil, melt and gradually disappear. It is during this stage of the operation that the pasting of the tallow takes place. Care must be taken to stir near the bottom, for without this precaution the paste will attach itself to it; it is perceived that this effect takes place when a white smoke escapes from the mass, and the stirring brings to the surface of the kettle hard crusts which are burned soap; a continual stirring prevents this inconvenience.

The pasting being completed, turn off the heat, and proceed to the separation.

§ 2. Separation.

This operation must be conducted carefully. To begin, pour little by little and in doses of three or four gallons at a time, lyes of coction at 22° to 25°; on the contact of the lyes, the soap is covered with an abundant foam, which is only moderated by a continual stirring by means of an iron shovel pierced with holes, and known in manufactories by the name of evaporating shovel. It is necessary, as we have said before, to throw the lye on the paste only by small portions at a time, and wait, before introducing new portions, until the effervescence produced by each addition of lye has ceased. The lye must be thrown slowly, so that it may heat gradually before touching the bottom of the kettle.

Continue to pour on the same lye, being careful to stir the mixture all the while; the operator must be attentive to the movement of the paste. In the beginning of the operation it is viscous, but as the salted lye penetrates it, it changes in appearance, and when the separation begins to take place, it is transformed into small grains which float in the lye. To ascertain if the separation has really taken place, pour a certain quantity of the paste into a tumbler; if right, after a few minutes' rest, the soap floats, and the lyes occupy the bottom of the glass.

It is important not to stop at the first signs, which indicate that the separation has taken place, for the paste still contains a certain quantity of old lye which has to be eliminated. To obtain a more complete separation, pour into the kettle from 38 to 50 gallons of the

same lye, and after an energetic stirring of about thirty minutes, when the paste is well separated and in fine grains, let it rest. As said before, a thick and abundant foam is formed at the surface of the soap, and disappears only during the coction. This foam is due to the reaction of the oleic acid on the carbonate of soda dissolved in the lyes, the carbonic acid is disengaged and causes the rising of the mass.

When the soap is entirely separated, which generally takes place in eight to ten hours, it is ready for the process of coction, as soon as the lyes are drawn off.

We must observe, that the second lyes drawn off from the kettle may be revivified and used in some other operation. The revivification is managed in the same manner as indicated for marbled soap.

§ 3. Coction.

The object of this operation is to complete the saponification of the fatty matters. It is necessary to obtain soaps of a good quality. Its duration varies according to the quantity of the materials and the degree of concentration of the lyes. For 2250 lbs. of fatty matters, the operation lasts about two days. It is subdivided into two services of new lye.

1. *First Service of Lye.*—After drawing off the lye left in the kettle, pour on the paste about 90 gallons of good new caustic lye at 24° or 25°. Then heat gently, particularly at the beginning, for when the soap is boiling, it does not require much heat to continue the operation. By continuing the ebullition for eight or ten hours, the alkaline liquid is gradually exhausted of the caustic alkali it contains; but as during so long a boiling, evaporation takes place, and diminishes the volume of

the lye, from two to three gallons of the same lye must be added every hour.

By the concentration of the lyes, the soap becomes more and more compact; and at the end of the first service, the lye must mark from 25° to 26°.

When the lye marks 25° to 26°, turn off the heat; give a rest of five or six hours, and draw off. This lye, which has a very intense brown shade, and a salt taste, still contains a quantity, often considerable, of carbonate of soda. It is regenerated by the usual process.

2. *Second Service of Lye.*—The old lyes being drawn off, the coction is completed with very caustic new lyes, marking from 27° to 28°. Pour into the kettle from 60 to 75 gallons of lye, and heat; when the ebullition begins, moderate, if necessary, the action of the fire, so as to have for four or five hours a gentle boiling.

When the aqueous part of the lye is thus evaporated, and when the paste, saturating itself little by little with alkali, has acquired more consistency, the action of the heat may be progressively increased; as fast as the lye concentrates, the mass diminishes in volume, first by the reduction of the lye in the kettle, and also by the contraction which takes place in the paste. Care must be taken at this stage to watch the state of the soap. It sometimes happens that the soap sticks to the bottom of the kettle, and is burned.

To obviate this inconvenience, the bottom must be stirred often, and the heat must be moderated.

To obtain a complete saturation of the paste, add from time to time from two to three gallons of new lye at 27° or 28°. The contraction of the paste is such that, at the end of the coction, thick crusts of soap are formed at the surface, and to prevent their becoming too hard by exposure to the air, they are forced into the mass.

In conclusion, for the soap to be completely finished, it is necessary—

1. That the lye should be yet alkaline and caustic, after an ebullition of eight to ten hours with the soap, and mark, while hot, from 28° to 30°; such is the essential condition to have a well-grained soap.

2. That the soap forms, when pressed between the fingers, thin, hard, and dry scales, which are reduced to powder when rubbed in the hands.

When all the signs are favorable, turn off the heat, cover the kettle to retain the heat in the mass, and after resting eight or ten hours, draw off the lye, and proceed to the finishing operation, the fitting.

§ 4. Fitting.

Pour into the kettle from 100 to 125 gallons of limpid lye of separation at 6° or 7°. Heat, and when the soap begins to boil, two men stir the paste very briskly for half an hour. All the mass at this stage experiences the action of the lyes, the grain of the soap dilates; but after a few hours of a gentle ebullition, it is formed again, but larger, more viscous, and more pliant; the heat is continued, and from time to time a few pails of cold water are thrown on the surface. When, after a gentle ebullition, continued for four or five hours, the paste appears homogeneous and melted, the degree of the lyes must be ascertained. For this purpose, some is drawn off into a glass and allowed to cool; it must mark from 16° to 18°; below 16° the soap will be too soft, above 18° or 20° it will be too hard and too brittle.

In the first case, boil the mixture long enough to bring the lye to the degrees indicated (16° to 18°). In

the second, pour water into the kettle, in sufficient quantity to reduce the lye.

When the lye marks 16° to 18°, and when the soap well melted forms small homogeneous lumps, turn off the heat for a few minutes, and after stirring briskly for five or six minutes, cover the kettle and let it rest twelve or fifteen hours.

It is during this rest that the soap refines itself and is deprived of the excess of saline matters and lye it contains; but to arrive at a complete refining, it is important to keep the heat in the mass as long as possible. If the cooling of the soap should be too rapid, the lye would be imperfectly separated and the soap would be less neutral and less pure, that is why the kettle must be exactly closed, not only with a wooden cover, but with thick cloths; too great a loss of heat is thus avoided.

§ 5. Drawing off the Soap.

After the soap has rested twelve or fifteen hours, the kettle is uncovered, and the layer of foam on the surface is taken off with a skimmer. This exposes to view a soft and thick fluid paste with an agreeable odor. This is the soap, which is drawn off.

The soap is removed with large iron ladles and carried into the frames. This operation must be conducted carefully to avoid the introduction of lye into the soap. To obtain a smooth and homogeneous paste, the soap must be well stirred in the frames, and the stirring must be continued until the paste has become very thick and nearly cold. Without this precaution the soap would be unequal and stained.

After eight or ten days, the soap is taken from the frames and divided into bars, which are dried for 24 to 48 hours in the open air.

§ 6. Amount of Soap Obtained.

Experience proves that the product in soap is not always identical; many circumstances cause it to vary; the surest and most rational method of obtaining an exact valuation, is to take the mean proportional of several operations made in the same manner.

Forty-two operations of soap have been made, each formed of

Oleic acid	2700 lbs.
Bone tallow	1800 "
	4500 lbs.

For the forty-two operations there has been used

Oleic acid	113,400 lbs.
Bone tallow	75,600 "
	189,000 lbs.

Together, there has been produced 298,620 lbs. of soap, or 7100 lbs. by each operation, which represents 158 lbs. of soap for 100 lbs. of fatty matters.

We give below the cost of an operation consisting of 1350 lbs. of oleic acid, and 900 lbs. of tallow. These prices are obtained from a Paris manufacturer:—

	Francs.
Oleic acid, 600 *k.* *at* 88 *francs the* 100 *k.* . . .	528
Bone tallow, 400 *k.* *at* 80 *francs the* 100 *k.* . . .	320
Soda ash, at 80°, *at the rate of* 33 *per cent. of the weight of the fatty matters*, 330 *k.* *at* 60 *francs the* 100 *k.* . . .	198
Lime, to transform the carbonate of soda in caustic lye, at the rate of 35 *per cent.* 115 *k.* *at* 2.25 *francs the* 100 *k.*	2.60
Coal, to prepare lyes and heat the soap, 400 *k.* *at* 4 *francs the* 100 *k.*	16
Boxes	30
Divers expenses	15
	1109.60

Products Obtained.

1558 *k. of soap at* 82 *francs the* 100 *k.* . . .	1277.56
5 *per cent. discount* . . .	63.68
net product	1213.88

The profit will be 104 francs, 28 centimes, or $20.

This soap may also be made by saponifying each fatty body separately, and when the soaps are liquefied and ready to be run into the frames, they are mixed together. This process is more costly, but the soap is finer and whiter, and the amount obtained larger.

SECOND PROCESS OF FABRICATION OF THE OLEIC ACID SOAP.

In the first process we have described, we have seen that oleic acid was mixed with variable proportions of tallow, or other animal greases. Whenever these substances can be had at a low price, they should be used mixed with the oleic acid, for a larger quantity of soap will be obtained, which is much harder. But there are many establishments in which oleic acid alone is saponified, and as the process of fabrication is not entirely similar for both cases we shall now give a complete description of the best method to be followed for preparing this soap.

§ 1. Pasting.

The operation is done on 6750 lbs. of oleic acid.

The saponification is effected in a sheet-iron kettle of a capacity of 1870 to 2000 gallons, into which the oleic

acid is introduced and melted with the help of a gentle heat.* The acid being completely liquefied, pour into the kettle 125 gallons of new lye at 25°, and 250 gallons of lye of coction perfectly limpid at 25° to 30°. It often happens that by the reaction of the lyes on the oleic acid, the mixture considerably thickens and forms a compact mass; this effect is due to the spontaneous formation of stearate and margarate of soda, but as the heat increases, the mixture becomes clear, the grains gradually disappear and the mass becomes fluid.

Continue to keep up a gentle heat, and when the ebullition begins a considerable quantity of foam is developed on the surface of the soap. This effervescence is moderated either by slacking the heat, or by stirring all the time, or by pouring a few pails of cold water into the kettle. This rapid reaction is due to the action of the carbonate of soda, which, in contact with the oleic acid, abandons its carbonic acid, but this effect would not take place if the lyes used were entirely caustic. When this first effervescence has ceased, increase the heat, and continue to boil quickly; care must be taken to stir all the time, so as to multiply the points of contact of the lye with the mass. By continuing the ebullition, the lye becomes more and more concentrated by the evaporation. The nature of the paste is modified, and by a progressive saturation with alkali, it acquires consistency. However, even when the pasting is finished, the paste has not the consistency of the ordinary soaps; this difference is explained by the nature of the oil on which we operate, this oleic acid being nearly entirely formed of the oily and liquid part of the tallows, that is, of the part the least apt to form hard soaps. It is only after

* This acid is generally liquid at the temperature of 50° to 53°.

the paste is completely saturated with alkali that it forms a very consistent soap. This remark may be applied, at least, generally, to every fatty or oily substance in which olein predominates.

The time for the first operation, on 6700 lbs. of material, varies from twelve to fifteen hours. It is ascertained that the pasting is terminated, when the grains of soap formed at the beginning of the operation are entirely dissolved; then the heat is stopped off, and after resting ten or twelve hours the lye is drawn off.

Observations.—The pasting being finished, it is important to let the mass rest for ten or twelve hours, to permit the lye not combined with the soap to separate as completely as possible. If much of it is left in the paste, it will be troublesome in the coction, for two reasons: first, on account of the great quantity of neutral salts it contains, and which would render the soap less hard; then because it would weaken the degree of the new lyes of the first service, in such manner that the action of these lyes on the olein would be less efficacious than if the operation had been conducted with a paste less saturated with neutral salts.

Whilst colored, this lye is generally limpid, and may be advantageously used to liquefy the olein soap; but as it marks from 18° to 22°, it has to be reduced to 8° or 10° by the addition of water. It is then left to settle for a few days, and passed through an old residuum of exhausted soda ash and lime.

For 6700 pounds of oleic acid, the quantity of lyes drawn off after ten or twelve hours' rest, amounts to 175 to 200 gallons marking from 18° to 20°.

§ 2. Coction.

The coction is effected with new caustic and concentrated lyes of soda ash. Two services are generally sufficient to bring the soap to the point of complete saturation.

1. *First Service of Lye.*—All the lye of the first operation being drawn off, pour into the kettle from 225 to 250 gallons of fresh lye at 27° or 28°. Heat and keep the mixture boiling. At the beginning the ebullition must be gentle; too active boiling would dilate the mass considerably, and cause the soap to stick to the bottom of the kettle.

Thus, for the first hours the kettle must boil gently; it is true the soap is separated from the lye but slightly; its grain is not completely formed, and is yet soft, flaccid, and dilated; but it is proper to have it so, for in this half viscous state, the action of the lye on the oleic acid is more direct and more rapid than if the grain of the soap were prematurely formed.

During all this first stage of the operation it is very important—we repeat it—to boil gently and uniformly. A more complete and equal saturation of the oleic acid by the lye is obtained. The formation of too much foam is also to be avoided. Later—that is, after five or six hours of ebullition—the heat is progressively increased; by evaporation, the lye concentrates, and the grain of the soap becomes larger and firmer. While the lyes do not separate as completely as in the first service, it is easy to see that the soap is not so viscous, and is less greasy than at the beginning of the operation. To render the separation more complete, and to compensate for the loss due to the evaporation, add every hour, for the first six hours, from ten to twelve gallons of new lye at 27° or 28°; add

also, towards the end of the first service, fifteen gallons of salt water at 25°. The addition of salted water contracts the soap, and facilitates its separation from the excess of lye with which it is mixed.

Lastly, after twelve or fifteen hours of continual ebullition, turn off the heat, cover the kettle, and let it rest eight or ten hours. This time is necessary to have a complete separation. Draw off the lye, which is strongly colored brown, and marks while warm from 22° to 25°; frequently, on cooling, the lye solidifies into a gelatinous mass. Alone, or mixed with new lye, it is used in the pasting of oleic acid.

2. *Second Service of Lye.*—This service, which is generally the last, consists of new lye at 28° or 30°.

The lye of the first service being drawn off, pour into the kettle about 175 gallons of new lye at 28° or 30°. Heat; very soon the mass begins to boil; at first moderate the heat, but when, by an ebullition of five or six hours, the paste has acquired more consistency, the heat is increased; then add every hour, for six hours, about twelve gallons of lye of coction at 28° to 30°. These successive additions of strong lyes have for their object the complete saturation of the soap, and to replace the evaporated water.

Towards the end of the operation—that is, after an ebullition of twelve to fifteen hours, add, as in the first service, from twelve to fifteen gallons of salt water, at 25°; by this addition, the paste becomes denser and harder; its great consistency presents obstacles to the ebullition, which then becomes tumultuous. The foam which covered the soap has entirely disappeared; the soap is then in hard and dry grains, of a brownish color. However, the end of the operation is indicated by the following signs:—

1. When a little of the warm soap is put into the hand and quickly rubbed with the thumb, it instantaneously forms thin and hard scales, which fall from the hand without leaving on it any adherent particles.

2. When the foam which covered the surface of the soap has disappeared.

3. When, after fifteen hours of continual ebullition, the lye is yet caustic; to obtain the soap well grained, it is necessary that the lye extracted from the kettle, at the end of the operation, should mark 28° to 30°.

When these indications are well defined, the soap is completely saturated with lye. Turn off the heat, cover the kettle, and, after resting ten hours, draw off the lye.

§ 3. Fitting.

For this operation, the lye of the pasting or a new lye can be used. The first slightly colors the soap, but deprives it more completely of the excess of caustic alkali it contains; the second does not color it, but sometimes causes an efflorescence of carbonate of soda; it is then better to use the first. As it generally marks from 18° to 20°, it is reduced to 8° or 10° by diluting with water.

The operation is conducted as follows:—

Two men stir the paste continually, while a third pours in the lye at 8° to 12°. Heat strongly, so as to keep the mixture very warm, for it is by the combined action of heat, stirring, and the successive additions of weak lyes that the grain of the soap is broken and refined, by depriving it of the excess of caustic alkali and saline substances it contains.

It is only when the paste is sufficiently impregnated with weak lye, and has acquired a temperature near the boiling point, that it becomes homogeneous and fluid; the

soap has then the form of soft, dilated, and flat grains. Generally from 250 to 300 gallons of lye at 8° or 10° are used in the operation. When the soap is entirely melted and floats in the lye, boil the mixture gently for a few hours; and to prevent the soap from again becoming granular by the concentration of the lyes, add from time to time a few pailfuls of water or of lye at 2° or 3°.

In consequence of the movement caused by the ebullition, an abundant foam appears on the surface of the soap; this foam consists of the most impure parts of the paste, and is strongly salted. It is known that the operation is finished, when the paste which is under the foam is smooth, fluid, and homogeneous; the density of the lye at the bottom of the kettle is also a sign to indicate when the paste has been macerated long enough. When cold this lye marks from 17° to 18° at the end of the operation. If below 15°, the soap would be less consistent and less firm; above 19° or 20°, it would be too hard. Thus, the proper degree of density of the lye ought to be, when cold, from 17° to 18°.

This result being obtained, the heat is stopped off, and the kettle well covered, so as to retain the heat in the mass as long as possible—an essential condition for a complete separation of the saline matters and the lye. Indeed, if the cooling should be too rapid, not only the soap will not be deprived of its heterogeneous and saline parts, but it will contain a considerable portion of lye, which then renders the soap less neutral and less pure.

After resting forty or fifty hours, the kettle is uncovered, and the scum on the surface of the soap carefully removed. This scum is introduced into a new operation.

The soap, which is fluid, syrupy, and well melted, is dipped out with large iron ladles, and carried to the frames.

If an iron-wire sieve is placed above each frame, and the soap passed through it, the foreign substances contained in the paste will be separated. The bottom of the kettle being reached, care must be taken not to dip up any of the lye mixed with the soap; the latter is always easy to recognize by its golden color, while the lye has a brown, blackish shade. As soon as the lye appears, manage the ladles in such a manner as only to remove nothing but the surface matters; but whatever is the care taken, there is always a small quantity of lye mixed with the soap. To prevent the inconveniences which would result from the mixing of the lye with the refined soap, it is better to pour the last portions of soap into a cylindrical vessel, provided with a cork at the bottom. By resting the lye precipitates, and the soap specifically lighter floats on the surface; then draw off the lye, and pour the soap into the frames.

Paris manufacturers slightly perfume this soap, to mask the generic odor of the oleic acid; they generally add two ounces of artificial oil of bitter almonds for 100 pounds of soap. This addition communicates to the soap a slight and agreeable perfume.

§ 4. Stirring the Soap in the Frames.

It would not have been enough to bring the soap to the proper point of coction and purification, if it could not be had perfectly homogeneous. It is true the soap would have the essential qualities which constitute a good oleic-acid soap; it would be foamy and detersive, but by the slow and gradual cooling it experiences in the frames, irregular marblings would be formed; it might even be often spotted by the lye, which would give it a very defective appearance.

To obtain the soap with a smooth and homogeneous paste, it must be submitted to the stirring operation, which consists in agitating the soap in the frames. The stirring must be continued until the soap becomes nearly pasty, which is easily ascertained by the difficulty of moving the stirrer.

The equality and perfect homogeneity of the paste, depend essentially on the stirring in the frames; the more complete the stirring, the finer will be the soap.

This operation is performed on all soaps, except the marbled soap, the marbling of which would be destroyed by stirring.

The time of the stirring varies according to the nature of the pastes, their more or less complete liquefaction, and their temperature at the time they are introduced into the frames.

But, as a general rule, soaps composed of fatty matters in which stearin exists in small proportions, and the liquefaction of which has been pushed too far, require a longer stirring than those made of fatty matters very rich in stearin. The stirring of olive soaps run into frames of about 2000 pounds, lasts from eight to twelve hours, according to the season; the stirring may be discontinued when the temperature of the mass is reduced to 110° or 120°.

After eight or ten days the frames are opened, and the soap divided into large cakes. These cakes are afterwards subdivided into square cakes, weighing about eight pounds.

Thus prepared, this soap is brownish-yellow, but by being exposed to the air, it becomes white. At first its consistency is somewhat soft, but it becomes hard in a short time. When well prepared it is very detersive; in

water it produces a very abundant lather; it is one of the best soaps.

By the saponification of 6750 pounds of oleic acid of good quality, the amount of soap obtained is 10,687 pounds, or 155 per cent.

The viscous lye from which the liquid soap has been drawn off, being mixed with 10 per cent. of salt water at 25°, and boiled for seven or eight hours, produces from four to five per cent. of its weight of a good soap, which only requires to be dissolved in a weak lye to get rid of the excess of saline substances it contains.

This soap being mixed with the other increases the amount obtained from 155 per cent. to 158 or 160.

When the soap is to be moulded it is divided into square cakes, weighing one pound, and dried in the open air in summer, and in a drying-room in winter.

When sufficiently dried, the cakes are moulded in a matrix, and then put up in wooden boxes, each box containing 100 cakes, the total weight of which is 100 pounds.

THIRD PROCESS FOR MANUFACTURING OLEIC-ACID SOAP.

In the two processes above, we have seen that the fabrication of this soap requires several successive operations; these processes are indeed the best, when the saponification is conducted with large masses of oleic acid, for then the soap is whiter. But if only a few hundred pounds are wanted, except the purification or fitting, it may be manufactured in a single operation by the following process :—

In a sheet-iron kettle, of a capacity of 250 to 300 gallons, introduce 450 lbs. of oleic acid. Heat it so as to render it liquid, and then pour on it 50 gallons of caustic

lye of soda ash at 28° to 30°; boil the mixture gently for three or four hours, then add 25 gallons of salted lye at 25°, which may be substituted by 12 gallons of a solution of salt at 20°.

On the introduction of this lye the soap is covered with an abundant and tenacious foam, which disappears only after an ebullition of seven or eight hours. It is known that the soap is completely saturated with alkali when it forms thin and hard scales when pressed between the fingers. If the quantity of new lye used is not sufficient to bring it to that point, add a new quantity of ten or twelve gallons, and continue the ebullition until the lye in the kettle marks 28° to 30°; or what is more certain, until the soap forms hard scales when pressed between the fingers.

To saponify the above proportions, the operation lasts ten or twelve hours. The soap being then in separate grains, the heat is stopped off, and the kettle covered. After a few hours' rest, draw off the lye and proceed to the fitting.

Fitting.

To liquefy the soap, pour into the kettle 25 gallons of salted lye, diluted with water, so as to have it mark 10° or 12°.

The lye being in the kettle, give a good heat, but without ebullition. The softening of the soap is rendered more easy by stirring it. When melted, it is in flat grains of a viscous appearance. The lye of the kettle must mark while warm from 16° to 18°. When in this state the heat is turned off, the kettle is well covered, and after resting fifteen or twenty hours the soap is run into the frames. The lye left at the bottom of the kettle is

much colored, and often acquires a gelatinous consistency on cooling. It contains a little soap in solution, which may be extracted by boiling it with salt.

This soap may also be liquefied by using pure water instead of lye. For this purpose, it is sufficient to pour into the kettle from 15 to 18 gallons of water, being careful first to draw off the strong lye. The operation is then conducted as above. With these proportions of water, a lye at 16° or 17° is obtained; the heat is then stopped off, and after resting fifteen or twenty hours, the soap is run into the frames. In both cases it is stirred until cold.

This second process is as good as the first, only the soap is not so firm, although it is purer and whiter. This soap is of very good quality; its consistency may be increased by adding to the oleic acid 10 per cent. of white tallow.

The amount obtained is from 152 to 155 lbs. for 100 lbs. of oleic acid.

CHAPTER XXXIV.

RESINOUS SOAP.

FIRST PROCESS—*Tallow Soap—Rosin Soap.*—SECOND PROCESS—*English Process—Dunn's Process—Meineke's Process.*

FIRST PROCESS.

INTO a sheet-iron kettle of a capacity of 625 to 750 gallons, introduce 1000 pounds of tallow which is melted by the aid of heat. When completely melted, it is

saponified with about 75 gallons of new caustic lye at 7° or 8°. While pouring the lye into the kettle, which consumes about twenty minutes, the mixture is well stirred to facilitate the combination of the alkali with the tallow. All the lye being introduced, increase the heat, and continue stirring the paste for 25 or 30 minutes; then stop the stirring. The mixture has become very white and very emulsive, the lye and the tallow are perfectly combined and form a viscous and homogeneous paste.

One hour after the last addition of lye, the ebullition is manifested by a tumultuous movement in the mass and the formation of a very abundant white scum. The action of the heat must be moderated and the paste stirred with a skimmer. If these precautions are not sufficient a few pails of cold water or weak lye are thrown into the kettle.

When this effervescence has ceased, the scum diminishes, and soon disappears entirely, when the soap boils uniformly. The paste is homogeneous, of a white color, slightly yellowish. Continue to boil gently; by boiling, the mixture becomes more and more intimate and perfect, and it acquires more consistency by the evaporation of the water of the lye. Continue the saponification with lyes at 15° to 18°, which are added in portions of six gallons at a time, every fifteen minutes, for one or one and a half hours. After the last addition of lye, continue to boil gently for a few hours without adding new doses of lyes. By continuing the ebullition, the paste is saturated slowly and gradually with alkali, it becomes denser and firmer, and may then receive stronger lyes without fear of having the tallow separate from the already saponified mass. There would be danger of separation if too strong lyes were used when the paste is imperfectly saturated with alkali. To prevent this incon-

venience, the mixture is boiled for a few hours after the addition of the lye. The object of this ebullition is to render the union of the molecules more intimate and more complete.

At last, the saponification is finished with 25 gallons of new lye at 20° to 25°, which is added by six gallons at a time, every ten or fifteen minutes. All the lye being poured in, the heat is stopped off and the mixture stirred for half an hour. By its combination with the strong lye, the paste thickens and acquires a consistency proportional to the quality of the tallow.

The time of this operation varies between eight and ten hours.

§ 1. Separation.

This operation is conducted with lyes of coction perfectly limpid, and marking from 20° to 25°. A man stirs the mass, while another adds the lye in small portions at a time.

When the quantity of lye is sufficient to determine the separation of the soap, a spontaneous change takes place in the condition of the paste, which forms small grains between which the lye is interposed. When the separation is completed, which is known when the lye abundantly separates from the soap, the operation is finished; however, the stirring is continued half an hour longer. If lyes of coction are not to be had, dissolve from 50 to 60 pounds of salt in about 75 gallons of new lye at 15° to 18°, and use it instead of lyes of coction; the separation will occur all the same, although the paste will contain an excess of salt; the use of lyes of coction is, therefore, to be preferred, whenever it is possible to obtain them. Seventy-five gallons of such lye at 20°

to 25°, or the same quantity of new lye after the addition of salt, are sufficient to effect the separation.

After resting five or six hours, the lye which marks from 12° to 15° is drawn off.

§ 2. Coction.

All the lye being drawn off, pour into the kettle about 75 gallons of new caustic lye at 24° or 25°, and heat the kettle.

When the ebullition begins, an abundant foam appears on the surface of the soap. This foam disappears only when the soap is entirely boiled. If after five or six hours of continuous ebullition, the lye is yet caustic, it must be boiled until all the foam has disappeared; if, on the contrary, the lye has lost all its causticity, pour into the kettle 75 gallons of new lye at 30°, and boil for four or five hours.

When the operation is finished, the soap is in the form of very hard and white grains, which, when pressed between the fingers, are reduced into scales; the heat is then stopped off, and the mass allowed to rest four or five hours; after this the lye is drawn off, the quantity of which is generally from 50 to 60 gallons at 27° or 28°.

§ 3. Fitting.

This operation is effected by pouring into the kettle 55 gallons of water, and heating to the boiling point, being careful to stir all the time. When the grains of soap are well melted and have the appearance of little flat molecules separated from the lye, the operation is finished. It is known that the soap is separated from the lye when, by taking out the stirrer, the lye is

seen running down in a small colorless stream.* When this result is obtained, the heat is stopped off, the kettle is well covered, and the whole is suffered to rest seven or eight hours; after this time the kettle is opened and the soap decanted into the frames and well stirred during the cooling. But to prepare resinous soap, the tallow soap is left in the kettle, and, after draining off the lye, is mixed with a resinous soap obtained as follows :—

Resinous Soap.—In a sheet-iron kettle of a capacity of about 375 gallons, introduce 75 gallons of new lye of soda ash at 30°, heat, and when the lye begins to boil, throw every five or six minutes, and in quantities of 16 to 20 pounds at a time, 1200 pounds of rosin reduced to a fine powder, and passed through a coarse sieve. During the whole time the mixture is well stirred. It is essential to moderate the action of the heat, as under its influence, the rosin soap has a great tendency to dilate, and too much heat would make it boil over. It is necessary during the whole operation that the mixture should be at a temperature near the boiling point. If the heat is not high enough, the soap will thicken and become black. Kept near the boiling point it is always perfectly limpid; warm, its color is reddish-yellow, and it is very fluid.

If, notwithstanding a well-managed heat, the soap rises, the heat is to be turned off, and a few pails of cold water thrown into the kettle, which immediately moderates the ebullition. The stirring of the mixture is important and essential to the success of the operation; if not stirred, agglomerations of rosin will be formed, which prevent the lye from penetrating to the centre of the mass.

* If the quantity of water indicated causes the inviscation of the soap, it is sufficient to pour into the kettle a few pails of lye of coction at 20° to obtain the separation.

The saponification of 1200 pounds of rosin requires about two hours. When the soap is finished, it is very fluid, and all the grains have disappeared.

As soon as the soap is finished, it is poured into the tallow soap perfectly liquefied and separated from its lye.

The two soaps being united, they are crutched for half an hour, so as to render their union as intimate and as perfect as possible.

Before mixing the two soaps, it is necessary to pass the rosin soap through a coarse sieve of iron-wire, so as to separate the straw, pieces of wood, and other heterogeneous substances, with the rosin not saponified. By taking this precaution the soap is purer.

We must here call the attention of the manufacturer to a fact important to be noticed. Powdered rosin, kept in barrels, agglutinates and forms a compact mass in a few days. The influence of an elevated temperature accelerates the phenomenon. Consequently, it is necessary to powder the resin only twelve or twenty-four hours before using it.

The two soaps, after being mixed, are run into wooden frames. To have a homogeneous paste, the soap is well crutched in the frames, until a thick pellicle is formed on the surface, which generally takes place after five or six hours of stirring.

When the soap has the required consistency, it is taken out of the frames and cut into blocks about three inches thick, and then subdivided into bars, weighing about eight pounds. They are dried a few hours in the air, and then put into boxes.

Thus prepared, this soap has a firm consistency, and is slightly alkaline. When new, it has a tarnished pale-yellow color, which grows dark by the contact of the air.

It is one of the best soaps for domestic uses; it produces an abundant lather, even with sea-water.

By operating as indicated above, 1000 pounds of tallow and 600 pounds of rosin produce 2500 pounds of good soap.

SECOND PROCESS.

In the above process a soap of good quality is obtained, but of a very dark-brown yellow color. By modifying this process a soap of a much lighter color is obtained, but the amount is not so large.

To prepare it, introduce 250 gallons of lye of soda ash at 8° or 10° into a kettle of a capacity of 750 to 875 gallons. Heat, and when the lye begins to be warm, add 1600 pounds of white tallow. Bring the mixture gradually to the boiling point, and keep up the heat for five or six hours, stirring it from time to time. The ebullition must be gentle, to prevent too rapid an effervescence in the mass.

When the union of the substances is well effected, and the paste is homogeneous, add 50 gallons of lye at 15° and boil, to determine the thickening of the mixture; lastly, finish the saponification with thirty to forty gallons of lye at 20°, and stir the mixture for half an hour. Then the heat is stopped off, and the soap separated from its lyes by means of lyes of coction at 20° to 25°, in the same manner as indicated in the first process.

After a few hours' rest the lye is drawn off, and the coction proceeded with by pouring into the kettle from 175 to 200 gallons of lye of soda ash at 25°. If, after an ebullition of eight or ten hours the lye is yet caustic, and the soap forms thin and hard scales when pressed between the fingers, add from 600 to 800 pounds of fine yellow rosin.

By this addition the paste acquires a fine yellow color, and the grain of the soap becomes softer, and homogeneous. Continue the boiling until complete saponification of the rosin. To obtain this result, pour again into the kettle from 75 to 100 gallons of lye at 25° to 28°. It is known that the operation is finished when, by pouring a small quantity of the paste upon a cold body, it acquires in a few minutes a very firm consistency. A surer sign is when the lye is still caustic, after four or five hours of ebullition.

When the coction is finished turn off the heat; and after a few hours' rest, draw off the old lye.

To liquefy this soap, pour into the kettle from 100 to 125 gallons of lye at 4°, and boil the mixture, stirring the whole time to facilitate the liquefaction. When all the grains of soap are melted, and form a nearly homogeneous paste, a little of it is introduced into a test glass. If, after a rest of a few minutes the lye separates, clear and limpid, the operation is finished; if, on the contrary, the lye continues combined with the paste, a new dose of lye of coction, perfectly limpid, is introduced into the kettle, so as to determine a beginning of separation, which is easily ascertained, when the lye separates from the soap. This result being obtained, the heat is stopped off, and the kettle carefully covered.

By resting, the soap purifies of itself, and is deprived of the excess of caustic lye with which it was mixed. After twenty or twenty-five hours the kettle is uncovered, and the soap run into the frames, being careful not to introduce any of the lye which would render the soap efflorescent and caustic.

All the soap being in the frames, stir it until cold. If it is desired to give it a slight perfume, add to it one ounce of anise oil for 100 pounds of soap. Frequently

the anise oil is substituted by adding 15 per cent. of palm oil to the tallow, and the whole is saponified together. The palm oil communicates to the soap a very agreeable aromatic odor, and renders the color lighter and brighter.

When the soap has the required consistency, it is taken from the frames and divided into bars, which are exposed for a few days to the air.

The soap thus prepared has a reddish-yellow color, agreeable to the eye, especially when it contains palm oil. It is not completely neutral, because it has not been entirely liquefied; but even in this state it is nearly as pure as Marseilles soap. It is more soluble in water than the latter, and gives a very thick, abundant, and detersive lather. By growing old, it becomes slightly transparent on the edges. This process is less advantageous than the former, in regard to the amount obtained, but the soap is finer and purer. Generally, with the above quantities, from 2800 to 3000 pounds are obtained, which makes from 175 to 187 per cent. of the materials saponified.

§ 1. English Method.

Charge the pan with 2000 pounds of tallow or soap grease, about 600 pounds of rosin, and 150 to 175 gallons of soda lye, marking 10° to 20° B.; and when the whole is melted, heat up the mixture to ebullition, being careful to stir all the while to prevent the adherence of the rosin to the bottom and sides of the pan. If the mass seems disposed to intumesce or swell, the fire must be lessened. This boiling should continue but two or three hours, because of the facility with which the union of the fat and alkali is effected. After six hours' repose, the exhausted lye is drawn off, and fresh 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 the frames, whence, after a week, or less, it should be taken and cut into bars.

Another Process.—The English now prepare this soap by a new process as rapid as economical.

They take—

White tallow	800 pounds.
Palm oil	200 "
Powdered rosin	400 "
Caustic lye of soda ash at 25° .	175 gallons.

The whole is introduced into a large Papin's digester, and the mixture submitted for one hour to ebullition under pressure, at a temperature of 252°. After this time the soap is finished and run into the frames.

§ 2. 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 stop-cock 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 2050 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 movement 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.

§ 3. 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 rosin 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.

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 proportions. 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.

CHAPTER XXXV.

SOAPS OF COCO OIL.

White Soaps—Rose Soaps—Gray Soaps—Yellow Soaps.

Coco-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 coco-butter and 40 parts of tallow. The addition of tallow or palm oil is indeed necessary to promote saponification, for coco-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 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 2100 pounds of coco-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 a 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 a 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 coco-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 coco 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 coco 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 decanted into the cooling-frames. Even when finished, the paste should be left to cool in the kettle to 155° F., before it is poured into 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 coco soap from one volume of 100 pounds of coco 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 coco 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 coco 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 at the proper temperature—condition for complete union.

White and Rose Soaps.—For these soaps, the oil must be very white and concrete; that of Cochin is the best and the most highly esteemed.

Suppose that a soap is to be prepared yielding from 500 to 600 per cent. Introduce 200 pounds of oil into a sheet-iron kettle of a capacity of from 375 to 400 gallons. Melt the oil by a gentle heat, and as soon as melted pour on it 50 gallons of new lye of soda ash at 15°, and boil the mixture, adding from time to time small portions of lye at 18° to 20°, until the paste has acquired a caustic taste. When in this state it is a sign that it is entirely saturated with alkali. This first operation lasts four hours.

To harden the soap and make it produce the quantity named above, add to it salt water at 18° to 20°, in the proportion of 5 gallons every fifteen minutes, and at the same time continuing the ebullition. It is in this second stage of the operation that the degree of coction of the soap must be ascertained, and for this purpose a certain quantity is taken from time to time and allowed to cool on a dish. When the sample becomes solid by cooling, the operation is finished. Generally, the quantity of salt water used is about the same as that of the lye, and at about the same degree.

For the above proportions, the operation lasts seven or eight hours, during which the mixture is constantly kept

in a state of gentle ebullition. When the operation is finished, the heat is stopped off, and the soap, before being run into the frames, is suffered to cool and rest for 12 or 15 hours. After this time, it is drawn off, and run into the frames, in which it becomes very hard on cooling.

If the soap is to be rose, it is colored as soon as run into the frames and while yet fluid, with four or six pounds of vermilion, which is well distributed in the mass by stirring. To have a uniform color, it is important that the paste should be very fluid, for if too cold a part would remain white. To be more certain, the paste is often colored in the kettle a short time before running it into the frames. It is essential also that the soap should not be too warm, for in that case the color of the vermilion takes an orange and sometimes violet shade, particularly when the paste contains a large excess of caustic lye. If the soap is to be slightly perfumed, add to it, when in the frames, from 40 to 50 ounces of some cheap essential oil; but these soaps are generally sold without perfume, for their price is so low that the manufacturer has to be very economical in the expenses.

After seven or eight days the soap is hard enough to be taken from the frame; it is then divided into blocks about three inches thick, then these blocks are subdivided into square cakes weighing one pound. When these cakes are still soft, they are stamped with the mark of the manufacturer, and put into boxes; each box contains one hundred cakes. This soap is very firm and very white, but is always alkaline and salted, because it contains all the lye and salt water employed in its fabrication. The soaps made with coco oil are never purified by a proper liquefaction, and the only way to have them

as pure as possible, is to combine the oil with the proportions of lye just sufficient for the saponification of the oil. We shall describe this process in speaking of toilet soaps.

Gray Soaps.—To prepare these soaps, coco oil is mixed with a small proportion of palm oil, which has received the following treatment:—

Pour 25 pounds of palm oil into an iron kettle of a capacity of at least 12 gallons, heat the kettle, and when the temperature has reached from 122° to 140°, add to it, very slowly, 12 ounces of nitric acid at 36°, and one pound of zinc in scraps. A rapid reaction takes place, accompanied by an abundant disengagement of nitrous vapors, easy to recognize by their color and odor. The oil is kept in a state of gentle ebullition for two hours. By increasing the proportions of acid and zinc, the operation would be more rapid; but numerous experiments have demonstrated that in operating as above, the results are always successful.

When the reaction has ceased, and the oil has a black color, the operation is finished. The heat is then stopped off, and when the temperature of the mixture has fallen to 122°, the oil is washed with from six to eight gallons of boiling water, to separate the acid. By settling, the oil floats on the surface of the liquid.

After a few days, the oil is completely solidified; it is separated from the water, and kept for use. This oil being mixed with proportions varying from two to eight per cent. of coco oil (according to the shades to be obtained), and saponified by the same process indicated for the white soap, yields gray soaps of all shades from the lightest to the deepest.

Yellow Soaps.—These soaps should be prepared directly with coco oil alone, colored afterwards with annotto,

or any other yellow coloring matter, not attackable by alkalies; but generally the coco oil is mixed with five to ten per cent. of natural palm oil, having a fine orange color.

The operation is the same as for the white soap—that is, by saponifying the mixed oils with lyes of soda ash at 15° to 18°, then adding salt water in sufficient quantity to harden the soap, which, without this addition, would remain soft. The proportions of lye, water, and salt to be used for 200 pounds of oil, and for conducting the operation, are the same as for the white soap.

If the color should be too pale, it may be made darker by mixing in the soap seven ounces of annotto—previously dissolved in a little water—or a weak lye. This addition must be made while the soap is warm and fluid, in the kettle, or in the frames.

We shall not speak of those soaps of coco oil, of which the proportions obtained are from 900 to 1000 per 100 pounds of oil used. These soaps contain too much salt and caustic alkali; they lose much weight, a short time after they are made, and by the least cold, they are covered with efflorescence. All we shall say about them is that they are obtained by saponifying coco oil with lye of soda ash at 30° or 32°, and the excess in weight is given by the addition of salt water, which must never be less than 22°; the average is of 25°.

CHAPTER XXXVI.

SOFT SOAPS.

*Preparation of the Lye—First Process for Making Soft Soap—Second Process—Crown Soap, First Quality—Crown Soap, Second Quality—Green Soap—Russian Soap—Medicinal Soft Soap—Bran Soap—Oleic Soft Soap—White Soft Soap—Economical Soap—*Soda Soft Soaps—*White Soft Soap—Soap for Silks and Prints—Conversion of Soft Soap into Hard Soap.*

In the fabrication of these soaps potash is substituted for soda. On account of their base, these soaps are always soft, unctuous, and never acquire the solid consistency of soaps made with soda. The oils preferred for this fabrication are those extracted from oleaginous seeds.

Soap manufacturers divide the oils into *warm* and *cold*. Whilst this distinction is not very exact, we shall use it, because it is generally admitted.

The *warm oils* are those of linseed, hempseed, camelina, and black garden poppy. They receive this designation on account of the property they possess of coagulating only at a temperature of from 5° to 1° below freezing. It is advantageous to use them in winter, because their natural limpidity is not sensibly affected by the temperature, and the soap made with them preserves all its transparency.

The *cold oils* are those of coleseed, rapeseed, and some others, which it is useless to name; they are rare, and not much used. Fish oils are also used, but they yield

a brown soap, having a disagreeable smell, and generally of inferior quality.

Mixed in proper proportions, these oils are of an advantageous use in the fabrication of soft soaps; in summer they give consistency to the soaps.

Sometimes a certain quantity of rosin is introduced in the fabrication of soft soaps. This addition when not too considerable, renders the detersive properties of the soap more energetic, besides it renders it fit to be used in washing with sea water and other hard waters.

Pearlash is to be preferred in this fabrication. For some years manufacturers have introduced a certain quantity of soda ash of a high degree, into the preparation of the lyes of potash. This improvement gives a more consistent soap and diminishes the expense of fabrication. Only it is essential not to use this salt in too large a proportion, because soaps would be formed which would be more or less opalescent, and be wanting in homogeneity. The general characteristics of well-prepared soft soaps, is their transparency and the perfect homogeneity of their paste; an excess of soda would considerably diminish these distinctive characteristics of their purity.

The lime used to prepare the lyes ought to be recently burned and of good quality. Its action is energetic in proportion to its purity.

Soft soaps are generally more alkaline than hard soaps, because their mode of preparation does not admit of a refining after coction, consequently they contain all the lye used in the saponification of the fatty matters which enter into their composition. From this, we see that it is proper to introduce only the quantity of lye necessary to saponify the oils. However, as these soaps are generally employed in the dressing of woollen goods, always impregnated with fatty matters, a slight excess of alkali,

in this case, is more useful than injurious; but it would be dangerous to use it to brighten some colors, because the free alkali they contain might destroy or change completely the original shade.

The chemical analysis of a well prepared soft soap has given the following result:—

Fatty acids	44.00
Potash	9.50
Water	46.50
	100.00

Preparation of the Lye of Potash.—In speaking of potash, we have indicated the method of preparing this lye. The following process may also be employed.

All commercial potash will furnish this lye, but generally the first qualities of potash, marking from 65° to 70°, are preferred.

When the potash to be used is in very hard masses slow to dissolve, they must be broken into pieces; for this purpose, the potash is spread on a hard stone and broken with an iron beetle; in this state of division the solution is easier and more rapid. If 300 or 400 gallons are to be prepared at a time, introduce into an iron kettle, of a capacity of about 875 gallons, from 450 to 500 gallons of water, and make it boil rapidly. As the water is heated, add to it, in doses, 80 to 100 lbs. of potash, being careful to add a new dose only when the preceding is dissolved. The solution is accelerated by stirring the mixture. Continue thus until the boiling solution marks from 20° to 22° Baumé.

To transform the carbonate of potash into caustic potash, use from 60 to 70 per cent. of lime recently calcined. The weight of the lime must be calculated on that of the potash. Some manufacturers introduce the

slacked lime immediately into the boiling solution of potash, but it is better to slack the lime with a sufficient quantity of water, and to pour slowly, by small portions, this milk of lime into the boiling liquor. By operating thus, a greater quantity of carbonate of potash is decomposed, and the caustic lye clarifies quicker by cooling. The mixture must be stirred all the time, to retain the lime in suspension in the liquor, and prevent it from adhering to the bottom of the kettle. All the lime being introduced, the operation may be terminated, but the lye is much better prepared and more caustic when the mixture is kept at a gentle ebullition for a few hours. The heat is then stopped off, and to avoid an absorption of carbonic acid by the potash, the kettle is carefully covered. By settling, the liquor is deprived of the lime and clarifies of itself. This liquor, which constitutes the caustic lye, must mark from 20° to 25°. It is clear, limpid, and nearly colorless, and is decanted into cisterns made of brick or sheet iron; it receives the name of *first lye*, or strong lye.

The residuum of lime left in the kettle is washed with a quantity of water about equal to the volume of the decanted strong lye. After stirring half an hour, it is allowed to rest twelve or fifteen hours, and the clear lye is decanted. It marks from 12° to 15°, and is designated by the name of *second lye.*

A new quantity of water is poured on the residuum and stirred as above. After a sufficient rest, the clear lye is decanted. It marks from 6° to 8°, and is used for the pasting.

Lastly, the residuum is continued to be washed until completely exhausted. The weak lyes thus obtained are used instead of pure water, either to make new solutions of potash, or to make the first and second washings

of the residuum of lye after extracting the first and second lyes. When it is necessary to introduce a salt of soda into the preparation of the lyes of potash, this salt must be dissolved at the same time as the salt of potash. As for the proportions to use, they vary from twelve to fifteen per cent. of the weight of the potash; some manufacturers use more, but their soap is wanting in transparency. It would be better to prepare pure lyes of potash and to add during the coction the necessary quantity of lyes of soda. This method of proceeding is more regular.

Some manufacturers prepare their lyes of potash in the same manner as indicated for soda—that is, they conduct the washing of the mixture of potash and lime with cold water. Whilst this method presents some advantages, it is too long, and does not exhaust the mixture of its alkali as completely as that described above.

First Process for the Fabrication of the Soap.

We have said before that these soaps are prepared with vegetable oils, sometimes mixed with tallow, animal greases, and especially oleic acid. The base is always potash.

A superior quality of soap is made with the following mixture:—

Linseed oil	600 pounds.
Coleseed oil	800 "
Oleic acid	200 "
	1600 "

To saponify the above quantities, a sheet-iron kettle of a capacity of at least 750 gallons must be used. To begin the operation, introduce the oils into the kettle,

and heat gently. When they are entirely liquefied, add gradually about 75 gallons of the third lye at 6° to 8°. The mass is well stirred during the time the lye is being poured in, so as to accelerate the combination of the alkali with the fatty matters. It is ascertained that the combination is completed when the mass is homogeneous, without the presence of lye at the bottom of the kettle, and without oil at the surface. Then the mixture is raised to the boiling point, and kept so for a few hours. When the paste begins to acquire a certain consistency, add little by little new caustic lyes, more concentrated and energetic than the first. The second lye, at 12° to 15°, may be employed at first; it is added by portions of six or eight gallons at a time, every fifteen minutes. Continue thus for a few hours to feed the paste with this lye, and keep on boiling. In the first hours of the operation, we remark an abundant and light foam, which entirely covers the surface of the soap, but when the operation is well conducted this foam disappears, and then the paste is perfectly limpid.

When the soap has reached this point of limpidity and transparency, introduce into it by portions of ten to twelve gallons at a time, a strong lye at 22° to 25°. These additions of lye must be made progressively and cautiously. The evaporation of the aqueous part of the lyes, by concentrating the alkali, gives to the soap more consistency. To ascertain the state of the soap, take a little of it, from time to time, and pour it on a piece of glass or of porcelain. When completely cold, its consistency shows if it is sufficiently boiled. The workman has a surer and more exact process; he takes a little of the soap, when cold, between the thumb and the forefinger, and withdraws them quickly. If the soap is well boiled,

it separates without forming threads; if, on the contrary, the boiling is imperfect, it strings out.

In the first case, the heat is stopped off; in the second, it is important to continue the boiling, and even to add a new quantity of strong lye to complete the saturation of the soap with alkali. The alkalinity of the soap is also a sign for determining its point of coction.

When lye of soda is to be introduced into the soap, it is generally towards the end of the coction that this addition is made, except when the soda has already been mixed with the potash, in the preparation of the lyes.

Some manufacturers, as it has been remarked before, introduce a certain quantity of rosin into the preparation of soft soaps. Generally, the proportions are from five to ten per cent. of the weight of the fatty matters. The rosin is coarsely powdered and thrown into the kettle at the beginning of the operation; it saponifies at the same time as the fatty substances.

At Liege, in the soap works of M. Capitaine, there is a very ingenious method of introducing the rosin into the soap. When the soap is nearly done, the quantity of rosin required to be added is deposited in a large sheet-iron caldron, pierced with holes like a skimmer. This caldron is then immersed to the three-quarters of its height in the boiling soap. In contact with the excess of lye contained in the soap, the rosin saponifies, and the resinous soap passes through the holes of the caldron, and combines intimately with the mass of the soap in the kettle. This arrangement deserves to attract the attention of manufacturers.

When the saponification is finished, and when, by a well-managed evaporation, the soap is well boiled, its natural color is brownish-yellow; if this color is required,

the heat is stopped off, and after resting a few hours, the soap is drawn off into barrels opened at one end. If, on the contrary, the color is to be green, this shade is given to it by adding a small quantity of indigo. To prepare this color, macerate for a few hours indigo of good quality in boiling lye. After separating the lye, rub it in a mortar, and pass it through a fine metallic sieve. To color the soap, add a certain quantity of this paste to the soap, and incorporate it by a good stirring. When the required shade is obtained, turn off the heat, give a rest of a few hours, and draw off the soap into barrels as before.

When the soap is entirely cold, weigh the barrels, and keep them in cellars, being careful to have them well closed.

Obtained by this process, the soap has the consistency of a soft and unctuous paste. In its natural state, its color is brownish-yellow. Generally, this soap contains more alkali than is necessary to saturate the fatty matters. Chemists consider it as a perfect soap; dissolved in a slight excess of alkaline lye, it is very detersive, and dissolves completely in water.

From the proportions of fatty matters indicated above, 3400 pounds of a soap of good quality are obtained—that is, 212 pounds of soap for 100 of fatty matters.

When 10 per cent. of rosin is added to the 1600 pounds of fatty matters, the quantity obtained is 3800 pounds of soap—that is, 240 per cent. Rosin is not injurious to this soap; it increases its weight and its detersive properties, and also renders it more transparent.

As an average, the fabrication of soft soap requires the equivalent of 35 to 38 gallons of lye of caustic potash at 22° for 200 pounds of fatty and resinous substances. The time for the preparation of soft soap depends upon

the quantity of substances to be saponified, and the degree of causticity and concentration of the lyes used. Generally, the operation lasts about one day.

Sometimes soft soaps are prepared with common tallows and greases, which are mixed with more or less rosin. Fish oils are often used in these mixtures. As to quality, these soaps are always inferior to those prepared with vegetable oils.

Second Process.

The processes we have described are principally applied in Belgium, Holland, and the north of France. In Paris, the composition of soft soaps is different; they introduce as fatty matters substances, which, by their saponification, give a soap more solid than that of vegetable oils; the rosin is avoided, for in warm countries it renders the soap softer.

The materials used are oleic acid, palm oil, and lye of potash, at 25°. The following proportions give a soap of superior quality:—

Oleic acid	800 pounds.
Palm oil	200 "
Lye of potash at 25° from 1800 to	2000* "

The fatty matters are melted at a gentle heat in a kettle of a capacity of 500 gallons. Add first 125 gallons of lye at 25°, and boil gently. When the substances are well mixed, add gradually, and by portions of 12 gallons at a time, the balance of the lye. Continue to boil gently, and try the paste from time to time by the process indicated before.

* 2000 pounds of lye of potash at 25° Baumé, represent a volume of 212½ gallons.

When the soap has reached the required point, turn off the heat, and let it rest a few hours. This soap has a fine yellow color. If it is wanted green, it is colored in the same manner as indicated in the first process, when it is drawn off into barrels.

This soap is in much demand; it has more consistency than that prepared with vegetable oils. It is much used for the washing of woollens. It is employed also in families for washing clothes. In this case it is better than sal soda; its action is more detersive and less corrosive than that salt, and it does not affect the fibre of the cloth.

The above quantities yield 2500 pounds of soap—that is, 250 per cent. of fatty substances.

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 potash. 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 now be introduced about 42 gallons of a stronger lye, containing 55 pounds of potash, and after a short interval an additional 42 gallons; and thus successively till nearly 600 such gallons have been added in the whole. After sufficient boiling to saponify the fats, the proper quality of soap will be obtained, amounting in quantity to 6400 pounds, from the above 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 potash, 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 soap. 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 a 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 sul-

phuric 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 consistency, color, and odor of the soap. Boiling is commenced with potash 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 extensively and advantageously employed in scouring fine woollen textures, by the cloth manufacturers of that country. Being very alkaline, it acts promptly, but should be replaced, in the second scouring or milling of the cloth, by a less caustic soap. Potash 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
Coco oil	150	Coco oil	150	Coco 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°, another third 24°, and the remainder 30° Baumé. The coco oil being held in reserve, the other two fats are 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 extinguished, 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 coco oil, previously melted and strained, and also a sufficient quantity 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 keeping qualities of the soap. The yield from the above quantity 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 potash base of soft soaps may, *in part*, be replaced 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 potash lye, and the first should be made from crystallized sal soda. A mixture of 100 pounds of red oil, 40 pounds of tallow, and 3750 pounds of hempseed oil, makes a good stock for this soap.

White Soft Soap.—A soft soap, of firm consistency, 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 coco 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 consistency 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.

Conversion of Soft Soap into Hard Soap.

We know that the consistency of soaps depends on the base used, and that those formed with soda are hard, while those formed with potash are soft. We have shown that, according to the researches of Chevreul and Braconnot, soaps are true salts. The first of these chemists has defined saponification to be *the phenomenon presented by fatty bodies not acid, when they manifest acidity, after being submitted to the action of an alkali.* According to this theory, it is evident that the decomposition of these salts must be effected whenever they are brought in contact with bases which have more affinity for their acids. It is the case when soaps are dissolved with water containing chloride of calcium, sulphate of lime, etc. Then, as it is well ascertained that potash has more affinity for acids than soda, it is evident that it ought to expel it from its saline combinations; this is what takes place when soft soap is boiled with a sufficient quantity of common salt.

MM. D'Arcet, Pelletier, and Lelievre indicate six pounds of salt for three pounds of oil, and recommend that it be dissolved in water, and added little by little to the soap kept at boiling point. The newly-produced soap soon separates from the lye, and the operation is finished in the usual way.

In this experiment, there is a triple reaction. The soap of potash is composed of oleate and margarate of

potash, and the hydrated salt of hydrochloric acid and soda. An exchange of bases takes place, the hydrochloric acid combines with the potash and forms a hydrochlorate of potash, which remains in solution, while the oleic and margaric acids unite with the soda displaced by the potash, and form oleate and margarate of soda, the union of which produces a hard soap.

This process is used in manufactories located in places where grease soaps are made, and the price of soda is much higher than that of potash.

CHAPTER XXXVII.

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 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 into 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. 27, 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.

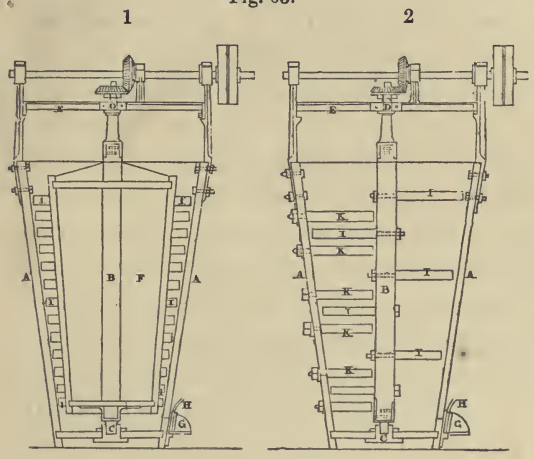
Rosin soap, which is to be treated by this process may contain rosin in as large proportion as one to two of fatty matters. The solution of glass must, for this soap, mark 51° B., and be added to the paste when it is "fitted" and ready to be "cleansed."

"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 revolutious per minute. I fix on the said upright shaft a closed tub or vessel (marked F, in Fig. 63, 1 of the drawings hereunto annexed), which said tub or vessel is of such diameter as 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 preference of sheet-iron, of such length as to approach within about half

an inch of the inside of the larger tub or vessel A. 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

Fig. 63.



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. 63, 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. 63, 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

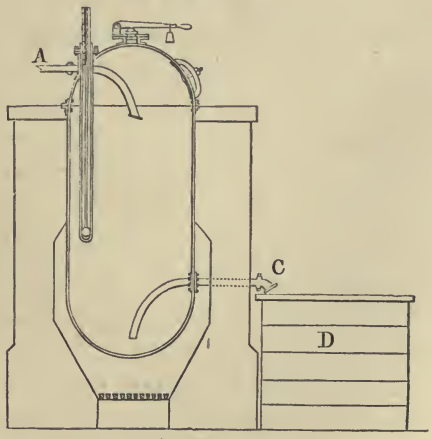
with the viscous solution employed, in such a tub or vessel as will contain about half a ton of soap, adding the soap and viscous solution at such temperatures as will yield a mixture, having a mean temperature about ten degrees higher than the previously ascertained temperature hereinbefore referred 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 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 com-

bined 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 ingredients, in a shorter time, with less waste, and at a diminution of expense.

Take the materials for soap in the usual proportions,

Fig. 64.



say for *yellow* soap, 7 cwt. of tallow, 3 cwt. palm oil, 3 cwt. of rosin, and 140 to 150 gallons caustic soda lyes,

21° B., and place the whole in a steam boiler, such as is represented by Fig. 64. The boiler should be furnished with a man-hole, safety valve, and all the ordinary appendages of such an apparatus, with a thermometer plunged into a mercury chamber. There should be a feed pipe as at A, and a discharge pipe as at C, through which the soap may be discharged into a pan or frame as at D. The fire being kindled, the pressure on the valve should be such as to allow the temperature in the boiler to rise gradually to about 310° F. When it has remained at this height for about an hour, the ingredients may be discharged from the boiler into the pan or frame, and allowed to cool down, when the process of saponification will be found to have taken place.

When silica is to be added, it must be put through a preparatory process, which is as follows: Crushed flint or quartz mixed with caustic soda or potash lye, in the proportion of one cwt. of silica to 100 gallons of lye, of 21° B., is placed in a steam-tight boiler, with apparatus, such as above described, and the whole 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 potash 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 expectations are to be realized in practice, must be determined by experiment.

Davis's Alkalumino-Silicic Soap.—This soap is a patent invention, by which, as the patentee says, the cost of the soap is diminished, whilst its detergent and normal properties, instead of being impaired, are much improved. The plan consists of a combination of fuller's earth, pipe-clay and pearlash, with the soap as soon as it is poured into the cooling frames. When pearlash or soda is employed, it is necessary that 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 pipe-clay, and 112 pounds of calcined soda or pearlash, all reduced to powder, and sieved as finely as possible, and thoroughly incorporate the whole by stir-

ring 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.

Soap with Silicate of Soda.

Silicate of soda (soluble glass) is much used now in the preparation of so-called rosin soaps. It is employed in the following manner:—

Prepare by the dry way a silicate of soda, containing five equivalents of silica and two of soda; dissolve it by a prolonged ebullition in water. The limpid solution, freed from all insoluble impurities, is decanted, and concentrated until it marks 35° Baumé.

The pure soap is prepared by the usual process, and when the boiling is just finished, it is poured while hot and in a fluid state, into the frame. At the same time add to it the solution of the silicate of soda. To incorporate this silicate thoroughly, the mass is well stirred, until the cooling of the soap renders this operation nearly impossible. The soap is then allowed to cool for several days, when it is taken out of the frame, and cut into bars. The quantity of silicate of soda to be used varies from 25 to 40 per cent. of the weight of the soap.

CHAPTER XXXVIII.

NEW PROCESSES.

Process of Mege Mouries—Pelouze's Process—Saponification by Pressure—Saponification by Agitation.—Bennett and Gibbs' Process.

Mege Mouries, a French chemist, found that the neutral fats in the oil seeds during germination as well as in the animal organism during life, have the state of movable globules, which offer a great surface to the action of

reagents. In this globular state, fats exhibit some peculiar properties of which we shall only notice such as are interesting to the soap-maker.

Fat, as for example tallow, in the ordinary state, becomes rancid by exposure to the air; in the globular state, in a milky form, or in a dry state, or in the form of a white powder, it remains unaltered any length of time. In practice it is obtained by mixing melted tallow at 113° with water at the same temperature, holding in solution 5 to 10 per cent. of soap.

It is difficult to combine tallow, in its ordinary state, with hot salty caustic lyes; but in the globular state the lye is immediately absorbed in proportions varying with the temperature. Each globule, as it is attacked by the alkali, quickly gives up its glycerin, and in a very short time each globule of fat is transformed into a globule of perfect soap. This result is obtained in two or three hours.

These saponified globules heated over 140°, give up the excess of lye with which they are charged, and retain only water sufficient for ordinary soap. They become eventually transparent, and by stirring form a layer of melted soap above the lye.

The saponification is so complete, that to prepare commercial stearic acid, it is only necessary to add a corresponding quantity of diluted sulphuric acid, and the fatty acids may be separated from the solution of sulphate of soda. By a melting with steam, a crystallization and pressure when cold, a commercial stearic acid is obtained perfectly pure, melting at from 136° to 138°, while the oleic acid flows off nearly colorless. This latter acid is of a better quality than fixed oils, and more useful to manufacture white soap of first quality either alone or mixed with some other fatty substances. By using it alone, it

has only to be neutralized by weak lyes; the formation of the soap takes place immediately, and it can be melted at once. If mixed with some other fat, this fat has to be transformed into the globular state, and the saponification is effected in six hours; and in twenty-four hours a soap may be prepared which is as neutral and good, as the best olive oil soap. Thus not only time is saved, but there is no loss of fat as in the ordinary process of boiling soap.

This chemist manufactures now 3000 pounds of fatty acids daily. He separates the stearic acid, and at the same time uses the oleic acid to manufacture soap.

Knapp attributes the great efficacy of the globular state not so much to the globular form as to the microscopic size of the tallow globules, which may be attacked to their centre by the lye, while a larger lump of tallow under the same circumstances, would soon be coated with a stratum of soap of a thickness which would render it impossible for the lye to penetrate it. As to the saponification in the kettle, there is, strictly speaking, only an emulsion of fat obtained, a homogeneous milky mass, formed by the union of the melted tallow with the lye; moreover, soap is simultaneously produced by the first contact of these substances. This emulsion, after standing a few hours in the cold, becomes gradually saponified. It might be expected that the process would be more rapid under the influence of heat and agitation, but this is not the case, and the hypothesis is that, in the boiling, each fat globule is immediately enveloped in a coating of stearate of soda, which protects the nucleus from further saponification. In like manner, and upon the same principle, heated soap bubbles are only denuded of their gelatinous coating, and the mass becomes a thickish soap solution rather than a chemical compound.

Again, concentrated soap in the heated mass will retain a considerable quantity of fat in solution, consequently diminishing the action of the alkali. This may be remedied by the addition of a middling strong lye; but in any case, cooling and quiet are found to promote the combination of fats with alkalies, after having been heated for a sufficient length of time to effect as minute a division of the molecules as possible in the characteristic form of an emulsion. For this purpose a temperature greater than 120° is not required.

Perutz* affirms that the facts discovered by Mege Mouries have been successfully applied in soap making. "To every rational manufacturer," he says, "it must be known that saponification is produced with greater ease when the fat is stirred for about an hour under a slight heat (about 140°), with the so-called combination lye, and suffered to remain undisturbed for one night." As this mixture never reaches the boiling point, it follows that the globular emulsive state must be produced and saponification expedited.

With the view of improving this discovery, and shortening the time of boiling, Perutz proposes to add to the fat the whole quantity of lye necessary for the saponification, and then proceed according to Mege Mouries' plan, leaving the mixture quiet all night. Until now, soap boilers have not, at the beginning, added the entire quantity of lye required, because experience has shown that saponification is thereby rendered more difficult; but on the other hand, it has also been ascertained that the saponification is more rapidly effected at a low temperature.†‡

* Die Industrie der fette und oele. Berlin, 1866.

† "Art of Manufacturing Soap and Candles." By Adolph Ott, Ph. D. Philadelphia, 1867.

‡ For views of the International Jury of Paris Exposition of 1867, on this process, see Appendix.

Pelouze's Process.

Pelouze, practically, did not succeed so well as the last named chemist with his method of saponification by *sulphuret of sodium.* However, his process is interesting enough to deserve a few remarks here. When crystallized sulphuret of sodium is brought into contact with neutral fats, saponification takes place at the ordinary temperature, and very soon. According to this chemist, a mixture of equal parts of crystallized sulphuret of sodium, olive oil, and water, produces after ten, or even after five or six days, a thoroughly saponified paste, consisting of soap, glycerin, and the excess of sulphuret of sodium. When subjected to heat, however, sulphydric acid gas escapes, and soap remains. In this case, one equivalent of sulphuret of sodium produces the same quantity of soap as one equivalent of pure caustic soda; but it is not at all necessary to make use of crystallized and chemically pure sulphuret of sodium, for that which is obtained by decomposing the sulphate of soda by charcoal may as well be employed. It is, also, much cheaper than caustic soda. One grave objection has been urged against this process, and it is this—that the escape of sulphydric acid will have a very deleterious influence on the health of the workmen; but there is reason to believe that in the application of this process the gas would not be allowed to escape into the atmosphere, but be collected so as to utilize the sulphur it contains.

As for the appearance of the soap produced by this process, it is stated that it is exactly the same as that made in the ordinary way; but it is also said that it has a disagreeable odor, not easily removed. For ordi-

nary purposes, however, such as scouring woollen goods, etc., it may readily be used.*

Saponification by Pressure.

This process was patented in England by Messrs. Hodson and Holden, and also by Mr. Davis. The former employ a rotary, and the latter a perpendicular immovable cylinder, both of which are furnished with a man-hole, a safety valve, feed, and discharge pipes, and the ordinary appendages to such an apparatus. In both instances, steam is employed, and saponification effected at a high temperature. Mr. G. W. Rogers, of Lancaster, N. Y., has originated the idea of conducting this operation at a *low* temperature. The advantages thus obtained are said to be considerable, among which may be mentioned the *saving of time*—from fifteen to twenty-five minutes—instead of one hour (the time required at a high temperature), being sufficient to produce a thorough saponification. Unlike other contrivances, by this one a *bleaching*, moreover, is effected, in consequence of which inferior qualities of stock may be employed. For mixing the materials, also, a tank heated by steam only is used, and the mass thus prepared run into a cylinder of boiler-iron, five-sixteenths of an inch thick, capable of holding one or more tons, and subjected to a pressure of about 400 pounds to the square inch, by means of a force-pump, also driven by steam. In this cylinder the mass remains until complete saponification is effected, when it is drawn into the frames and manipulated in the usual manner. Any of

* "Art of Manufacturing Soap and Candles." By A. Ott. Philadelphia, 1867.

the ordinary mixtures for making soaps are suitable, while the product is firmer and more translucent.

In this process no caustic soda is used, as the carbonate in smaller quantities answers every purpose.*

Saponification by Agitation.

This process is proposed by Mr. Hawes, of London. For 100 pounds of tallow, he uses 20 gallons of lye at 1.125 specific gravity. His apparatus consists of a cylinder six feet in diameter and twelve feet long, capable of working 5000 pounds of tallow. Through the cylinder, lengthwise, a shaft extends, provided with radiating arms, to which an oscillating or rotary motion is communicated. Convenient doors are attached for charging and emptying the cylinder. After charging the *container*, agitation is commenced and continued for about three hours, when the whole is left undisturbed for awhile, and ultimately removed into an open boiler, and completed as usual.*

Bennett and Gibbs' Process.

In addition to the processes for making soap by pressure and by agitation, using carbonated alkalies already described, we would call attention to that of Messrs. Bennett and Gibbs, of Buffalo, N. Y., who have made a great improvement in that process, by combining the two together, for which they took out a patent in 1865. Their process consists in agitating the saponifiable materials with caustic or carbonated alkalies in solution in water in a closed vessel while under heat and pressure,

* "Art of Manufacturing Soap and Candles." By A. Ott. 1867.

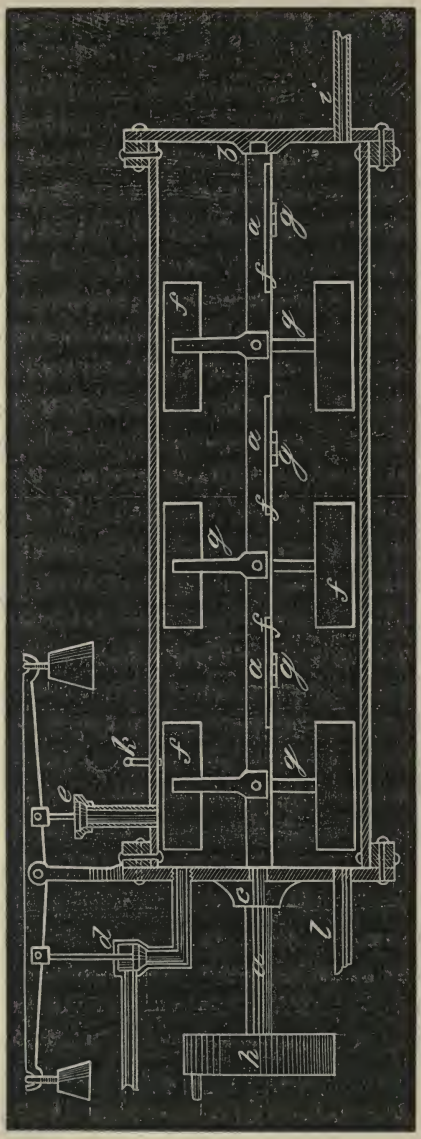


Fig. 65.

BENNETT AND GIBBS' APPARATUS.

in such a manner as to cause a thorough mixing of the fats with the alkaline solution, and producing an instantaneous combination of the fatty acids with the base of the alkaline solution.

We suppose a quantity of fatty matter inclosed in a vessel with a solution of carbonate of soda in water, and heat applied to produce a pressure of 220 to 280 pounds per square inch, and a temperature of 350° to 400°, a combination between the fatty acids and the soda of the solution will take place only at the upper surface of the solution when in contact with the under surface of the grease, the heavy lye occupying the lower part of the vessel, and soap will only be produced when the fat and alkali unite.

If we now agitate in such a manner as to stir together and thoroughly mix the contents of the vessel, the whole will be instantly converted into a homogeneous and even quality of soap. It is advisable to use no more water than is wanted in the soap.

The inventors use a boiler or cylinder similar in shape to a plain cylinder steam boiler, resting horizontally and heated in any convenient manner; one or both heads of the cylinder is made so as to be conveniently removable, and is about the full size of the inner diameter of the cylinder, so as to admit of the insertion of a revolving shaft *a a a* (Fig. 65), which should be as long as the cylinder itself. The bearings of this shaft should be in the centre of the cylinder, and either or both ends worked through a stuffing box *c*, for the convenience of applying to the pulley *h*, power to revolve the shaft. On the shaft are fastened arms *g g*, with floats *f*, or stirrers, extending nearly to the sides of the cylinder; the arms, floats, or agitators on one side of the shaft when revolved carrying the fat down into the alkali, while the agitators on the other

side carry the alkali up into the fat, thus, while under heat and pressure, thoroughly mixing the whole and causing the conversion of the whole contents of the vessel instantly into a uniform, even, and good quality of soap.

At the fire end of the cylinder are placed two safety valves, one *e*, on the top of the cylinder, the other *d*, on an outlet pipe inserted in the head of the cylinder; they also use a mercury bath *k*, of about four inches in length of gas pipe, and which is screwed into the boiler or cylinder in any convenient place for the insertion of the thermometer bulb. At the opposite end of the cylinder is an opening *r*, for the insertion of a supply pipe; at the fire end is also an opening *l*, for the insertion of a second outlet pipe, and which is intended to be used only when it is desired to draw off the whole contents of the cylinder.

The contents of the cylinder when operated upon should be subjected to a pressure of about 220 to 280 lbs. per inch, and under a heat of about 350° to 400° F.

When the shaft is revolved, all of the ingredients in every part of the cylinder are immediately and thoroughly mixed, and the same will take place by means of any other revolving machinery, perfect saponification is at once effected, and the soap produced is of uniform and good quality.

When the machinery is first put in operation, it is necessary to allow some carbonic acid gas to escape by one of the safety valves, if carbonate of soda is used, in order to prevent undue pressure by the liberation of the carbonic acid when combination of the fatty acids with the alkali takes place.

If any of the liquids be allowed to escape before the temperature reaches 325° to 375°, they should be returned to the cylinder.

The safety valve on the outlet pipe *d*, may be so loaded as to allow an escape of soap at a pressure of 250 to 270 lbs., and a quantity of lye and oil may be pumped in at the opposite end, the agitation by the revolving shaft being still kept up, and thus a continual stream of soap is kept up as long as the feeding is continued.

The product may then be prepared for market by the cooling, moulding, and cutting processes in ordinary use.

By this process the soap is made in less than one hour from the time the ingredients are introduced into the boiler, but a uniform and thorough saponification is obtained at the instant that the heat and pressure arrive at the required degree, be the time long or short; if this degree is reached in five minutes the soap is made.

The inventors use from 30 to 33 lbs. of carbonate—48° English, and 100 lbs. water to 100 lbs. of lard, tallow, or oil; 27 lbs. of carbonate will make a neutral soap for soft water.

The product obtained is 200 lbs. of soap for every 100 lbs. of grease.

Any kind of soap can be made by this process; soft soap is prepared with the same rapidity as any other, and is much more perfect and uses a less quantity of potash than by the open kettle process; four lbs. of potash being required for one barrel.

To conclude, we would state that the advantages of this process are :—

1. The rapidity of manufacture.
2. The improvement in quality.
3. The increased quantity.
4. Economy in labor.
5. Saving of fuel.
6. The use of cheaper materials.
7. The saponification of all the grease.

8. The uniform certainty of the result.
9. The saving of the valuable property of glycerin which greatly improves the quality of the soap.
10. The ability to use alkaline salts instead of caustic lye, obviating the necessity of using chloride of sodium, which is required by the common process, in order to get rid of the waste lye.

The editor has had occasion to examine two specimens of soap made by this process, and he has found them perfectly neutral, and entirely saponified, without a trace of carbonated alkali, and not containing as much water as soap made by the ordinary process.

SECTION VI.

TOILET SOAPS.

In the fabrication of toilet soaps, fatty matters of the best quality, and perfectly pure, are generally used. Salts of soda very white, very rich in alkalimetric degrees, and entirely free from sulphurets, are employed for the fabrication of the lyes. The fatty matters which enter into the preparation of toilet soaps are lard, suet, palm, and coco oils; the latter is always employed in small proportions, to cause the soaps to yield more lather. Many varieties of toilet soap are found in commerce; some are white, marbled, yellow, brown, rose, etc. Except the yellow color which is furnished by the saponification of palm oil, all the other shades are produced by foreign substances, incorporated in the paste of the soap. It is thus that all the shades of rose are obtained by vermilion, the brown by the Prussian brown, the factitious yellow by yellow ochre, turmeric, etc. However, we shall treat specially hereafter of the coloration of soaps.

Toilet soaps are of two kinds—hard and soft, according to the alkali employed to prepare them. Hard soaps have soda for base, soft soaps have potash. The latter are more generally known by the name of cream soaps; they are usually employed for shaving, and for the bath.

The fabrication of hard toilet soaps is very little different from that of ordinary soaps. The only essential

difference is that the toilet soaps are prepared with very pure fatty matters, and their fitting has been conducted very carefully, important conditions for obtaining pure pastes as free as possible from caustic alkali. These soaps are generally very hydrated; that is, they contain much more water than ordinary soaps.

We shall begin with the fabrication of the white soaps which are obtained from lard, beef and mutton suet, with an addition of five to ten per cent. of coco oil.

CHAPTER XXXIX.

WHITE TOILET SOAP MADE WITH LARD.

Purification of the Grease—Pasting—Separation—Coction —Fitting.

White toilet soap of the first quality has lard for its base; this soap is as much finer in proportion as the grease itself is of good quality and whiteness. This grease is obtained very pure by the following process.

Purification of the Grease.

Fat of good quality and very fresh must be selected, the membranes of which are carefully removed. This operation being performed, it is spread on a strong piece of oak wood and strongly beaten to open the adipose cells in which the grease is contained; by this means the extraction of the grease is more easy and quicker. The fat is then washed five or six times in cold water, the water being renewed each time. This operation is

performed in large buckets two-thirds filled with water; the water of the last washing must remain clear and limpid. The object of these washings is to remove, as completely as possible, the coloring and bloody parts which are adherent to the grease, and which would color and alter it during the trying out, and would render its preservation uncertain and difficult.

These washings being finished, the fat is drained on clean cloths, then melted in a copper kettle, in which is a quantity of water about equivalent to one-third of the weight of the fat. All being thus ready, heat the kettle, and, when the grease is melted, add from five to seven ounces of pure salt for every 100 pounds. Boil for eight or ten minutes, and as by the boiling scum is formed, it is carefully removed with a skimmer. The melting being finished, decant the liquid grease into large copper vessels having a conical form; but to have clean grease, pass it through a hair sieve which prevents the solid and insoluble substances from passing through.

Let it rest two or three hours; during this time the water separates, carrying with it the dirt contained in the grease. It is then carefully decanted and put back into the scoured kettle, and melted with water, to which are added a few quarts of rose or orange-flower water.

Heat anew, and when the grease is melted, add to it two ounces of pure powdered alum for 100 pounds of grease, boil gently for eight or ten minutes, and carefully remove the scum formed on the surface of the grease. Then turn off the heat, cover the kettle with care, which is essential for keeping the mass at an elevated temperature. Let this stand for eight or ten hours, or what is surer, until the grease begins to whiten and solidify on the sides of the kettle. When in this state, decant it into clean barrels and keep for use.

As the last portions of grease which swim on the water are less white and pure than the first, they are kept separate to prepare soaps of second quality. The grease thus purified may be kept a long time without alteration, and forms the base of toilet soaps of the first quality.

Saponification or Pasting.

In the fabrication of toilet soaps, the fatty substance to be saponified is generally mixed with five to ten per cent. of coco oil, so as to render the soap softer and more frothing. To prepare white soap of first quality take

Lard	1080 lbs.
Coco oil	120 "

Introduce these substances into a sheet-iron kettle of a capacity of 500 to 600 gallons, heat the kettle, and when the greases are melted, saponify them with new lye of soda ash at 8° or 10°. The quantity of lye used varies from five to seven gallons for every 100 pounds of fatty matters. While one man throws the lye, little by little, into the kettle, another stirs the mass continually, to accelerate the combination of the substances. It is during this stage of the first operation that the pasting takes place, that is, that the alkali combines with the fatty matters. This is ascertained by the opalescent and homogeneous appearance of the paste and the complete absence of lye at the bottom of the kettle, and fluid greasy parts at the surface. When these characteristics, which indicate that the pasting is complete, are well defined, gradually raise the temperature of the mixture to the boiling point, but without boiling; and keep it thus for three or four hours, stirring all the time.

After this time the paste has acquired some consistency. Then introduce 25 gallons of lye at 15°, and boil gently.

By the addition of this new lye, the paste is progressively saturated with alkali, and becomes more and more thickened. Lastly, after three or four hours of ebullition, the pasting is finished, by pouring into the kettle 50 gallons of new lye at 20°. After the introduction of this lye the heat is stopped off, and the mixture is well stirred for half an hour. The pasting is then finished, and if the operation has been well managed, the paste is smooth and homogeneous, without oily parts at the surface.

Separation.

The object of this operation is to separate the soap from the aqueous lyes, in the midst of which it has been formed. One man stirs the paste from bottom to top, while another pours into it lyes of coction, perfectly limpid, at 20° to 25°. Small quantities of lyes are poured in at first; but when the soap begins to separate from the lye of the first operation, and forms grains, the quantity of lye may be increased without danger. The operation is continued until the soap is in grains, and the lye is completely separated. This result being obtained, cover the kettle, let it rest six hours, and then draw off the lye.

If the saponification has been well conducted, the separation of the soap may be completely effected with 50 gallons of lye at 25°. If lye of coction is not to be had, a lye of soda ash, containing salt in solution, may be used. This solution is made by dissolving 40 pounds of salt in 50 gallons of new lye at 15°. The salt brings the lye to 20°.

Several authors assert that the separation of these kinds of soap ought to be conducted with strong lyes, free from salt. We believe that the same results are obtained by using salt or lyes of coction. Besides the considerable economy that the salt affords, it separates the soap more completely from the old lyes. Truly, the paste is less pure, but the salt is removed by the following services of new and pure lyes.

Coction.

When the mass has been separated from the excess of weak lyes used in the saponification, and when these lyes have been drawn off, the coction of the soap may be proceeded with immediately. This operation, the object of which is to completely saturate the fatty acids with caustic alkali, is generally accomplished by the services of new colorless lyes prepared very caustic from very pure soda ash.

To obtain a complete saponification of the fatty body, it is advantageous to use for the first service lyes at a degree of concentration weaker than that which must bring the soap to its proper point. Indeed, the use of too strong lyes at the commencement of the operation, besides some other inconveniences, has that of forming the grain of the soap too soon, for it must be formed slowly and progressively, as all the parts of the paste become saturated with alkali.

First Service.—The lye being drawn off, pour into the kettle about 75 gallons of new lye at 15° to 18°. Heat gradually, until the mixture begins to boil; as soon as the ebullition begins, there forms at the surface of the soap a considerable scum, and it is to prevent the too

great expansion that a gentle heat is kept up, so as to obtain a regular and uniform ebullition.

However, after a few hours of a gentle ebullition, and when the paste has acquired more consistency, increase the heat a little, and continue to boil for six to eight hours, adding every hour from three to four gallons of new lye at 20° or 25°.

When by boiling, the lye has lost its caustic taste, stop off the heat and after a few hours' rest, draw off the lye. Proceed then to the second service.

Second Service.—This service is made with new and caustic lyes marking 25° to 28°. The lye from the first service being drawn off, pour into the kettle about 60 gallons of new lye at 25° or 28°. Heat, and when the temperature is sufficiently high the mass begins to boil; the surface of the soap is soon covered with scum which is present until the end of the operation, that is, until the time the soap is perfectly boiled. As by boiling, the volume of the lye diminishes at the same time that it concentrates, introduce new lyes of coction at 25° or 28°, in doses of four or five gallons, every hour for ten or twelve hours, which is the ordinary time of the coction.

When the soap is completely boiled, which is ascertained when it forms hard scales when pressed between the fingers, stop off the heat, cover the kettle, and let it rest a few hours, so as to obtain the separation of the lye. Draw off this lye and proceed to the refining or fitting of the soap.

Fitting.

All the lye being drawn off, pour into the kettle 100 gallons of caustic lye of soda at 10°, and bring the temperature quickly to the boiling point, being careful to stir

from time to time to facilitate the liquefaction of the grains of soap. Under the influence of heat and agitation, the grains of soap soften and experience a semi-liquefaction. Boil the mixture gently for a few hours. This first operation has for its object to deprive the soap of the excess of caustic alkali it contains, and dispose it to a complete liquefaction. This first lye is drawn off from the kettle, one or two hours after the heat has been stopped off.

To continue and complete the liquefaction of the soap, pour at first into the kettle about 50 gallons of lye at 5°, and heat. Boil gently, stirring from time to time, to prevent the soap from sticking to the bottom of the kettle. If the 50 gallons of lye are not sufficient to completely liquefy the paste, finish the operation by adding in small portions, and gradually, lye at 2° or 3°.

The liquefaction is completed when the paste has become fluid and begins to have a gray color. This second liquefaction requires generally for the quantity of greases indicated above, 50 gallons of lye at 5°, and about 25 gallons of lye at 2° or 3°.

In some manufactories this soap is liquefied in a single operation, beginning at first by using lyes at 7° or 8°, then at 5°, at 3°, at 2°, and lastly, with a very small quantity of pure water at the end of the operation. This process is good, but we have remarked that when the liquefaction is conducted in two operations, a finer and purer soap is obtained.

The liquefaction being finished, stop off the heat and stir the mass for five or six minutes. Cover the kettle and let it rest for twelve or fifteen hours. After this remove the scum which covers the surface of the soap. Draw off the soap and pour it into the frames. The pure soap is always between the scum and the impure soap, which being combined with the lye remains at the

bottom of the kettle. This latter being always more liquid, darker and more caustic, it is important not to mix it with the pure soap. The quantities of fatty matters indicated above give :—

Soap of scum from	. . .	100 to 120	lbs.
Pure soap, from	. . .	1600 to 1700	"
Impure soap, from	. . .	200 to 300	"

The latter is separated from the lye by lyes of coction at 25°.

After eight or ten days the soap is taken from the frames. It is very white, pure, and has a firm consistency. It has no odor, and forms the base of fine white and rose toilet soaps.

CHAPTER XL.

SOAP MADE OF TALLOW.

Pasting—Separation—Coction—Fitting.

The tallows from mutton or beef are preferred to manufacture soaps. They form the whitest and hardest soaps, but as they contain too much stearin, the soaps obtained with them are wanting in homogeneity. By saponifying them with 20 or 25 per cent. of lard, this inconvenience is removed.

Beef tallow, less rich in stearin, and consequently more abundant in oily parts, forms soaps which are not so firm, but have more homogeneity. Whilst less white than the first, they are generally preferred. Melted tallow is the only one used to prepare fine toilet soaps. Un-

happily, those found in commerce have not always been carefully prepared, and frequently they differ from each other in quality, purity, and whiteness. A manufacturer of toilet soap ought always to melt his tallow himself, either by the process we have indicated for extracting white grease, or by melting the crude tallow by steam. This process we have also described.

Tallows prepared by either process are very pure, have very little odor, and are free from gelatinous matters; their product in soap is always more considerable and of the best quality.

Pasting.

Take

Tallow	1080 lbs.
Coco oil	120 "

Into a sheet-iron kettle of about 550 to 625 gallons, introduce 135 gallons of caustic lye at 6° to 8°, and boil; then introduce, gradually, the 1200 pounds of grease. At first a quick emulsion is produced, moderate the heat, and to accelerate the combination of the substances, stir the mixture. This stirring, repeated from time to time, accelerates the operation. When after an ebullition of four to five hours the paste has acquired consistency, and has become perfectly homogeneous, introduce into it, little by little, 37 gallons of lye at 12° to 15°, and continue to boil for two or three hours, so that the new lye may combine with the paste.

Complete the operation by adding 25 gallons of a third new lye at 20° to 25°. This lye is introduced in small doses at a time, for example, six gallons every fifteen minutes; after the addition of the last six gallons, boil from 1 to 1½ hours, to terminate the operation.

The pasting of tallow is a delicate and difficult operation which requires much care. The lyes must be used with intelligence and their degree of strength must be progressively increased. The success of the pasting requires that all the constituent elements of the fatty bodies should be saponified at the same time and together. This result is completely attained only by following the rules we have indicated, that is, to begin the operation with new caustic lyes below 10°, then to continue with lyes at 12° to 15°, and lastly, finish with strong lyes at 20° to 25°.

When the pasting is done, the soap is separated from the excess of aqueous lye it contains.

Separation.

When the mass has a good consistency, and is without oily parts on the surface (which is an indication of an imperfect combination of the fatty matter with the lye), the heat is stopped off. Then pour little by little into the kettle colorless and limpid lye of coction at 25° ; while one man is pouring the lye, another continually stirs the paste, and when the soap is transformed into grains, which separate from the lye, the operation is finished.

After resting six hours or more, the lye is drawn off. The longer it stands the lye drawn off will be greater in quantity, and be clearer and more limpid. When the operation has been conducted under favorable conditions, about two-thirds of the lyes used in the pasting and separation are drawn off.

Coction.

The coction of this does not differ much from that of other soaps; only as tallow has generally a disagreeable odor, the principal object is to deprive the soap of it.

This object is attained by multiplying the services of lyes. Thus, after drawing off the first lyes, pour into the kettle from 75 to 100 gallons of new lye at about 15° and boil gently for seven or eight hours, adding every hour a few pails of lye of the same degree, or of a higher degree, to take the place of the evaporated water. The operation must be well watched, and care taken that the soap does not stick to the bottom of the kettle, a result which is obtained by keeping the mixture at a gentle ebullition. However, if in consequence of the weakness of the lyes, it happens that the grains of the soap should reunite together, a complete separation is obtained, by adding a sufficient quantity of strong lye, in which ten pounds of salt have been dissolved for 25 gallons. The use of colorless and limpid lyes of coction gives the same result. The separation being accomplished stop off the heat and allow a rest of a few hours, so as to permit the lye to separate from the soap; the lye is then drawn off.

The second service is given with 75 gallons of new lye at 20°. This lye being poured on, boil gently for eight to ten hours. Add, if necessary, from time to time a few pails of strong lye. During the second service the soap is constantly separated from the lye. When the lye has lost all caustic and pungent taste, and is only salted, stop off the heat, and let it rest a few hours; then draw off the lye.

The coction is finished by giving a third service of lye at 25°. Pour 75 gallons of this lye into the kettle and submit the mixture to a strong ebullition. To obtain a

complete saturation of the fatty acids, the lye must be still caustic after an ebullition of seven to eight hours.

When in this state the soap forms hard scales when pressed between the fingers. If this result is not obtained, it is sufficient to add a few pails of strong lye and continue the ebullition until the soap is completely saturated. The heat is then stopped off and the mass allowed to rest; after a few hours the lye is drawn off.

Some manufacturers proceed in a different manner, they give the first two services with perfectly limpid lyes of coction purified on old residuum of lime and soda. As these lyes contain much neutral salts, they have the advantage of preventing the inviscation of the soap, a result not always obtained with new lyes. They finish the coction by one or two services of new lyes at 25°. This method of proceeding enables them to realize a notable economy in the use of new lyes, the cost of which is greater than that of lyes which have been once used.

Fitting.

To begin this operation, pour into the kettle 75 gallons of new lye at 5° or 6°, heat, and during the heating of the kettle stir the mixture until the soap acquires the appearance of small swollen grains half melted in the lye. When in this state, which requires from one to two hours, boil gently for five or six hours, and complete the liquefaction of the soap with lyes at 2° or 3°, operating in the same manner as with lard. When the grains of soap are entirely liquefied and form a syrupy and fluid paste, the operation is finished, the heat is stopped off, and the kettle is covered. After ten or twelve hours, the soap is run into the frames, being careful to remove the scum which is on the surface, and not to disturb the

black soap which is at the bottom of the kettle; the latter being mixed with the lyes used for the liquefaction is always more fluid than the true soap; it is alkaline and caustic while the first is neutral.

The saponification of 1080 lbs. of tallow, and 120 pounds of coco oil produces :—

Soap scum, from . .	60	to	70 pounds
White soap, from . .	1680	"	1700 "
Black soap, from . .	260	"	320 "

The scum and black soaps are added to a new operation for white soap.

In the fabrication of tallow soap destined for the uses of the toilet, lyes of soda ash must always be used; lyes of crude soda would give a soap less white.

This well purified is one of the best soaps for use. Less unctuous than that of lard, it resists better the effect of warm climates. Mixed with palm oil soap, it forms the base of all the yellow soaps found in commerce under the name of *guimauve* (*marsh-mallow*).

Purification of Ordinary White Soap.

Soap, particularly tallow soap, requires an extra operation when used for the toilet. To obtain a prime article it is purified in the following manner: Cut the soap into small pieces and melt it in a water bath with rose and orange-flower waters, and salt. For 25 pounds of soap take one gallon of rose water, one gallon orange-flower water, and two handfuls of salt. The next day, if the soap is solid, cut it into very thin pieces and dry it in the air in the shade. When dry melt it again, adding rose and orange-flower waters, then let it cool and dry.

Another process consists in melting in three pints of

water six pounds of good white soap. When melted, pass it through a cloth, put it back into the kettle and give it a good boiling; add then one pint of water, a large spoonful of salt, and stir it well. Stop off the heat and let it cool, stirring continually. Melt it again, and run it into a frame. When cold, the soap is cut into thin pieces and dried in the air in the shade.

CHAPTER XLI.

PALM OIL SOAP.

Pasting—Separation—Coction—Fitting.

Palm oil is rarely used alone; it is always mixed with variable proportions of tallow or animal greases. But for the preparation of fine toilet soaps, this oil is saponified alone, or with five to ten per cent. of coco oil.

To obtain this soap perfectly pure, the natural palm oil must be of the first quality; in this state it has the consistency of butter. When fresh, its color is a fine golden-yellow, and its aromatic odor is similar to that of violets.

Pasting.

Take

Palm oil	900 lbs.
Coco oil	100 "
	1000

Into a sheet-iron kettle of a capacity of 500 to 625 gallons, pour 75 gallons of new lye at 12° or 15°; heat, and when the lye begins to boil add the oils at intervals.

To facilitate the fusion of the oils and hasten their combination with the lye, stir the mixture well. The combination is effected when the mass forms a thoroughly homogeneous paste, in which neither oil nor lye can be seen.

The paste must then be kept at a gentle ebullition; too rapid ebullition would separate the coco oil from the mixture. In the event that this separation does occur, the oil is again incorporated with the mass, by moderating the boiling, and pouring into the kettle twelve or fifteen gallons of very weak lye, or even cold water.

After a gentle ebullition of three to four hours, begin to add lye at 20°, in doses of six gallons every half hour for four or five hours. It is important to add this second lye very gradually, and in the time indicated above, for if it is added in one operation, the paste will become granulated before all the molecules are saturated with alkali.

When the quantity of lye at 20° has been used, the pasting is finished by pouring into the kettle twelve or fifteen gallons of lye at 25°, which is incorporated with the mass by brisk stirring. Turn off the heat and proceed to the separation.

Separation.

The separation is managed in the same manner as for other soaps, that is, by pouring little by little in the kettle and stirring all the time, lyes of coction of soda ash at 20° to 25°. As we have said several times, if these lyes are not at hand, they may be substituted by new lyes at 15° or 18°, in which ten to twelve pounds of salt are dissolved for every twenty-five gallons. It is better, however, to give the preference to lyes of coction, although

the result is the same in either case, only as lyes of coction owe their density to different salts and especially to carbonate of soda, they introduce less salt into the paste. Experiment proves that the exclusive use of salt for the separation renders the soap less soluble and less pure; it renders it also more hygrometric, when it has not been properly purified.

In the separation of every kind of soap containing coco oil, it is advantageous to let the paste rest five or six hours, after stopping off the heat and covering the kettle. After this time, the separation is better effected and requires less lye than if the operation follows immediately after the pasting is terminated.

When the separation is finished, the soap is in small grains, and the lye separates clear and limpid, but colored yellow. The stirring of the paste is then stopped, and after a few hours' rest the lye is drawn off. The quantity drawn off is generally from 125 to 150 gallons at 15° or 16°.

Coction.

Pour into the kettle seventy-five gallons of new caustic lye at 28° or 30°. When all the lye is introduced, heat the mixture; three-quarters of an hour after the ebullition has begun, an abundant scum covers the surface of the soap, and disappears after an ebullition of five or six hours. The soap has the form of large rough grains, very dry, of a very dark yellow color; when pressed warm between the fingers, they form hard and pulverulent scales. There is, however, no inconvenience in continuing the ebullition a few hours' longer, and even in adding a new portion of ten to twelve gallons of lye at 28° or 30°. This prolongation of the operation improves the quality

of the soap, by saturating it more completely with alkali. This condition is particularly necessary in the fabrication of toilet soaps, it renders the purification easier. The coction is finished when the lye in the kettle marks when cold 28° or 30°, and is still caustic.

The heat is then stopped off, and after a few hours' rest, the lye is drawn off.

Fitting.

To obtain pure palm oil soap, dilute the paste at a boiling heat with weak, limpid, and pure lyes; cover the kettle carefully and let it rest. The operation is conducted as follows: Pour into the kettle seventy-five gallons of new lye of 5° or 6°, and submit the mixture to a gentle ebullition. To accelerate the operation, stir the paste from time to time. After an ebullition of a few hours, the soap has the form of voluminous clots swimming in the lye. Continue the liquefaction, by adding in small portions of three to four gallons, lyes at 2° or 3°, so as to obtain gradually the perfect liquefaction of the paste. The operation lasts five or six hours. The quantity to be used of these second lyes cannot be precisely determined, but it generally requires from fifty to sixty gallons to bring the paste to the fluid state proper for its purification. It is known that the operation is finished when the ebullition brings to the surface the parts from the bottom, and when these parts have a blackish shade. This sign is apparent only when the paste is sufficiently fluid and homogeneous.

When this state is reached, turn off the heat, and cover the kettle carefully so as to retain the heat as long as possible. By resting, the soap is entirely deprived of the fat, and excess of alkali it contains. After 30 or 36 hours, open

the kettle, and while the soap is yet fluid run it into the frames, and stir it until it is cold. Before drawing off the soap, the scum on the surface must be removed, and the black soap must be left at the bottom of the kettle. The pure soap has a beautiful golden-yellow color, and is completely neutral.

The proportions of oils used (1000 lbs.) produce

Scum soap, from . . .	60 to 70 lbs.
Pure yellow soap, from .	1300 " 1400 "
Black soap, from . . .	160 " 200 "

The black soap is separated from the lye by means of a sufficient quantity of lye of coction at 25°, and is introduced into an operation for half palm soap.

After twelve or fifteen days the pure soap is sufficiently solidified to be cut up. The block of soap is cut into plates about one inch thick, and twenty-five inches long. These plates are kept for use.

Thus prepared, it has a fine orange-yellow color, its odor is agreeable and aromatic, it produces an abundant lather, and it stands well when used for the hands.

This soap is principally employed in preparing yellow or brown toilet soaps.

CHAPTER XLII.

HALF PALM SOAP.

Pasting—Separation—Coction—Fitting—Formulæ.

This soap is the result of the saponification of a mixture of palm oil and tallow; generally a small proportion of coco oil is added. Rosin produces the same result. The pro-

portions of these three substances are not fixed, and vary according to the uses for which the soap is destined. In England it is prepared with common tallows and an addition of rosin. In France, where this soap is used only for toilet purposes, it is better attended to, and its purification more complete. The following composition gives a soap of superior quality, and the use of which is very advantageous in the preparation of toilet soaps :—

White tallow	1100 lbs.
Palm oil	300 "
Coco oil	100 "
Pure yellow rosin	100 "
	1600

Pasting.

Effect, at a gentle heat, the melting of the tallow and oils, in a kettle of a capacity of at least 625 gallons. When melted, pour into the kettle 100 gallons of new lye at 8° or 10°; heat slowly and gradually, stirring from time to time, and when the ebullition begins, mode rate the action of the heat, to avoid too rapid a reaction in the mass. After continuing the ebullition for about four hours, pour little by little on the paste from thirty five to fifty gallons of new lye at 15° or 18°, and incorporate it by stirring for fifteen minutes. This being done, continue to boil for three hours, or rather until the paste appears quite homogeneous and has acquired a certain consistency. Then a new quantity of thirty-five gallons of lye at 20° may be added, and after a new ebullition of two hours the operation is finished.

Separation.

The pasting being finished, the heat is stopped off, and after a few hours' rest, pour into the kettle a limpid lye of coction at 20° to 25°, or a new lye containing salt in solution. While one man pours in the lye, another stirs the paste all the time. When the quantity of salt lye introduced into the kettle is sufficient, the soap is transformed into small grains, and the lye separates abundantly. After resting five or six hours, draw off the lye. About two-thirds of the lyes which have been used are drawn off; they have a yellowish color, and mark when cold from 15° to 16°. The pasty mass left in the kettle has a fine yellow color.

Coction.

The coction of this soap is very little different from that of pure palm oil soap. Like the latter, it is effected with new and caustic lyes of soda ash marking 25° or 28°. When the operation is done in two services, lyes at 18° or 20° are used for the first service, and lyes at 25° or 28° for the second. When, on the contrary, the coction is finished in a single operation, lyes at 25° are used. This last process is the quickest and most economical.

The lyes being drawn off, pour into the kettle from 150 to 175 gallons of new lye at 25°; heat, and give a gentle boiling, for in the first hours the soap dilates and swells considerably. Its surface is then covered with an abundant scum, which gradually disappears only as the coction progresses. It is necessary to stir from time to time during the whole of the operation. This agitation

is very important for it accelerates the coction of the soap.

When the soap has been gently boiled for three or four hours, the heat may be increased without fear of burning the soap. Generally, after eight or ten hours of ebullition with lye at 25° the soap is completely boiled. The scum has entirely disappeared or there remains very little on the surface of the soap, which then has the form of hard and dry grains. When these grains are pressed between the fingers, they form thin and hard scales. The rosin has been added at the beginning of the coction, so as to saponify it completely.

When the soap is sufficiently boiled, which is known when it forms scales, stop off the heat, let it rest a few hours, draw off the lye, and proceed to the fitting.

Fitting.

Two operations are necessary to completely refine the soap. The first has for its object to soften the grains of soap, and to separate the greater part of the free alkali and saline matters; the second has for its object to completely liquefy the grains of soap and precipitate the coloring and heterogeneous substances, and the excess of caustic lye it contains.

First Liquefaction.—When the lye has been drawn off, pour into the kettle 100 gallons of new lye at 8° or 9°, and heat gradually until boiling, being careful to stir the mixture well. When the grains of soap have become soft, cease the stirring; and to complete the precipitation of the strong lye contained in the soap, boil for five or six hours, or even eight hours.

As by such a long ebullition the grain of the soap has a tendency to be formed again, pour from time to time

into the kettle a few pails of lye at 2° and even pure water. It is, however, necessary that the soap should be always separated from the lye; this is ascertained by pouring some into a glass, and if so, the lye precipitates at the bottom of the glass. It is important and essential to have during the whole operation, the lye separated from the soap, to obtain the separation of the strong lye mixed with the paste.

When this result is obtained, stop off the heat and cover the kettle. Let it rest six hours, then introduce the soap into another kettle and proceed to a second liquefaction.

Second Liquefaction.—Whatever has been the care taken in the first liquefaction, the soap has not been completely deprived of all its causticity; it always contains a certain quantity of caustic alkali, which must be eliminated to obtain a pure product. This is the object of the second liquefaction. But to obtain all the good results this operation may produce, substitute for the caustic lyes of soda ash, a *non caustic solution of crystals of soda.* By its extreme purity and the absence of causticity, this solution completely purifies the soap, depriving it of all its caustic parts.

Pour into the new kettle about 36 gallons of a solution of crystals of soda at 4½° or 5°, and heat to a temperature near the boiling point. Then introduce the soap from the first kettle into the second, being careful not to draw any of the lye.

This being done, boil the mixture gently for four or five hours, being careful to stir from time to time.

By the ebullition with weak lyes (aqueous solution of crystals of soda), the soap entirely loses its granular appearance, and becomes syrupy, fluid, and homogeneous.

As in the first liquefaction, a scum is formed on the

surface of the soap, and this scum is more considerable on account of the greater dilatation of the paste. As by evaporation the lye concentrates, add from time to time very small portions of water, so as to keep the paste always fluid. The heterogeneous coloring and saline parts will be precipitated by resting. The soap must not contain too much water, for in this case it would be too long in hardening. The signs by which it is ascertained that the paste is sufficiently liquefied, are manifested by a slightly blackish coloration, which proves that the black soap has been precipitated to the bottom of the kettle, and is brought up in the mass by the ebullition. When these characteristics have been observed, the operation is finished; stop off the heat, cover the kettle and let it rest eighteen or twenty hours. By resting, the black soap precipitates with the lye, and the pure soap is between it and the scum.

After eighteen or twenty hours' rest, open the kettle and remove the scum on the surface of the soap. Remove the pure soap and introduce it into the frames, passing it through a metallic wire sieve; all the foreign bodies in the soap remain on the sieve.

When all the pure soap has been introduced into the frames stir it well till cold; this manipulation is necessary to obtain it homogeneous. By operating as we have indicated, the above quantities of fatty matters generally give

Soap scum, from	.	140 lbs.	to	160 lbs.
Pure soap, from	.	2100 "	"	2160 "
Black soap, from	.	500 "	"	600 "

The scum and black soaps are mixed with the next operation. The half palm soap has a very pure yellow color when manufactured with good materials. It has

an aromatic odor, and is principally used for fine and half-fine guimauve (marshmallow) soaps.

Formulæ.

The following mixtures may be advantageously used :—

Palm oil	300 lbs.	Palm oil	450 lbs.
Tallow	200 "	Coco oil	50 "
Rosin	200 "		
Tallow	500 lbs.	Lard	550 lbs.
Palm oil	300 "	Palm oil	150 "
Rosin	200 "	Coco oil	50 "
		Rosin	50 "

CHAPTER XLIII.

COCO OIL SOAP.

Preparation of the Lyes—White Soap—Rose Soap—Yellow Soap—Gray Soap.

In speaking of coco oil soaps found in commerce, we have remarked that these soaps are very caustic, and that their causticity is due to the excess of the caustic soda they contain; but when the proportions of lyes are exactly calculated to saturate the fatty acids, a fine white soap is obtained which has the advantage of being very pure.

To obtain it perfectly white, the oil must be of the first quality. Even the oil must be purified by liquefying it, and passing it through a hair sieve to separate

the foreign matters contained in it; by this purification the soap is made whiter.

The lyes must be prepared with soda ash entirely free from sulphurets, and of the most elevated alkalimetric titer, which must never be below 80°. It has been ascertained that by using a certain quantity of potash in the lyes, the soap is more foamy, softer, and more detersive than when prepared with soda alone. Potash, besides, has the property of attenuating the strong consistency of the soaps of coco oil, and preventing them from becoming efflorescent.

Preparation of the Lye.

Experiment has demonstrated that the best proportions of soda and potash to use for preparing this soap are the following:—

Soda ash at 80° to 85° (alkalimetric degrees) . .	188 lbs.
Pearlash, or potash, first quality	12 "
Lime recently burned	70 to 80 "

With the above proportions, the quantity of water to be used to obtain a lye at 30° is seventy-five gallons. The water is heated in a kettle of a capacity of about 175 gallons, and when it begins to boil, the soda ash is thrown into it little by little, being careful to stir all the time, to prevent the soda from sticking to the bottom. When it is dissolved add the potash, and after complete solution of the two salts turn off the heat.

Slack the lime with a small quantity of water, and when reduced to powder add enough water to make a thick paste, which is poured into the boiling solution of potash and soda. Stir for three-quarters of an hour, and cover the kettle.

After twelve or fifteen hours' rest decant the lye, which must mark 30°. It is colorless and perfectly limpid. From the above proportions about 140 to 150 quarts, or 352 to 378 pounds, are obtained.

By washing the residuum with twenty gallons of water, ninety quarts of lye at 20° or 22° are obtained after 12 hours' rest. By continuing to wash the residuum with cold water, it is completely exhausted of all the alkali it contains. All the weak lyes are mixed together, and are evaporated to 30° in a cast-iron kettle. The above quantities of potash and soda yield altogether seventy-five gallons, or 756 pounds of lye at 30° Baumé.

This lye may also be prepared by dissolving four pounds of pearlash in twenty-five gallons of a new and caustic lye of soda ash at 27° or 28°. After the solution of the potash the lye marks about 30°. Let it rest 12 hours or more, decant the clear lye, and keep for use.

Fabrication of the White Soap.

The saponification of the oil takes place in sheet-iron kettles heated by the naked fire or by steam. The capacity of the kettle varies according to the importance of the operation. To prepare 400 lbs. of soap, introduce into a kettle of a capacity of 200 to 250 gallons, 200 pounds of pure white coco oil; add afterwards 200 pounds of colorless and perfectly limpid lye at 30°.

All being ready, heat the kettle, and to accelerate the combination of the substances, stir well from time to time. Under the influence of heat the material, which at first was in the form of grains, softens and becomes liquid; continue to heat slowly and gradually until the combination between the oil and alkali is effected, which generally takes place when the ebullition begins.

When properly boiled, the soap has the appearance of a fluid, homogeneous, and sirupy paste. Its color is amber white. It is useless to boil it; stop off the heat and draw off the soap into the frame.

If, on the contrary, it happens when the mixture begins to boil that a certain quantity of oil swims at the surface of the paste, it may be combined with the saponified mass, by adding ten to twelve pounds of coco oil soap. The same result is obtained by adding eight or ten quarts of pure water. After stirring a few minutes, the homogeneity of the soap is re-established, and the combination of the substances is perfected. The heat is then stopped and the soap drawn off into the frame.

To give this soap an agreeable odor, it is perfumed with essential oils, which are introduced as soon as the soap is in the frame; the proportions of oil to be added are generally one drachm to the pound. Then to perfume the 400 pounds of soap, the quantity to be used should be 53 ounces. The following composition gives a sweet and delicate bouquet:—

Oil of lemon	8	ounces.
" caraway	10	"
" rosemary	5	"
" thyme	3½	"
" lavender	20	"
" peppermint	6½	"
	53	

Mix the oils and incorporate them in the soap as soon as it is in the frame, for if the soap is too cold the combination will be imperfect.

The composition of the perfumes may be varied indefinitely, but it must be managed with intelligence, for all odors do not harmonize. The use of colored oils must be avoided, for they destroy part of the whiteness of

the soap. After five or six days, the soap is firm enough to be taken out of the frame; it is then divided into cakes weighing about three ounces. These cakes generally bear the name of the manufacturer or the nature of the soap.

Obtained by the above process, this soap is very white, does not contain any excess of alkali or oil, and may be employed for toilet uses. From the quantities indicated above, from 396 to 420 pounds of soap are obtained, according to the quantity of water added. The operation lasts about one hour.

Rose Soap of Coco Oil.

To give this soap a rose color, mineral substances only can be used, for those derived from the vegetable or animal kingdoms are always more or less modified by their mixture with the soap. Among the mineral substances used to impart a rose color to soap, we name minium, orange mineral, and especially vermilion.

The method of operating is very simple. When the white soap is prepared and ready to be introduced into the frame, incorporate with it from ½ to 1 drachm of vermilion to the pound, according to the shade to be obtained. When by a proper agitation, sufficiently prolonged, the color is mixed in the mass, and all the parts are uniformly colored, pour the soap into the frame. Sometimes the soap is colored in the frame itself, but experience has demonstrated that it is preferable to color it in the kettle after turning off the heat. If the soap is to be perfumed, add the essential oils while it is yet fluid.

There exists in commerce a kind of white soap full of rose marblings. To obtain this soap, pour into a frame a certain weight of white soap, 180 pounds, for example.

When this soap begins to lose its fluidity and begins to grow thick, pour on it, nearly boiling, twenty pounds of strongly colored coco oil soap. Mix the two soaps by an agitation of a few minutes only. The colored soap, by spreading unequally in the mass of the white soap, forms the marblings so agreeable to the eye. If the white soap is too warm, or if the stirring of the two soaps is too much prolonged, instead of marblings a paste uniformly colored will be obtained. It is then important to conduct the operation as indicated above.

Yellow Soap of Coco and Palm Oils.

To prepare this soap, mix ten per cent. of natural palm oil with coco oil, and saponify the two oils together in the same manner as for white soap. If the soap has not the required shade, add to it a solution of annotto, obtained by boiling for ten minutes three ounces of annotto in one gallon of lye at 10°; pass this solution through a cloth before adding it to the soap.

When the soap is uniformly colored, introduce it into the frames and perfume it. The following composition gives a sweet perfume:—

Essential oil of	cinnamon	. . . .	3	ounces.
" "	bitter almonds	. . .	5	"
" "	thyme	. . . .	13½	"
" "	cloves	. . . .	2	"
" "	lemon	. . . .	6½	"
" "	lavender	. . . .	13½	"
" "	rosemary	. . . .	10	"
			53½	

Incorporate this composition into the soap as soon as it is poured into the frame, and stir for a few minutes.

Gray Soap of Coco and Palm Oils.

As we have said before, while speaking of the fabrication of ordinary coco oil soaps, this may be obtained of a gray shade by saponifying coco oil with a certain quantity of palm oil, on which a mixture of nitric acid and zinc has reacted so as to give it a black color.

To prepare a gray toilet soap, treat a mixture of 192 pounds of coco oil and 8 pounds of black palm oil, with their weight of a lye of soda and potash at 30°, and operate exactly in the same manner as for the white soap.

The proportions of palm oil we indicate are sufficient to communicate to the soap a very agreeable gray shade. It may be perfumed with the same composition used for the yellow soap.

CHAPTER XLIV.

SOAPS MADE BY THE COLD PROCESS.

Preparation of the lye—White Soap—Rose Soap—Yellow Soap—Windsor Soap for Shaving—Lard Soap—Beef-Marrow Soap—Sweet Almond Soap—Hawes' Soap—Macquer's Soap—D'Arcet, Pelletier, and Lelièvre Soap—Chemical Oil Soap—Red Oil Soap—Formulæ for Perfumed Soaps.

The cold saponification of oils and animal greases by lyes of soda, forms soaps which are never completely neutral. Whatever may be the care taken in their preparation, these soaps are always more alkaline than those made by the warm process, and perfectly deprived

of all excess of alkali by the liquefaction of the saponified paste. Besides, the saponification by the cold process can be applied only to the fabrication of white and colored soaps, but not to that of Marseilles soap.

As to economy, the fabrication by the cold process is possibly less advantageous than by the warm process, because it requires a previous concentration of the lyes used to prepare them. Independently of the kettles, this concentration of lyes by the action of heat requires an expense as much greater as the lyes may be weaker.

Nevertheless, for some years this fabrication has been considerably extended, and in the numerous manufactories already existing, the relative proportions of alkali and fatty matters they employ are exactly calculated, so that the use of these soaps cannot be injurious.

Preparation of the Lye.

To prepare a perfectly caustic lye operate as follows: Introduce 125 gallons of water into an iron kettle of a capacity of about 250 gallons; heat the kettle, and when the water begins to boil, dissolve in it a sufficient quantity of crystals of soda so as to have a solution at 18° or 20°; add afterwards, by small portions to the boiling liquor, lime recently burned and mixed with a little water. To transform the carbonate of soda completely into oxide, use for every 100 pounds of crystals of soda, from forty to fifty pounds of lime. By the addition of the lime a rapid effervescence is produced. All the lime being introduced into the solution of soda, submit the mixture to a gentle ebullition so as to transform the liquor into hydrate of soda. It is ascertained that the decomposition is complete, by pouring a small portion of the clear liquor into a test glass, and saturating the liquor

by an excess of hydrochloric acid. If all the carbonate has been transformed into caustic soda, no effervescence is produced; if, on the contrary, there is any effervescence, continue the ebullition until it is no longer produced, by the addition of hydrochloric acid.

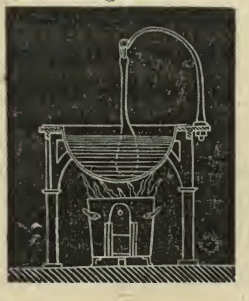
When this result is obtained, stop off the heat and let the liquor settle. During the rest, the lime slowly deposits at the bottom of the kettle and the clarified liquor contains the pure and decarbonated alkali, that is, the hydrate of soda or caustic lye. As this lye is of too weak a degree, decant it carefully. To obtain it in a proper state of concentration, evaporate it in a cast-iron kettle until it marks 36°. The lye thus prepared is colorless and entirely caustic.

White Soap.

The saponification of fatty matters by the cold process is generally effected on only a few hundred pounds of soap at a time, and often on smaller quantities. This fabrication requires apparatus little costly, which are:—

Two cast-iron kettles; one to prepare the lyes, the

Fig. 66.



other to manufacture the soap. Their capacity varies according to the importance of the fabrication, but is

rarely above 125 to 150 gallons. That destined to manufacture the lyes is fixed in a furnace of masonry, the other is movable and heated by a small furnace in which charcoal is burned. The Figure 66 represents this last kettle.

The fatty substances used are principally tallow, lard, coco, and palm oils.

To obtain white toilet soap of the first quality, employ white grease and coco oil. The following are the best proportions to use :—

Pure white grease . . .	120	pounds.
Coco oil	40	"
Lye of crystals of soda at 36° .	80	"
	240	"

Saponify as follows: Melt the grease and the oil in a cast-iron kettle of a capacity of about 75 gallons. This kettle is heated by charcoal in a small furnace (see above, Fig. 66). To operate with great precision, dip a thermometer into the melted grease, and when the temperature has reached from 113° to 122°, pour in slowly the 80 pounds of lye at 36°, stir the mixture all the time with an iron spatula until the entire saponification of the materials. It is important not to raise the temperature above 122°, for in that event a part of the lye would separate from the fatty substances.

For the quantities indicated above, the operation lasts about two hours. When the saponification is finished, which is ascertained when the fatty matters are exactly combined with the lye, run the soap into a frame. While the soap is yet soft, it may be perfumed with 13 ounces of oil of bitter almonds, and 4 ounces of oil of lemon for 100 pounds of soap. The above mixture may be substituted by thirteen ounces of artificial oil of bitter

almonds, but this last communicates to the soap a yellowish shade. This soap may be also perfumed with the following mixture for 100 pounds :—

Oil of vervain	. . . . .	2½ ounces
" lavender	. . . .	2 "
" bergamot	. . . .	2 "
" lemon	. . . . .	2 "
" thyme	. . . . .	3 "

The oils must be added as soon as the soap is poured into the frame ; it would be better to incorporate them with the soap before running into the frame.

A remarkable phenomenon, not produced with soaps boiled on the lye, occurs five hours after the soap is poured nearly cold into the frame ; a spontaneous reaction takes place, which raises the temperature above 176°. Under the influence of this temperature the different constituent principles of the soap combine more directly and intimately, and the product is better. It is then important to hasten that reaction by closely covering the frame.

A few days after the mass of soap is cooled and solidified, take it out of the frame and divide it into little cakes weighing from three to seven ounces, which are dried in the drying room.

The addition of a quarter of coco oil to this soap has for its object, to render it softer and more detersive. Without this addition, it would be little suited for washing, because the large proportion of stearate of soda contained in it considerably diminishes its solubility; we think, also, that a certain quantity of potash in the lyes would improve the quality of the soap, and increase its solubility. The quantities of substances used give from 236 to 238 pounds of soap, or 149 per 100.

When well prepared, this soap is of a very pure white, not very alkaline, and produces an abundant lather with water.

Rose Soap.

In rose soaps prepared by the cold process, the coloring matter is introduced into the melted greases before adding the lye; the color is thus better mixed. The proportions of vermilion are from ½ to 1 drachm to the pound of soap. When the coloring matter has been well mixed in the melted greases, introduce the lye at 36°, and operate as for white soap.

To perfume this soap, use for 20 lbs. :—

Oil of rose	1 ounce.
" geranium	1½ ounces.
" cinnamon	½ ounce.
" cloves	3 drachms.
" bergamot	1 ounce.

Mix the oils and incorporate them in the soap just before running into the frame.

This composition communicates to the soap a very sweet odor.

To obtain a cinnamon color, substitute brown ochre for vermilion. We may observe that the Prussian brown or burnt sienna produces finer shades. All the varieties of brown shades are obtained by mixing these substances and introducing them into the melted greases before the addition of the lye. For the lighter shades, the proportions are half a drachm per pound, but for the dark shades, half an ounce, and sometimes more, is used.

This soap is perfumed with the following composition for twenty pounds of paste :—

Oil of cinnamon	2½ ounces.
" cloves	2½ drms.
" sassafras	½ ounce.
" bergamot	½ "
" lemon	2¾ ounces.

Yellow or Marshmallow Soap.

This soap, which has a fine yellow color, is obtained with tallow, palm, and coco oils. The following proportions give excellent results:—

White tallow	50 lbs.
Coco oil	30 "
Palm oil	20 "
Lye of soda at 36°	50 to 52 "

Melt the tallow and other fatty substances in a sheet-iron kettle, add the lye, and operate as for white soap. If the color is not dark enough, add a solution of annotto, prepared by boiling one ounce of annotto in one quart of lye of soda at 10°, boil five minutes and pass through a cloth.

Perfume this soap with the following composition calculated for 150 lbs. of soap:—

Oil of lavender	16 ounces.
" lemon	3 "
" vervain	2 "
" peppermint	½ ounce.
" neroly petit grain	1 "

Windsor Soap for Shaving.

Take

White tallow	80 lbs.
Coco oil	40 "
Lye of crystals of soda at 30°	68 "
" " potash at 30°	12 "

Melt the greases in a kettle of a capacity of about fifty gallons. When the fusion is complete and the temperature is at about 95°, introduce the lyes little by little, stirring all the time, and continue until the substances

form a homogeneous paste; the operation lasts about fifteen minutes. This soap is perfumed with

Oil of carvi (caraway), . . .	6½ ounces.
" bergamot	10 "
" Portugal	1½ "
" cloves	½ ounce.
" lavender	4 ounces.
" thyme	3½ "

Add the oils to the soap a few minutes before introducing into the frames.

When the soap has become solid divide it into cakes weighing from two to four ounces, according to the size of the mould.

The soap thus prepared is of a very pure white, and does not contain too much caustic alkali.

Lard Soap.

To prepare this soap, weigh 112 pounds of lard, and 56 lbs. of caustic 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,. being careful not to raise the temperature above 149° F. The paste should be well united, homogeneous, and of a certain consistency. 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 consistency.

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 2000 parts of boiling water, and then pour in 1000 parts of brine, holding in solution 180 parts of common salt, during uninterrupted raking, and then leave to repose. After some time, pour into the 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 from 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 several 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 consistency becomes such that it can be turned into porcelain moulds. When submitted to 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.

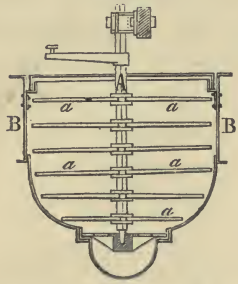
Hawes' Soap.—The invention of Mr. Hawes has for its object, the intimate combination and admixture of the soap ingredients by mechanical means, and without boiling, and the inducement of perfect saponification of the fat with the alkali, without recourse to that high degree of heat requisite in making 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 a 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. 66, 67, and 68. It consists of an

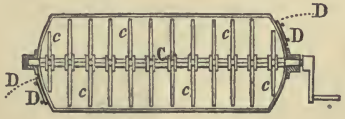
upright shaft A (Fig. 67), from which arms, *a a a a a*, radiate to the sides of the caldron B. This shaft, either permanently or temporarily fixed in the copper, may be of wood or iron. The mode of fixing the apparatus and

Fig. 67.



the materials used first, will depend on the nature of the caldron, and the convenience of the manufacturer. An oscillating motion, or rotary 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. 68) passing through it

Fig. 68.

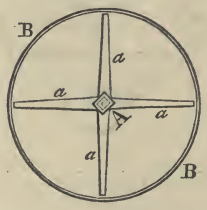


horizontally, and from which arms, *c c c c c c*, may radiate, when a rotary motion will thoroughly incorporate the fatty matter and the lye.

"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. 69.



"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 d'Arcet, 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 consistency. 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 Morfit, 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 coco 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 1000 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.

Formulæ for Perfumed Soaps.

Savon fleur d'Italie, extra fin (for 240 lbs.).

Lard body with vanilla	70 lbs.
Pommade de Grasse with orange flower	30 "
Oil perfumed with rose	20 "
Coco oil	20 "
Butter of cacao	16 "
Olive oil	4 "
Wax	2 "
Caustic lye	78 "
Gum tragacanth	7 ounces.

Melt the wax over a water-bath, add the olive oil, then the cacao, and coco oil. All being melted, mix them with the pomade and the perfumed body, and stir well until the whole has become fluid; then pour the mixture into the kettle, add the lye, and saponify in the usual way. This soap may also be perfumed with

Oil of neroli	1½ ounce.
" cloves	3½ ounces.
" bouquet anglais	6½ "
" rose	2 "
Tincture of amber	1 ounce.
" " musk	1 "

Savon Jonquille, extra fin (for 240 lbs.).

Pommade de Grasse with orange flower	50 lbs.
" " tuberose	50 "
" " jasmine	40 "
Oil de Grasse with jasmine	16 "
White wax	4 "
Caustic lye	80 "
Gum tragacanth	3 ounces.

Operate as above. To give this soap a yellowish color, boil for five minutes, one ounce of annotto in one quart

of lye of soda at 10°, pass through a cloth and pour into the soap.

Perfume with

Tincture of storax	20 ounces.
Liquid balsam of Peru	8 "
Tincture of musk	6½ "
" amber	6½ "

Melt the white wax, and pour in the balsam of Peru, dissolve it and continue as above.

Savon au Benjoin, extra fin (for 240 lbs.).

Lard body with benzoin	80 lbs.
" " flowers of benzoin	28 "
Olive oil	20 "
Coco oil	30 "
Caustic lye	80 "
Gum tragacanth	6 ounces.
White wax	2 lbs.

Operate as above and perfume with

Oil of bergamot	13 ounces.
" lemon	10 "
Powdered benzoic acid	7 "
Oil of rose	1 ounce.
" lavender	1 "
Tincture of benzoin	27 ounces.

Savon Ambré, extra fin (for 240 lbs.).

Lard body with musked amber	80 lbs.
Pommade de Grasse with jasmine	40 "
Lard body with ambrette	20 "
Oil with rose	20 "
White wax	1 lb.
Caustic lye	76 lbs.
Gum tragacanth	5 ounces.

Operate as above, and perfume with

Compound tincture of amber	2 lbs.
Extract of lavender	2 "

Savon Mille-fleurs, extra fin (for 240 lbs.).

Lard body with vanilla	60 lbs.
" " ambrette	46 "
Pommade de Grasse à la rose	30 "
Oil with rose	20 "
White wax	2 "
Butter of cacao	6 "
Caustic lye	76 "
Gum tragacanth	7 ounces.

Operate as above and perfume with

Oil of lavender	2½ ounces.
" lemon	3½ "
" bergamot	1½ "
" cloves	1 ounce.
" geranium	6 drachms.
Tincture of amber	5 "
" " musk	2½ "
" " civet	1 drachm.

Savon au Miel d'Angleterre, extra fin (for 120 lbs.).

Pommade de Grasse à la tubereuse	30 lbs.
" " au jasmin	20 "
Oil with jasmine	10 "
Lard body with vanilla	10 "
" " orris root	10 "
" " benzoin	2 "
White wax	2 "
Caustic lye	40 "
Gum tragacanth	5 ounces.

Operate as above and perfume with

Extract miel d'Angleterre	2 ounces.
Tincture of musk	2 "
" amber	2 "
" civet	5 drachms.
Oil of rose	2½ ounces.
" cloves	1 ounce.
" bergamot	2 ounces.

Savon à la Maréchale, extra fin (for 122 lbs.).

Lard body à la maréchale . . .	48 lbs.
Pommade de Grasse au jasmin . .	6 "
" " à la fleur d'orange	6 "
" " à la tubereuse .	6 "
" " à la cassie . .	6 "
Lard body à l'ambre	2 "
" au musc	1 lb.
Olive oil	4 lbs.
White wax	1 lb.
Coco oil	4 lbs.
Caustic lye	38 "
Gum tragacanth	6 ounces.

Operate with great care in the fabrication of this soap; do not apply too much heat. Perfume with

Compound tincture à la maréchale . .	1 lb.

Savon au Bouquet, extra fin (for 120 lbs.).

Purified lard body	50 lbs.
Coco oil	20 "
Olive oil	10 "
White wax	2 "
Caustic lye	38 "
Gum tragacanth	4 ounces.

Operate as above, and perfume with

Oil of bergamot	16 ounces.
" cloves	3 "
" neroli	3 "
" sassafras	2 "
" thyme	2 "

Savon au Suc de Concombre, extra fin.

For the fabrication of this soap, prepare the lye by dissolving two pounds of pearlash in fifty quarts of new and caustic lye of soda ash at 27° or 28°.

After the solution of the potash, the lye marks about 30°. Let it settle 12 hours and decant the clear lye.

Saponify in a sheet-iron kettle heated by steam or a naked fire. If the operation has to be done on 200 lbs. of soap, introduce into a sheet-iron kettle of a capacity of 100 to 125 gallons, 80 lbs. of coco oil, and 20 lbs. of bleached palm oil. Add afterwards, 100 pounds of lye at 30°, prepared as indicated above. All being ready, saponify as usual. When the soap is made, it has the appearance of a fluid, homogeneous, and sirupy paste. Its color is amber white.

Perfume with the following mixture :—

Oil of cucumber	3	ounces.
" bergamot	10	"
" cloves	1	ounce.
" geranium	6½	ounces.

Soap Made of Coco Oil.

White coco oil	100	lbs.
Lye at 30°	100	"

Same lye as the above, and operate in the same manner. Perfume with one drachm of oil to the pound of soap. The following perfume is very good :—

Oil of peppermint	5½	ounces.
" sage	5½	"
" thyme	5½	"
" lavender	4	"
" rosemary	3	"
" serpolet (wild thyme)	3	"

Savon Mousseux de Guimauve.

Coco oil	80	lbs.
Palm oil	8	"
Cameline oil	6	"
Colophony	6	"
Lye at 30°	100	"

Operate as above ; after pouring in the lye incorporate

Gum tragacanth	10	ounces.

If, towards the end of the operation, some of the oil swims at the surface, it is combined with the paste by an addition of four or five quarts of pure water.

Perfume with

Oil of cloves	2 lbs.
" cinnamon	1 lb.
" portugal	3 lbs.
" thyme	3 "

Savon Hygiénique Dulcifié Lactarius.

This soap is successfully used for allaying the irritation of the skin, and its results are excellent.

Lactarine cream	14 lbs.
Spermaceti	2 "
White wax	4 "
Oil of sweet almonds	6 "
Coco oil	28 "
Lard body	30 "
Caustic lye	38 "
Gum tragacanth	4 ounces.

Operate as above, and perfume with

Oil of bitter almonds	2½ ounces.
" bergamot	12 "
" cloves	1 ounce.
" geranium	5 ounces.

Add to the paste of the soap before perfuming

Almond flour	8 ounces.
Rice flour	2 "
Powdered orris root	1 ounce.
" white soap	1 "

Mix all these substances and incorporate them.

Savon Amygdalin au Suc Laiteux de Framboises.

Soap of beef suet	140 lbs.
" coco oil	60 "

Color light rose.

Moisten it with seventeen quarts of double water of raspberries, and perfume with

Pure rose powder à la framboise	1 lb.
Concentrated infusion of raspberries	2 qts.
Balsam Peter's balm	6½ ounces.
Oil of rose	3½ "
Tincture of amber	2 "

Savon Cold Cream Solidifié.

Lard	30 lbs.
Coco oil	28 "
Oil of sweet almonds	6 "
Spermaceti	2 "
White wax	4 "
Cold cream	14 "
Caustic lye	38 "
Gum tragacanth	4 ounces.

Operate as above, and perfume with

Oil of bitter almonds	2½ ounces.
" bergamot	12 "
" cloves	1½ "
" geranium	5 "

Savon à la Rose. No. 1.

Paste of soap à la rose	40 lbs.
Infusion of storax	½ oz.
Oil of civet	1¼ drm.
" musk	2½ "
" bergamot	1¼ "
" thyme	¼ "
" rose	3 ounces.
Powdered rhodium wood	3½ "

Savon à la Rose. *No.* 2.

Paste of soap à la rose . . .	40 lbs.
Oil of rhodium wood . . .	3½ ounces.
" rose	1 ounce.
" cloves	5 drachms.
" civet	2 "
" thyme	½ drachm.
" bergamot	2½ drachms.
Infusion of storax . . .	2½ "

Savon à la Rose. *No.* 3.

Paste of soap à la rose . . .	24 lbs.
Rhodium wood	2 ozs.
Oil of rose	½ oz.
" cloves	1 "
" civet	½ drm.
" thyme	¼ "
" bergamot	1¼ "

Savon à la Rose. *No.* 4.

Paste of soap à la rose . . .	35 lbs.
Rhodium wood	3 ozs.
Oil of rose	1 oz.
" cloves	½ "
" civet	1¾ drm.
" thyme	½ "
" bergamot	2 "
Infusion of storax . . .	2 "

Savon aux Violettes des Bois, extra fin (for 120 lbs.).

Pommade de Grasse à la cassie . .	42 lbs.
" " au jasmin .	4 "
Oil with jasmine	10 "
Lard body with orris root . . .	14 "
" " ambrette . . .	14 "
White wax	2 "
Caustic lye	36 "
Gum tragacanth	4½ ozs.

Operate as above and perfume with

Tincture of orris root	6 ounces.
" ambrette	6 "
Oil of geranium	10 "
" bergamot	10 "

Savon aux Violettes de Parme, extra fin (for 120 lbs.).

Pommade de Grasse à la violette	48 lbs.
Oil with jasmine	4 "
" rose	4 "
" cassia	4 "
Palm oil	20 "
White wax	2 "
Caustic lye	38 "
Gum tragacanth	5 oz.

Operate as above, and perfume with

Essence of bouquet Anglais	13 ounces.
" orris	7 "
Extract of violet	16 "

Savon Hygiénique, extra fin (for 120 lbs.)

Pommade à la fleur d'oranger	20 lbs.
" " rose	18 "
Coco oil	20 "
Palm oil	10 "
Olive oil	10 "
White wax	2 "
Caustic lye	38 "
Gum tragacanth	5 ozs.

Operate as above, and perfume with

Tincture of benzoin	1 qt.
Oil of bergamot	13½ ozs.
" lemon	1 oz.
" sandal	1½ ozs.
" cloves	1½ "
" geranium	4 "
" lavender	1 oz.
" cinnamon	½ "
" citronella (balm mint)	2¾ drms.

Savon Impérial Français, extra fin (for 120 lbs.).

Pommade de Grasse à la rose	16 lbs.
" " à la fleur d'oranger	16 "
Lard body with amber	12 "
Extract of pomade with musk	6 "
" " " vanilla	6 "
Palm oil	8 "
Coco oil	8 "
Olive oil	8 "
White wax	3 "
Caustic lye	38 "
Gum tragacanth	4½ ozs.
Powder body of mousseline	2 "

Incorporate the body of mousseline with the gum, and introduce into the mixture; operate as above, and perfume with

Extract of lavender	1 quart.
Oil of cloves	1 ounce.
" bergamot	8 "
" sandal	2 "
" geranium	2 "
" rose	5½ drms.
" citronella	1¼ "
Tincture of storax	4 ounces.
" balsam of Peru	2 "

Savon à la Mousseline, extra fin (for 120 lbs.).

Lard	16 lbs.
Coco oil	16 "
Butter of cacao	12 "
Oil of sweet almonds	6 "
Olive oil	6 "
Infusion of St. John's wort in olive oil,	8 "
Palm oil	12 "
Spermaceti	2 "
White wax	2 "
Caustic lye	38 "
Gum tragacanth	6½ ozs.

Melt together over a water-bath the wax and spermaceti, then operate as above, and perfume with

Extract of mousseline	1 quart.
Powdered body of mousseline	3½ ounces.

Then perfume with

Body of powder of amber	2½ drms.
" " musk	1¼ "
Tincture of civet	1¼ "

Savon au Musc, extra fin (for 240 lbs.).

Palm oil	40 lbs.
Lard	80 "
Coco oil	24 "
Olive oil	16 "
Caustic lye	80 "
Gum tragacanth	4 ozs.

Operate as above, and add

Oil of bergamot	16 ounces.
" rose	2 "
" cloves	2 "
Tincture of musk	3 "

Color with one pound of Prussian brown.

Savon Médicinal, extra fin (for 240 lbs.).

Lard	80 lbs.
Infusion of lily flowers in oil	32 "
Butter of coco	24 "
Oil of sweet almonds	16 "
White wax	8 "
Caustic lye	80 "
Gum tragacanth	5 ozs.

Operate as above, and perfume with

Oil of citronella	10 ounces.
" vervain	6½ "
" peppermint	5 "
Tincture of amber	2½ "
" musk	2 "
" civet	2½ "

KURTEN'S TABLE

Showing the composition and product of soap by the cold process from concentrated lye, and mixtures of coco oil with palm oil, lard, and tallow.

Soap.	Tallow.	Coco oil.	Palm oil.	Lard.	Lye.	Degrees.	Salt water.	Degrees.	Potash.	Degrees.	Product.
Coco-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	or	...	...	120	27	...	...	...	...	214
	33	34	33	...	...	...	...	...	...	...	...
" No. 2 . .	33	34	33	...	120	27	12	12	...	...	226
Washing, No. 1 . .	60	40	...	...	...	...	...	...	...	...	...
	or	or	...	...	125	27	25	12	...	...	244
	30	40	30	...	...	...	...	...	...	...	...
" No. 2 . .	40	60	...	...	...	...	...	...	...	...	...
		or	...	...	135	27	50	15	...	...	278
	...	60	40	...	...	...	...	...	...	...	...
Ordinary coco oil .	...	100	...	...	...	...	...	...	...	...	...
	or	or	...	...	...	...	...	...	...	...	...
	10	90	...	...	225	21	75	12	...	...	400
		or	...	...	...	...	...	...	...	...	...
	...	90	10	...	...	...	...	...	...	...	...

CHAPTER XLV.

FLOATING SOAPS.

The lightness and porosity of these soaps are due to the introduction of a certain quantity of air into the paste, which, by considerably dilating its molecules, increases proportionally its volume.

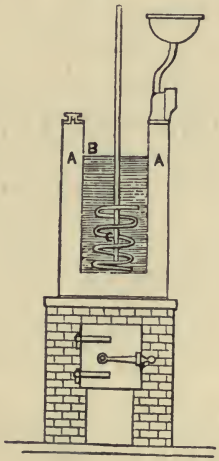
Sometimes, but rarely, these soaps are prepared with the scum which results from the preparation of white soaps; sometimes, but more rarely, they are also obtained by strongly stirring the fat of the same soap, that

is, the residue which is left in the kettle after the liquefaction of the white soap; but the soap thus obtained is very defective.

The perfumer prepares these soaps by a very different process. The principal object in the fabrication of light soaps being, as we have said, to introduce air into the paste, the following process is the best :—

Take 20 pounds of fine white tallow soap, reduce it into fine shavings, and melt with half its weight of clear water. Use for this operation the apparatus represented below.

Fig. 70.



Under the influence of heat and by stirring, the soap becomes frothy, and forms a very abundant foam; when it is in this state turn off the heat.

A A (Fig. 70) is a cucurbit.

B is a tinned copper water-bath.

C is a beater or stirrer, to which a movement of rotation is given.

The capacity of the water-bath for twenty pounds of

soap must be twenty-five gallons. The soap is put into the water-bath B, with the necessary quantity of water, and when it is melted, the beater C is put in motion. For the operation to succeed well, the temperature of the mixture must be between 158° and 176°.

After settling two or three hours, draw off the soap into one or more frames, being careful that the thickness of the soap in the frames is not more than six or seven inches. Seven or eight days after, cut the soap into cakes. This soap is nearly always colored rose with ½ to 1 drachm of vermilion for one pound of soap. Aromatize according to taste.

CHAPTER XLVI.

POWDERED SOAPS.

Powdered soap is a cosmetic very much employed for the hands, baths, and shaving. The principal and essential qualities which distinguish powdered soap, are a very slight alkaline taste, and a great solubility in water and boiling alcohol.

In the manufacture of toilet soaps, the powder is often prepared by grinding in a marble mortar the scraps from the small cakes destined to be moulded. When these pieces have been properly pulverized, the fine powder is separated by means of a silk sieve.

But when the powder has to be directly prepared, take cakes of pure white soap, and reduce them to very thin shavings, which are spread on sheets of paper and dried in a room heated by hot air. When the soap is entirely dried, which is ascertained when it has lost its flexibility, and is reduced to powder when pressed between the

fingers, it is ground in a marble mortar. To avoid the loss of a certain quantity of soap, a mortar closed by a bag of leather must be used.

As fast as a certain quantity of soap has been powdered, pass it through a drum sieve to separate the finer portions.

When the powder is to remain white, aromatize the soap with two drachms of oil of bitter almonds per pound of soap. Experience has proved that it is better to aromatize the soap before powdering it; it is then whiter, drier, and more uniformly perfumed.

To obtain a rose colored powder, grind the soap with half a drachm of vermilion per pound. This is ordinarily perfumed with oil of rose.

To obtain a yellow powder, grind the soap with one or two drachms of gamboge, according to the shade to be obtained. Aromatize according to taste.

Such are in general the processes followed to prepare the different kinds of powdered soaps found in commerce. As a cosmetic, it is one of the best to use for shaving.

As powdered soap is always more or less hygrometric, it must be kept in very dry and well-corked bottles.

Poudre de Savon de Windsor.—Take Windsor soap as white and dry as possible, pulverize it and pass it through a sieve; melt over a water-bath; when melted, run it into a box, and when cold, cut into fine shavings, dry it, powder, and pass it through the sieve.

Poudre de Savon au Beurre de Galam.—Take one part butter of Galam, one part of good white soap, and cut them into fine shavings. Subject to a very gentle heat over a water-bath, so as to have it dry but not melted. When entirely dry, powder it and pass through the sieve.

Poudre de Savon Onctueuse.—Take light soap, cut it into fine shavings and dry it; powder and sift it.

Poudre de Savon Parfumé à toute Odeur.—This powder is perfumed by introducing, when the soap is melted, the same quantity of essences as for the cakes, that is, for six pounds of soap take:—

Oil of bergamot	4	ounces.
" lemon	1	ounce.
" Portugal	½	"
" anise-seed	½	"

Perfume with any other oils if desired.

CHAPTER XLVII.

ESSENCE OF SOAP.

By this name is designated a solution of soap in alcohol. As soap is less soluble in cold than in warm alcohol, the solution must be made while warm. It is also desirable to employ the alcohol at such a degree of concentration as to have a limpid solution. When this liquid is below 80°, it has a nebulous aspect on cooling. Alcohol at 80° to 85° is the best to use.

All kinds of soap are not suitable to prepare the essence; those made with animal greases, while very soluble in boiling alcohol, solidify by cooling.

The soaps made with vegetable oils, are also very soluble in boiling alcohol, and have the advantage of forming solutions which retain their limpidity and fluidity after cooling, consequently they are preferable. The addition of a small quantity of potash increases the solubility of soaps in alcohol, but this addition must be made carefully, so as not to render the essence too caustic;

generally, two to three drachms of potash for one pound is sufficient to give an alkaline reaction. We give now a general formula for preparing the essence of soap.

Take

White Marseilles soap . . .	6½ ounces.
Alcohol at 85°	1 quart.
Potash	6 drms.

Cut the soap into fine shavings, and put it into a bottle of half a gallon capacity ; add the alcohol and potash, and heat gently, without boiling, over a water-bath. Stir with a glass rod. When the solution is complete, take it out of the water-bath, and add the essence. A very sweet perfume may be given to this preparation by adding to it :—

Oil of geranium	1½ drms.
" vervain	2½ "

To color yellow add two and a half drachms of saffron.

This essence continues limpid at the ordinary temperature. To use it, pour a little into half a tumbler of water and stir quickly. It is a cosmetic very generally used.

In the following formulæ the quantities are calculated for two pounds, six ounces.

Perfume of Bitter Almonds.

Take

Oil of bitter almonds	2½ drms.
" bergamot	1¼ "

Another.

Take

Artificial oil of bitter almonds . .	1¼ drms.
Oil of bitter almonds	1¼ "
" cinnamon	¼ "

Perfume for Windsor Soap.

Take

Oil of bergamot	1¼ drms.
" cloves	¼ "
" thyme	1¼ "
" peppermint	½ "

Perfume of Lemon.

Take

Oil of lemon	3 drms.

Perfume of Portugal.

Oil of Portugal	3 drms.

An essence of soap having a very sweet and fine perfume may be prepared as follows:—

Spirit of roses	6½ ounces.
" vanilla	3½ "
" orris	6½ "
" orange flowers	16 "
White soft soap	3½ "
Potash	2½ drms.

Melt over a water-bath the soap and potash in the perfumed spirits, and proceed as above. When the soap is entirely dissolved, filter.

Essence de Savon d'Italie.

White soap	10 ounces.
Alcohol at 85°	24 "

Perfume with rose or orange flower.

Essence de Savon de Prusse, Hanovre, et Saxe.

White soap	10 ounces.
Rectified alcohol	30 "
Rose water	10 "

Essence de Savon de Bavière.

White soap	10 ounces.
Alcohol at 50°	40 "

Essence de Savon de Vienne.

White soap	3 ounces.
Carbonate of potash	1 drm.
Alcohol at 95°	18 ounces.
Lavender water	6 "

Digest and filter.

Essence de Savon de Corinthe.

Alcohol at 80°.	1 quart.
Dry white soap	10 ounces.
Potash	2 "
Essential oil	a few drops.

Essence Double de Savon de Corinthe.

Dry white soap	10 ounces.
Alcohol at 85°	30 "
Distilled water	10 "

There was, some years ago, in the market, a composition called *saphofane*, much used for the toilet. This product, which has always a very thick sirupy consistency, is nothing but a solution of rosin and tallow soap.

A perfect imitation is thus prepared :—

Soap of rosin and tallow	2 lbs.
Alcohol at 85°	2 quarts.
Saffron	1 ounce.

The soap is cut into fine shavings and dissolved in the alcohol without ebullition. Perfume with

Oil of cinnamon	½ ounce.
" cloves	1¼ drms.
" lemon	1¼ ".
" peppermint	½ drm.

Mix well, and while the mixture is warm, pass it through a fine silk sieve. When cold, bottle it. This preparation makes a fine foam with water.

CHAPTER XLVIII.

TRANSPARENT SOAPS.

The transparent soaps, colored or colorless, are prepared by dissolving tallow soap, well dried, in alcohol. All solid soaps are not suitable for the preparation of transparent soaps; those made with olive oil treated by alcohol, acquire with difficulty a solid consistency, and the soap which results from it is opalescent. Fine tallow soap is preferable, although resinous soap with tallow is very good.

The principal condition to be observed in their preparation is the use of perfectly dried soap and highly concentrated alcohol.

Let us suppose that we use white tallow soap. Reduce it into very fine shavings, spread it on sheets of paper, and expose it in an oven until completely dried; powder it in a marble mortar, and pass it through a silk sieve. The powder thus prepared is directly dissolved in alcohol. This last operation is the most delicate, and on the manner in which it is conducted depends the success of the operation.

Dissolve the soap directly in its weight of alcohol in a kettle; when the soap is dissolved, draw the limpid and transparent liquid into a frame, where it solidifies by cooling. Introduce the colors and perfumes before the solidification.

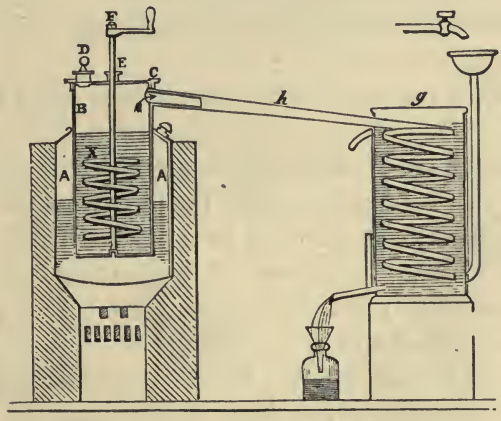
This process presents inconveniences: the direct action of the fire injures the beauty and transparency of the soap, and at each operation a large quantity of alcohol

is lost; it is generally prepared in an alembic; below we give a plan of the best apparatus for manufacturing these soaps.

For every 2 lbs. of soap, the capacity of the water-bath must be four quarts; thus, supposing an operation on 20 pounds, the water-bath used must have a capacity of ten gallons.

Introduce into the water-bath B, twenty pounds of soap previously perfectly dried and powdered, pour on it ten gallons of alcohol at 95°, and after a contact of 24 hours, heat the apparatus, and when the alcohol begins to boil, stir the mixture with the stirrer F. During the operation a part of the alcohol volatilizes and condenses in the worm *g*, surrounded with cold water.

Fig. 71.



A A. Cucurbit of copper fixed on a brick furnace.

B. Water-bath which exactly fits into the cucurbit; the solution of the soap is operated in the vase.

C. Cover of the water-bath. It has two apertures D, E. The first is closed by a large cock, the other gives passage to the stirrer X, F.

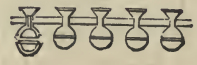
F. Stirrer.

g. Worm of copper or tin, destined to condense the alcoholic liquors.

h. Copper pipe, serving to make the connection between the alembic and the worm.

When the soap is entirely dissolved the operation is finished. Allow a rest of a few hours and draw off the soap into small moulds lined with lead, which open in two parts, and are represented below.

Fig. 72.



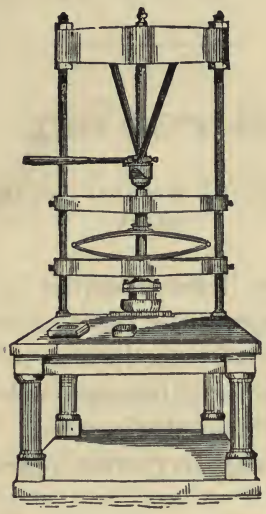
When the soap is solidified and cooled, draw it from the frames or moulds, and dry it in the air When dried, it presents a tarnished aspect; to render it transparent, it is necessary to rub it with a cloth saturated with alcohol.

Sometimes the soap is run into moulds having a square form.

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, according to the season, it is taken out and cut up into bars, and these again subdivided into tablets, which are pressed against dies (Fig. 73), bearing on one side some ornamental device, and upon the other, the name and place of business of the manufacturer. These tablets or pressed cakes are then dried in a moderately heated room.

After this operation, the soap is very transparent and its color is white. It is perfumed in the frame when

Fig. 73.



fluid, with one or one and a half drachms of essential oil per pound. Transparent soaps are generally colored yellow and rose. The first may be obtained naturally so by using the tallow and rosin soap, but if you want to obtain a yellow soap with tallow soap, you must infuse 2½ drachms of turmeric for every quart of alcohol. 1¼ drachms of annotto produces the same effect.

The rose color is obtained by treating the same quantity of alkanet or archil by alcohol; the blue is produced with carmine of indigo. We specially recommend for these soaps the use of the aniline colors.

In Belgium and Prussia, transparent soaps are prepared with a soap made by the cold process, as follows:—

Tallow	18 lbs.
Coco oil	2 "
Lye at 36°	10 "

Saponify as we have indicated for soaps by the cold process, and treat by the ordinary method to make transparent soap.

CHAPTER XLIX.

SOFT TOILET SOAPS, OR ALMOND CREAM, AND WINDSOR SOAP.

Soft toilet soaps have potash for a basis; they are prepared with white grease, which is sometimes mixed with five per cent. of coco oil, so as to render the soap more foamy. They owe their agreeable odor to the oil of bitter almonds, hence their name.

To prepare this soap very white, operate in the following manner:—

Melt in a sheet-iron kettle of a capacity of about 50 gallons, 50 pounds of white fat, and 10 lbs. of coco oil. When the fatty matters are entirely melted, add 50 lbs. of lye of potash at 20° or 21°. Stir all the time, so as to aid the saponification, the temperature being kept at from 140° to 158°. Under the influence of heat and stirring, the aqueous part of the lye evaporates and the mixture acquires a thicker consistency. Sometimes it happens that a part of the fatty matters separates; this effect is produced especially when the temperature of the mixture is raised near the boiling point, because at that temperature, concentrated lyes have little affinity for fatty substances. This effect may also be produced by the insufficiency of alkali in the mixture. In the first case the homogeneity is re-established by moderating the action of the heat, and in the other, by pouring into the

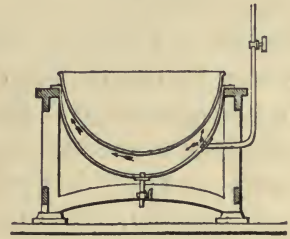
kettle the quantity of strong lye necessary to complete the saponification.

This first stage of the operation lasts about four hours. To obtain a perfect soap, add a new portion of 30 lbs. of lye of potash at 36°, and be careful to keep the mixture very uniform by a continual stirring. Keep the temperature below the boiling point, and as much as possible between 140° and 158°.

It is ascertained that the saponification is finished, when the paste has acquired a very thick consistency; at this point turn off the heat.

Many perfumers prepare this soap in iron kettles with a double bottom, heated by steam; some use silver kettles which are preferable, because the soap will retain in them all its whiteness.

Fig. 74.



The above figure represents a kettle with a double bottom, heated by steam. This kettle is of tinned copper and may be used also to purify tallow and greases.

The operation lasts in all from seven to eight hours.

When the soap is entirely cooled down, pour it into large stone jars in which it is kept for use.

Soft soap, as obtained by the saponification of fatty matters by potash, has not that bright and nacreous appearance required for the toilet. To obtain it in this state it is ground in a marble mortar, and aromatized with

oil of bitter almonds. Proceed as follows: Take a few pounds of soft soap which is introduced into a marble mortar and is strongly triturated with a wooden pestle. The operation is finished when the soap forms a soft and homogeneous paste; the more it is beaten, the finer it will be. To perfume it, incorporate from 1½ to 2 drms. of oil of bitter almonds per pound.

Thus prepared, this soap forms an unctuous paste very soluble in water. When it contains some coco oil it is yet softer.

To give this soap a slight rose color, heat it with one-quarter to one-half a drachm of vermilion per pound of soap; it then takes the name of *Naples soap*.

Crême de Cacao Mousseuse.—In this cream substitute bitter almonds by cacao.

Crême d'Ambroisie.—Perfume with liquid storax and benzoin.

Saponaire Orientale, or Cream of Soap.—To prepare this cream, melt two pounds of fine coco oil, which is saponified with two pounds of lye of potash at 22°; heat to the boiling point, and to thicken the mixture add 3½ ounces of lye of soda ash at 30°. The lye of soda may be substituted by 24 ounces of lye of potash at 30°.

The soap being finished, perfume it when cold with two drachms of oil of vervain, and two drachms oil of geranium. This composition is very white; its odor is very agreeable and very sweet; it is detersive, and produces an abundant foam in water.

Soap of Yolk of Egg.—The yolk of egg contains more than half of its weight of water, an albuminoid substance called *vitelline*, a thin fatty matter, a soap of ammonia containing oleic and margaric acids, and glycerin.

Olein and margarin exist in it in the proportion of 21

per cent., and the oleic and margaric acid in about seven per cent.

The yolk of egg gives a weight equal to its own of a soft soap; seventy yolks occupy a volume of one quart, and weigh about forty ounces.

M. Sau, of Wesserling, prepares a soft soap with the yolks of eggs left as a residuum in the preparation of albumen; 264 eggs give 9½ lbs. of yolks.

To prepare the soap, the yolks are separated from the whites, and are introduced into a dish heated over a sand-bath, in such a way that the organic matter will not burn and the temperature is kept very regular. During the elevation of temperature stir all the time, until an oil is formed which swims at the surface and is collected in a receiver.

This oil is used instead of fatty matter to prepare a soft soap, and is perfumed in the same manner.

Soap made with Glycerin.—To prepare this soap, care must be taken to mix the glycerin with the soap, avoiding saponification of the glycerin. For this purpose, take a mixture of soap finely divided and equal parts of water and alcohol, heat over a water-bath, and when the soap is as liquid as oil, and the greater part of the alcohol has evaporated, add to it a corresponding quantity of glycerin, stir well and let it cool slowly.

The quantity of glycerin to be added depends on the use to which the soap is to be applied.

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 improved 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

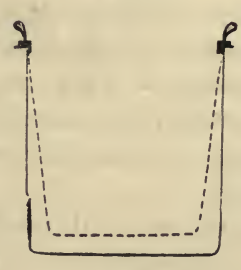
of mixing with the suet a certain quantity of olive oil or lard, the product is superior.

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 2000 pounds of paste, 18 pounds of the following mixture :—

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

Fig. 75.



dip out the paste and put it into a water-bath caldron, (Fig. 75), and when heated sufficiently, to stir in the

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 coco-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 L.

SAVONNETTES.

With the exception of liquid soaps, all the above may be made into savonnettes (wash-balls).

Form of the Savonnettes.—They are generally spherical; the perfumers give them this form with a conical glass, similar to an ordinary tumbler, the edges of which have been rendered sharp.

Taking the piece of soap with the left hand, they turn over it the edges of the glass in all directions with the right, whilst the left turns the soap. By this simple process they form regular balls.

Color of the Savonnettes.—*Yellow* savonnettes are made by adding a sufficient quantity of an alcoholic tincture of *terra merita; green*, with juices of herbs; *brown*, with terra umbra (umber); *fair*, with a little yellow ochre; *rose*, with vermilion and carmine; *blue*, with indigo. These shades must be very light, but white is generally preferred.

Common Savonnettes.—Take six pounds of soap which is cut as thin as possible; melt it in one pint of water, in which have been previously boiled half a dozen lemons cut into slices; pass the whole through a cloth and express.

The soap being melted, remove it from the fire; add three pounds of powdered starch, a little oil of lemon, and knead the whole into a paste. When the paste is finished, mould the savonnettes of the required size.

Marbled Savonnettes.—When the paste of soap is prepared, cut it in two equal portions and give to each one a different color, dissolving the color in a solution of gum Arabic. Unite the two portions by mixing them in a dish, let the whole dry, and cut into slices; finish the savonnettes by making them round.

Savonnettes aux Fines-herbes.—For twelve pounds of soap prepare the following mixture:—

Oil of bergamot	4	ounces.
" lemon	4	"
" thyme	1	ounce.
" lavender	1	"
" wild thyme	1	"
" myrtle	1	"
" marjoram	1	"
" fennel	2	ounces.
" mint	½	ounce.
" sage	½	"
" wormwood	½	"

Savonnettes à l' Œillet.—For twelve pounds of soap, grind together

Cloves	12 ounces.
Cinnamon	2 "

Add to the soap with about one pint of rose water :—

Oil of cloves	4 ounces.
Tincture of cinnamon	1 ounce.
" vanilla	1 "
Oil of amber	1 "
Tincture of musk	1 "

All being mixed, beat it well before adding to the soap, and when the whole has the proper consistency, prepare the savonnettes.

Savonnettes à la Vanille.—Take twelve pounds of soap, eight ounces of vanilla, and cut into thin pieces; then powder

Storax	4 ounces.
Benzoin	4 "

Mix them with the soap, and grind the whole together.

Melt over a water-bath with rose water. When melted, leave it to infuse for several days; melt again, pass through a cloth, and press well; infuse the residuum in one pint of rose water over a water-bath, and pass through the same cloth. This water is used to work into the savonnettes, and add

Tincture of vanilla	4 ounces.
Balsam of Tolu	4 "
" Peru	2 "
Tincture of cinnamon	1 ounce.
Oil of cloves	2 drms.
Tincture of amber	1 ounce.
" musk	1 "

Mix, and add to the soap; color with four drachms

of brown powder with vanilla. Prepare the savonnettes by the usual process.

Savonnettes à l'Ambre.—Take twelve pounds of soap, grind in a mortar eight ounces of ambrette (musk-seed), add the soap to it and grind; melt over a water-bath, adding to the mixture about one pint of orange-flower water, or more if necessary, according to the state of dryness of the soap. Let the whole macerate for a few days, and melt again; pass then through a thick cloth, let it cool, and then if not too liquid, grind it, adding to it the following:—

Brown powder with vanilla	2 ounces.
Cyprus powder	4 "
Orange powder	2 "
Black powder	1 drachm.

Mix the powders and incorporate them into the soap, grinding it with rose and orange-flower waters; then incorporate into the mass

Essence of amber	12 ounces.
" " musk	4 "
" " vanilla	4 "

Mix well and prepare the savonnettes by the usual method.

Savonnettes au Musc.—These are prepared in the same manner as the above; instead of orange powder, introduce

Terra umbra (umber)	½ ounce.
Essence of musk	12 ounces.
" " vanilla	4 "
" " amber	4 "

Savonnettes à la Bergamotte.—For twelve pounds of soap, use

Orris powder	1 lb.
Bergamot	2 ounces.
Oil of bergamot	4 "

Savonnettes au Neroli.

Prepared soap	12 lbs.
Orris powder	1 lb.
Orange powder	3 ozs.
Oil of neroli	12 drms.
Essence of amber	4 "
" " musk	4 "

Savonnettes du Serail.

Prepared soap	6 lbs.
Storax	6 ozs.
Orris	3 lbs.
Benzoin	12 ozs.
Cloves	1½ "
Cinnamon	3 drms.
Sandal	6 ozs.
Nutmegs	3 drms.

Savonnettes au Miel.

Soap	4 ounces.
Honey	4 "
An essential oil (as desired)	½ ounce.
Rose water	4 drms.

Light Savonnettes.—Take six pounds of pure white soap, four pounds of distilled water, in which three ounces of common salt are dissolved. Filter the solution, and melt with the soap at a gentle heat. Beat the whole well for two hours, and prepare the savonnettes in the usual manner.

Savonnettes de Boulogne.

Take

Soap	1 lb.
Lime	¼ ozs.

Mix; pour on the mixture seven ounces of brandy.

Let it macerate twenty-four hours, and afterwards spread the mixture on a sheet of paper and let it dry.

When dried, grind it in a mortar with

St. Lucie wood	4 drms.
Sandal wood	1½ ozs.
Orris root	4 drms.
Calamus aromaticus	4 "

Grind with a few whites of eggs, and add four ounces of gum Arabic dissolved in rose-water; then prepare the savonnette.

CHAPTER LI.

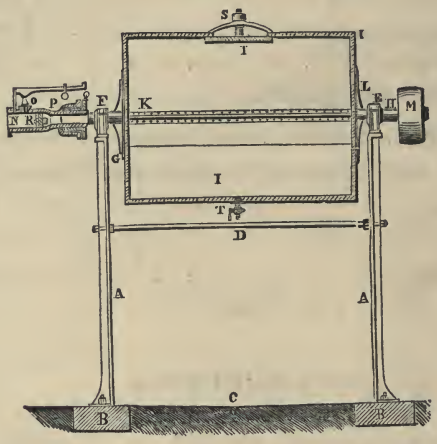
DIFFERENT PREPARATIONS OF TOILET SOAPS.

New Apparatus to Manufacture Toilet Soaps.—We give below the description of an apparatus to manufacture toilet soaps, invented by MM. Hodgson and Holden.

This apparatus, of which the following is a vertical section through the centre, is made with two parallel upright posts of cast iron A A, screwed on wooden blocks or stones B B, fastened to the floor, and of which the upper face is on the level C of this floor. The upper part of each of these upright posts receives pillow blocks E F, destined to be used as supports to the two axes G and H, of the cylinder I. The axis G, of this cylinder, has a tubular form to give passage to the steam, and is attached to the corresponding head of the cylinder by a large shoulder. This tube continues inside of the cylinder, as seen in K, and the portion which is thus inside is pierced along its length by numerous small holes. The opposite axis

H, is solid, and also attached by a wide shoulder L, to the other head of the cylinder I; it carries at its outside

Fig. 76.



extremity a pulley with a belt M, for transmitting motion. The steam is furnished to the pipe N, which is in direct communication with a boiler, and has a safety-valve O, to let off the excess of steam. This pipe N is provided with a stuffing box P Q, so that the steam cannot escape between the steam-pipe N, and the movable pipe G; there is also in R, on this pipe N, a self-acting stop-valve to shut it in this direction, so that the matter contained in the cylinder I, cannot get into the steam-pipe when the pressure is too high in the cylinder.

The ingredients for the manufacture of the soap are introduced by the man-hole S, while the cock T is used to draw them off when necessary.

When the cylinder has been properly charged, it is hermetically closed, and steam introduced by means of the pipes N G, and the pipe K pierced with holes. The

steam penetrates the ingredients while the cylinder is turning. Before admitting the steam into the cylinder, the valve R, should be opened, so that the steam may expel all the air contained in the cylinder, and when this is done, it is to be closed again. Thus, the action of steam, combined with the movement of rotation, accelerates the work of saponification of the ingredients in the most economical, rapid, and efficacious manner.

When the proper degree of saponification has been reached, shut off the steam, draw off the matters from the cylinder, and begin another operation. To draw off these matters, open the cock T, and the steam has yet tension enough to cause them to run out.

This apparatus is very ingenious, and we recommend it to all manufacturers of toilet soap.

Toilet Soap Prepared with a Mixture of Olive Oil Soap, and Tallow Soap.—Take fifteen pounds of fine olive oil soap, ten pounds of tallow soap, and reduce them to thin shavings. Introduce the shavings into a copper kettle heated over a water-bath, and add about 1¼ pint of water, according to the state of desiccation of the soap. The temperature during the operation must not be above 212°, and the operation must be terminated as quickly as possible. The soap is then perfumed and moulded into cakes.

Savon à la Rose.—Take twenty-five pounds of the above soap, melt it, add 6½ ounces of vermilion, mix well, and when ready to run into the frames, add the following essential oils :—

Oil of rose	. . . . .	10¼ drms.
" cloves	. . . . .	4 "
" cinnamon	. . . . .	4 "
" bergamot	. . . . .	8 "

Savon au Bouquet is obtained as the above, only the

color is produced by four ounces of powdered brown ochre. Perfume with

Oil of bergamot	2 ounces.
" cloves	1¾ "
" neroli	6 drms.
" sassafras	1¾ ounce.
" thyme	1¾ "

Savon à la Cannelle.—Liquefy fifteen pounds of tallow soap, and ten pounds of palm oil soap, and color the paste with eight ounces of yellow ochre. Perfume with

Oil of cinnamon	3½ ounces.
" sassafras	6 drms.
" bergamot	6 "

Savon à la Fleur d'Oranger.

Animal soap	60 lbs.
Palm oil soap	40 "
Oil of Portugal	14 ozs. 6 drms.
" amber	14 " 6 "

Color with

Yellow green	1 lb.
Minium	2½ ozs.

Savon au Musc.

Animal soap	60 lbs.
Palm oil soap	40 "

Perfume with

Powder of cloves	6½ ounces.
" roses	6½ "
" pinks	6½ "
Oil of bergamot	6½ "
" musk	6½ "

Color with eight ounces of brown ochre.

Savon Musqué: to Whiten and Soften the Hands.—Take four ounces of marshmallow roots well washed, and dry

in the shade; powder them. Take one ounce of starch, one ounce wheat flour, six drachms fresh Barbadoes-nut, one and a half ounces of orange seeds, two ounces oil of sweet almonds, and a half drachm of musk; reduce to a fine powder, and to each ounce of the powder add a half ounce of orris root.

Macerate the marshmallow root in rose or orange flower water. After twelve hours' maceration, pass through a cloth, and press well. Make a paste with this mucilage and add the powders; let the mixture dry, and mould it into balls.

Perfumed Soap.

Take

White soap	8 ounces.
Orris root	2½ "
Calamus aromaticus	3 drms.
Elder flowers	3 "
Dry roses	4 "
Cloves	4 "
Coriander	1 drachm.
Lavender	1 "
Laurel leaves	1 "
Storax	3 drachms.

Reduce the whole to a very fine powder, and make a paste; add a few grains of musk or ambergris, and enough oil of sweet almonds to soften the paste.

Savon de Toilette Anglais (Lady Derby's Soap).

Take

Blanched bitter almonds	4 ounces.
Tincture of benzoin	2½ "
Powdered camphor	2 drms.
White soap	2 lbs.

Reduce the almonds to a fine powder, add the cam-

phor and the tincture of benzoin; melt the soap at a gentle heat and add to it the above mixture.

Savon de Toilette Perfectionné (FAGUER-LABOULLÉE).

Take

Good white soap	1 lb.
Alcohol at 95°	1 "

Dissolve the soap in the warm alcohol; to the solution add a few drops of acetic acid, so as to saturate the excess of alkali. Distil the mixture in a retort to recover the alcohol; then to the residuum add a mucilage made with one ounce of gum tragacanth. Perfume at will.

Thus prepared, this soap has lost its injurious action on the skin, and has acquired a remarkable softness and unctuosity.

Savon d'Aveline Mousseux (VIOLET AND MONPELAS).

This soap contains per cent.

Potash	7
Fatty matter	64
Water	28
Salt	1

After preparing lyes of potash at different degrees, at 8°, 12°, 15°, 16°, and having rendered them caustic by equal parts of lime, three parts of hazel-nut oil, and one part of lard are saponified. This soap is solidified by salt lyes at 10°.

Savon de Resine Balsamique (MOREAU).

Take

Fresh lard	8 lbs.
Rosin	8 ozs.
Lye of potash at 36°, reduced to 10°, by two quarts of water	20 ozs.

Melt the grease and rosin together, add the lye and heat gently, being careful to stir all the time. When the mixture becomes thick, add successively 3 lbs. of lye at 36°, and continue to heat until the soap is well formed. This soap is purified by melting it over a water-bath, and filtering it at a temperature of 104°. Perfume at will.

English Rosin Soap (BOWDEN & LONGMAID).

Prepare a caustic lye of soda at 34° B. Then take

Lye	105 lbs.
Tallow	12 "
Rosin	8 "

Introduce the tallow and rosin into the lye, and when dissolved, boil for about half an hour. The soap is then made ; perfume, and run into moulds.

Another Process (MABLEY).—Mix 1000 parts of turpentine with 400 parts of a solution of soda containing 33 per cent. of pure alkali. The soda combines with the resinous portion of the turpentine forming a soapy mass, while the spirit of turpentine is set free. To separate it, add a solution of common salt, and boil the mixture in an alembic, so as to collect the vapors.

Afterwards, take off the coloring matter produced by the reaction of the alkali on the rosin, by submitting the mass to several washings with salt water. The rosin soap obtained after these washings, may be mixed with tallow or some other greases in the proportion of one part of rosin soap to two parts of grease.

As for the spirit produced in this operation, it essentially differs from that obtained by the other processes; it burns with a lighter and brighter flame, and does not leave a residuum after its combustion.

Very Hard Soap.—This soap is extremely white, and contains only the proportion of water exactly necessary

to its composition, and can be sold the day after it is manufactured.

Take 40 lbs. of lard, and 20 lbs. of lye of soda at 36°. Melt the grease at a gentle heat, and when in a milky state, add 10 lbs. of the lye, and stir well for one hour. The temperature reached in the saponification must not exceed 149°. After this time, add the remaining 10 lbs. of lye, mix it well, being careful to manage the temperature. The paste must be perfectly homogeneous, as its consistency increases every hour until it is solid enough to be drawn off into a frame; it is then perfumed. The next day the soap is hard enough. It must be cut into cakes immediately, for it often happens that a day longer will render it brittle.

Savon au Miel.—Take four ounces of white Marseilles soap, four ounces of honey, one ounce of benzoin, one-half ounce of storax; mix well in a marble mortar. When the whole is well incorporated, melt over a water-bath, pass through a fine sieve, and run it into moulds; divide it afterwards into cakes.

Savon Demi-Lourd.—Take six pounds of good soap, and melt it with 1½ quarts of water; when melted, pass it through a thick cloth, heat it again, and add one pint of water and a spoonful of salt. Beat it until it is swollen enough, and continue the heat during the whole time; when sufficiently raised, stop off the heat, and run it into a frame. When solidified, take it out of the frame, cut it into bars, dry it, and when half dried cut it into cakes.

Vegetable Soap used by Odalisques (ARDIN-DELTEIL).—The composition of this soap is of five parts, divided as follows:—

Flour of Aleppo pistachio . . .	3 parts.
Beech-nuts	1 part.
Buckwheat flour, orris, and patchouli, of each	1 part.

Perfume with oils of rose, almonds, bergamot, ambergris, and musk.

Savon Oriental (LAUGIER).—Mix 100 lbs. of pearlash with 24 lbs. of quicklime, dilute with water, and when slacked, introduce the mixture into a vat and pour in a quantity of water sufficient to make a liquor marking from 33° to 35°.

In a kettle having the form of a fan, introduce 100 pounds of lard, and melt it with the above lye. The lye is poured in at different degrees of strength, the heat is kept regular, and in 41 hours the soap is formed.

The soap being thus prepared is perfumed in the usual manner.

Soap of Sweet Almonds.—As this soap is sold for a high price, the materials used must be of the first quality, the oil of sweet almonds must be perfectly fresh, and the carbonate of soda chemically pure. The soda is dissolved in water, adding to it one-third of its weight of slaked lime; stir from time to time, and after several hours, filter; concentrate the lye by evaporation until it marks 36°, then take 12 parts for 25 parts of oil. Introduce the lye into a jar, and gradually incorporate the oil, being careful to stir the mixture until it has the appearance of a soft grease. In two or three days its consistency is such that it can be run into china moulds, placed in a room the temperature of which is from 71° to 107°. In about one month it can be taken from the moulds. The temperature of the lye must be from 40° to 59°. But the soap may be prepared more rapidly by placing the mixture on warm ashes and adding a little warm water to the lye, so as to prevent its concentration. This soap is very white, with a sweet taste and odor; it becomes very hard.

Savon de Naples Liquide.—Take twelve pounds of

good soap, cut it into pieces and melt it in two or three quarts of rose or orange-flower waters; add to it to keep it liquid, two pounds of *huile aux fleurs*, melt and boil a little; pass through a thick cloth and perfume as usual. To color it, melt it, adding to it four ounces of bergamot peel in fine powder.

If oil is not to be had when the soap is melted, add 2 quarts of good essence of soap, and incorporate with the soap; pass then through a cloth and perfume.

Savon Liquide des Iles Vierges (BLANCHE).—For six pounds of soap use

Caustic lye of potash at 26°	2 lbs.
Lard	2 "
Oil of bitter almonds	1½ "
Spermaceti	8 ozs.

Melt the spermaceti, add the lard and the oil, then the lye; expose the whole to a gentle heat in a jar, until the alkali is concentrated; next day, grind the mixture in a mortar with ⅛ of alcohol at 85°. Perfume with one ounce of oil of bitter almonds.

SECTION VII.

DIFFERENT MANIPULATIONS TO WHICH THE PASTES OF CRUDE SOAPS ARE SUBJECTED TO BE TRANSFORMED INTO TOILET SOAPS.

The principal object of this work being to describe the practical applications of the art of soap making in its most important developments, we think it essential to enter into the details of the different operations to which the pastes of soap are submitted to transform them into toilet soap. The pastes of soap are the refined and liquefied soaps obtained by the processes described in the above sections. Before entering into the description of operations as numerous as they are various, we think it will be useful to precede it by a short description of the different machines and apparatus, the use of which is indispensable for these different operations.

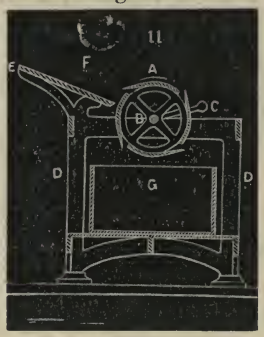
CHAPTER LII.

THE CUTTING MACHINE.

This machine presents great advantages. It is found now in all well-established manufactories of toilet soap. It consists of a cylindrical cutter of wrought or cast iron, from eight to ten inches in diameter, and 2½ to 3½ inches wide. This cutter has on its circumference three or four broad grooves provided with strong blades, of highly tem-

pered steel, by means of which, the cakes of soap can be divided into very thin shavings and even into ribbons. Figure 77 represents the machine.

Fig. 77.



A. Cutter.

B. Iron shaft which traverses the centre of the cutter and carries a handle C, at one of its ends; this handle is used to give motion to the machine.

D D. Frame of wood or cast iron, on which the shaft of the cutter rests.

E. Inclined plane of wood, on which the soap is placed to be cut into shavings; F, is the cake of soap.

G. Large wooden box to receive the shavings of soap.

The method of using this machine is very simple. The cake of soap to be cut being laid on the inclined plane E, and touching the cutter at one end, a movement of rotation is given to the machine by the handle C. During the rotation, each time the blades of the cutter touch the cake of soap, they take off a shaving which falls into the box. The first cake being cut, substitute a second, and so on.

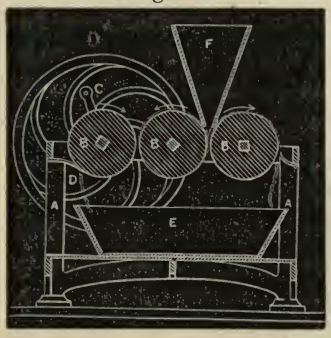
This machine renders immense service in the manufacture of toilet soaps. A man with it can reduce 200 pounds of soap to shavings in one hour.

CHAPTER LIII.

GRINDING MACHINE.

This machine is represented in Fig. 78. It consists of three cylinders of porphyry, from five to six inches in diameter, by twelve or fourteen inches in length. They are separated from each other. The distance between them is regulated by screws, at will. They are set in motion by a system of gearing, the unequal dimensions of which, produce also an unequal rotation for each cylinder. We give the indication of the principal pieces which compose it.

Fig. 78.



A A. Frame of cast iron which supports the cylinders.

B B B. Cylinders to grind the shavings.

C. Crank fixed on the axis of the first cylinder; used to put the machine in motion.

D. Scraper. It is formed of a large steel blade, fixed horizontally against the last cylinder, which it traverses

in all its length. The use of this blade is to scrape off the soap adhering to the cylinder.

E. Large wooden box lined with lead. This box receives the soap which has been crushed between the cylinders.

F. Movable hopper of wood lined with zinc. Its object is to receive the shavings of soap and transmit them to the cylinders.

The use of this machine has effected a revolution in the manner of preparing toilet soaps. Before, the manufacturer was obliged to melt the pastes of soap to color and perfume them; now all these operations are performed at the ordinary temperature. The soap being reduced to shavings, these shavings are introduced into a large wooden box and mixed with the oils and coloring matters proper for producing the color.

The mixture being complete, fill the hopper F with soap shavings; the cylinders B B B are then put in motion, when they take these shavings, grind them, and form thin sheets which fall into the box E. When the shavings have passed once through the cylinders, they are taken out from the box, and passed through a second time. The operation is thus continued until a soft and homogeneous paste is obtained. For white soaps, two or three times is sufficient, but for soaps colored rose, yellow, brown, or any other shade, it requires five to six passages through the cylinders, so as to incorporate completely the colors, which is known when the sheets of soap are uniformly colored.

In a well-regulated work, this machine will grind 400 pounds of soap in a day.

CHAPTER LIV.

MORTARS IN WHICH TO POUND THE SOAP.

As we have seen, the grinding machine has the advantage of reducing soap shavings into thin sheets, but these sheets are entirely separated from each other. To unite them, and to form a perfectly homogeneous mass, they must be strongly pounded in a mortar. These mortars are generally made of wrought or cast iron, copper, marble, etc. Notwithstanding their greater solidity, metallic mortars are rarely used, because they have the disadvantage of changing the shade of the pastes, particularly if the soap is to remain white. Marble mortars not having the same inconvenience are generally preferred. Those used in toilet soap manufactories must be large enough to pound from ten to twelve pounds of soap each time; the pestle is of wood.

CHAPTER LV.

MOULDS AND PRESSES.

Moulds.

A MOULD is a kind of copper matrix formed of two pieces, so as to introduce into it the pieces of soap to be moulded; by pressure the soap takes exactly the form of the mould.

Each model of soap has generally two moulds: one a little larger than the other, is used to give the first shape to the soap by means of a press; the second mould gives them the definitive shape with the help of a screw press.

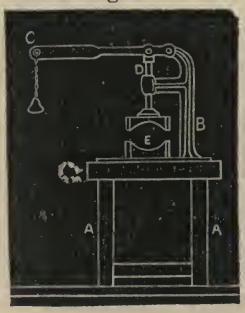
Presses.

Presses are too well known to require a long description; we shall consider only those used by the toilet soap manufacturer, viz: the lever press and the screw press.

Lever Press.—In the lever press, the pressure is given by means of a lever or brake. The resulting shock takes the place of the pressure by the screw.

Figure 79 represents this press.

Fig. 79.



A A. Wooden posts supporting the press.

B. Cast-iron frame, forming the body of the press.

C. Lever to give the pressure.

D. Piston of the press; a groove made in the lower part of this piston is used to attach the upper part of the mould.

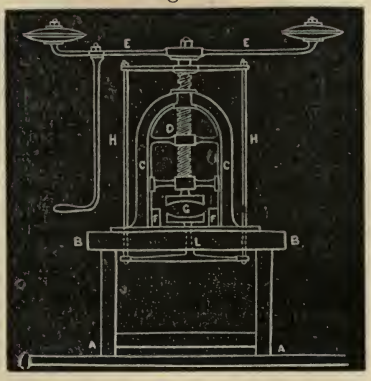
E. Mould in which the soap to be submitted to the pressure is inclosed.

The principal advantage of this press is to give a first pressure to the imperfectly dried soap without cracking it. As for the manner of operating, it is very simple. A piece of soap is placed in the cavity of the mould E, then a blow is given, by pulling down the lever, which flattens the soap and fills the capacity of the mould. This done, take out the soap, substitute another cake and continue in the same manner. With such a press, 500 pieces of soap can be pressed in the first mould in an hour.

Screw Press.—When the soaps pressed in the first mould are entirely dried, they are slightly scraped at the surface and dipped into alcohol; they receive their definitive shape by means of a second mould which is placed under a screw press.

Figure 80 represents this press.

Fig. 80.



A A. Oak posts supporting the press.

B B. Strong oak board used to receive the press.

C C. Frame of the press.

D. Iron screw provided at the end with a groove to receive the upper shell of the mould.

E E. Fly. It is surmounted with a ball at each end.

F F. Cast-iron matrix used to receive the copper mould.

G. Copper mould formed of two pieces.

H H. Rods of wrought iron adapted by means of screws to a horizontal bar below E E; these rods pass under the cast-iron matrix F F, and raise the movable rod L, after each pressure; then this raises the mould G, fixed in the cast-iron matrix. In this way, after the pressure has been given by the screw, the soap can be taken from the mould and another substituted.

The other accessories which complete the establishment of a toilet soap factory are the drying-room, which we have already described.

1. A scale to weigh the bars of soap.
9. Another scale to weigh small quantities.
3. Several large wooden boxes lined with lead, to mix the shavings of soap with the colors and the oils.
4. Several tables covered with marble for balling the soap.
5. Several marble mortars to grind and pound the soap.
6. Several fine drum sieves to pass the colors to be incorporated into the soap.
7. Boards for drying the soap.
8. Scrapers and knives: the former for cleansing the surface of the bars of soap, the latter for dividing the soap into small cakes.

CHAPTER LVI.

FABRICATION OF THE TOILET SOAP.

Reduction of the Soap into Shavings—Mixture of the Essential Oils and Colors with the Soap—Grinding the Soap—Pounding the Soap—Balling the Soap.

THE principal apparatus which compose a manufactory of toilet soap having been studied, we shall enter into the details of the operations to which the pastes of soap are submitted to be transformed into toilet soaps.

REDUCTION OF THE SOAP INTO SHAVINGS.

The soap used in the fabrication must be pure and free from any excess of alkali. We suppose that the cake of soap weighs from 40 to 60 lbs., and is from 3 to 3½ inches thick. With a knife take off all the dirt which is adherent to the surface. This being done, divide the cake into smaller ones, about 1 to 1½ inches thick.

The soap being cut into cakes is placed on a table near the cutting machine, Fig. 77. Take one of these cakes and place it on the inclined plane of the machine in such a way that the end of the cake will touch the cutter. The cake being fixed, turn the crank, and the rotation of the cutter in a short time reduces the soap to shavings, which fall into the box destined to receive them. When one cake is nearly reduced to shavings, place another near by it, and continue to the last. The soap thus divided can be immediately used to manufacture toilet soap.

Mixture of Oils and Colors with the Soap.

To make these mixtures, introduce the shavings into a large wooden box lined with lead. If the soap is to remain white, add the essential oils necessary to perfume it. But if the soap is to be colored at the same time as it is perfumed, add the quantity of colors determined by the shades to be obtained. Mix the oils and colors with a little alcohol, and pour this preparation on the shavings; stir the whole, and when well mixed proceed to the grinding.

As a practical application we suppose the preparation of fine marshmallow toilet soap. Take

Pure palm oil soap	100 lbs.
Pure white tallow soap . . .	100 "

Reduce the two soaps to shavings, operating as we have indicated before. As palm oil does not give a lasting yellow, the soap is colored with the following substances passed through a silk sieve.

Yellow ochre	10 ounces.
Orange mineral	10 "
Gamboge	7 "

To perfume the soap aromatize it with the following composition, the proportions of which are calculated at 1½ drachm per pound:—

Essential oil of lavender . .	25 ounces.
" " lemon . . .	5¼ "
" " neroli petit grain .	5¼ "
" " vervain . . .	3½ "
" " mint . . .	1 "

The oils are poured into a large iron pot, and the colors mixed with them. To perfect the mixture, stir the whole for a few minutes with a wooden spatula. When the mixture is complete, pour it by small quantities at a

time on the soap, and stir the whole a sufficient time to incorporate the oils and colors with the soap.

Grinding the Soap.

This operation presents no difficulties. When the shavings have been well prepared, fill the hopper F, Fig. 78, and put the machine in motion. The shavings, by successively passing between the three cylinders B B B, are crushed and fall into the box E. The hopper being empty, charge it a second time, and so on until all the shavings of soap have passed a first time through the cylinders. For toilet soaps in which enter as coloring matter, ochres, metallic oxides, minium, vermilion, etc., it is necessary, in order to procure a complete incorporation, to pass the soap five or six times through the cylinders. This is ascertained when the sheets of soap falling into the box have a homogeneous and uniform color.

If, on the contrary, the colors are not uniform, continue the grinding between the cylinders until the mass is homogeneous throughout.

When the soap is properly ground, it forms a soft and unctuous paste. The pastes of white Windsor soaps or others, being entirely deprived of coloring matter, present less difficulty for grinding. Two or three passages between the cylinders are sufficient to obtain a perfect homogeneity. Generally, the more the soap is ground, the finer it is. The soap thus laminated is pounded into a mortar.

With a machine as described above, one man can grind from 150 to 200 pounds of soap daily.

Pounding the Soap.

The object of this operation is to agglomerate the sheets of soap, and form of them a compact mass. Introduce into a marble mortar from ten to twelve pounds of soap in sheets, and pound it strongly with a wooden pestle. To hasten the operation, divide the mass from time to time with a knife. Continue to pound it until it has the form of a compact and homogeneous mass. For the above quantities, the operation lasts ten minutes. The soap must be pounded only as fast as it is worked. If it is prepared a long time beforehand, it will become too hard and too dry to be balled.

Balling the Soap.

The balling (called also *peloting*), has for its object to give to the pounded soap the shape of small cakes, so as to mould it. We may remark, that there are models of soaps of every weight from two to seven ounces. We shall take as an example a weight of 3½ ounces.

The soap being conveniently pounded, place it at the end of a table, on which is a marble slab.

To establish an agreement between the weight of the damp soap and the weight of the moulded soap, and compensate for the loss resulting from the different operations, and the loss the soap experiences during its desiccation, it is necessary to give to each small ball of soap an excess of weight of about 25 per cent. Thus to have a moulded soap weighing 3½ ounces, the damp soap should weigh 4½ ounces. Weigh as many pieces of 4½ ounces as you want of cakes of 3½ ounces, knead with the hands each little mass of soap, so as to form a ball which is made round on the marble slab. For this purpose, the

ball being on the marble, give it a movement of rotation with the right hand. The ball being obtained, leave it on the marble and give it a cylindrical shape, by rolling it with the flat of the hand. This cylinder must not be longer than the model.

Nevertheless, as the cylindrical shape is not that which the soap ought to have, strike the cylinder on all its sides on the marble to square it, that is, to form an oblong square, and round the angles by striking them slightly on the marble.

If any unforeseen circumstance requires a suspension of the work, cover the pounded soap with a damp cloth and keep it in a cool place. If the soap is too dry, it will be difficult to work well. Once begun, it must be worked quickly and without interruption.

The small cakes being shaped as we have indicated, dispose them on trays or frames of white wood traversed in their length by small rods of wood, in such a way that each frame presents as many empty spaces as full ones. These frames have a length of twenty-seven inches by eighteen wide; they are arranged on shelves at a distance of five to six inches from each other.

It is essential to leave between each cake of soap a space of about half an inch, so as to permit the air to circulate all around them, and to dry them as equally as possible. In summer, they may be dried in a room in which the air freely circulates; this condition is necessary to obtain a rapid desiccation.

After six or eight days, there has formed on the surface of each cake a hard and shiny crust; this is the time to strike them in the first mould, for by waiting too long, the soap by becoming too dry, will not have the same elasticity, and will not mould so well. If, on the contrary, the soap is not sufficiently dried, it will stick

to the mould; it is then important to strike it as soon as a hard and dry crust has formed at the surface.

To strike the soap in the first mould use the lever press. The first mould indicated in E, Fig. 79, is a little larger than the last mould; its only object is to give the cake of soap the shape of the model.

To strike the soap, it is taken out from the frames and carried to a table placed near by the press. Fix a piece of soap on the lower shell of the mould E, then strike with the lever, which flattens the soap and gives it the shape of the mould. Raise the lever, and substitute another for the cake stamped. When all the cakes have been struck, with a sharp knife take off the little string of soap which has formed at the junction of the two shells of the mould; this being done, place the soap back in the frames and finish the desiccation.

The 200 lbs. of soap, with the oils and colors, form a total weight of 204 lbs. 3½ ounces. This weight gives 756 cakes, weighing 4½ ounces each. After a drying of eight days, there is only 200 lbs.; it has then lost 4 lbs. 3½ ounces. By the striking in the first mould the loss is 40½ grains for each cake, or 4 lbs. 6 ounces for the 756 cakes. The soap is allowed to dry until it has become very hard and very dry, which requires from 30 to 40 days, and sometimes more. Nevertheless, in a hurry, fifteen days are sufficient for drying in the air in summer, and eight days for drying with hot air.

The cakes of soap being properly dried, they are taken from the drying-room, and the crust which covers them is carefully removed. Without this care, the soap would not be as polished, as bright, nor as fine.

This operation is managed as follows: Arrange on a table all the cakes of soap, and with the help of a sharp knife scrape and remove the crust of hard soap

which has formed on the surface by drying. To execute this operation well, the blade must run all over the length of the cake without stopping. All these manipulations are very simple; they require only care and practice. A good workman in a day can scrape 40 dozens of of soap.

After being scraped, the cakes are moistened with alcohol to render their surface smoother, and to remove the litasperities and white spots adhering to them. For this operation the cakes of soap are put into a heap; take them one by one with the left hand, dip the ends of the fingers of the right hand into alcohol, and pass them over the soap which is quickly rolled in both hands; in a few seconds it is dampened all over. Proceed in the same manner for the rest; this operation must be done rapidly. A man can rub with alcohol more than 500 cakes of soap in an hour.

After this operation, the soap is dried a third time. Expose it for 25 or 30 hours to a current of hot air, and give it the finishing stroke.

All the cakes of soap are carried to a box near the screw press; a man seated in front of the press takes a cake and places it in the bottom shell of the mould G, Fig. 80; he gives a turn to the screw to join the two parts of the mould, and when the junction is exact, the soap is moulded and has the required shape. Raise the screw; the mould opens, then remove the soap which remains in the bottom shell, and substitute another.

When the soap is struck, it is important not to force the press; stop the pressure when the junction of the two parts of the mould has taken place. A man can mould 1500 cakes of soap in a day.

In the above operations the loss experienced for the

756 cakes of soap is 52 lbs. 3½ ounces; this loss may be thus accounted for :—

Loss of water by three desiccations .	28 lbs.	10 ounces
Scrapings of soaps	23 "	9½ "
Weight of the 756 cakes . . .	152 "	
Original Weight	204 "	3½ "

These results represent the average of 30 operations. We may remark that the scrapings of soap represent a soap as pure as that moulded, and may be transformed again into toilet soap. The real loss consists in 28 lbs. 10 ounces of water, evaporated during the desiccation; but this loss is necessary to bring the soap to the proper degree of solidity.

CHAPTER LVII.

FORMULÆ FOR PERFUMING AND COLORING TOILET SOAPS.

THE quantities of essential oil indicated in the following formulæ are for 20 lbs. of soap :—

Savon d'Amandes Amères.

Pure white soap	20 lbs.
Oil of bitter almonds	4 ozs.

Windsor Soap.

White tallow soap	20 lbs.

Perfume with

Oil of bergamot	2 ounces.
" carvi (caraway) . . .	1 ounce.
" cloves	½ "
" thyme	1 "

Another.

Oil of bergamot	1 ounce.
" lavender	½ "
" carvi (caraway)	2 ounces.
" rosemary	½ ounce.

Savon à la Rose.

White soap	20 lbs.

Color rose with 2 or 2¾ ounces of vermilion, according to the shade required. Perfume with

Oil of rose	1½ ounces.
" cloves	½ ounce.
" cinnamon	½ "
" bergamot	1 "
" neroli	½ "

Another.

Oil of rose	1 ounce.
" geranium	2 ounces.
" cloves	½ ounce.
" cinnamon	2½ drms.

Savon de Palme.

Pure palm soap	10 lbs.
" half palm soap	10 "

Perfume with

Oil of bergamot	2 ounces.
" cinnamon	1 ounce.
" lavender	1 "
" cloves	½ "

Savon de Guimauve, fin.

White tallow soap	10 lbs.
Palm oil soap	10 "

To keep the yellow color, add

Yellow ochre	1 ounce.
Orange mineral	1 "
Gamboge	5 drms.

Perfume with

Oil of lavender	2½ ounces.
" lemon	½ ounce.
" neroli	½ "
" vervain	2½ drms.
" mint	¾ "

Another.

Oil of Portugal	1½ ounces.
" thyme	1 ounce.
" lavender	2½ drms.
" cinnamon	½ ounce.
" cloves	6 drms.

Perfume for Savon de Guimauve, demi fin.

Oil of lavender	1½ ounces.
" mint	½ ounce.
" carvi (caraway)	½ "
" rosemary	2½ drms
" lemon	5 "
" thyme	2½ "

These three formulæ may be used for white, rose, and yellow marshmallow soaps.

Savon au Bouquet.

White tallow soap . . . . 20 lbs.

Perfume with

Oil of bergamot	2½ ounces.
" cloves	½ ounce.
" neroli	½ "
" sassafras	½ "
" thyme	2½ drms.

Perfume au Bouquet des Alpes.

Oil of lavender	5 drms.
" mint	5 "
" sage	5 "
" serpolet (wild thyme)	2½ "
" rosemary	4 "
" lemon	6

Savon aux Fleurs d'Italie.

Oil of citronella	1½ ounces.
" geranium	½ ounce.
" vervain	1 "
" mint	2½ drms.

Color with 2½ ounces of brown ochre.

Savon au Benjoin.

White soap	20 lbs.
Tincture of benzoin	27 ounces.

As the introduction of the tincture will render the soap a little soft, the shavings of soap must be perfectly dried before using them. Color the soap with brown ochre.

Savon à la Vanille.

White tallow soap	20 lbs.
Tincture of vanilla	1 "
Oil of rose	1¼ drms.

Color with 3½ ounces of burnt sienna.

Savon à l'Huile de Cannelle.

Pure palm oil soap	10 lbs.
Tallow soap	10 "

Perfume with

Oil of cinnamon	2½ ounces.
" sassafras	6 drms.
" bergamot	1 ounce.

Color with 2½ ounces of yellow ochre, and 5 drachms of burnt sienna.

Savon au Musc.

Palm oil soap	10 lbs.
White tallow soap	10 "

Perfume with

Oil of bergamot	2½ ounces.
" rose	1¼ drms.
" cloves	1¼ "
" musk	2½ "

Musk is rarely used alone; it is always employed in solution in alcohol. This solution is prepared as follows: Grind in a marble mortar the 2½ drachms of musk with its weight of white sugar and 1 drachm of pure potash. When completely powdered, add little by little 5 ounces of alcohol and rub the whole together for about 15 minutes. Pour the mixture into a bottle and let it macerate for 15 days, being careful to shake from time to time. The shavings of soap are perfumed with the whole of this mixture, which has been filtered; the oils are added afterwards, and the soap is worked as usual.

This soap may be colored with 2½ ounces of brown ochre.

Savon à la Fleur d'Oranger.

White soap	12 lbs.
Palm soap	8 "

Perfume with

Oil of Portugal	3½ ounces.
" ambergris	2½ drms.

Another.

Oil of geranium	1½ ounces.
" neroli	1¾ "

Savon de Crimée.

White soap	16 lbs.
Palm soap	4 "

Perfume with

Oil of thyme	1 ounce.
" lavender	2½ drms.
" mint	1 ounce.
" rosemary	1 "
" cloves	1¼ drm.
Tincture of benzoin . . .	1½ ounces.

Color with 2½ drachms of vermilion, 1 ounce of brown ochre, ½ drachm of ivory black.

Wrapping of Toilet Soaps.

Fine toilet soaps are always sold in wrappers. This is not a matter of indifference, for it has the double advantage of preserving the brilliancy and odor of the soap. The manner of wrapping is not always the same. Sometimes the soap is put in a first envelope of tissue paper, then in a second of stronger paper, and lastly in a third of glazed paper, on which is the name of the manufacturer. This method is generally adopted for the half-fine soaps.

But for extra fine soaps greater care is taken. The soap is first wrapped in tissue paper, then in a tinfoil; this done, the soap is introduced into a little box made of thin pasteboard, which is afterwards covered with ordinary paper, and the whole is wrapped in fine glazed paper with the name of the manufacturer, etc.

We may remark, that all the manipulations for preparing toilet soaps require much care. The different apparatus used in this manufacture must always be kept very clean. They must be entirely cleaned whenever the color is changed. Indeed, if white soap, or soap of a very delicate color is prepared after a colored soap, the required shade will be changed by the small quantity of old soap adhering to the apparatus, if these have not been thoroughly cleaned.

SECTION VIII.

FORMULÆ FOR PREPARING DIFFERENT KINDS OF SOAP, AND IMPROVEMENTS IN THE FABRICATION.

CHAPTER LVIII.

PREPARATION OF DIFFERENT KINDS OF SOAP.

Liquid Soap of Chaptal.—Take ashes obtained from the combustion of good wood, and prepare a lye by the ordinary process, by mixing with the ashes a suitable proportion of quicklime recently slacked. Let the lye settle, so as to permit the foreign substances to deposit. Keep this lye for use. When the lye is to be used, take a certain quantity, which is poured on a thirtieth or fortieth of oil; immediately a white magma like milk, is formed, which, when strongly beaten, foams like good soap water. Pour this liquor into a large vat, dilute it with more or less hot water, and dip into it the clothes to be washed and rub them as usual.

Another method consists in taking artificial soda and breaking it into small pieces, which are then introduced into a vessel with water; the water is left on it until it is slightly salt to the taste.

Introduce oil into an earthen jar and pour on it about forty parts of the lye; stir the mixture well until it becomes white, and use it as a soap water, by diluting it with more or less water, according to the use for which it is required. The soda may be substituted by potash.

Family Soap.—No fixed rule can be given for making this soap, as it may be prepared in different proportions. A good one may be made by taking lye strong enough to bear an egg; it is then introduced into a jar with rancid oil, or rancid butter, old greases, etc. etc., and frequently stirred. Very soon a soapy mass more or less solid is obtained; as grease is added, pour some of the lye in the proportion of one of lye to two of grease.

Soap to Bleach Cotton Thread.—Mix one and a half barrels of wood ashes with a quarter of a barrel of lime. This mixture is introduced into a kettle, with a sufficient quantity of water to moisten it, and the mass is stirred with a shovel. Afterwards, pour on it two barrels of boiling water; this water is passed several times through the mixture, and the lye is boiled until strong enough to bear an egg. Then take the quantity which is needed, and boil it in a kettle with one pound of tallow and half a pound of grease. During the boiling, stir all the time; when the mass boils too rapidly, add new lye, as much as may be necessary, and continue thus until the whole is reduced to the consistency of soap.

The soap being drawn off from the kettle, if there is any grease on the surface, or if it looks white, it is a sign that it is not well saponified; the boiling must be continued, adding new lye each time. The more the soap is boiled the thicker it becomes. When it is at the proper point, add six pounds of common salt, and boil for one hour, stirring all the time.

If afterwards this soap does not cut well, add one pound of salt, and boil until firm enough. It is then allowed to cool for twelve hours, and is cut into thin shavings and boiled for three-quarters of an hour in 7 or 8 quarts of strong beer.

After this last boiling, the whole is poured into a

wooden box and allowed to cool for twelve hours. When sufficiently hard, it is cut into square cakes and dried in a warm room or in the sun.

To bleach cotton thread, take two and a half ounces of thread, and one ounce of soap, boil one and a half hours in two quarts of water, and expose the thread, thus coated with the soap, to the sun.

As it dries, moisten it slightly with water.

When the thread is white, clean it with ordinary soap, and wash with salt water.

Soap from Beef Marrow.—Melt in a dish 500 parts of pure beef marrow, add to it 250 parts in weight of a lye of caustic potash at 36° B. Stir all the time with a wooden spatula, and continue to heat the mixture until it forms a mass soluble in water, then dilute it in 2000 parts of boiling water and add 1000 parts of water containing in solution 180 parts of common salt, stir well, and let it rest. Some time after, take off the soap, let it drain, and put it in china moulds.

Soap from Rancid Butter.—If the butter is salt, boil it in water so as to dissolve the salt. Then take three lbs. of this butter and treat it with lyes in the usual manner. Butter saponifies very well. When in the state of soap, it absorbs much water without losing its firmness. Three and a half pounds of rancid butter without salt yield a soap which, when taken from the frame, weighs eleven pounds; it is very white, with a slight odor of butter. In two months it will lose four pounds.

Soap from Horse Grease.—Three pounds of this grease, saponified by the ordinary process, yield seven pounds of a soap which is nearly white, and without any disagreeable odor. Exposed two months to the dry air it loses two pounds and is then very consistent.

Soap from Wool.—Chaptal is the first chemist who has tried to substitute wool for oils and greases in the fabrication of soap. For this operation, boil a caustic lye, and add to it old pieces of wool, stirring all the time, until the lye will not dissolve any more. This soap may be advantageously used in manufactories.

Soap of Lime.—This soap is obtained by pouring lime water into a solution of soap; it combines with the stearic, margaric, and oleic acids, and sets free the alkali. This soap is insoluble in water and alcohol; it is decomposed by carbonate of potash, and melts at a high temperature.

Soap of Magnesia is the product of the decomposition of soap by a solution of sulphate of magnesia. This soap is very white and unctuous, dries with difficulty, and is insoluble in boiling water, but quite soluble in alcohol and alkalies. It melts at a gentle heat into a transparent mass slightly colored yellow.

Soap of Alumina is produced by pouring a solution of alum into a solution of soap. This soap is soft, flexible, and retains its suppleness and tenacity when dry. It is insoluble in water, alcohol, and oils; it melts easily, and forms a transparent mass.

Soap of Wax.—In speaking of wax, we have seen that it contains two immediate principles, the *cerin* and *myricin;* we have said, that it saponifies very well with potash and soda; we may now add that this saponification becomes very easy with the aid of heat. Indeed, when wax is boiled with solutions of caustic alkali, the liquor is not long in becoming muddy, and the soap separates and floats on the surface. The wax separated from the soap by acids has undergone alterations which have not as yet been well examined.

Ammoniacal Soap.—Ammoniacal soaps are yet little known, and are prepared only for pharmaceutical pur-

poses. They are prepared at the ordinary temperature with the different fixed oils, but most ordinarily with oil of sweet almonds. The proportions are

Ammonia at 22°	1 drachm.
Oil of sweet almonds . . .	1 ounce.

Mix and shake in a bottle. This soap soon acquires a fine white color, and the consistency of honey. A solid ammoniacal soap may also be prepared by passing ammoniac gas through oils, or, what is better, greases.

Starkey's Soap.—This soap is a combination of caustic potash and soda with oil of turpentine.

Whilst fixed alkalies are not absolutely without action on essential oils, they have not the same facility of uniting with these oils as with fixed oils. If we try to combine an essential oil, and particularly that of turpentine, with a caustic lye, as in the preparation of ordinary soap, it will be soon ascertained that there is no combination, or if one, it is very imperfect.

Starkey's method consists in introducing dry alkali into a glass balloon, pouring on it oil of turpentine about two or three inches deep, and giving the combination all the time necessary to effect itself. Indeed, after five or six months, a part of the alkali and lye are combined, and form a kind of whitish soapy compound. This soap is separated, and a new quantity is left to be formed by the same method. The preparation of this soap is so tedious that its use has been abandoned even in medicine.

Action of Caustic Alkalies on Essential Oil of Cloves, and Oil of Pimento.—Oil of cloves, as well as that of pimento, has a property not possessed by many others: it is to instantaneously concrete by the contact of alkalies and to form soaps and savonules.

By Cold Soda.—If 12 parts of caustic soda, called soapmaker's lye, are poured on 24 parts of oil of cloves

by stirring a little, the mixture hardens and becomes opalescent.

This savonule, when recently made, is dry, most frequently it is in thin white plates; it does not attract moisture from the air, especially if it has been pressed between blotting paper to absorb the excess of water.

It is very soluble in alcohol; submitted to the action of nitric acid, it takes a blood-red color. It has very little odor, and is very acrid.

By Potash.—Potash combines in the same manner as soda with oil of cloves; the resulting compound is concrete and dry in the beginning, but the union is not so intimate, the potash attracting more easily the dampness of the air; the soap dissolves, and the oil appears in the form of drops, and is browner than before its treatment by the alkali.

If the operation is conducted at a temperature near the boiling point, the soap obtained is entirely brown. Exposed to the air it attracts dampness, the volatile oil is set free, and its presence is ascertained by its heaviness and its oleaginous appearance. This soap is very soluble in alcohol; it has an acrid and strong taste.

Action of Ammonia.—By its mixture with ammonia, the oil of cloves takes a granular appearance, and its color becomes darker. This combination is not so firm as that with potash and soda; exposed to the air the ammonia is partly disengaged and the oil is set free.

By Ammoniac Gas.—A current of dry ammoniac gas was passed on oil of cloves kept in a refrigerating mixture; after a few minutes the oil was completely solidified; at first, it took the appearance of a butyrous granular mass, in which could be seen crystals having the form of needles. If the action of the gas be continued, it becomes as firm as wax; but by time, and an elevation of

temperature, or by exposure to the air, the gas is disengaged and the oil reappears. If this combination is preserved in a closed vessel, the crystals may be kept longer, they are bright, but the color of the oil is much changed, and all the while they are combined with the dry ammoniac gas they do not dissolve in water.

Animal Soaps.

Bernadet's Process.—It has been known for a long time that alkaline caustic lyes saponify animal substances, but until now the action of alkalies on intestines of animals to make soap has not been applied. M. Bernadet operates as follows :—

The intestines are deposited in a lye of caustic soda to prevent their decomposition, until they are to be used. Then the alkali is heated the necessary time to operate the entire saponification. This operation is easy, and, when care is taken, a soap very slightly colored gray is obtained.

If a perfectly white soap is required, and when the saponification is finished, a suitable quantity of a solution of hypochlorite of soda is poured into the kettle. The mass being well stirred, the soap passes to a perfectly white color. When all these operations are finished, the quantity of common salt necessary to separate the soap from the water is added.

C. J. Villart's Process.—The object of the following process is to convert into soap animal matters in general, but particularly the residuum of meat, or scrapings of tallows, the intestines, etc.

Two kinds of soaps may be obtained ; the first, without much firmness, is of a white color, slightly greenish ; it

has a disagreeable odor, and melts very easily; it may be advantageously used in several industries.

The second kind is the same as the above, but with an addition of rosin and tallow properly saponified, and mixed with the animal soap.

The work is divided into four operations: the maceration, the washing, the solution of the matters saponified during the maceration, and the coction.

Maceration.—The substances are placed in wooden tubs large enough to contain about 300 to 400 pounds. Pour on them a lye made as follows:—

Lime	10 parts.
Soda ash	12 "
Water	100 "

Slack the lime in a sufficient quantity of water, then dissolve the soda ash in water, and pour the solution on the lime. Stir well, and pour the liquid on the animal substances which must remain in this condition, being careful, to stir from time to time, and to observe the progress of their decomposition, as we shall see hereafter.

Washing.—When the saponification has taken place by the maceration, the animal substances are washed in tubs so as to deprive them of the lime they contain, then they are exposed to the air.

Solution.—After an exposure more or less continued, place these animal substances in a kettle with a sufficient quantity of water, and for every pound of them add twelve gallons of lye at 4°, prepared as follows:—

Soda ash	1 lb.
Lime	1 "
Water	6 lbs.

This lye marks 15°, and has always succeeded; however, weaker or stronger lyes may be used, that is, from 2° to 30°, and give a good result.

The animal matters being completely dissolved, decant to separate the lime, heat the solution again, add during the coction 25 gallons of lye No. 2 for every 2 lbs. of substance, and continue to boil until the liquid by cooling has the appearance of a firm paste.

Coction.—This operation has for its object to give to the soap obtained during the solution a consistency which permits of its introduction into commerce.

This operation is completed, as we have said, before adding to this animal soap rosin and tallow, or any other resinous substance, in proportions which vary from 2 to 100 per cent.

To succeed, melt together in the kettle the rosin, tallow, and the liquor No. 2. Thus, we suppose the treatment of 500 lbs. of the soap of the first kind; take

Rosin	100 lbs.
Tallow	50 "
Liquor No. 2	200 ".

Boil until perfectly saponified, which is ascertained by the green and transparent color of the mixture; add then the soap in small portions so as to avoid too much swelling; boil until the paste on cooling becomes hard, run into the frames, and 24 hours after, the soap is ready for market.

Crevel's Process. First Process.—Melt in boiling water the greases, meats, or the other parts of the animals, press and keep the residuum; triturate and grind this residuum, macerate it in alkaline water for several days, introduce the macerated substance into a kettle, and heat to the boiling point. The liquefaction being effected, let cool; then heat again, and introduce successively the alkali, being careful not to use too strong lyes; when the mixture has reached its proper strength in alkali, moderate the action of the heat, and let it cool.

Second Process.—When the substance is liquefied, introduce into it from 10 to 15 per cent. of resinous matter; the saponification being finished, let the mixture cool; afterwards heat gently for about one hour, and run into the frames.

C. E. Coffignon's Process.—This soap is composed in principle of beef, sheep, and pork fats, mixed together. Each of these fatty bodies must at first be submitted to a preparation to extract all the heterogeneous parts which might be hurtful in the fabrication.

This preparation consists in melting separately each of these fatty bodies, so as to extract all the useful portions in a pure state. When thus purified they are mixed together; they are then heated, and mixed with several substances.

We suppose 100 pounds of sheep, beef, and pork fats in equal portions, to which we add 6 per cent. of white wax, 10 per cent. of coco oil, and 10 per cent. of spermaceti.

These substances are submitted to the action of a lye of potash or soda reduced to a convenient degree, according to the composition of the three original fatty substances. This mixture must be heated more or less, but a soap-maker can easily ascertain the proper temperature; the heat is then stopped off, and the mixture allowed to rest for 24 hours; then take off the grease which swims at the surface, and expose it to the air for 24 hours.

The mixture thus treated is introduced into a cast-iron vessel, and is heated; when the fatty substances are about melted, add to them 10 per cent. of talc and 10 per cent. of rotten stone. The mixture is heated for a variable length of time, until it is liquid enough to be put into moulds, then alcohol is added to extract the alkali, and it is perfumed by the addition of some essential oils.

This soap softens the skin and is very good to clean silver, gold, and copper.

L. M. Villacrose's Process.—The trials made on the intestines of animals have not succeeded well on account of the difficulty of properly drying the products without raising their price too much.

The first process requires lyes of soda prepared as follows:—

Take equal parts of lime and soda ash at 80°. After introducing the lime into a vat, dissolve separately the soda ash in the quantity of water necessary to slack the lime, and pour this solution on it.

Let the whole rest one hour, so as to let the lye filter, then open the cock of the vat. This first lye is set aside and the lime is washed, so as to exhaust all the soda.

The last lyes are set aside; their uses will be indicated hereafter.

Evaporate the first lye until it becomes thick, and is covered with a scum; pour a few drops into a porcelain dish, and if it becomes hard by cooling, run the whole on a marble, and keep in well-corked jars.

The last lyes are poured on new mixtures of lime and soda made in the same proportions.

A cast-iron or copper kettle of a capacity of 200 lbs. is placed on a brick furnace in such a manner that the heat circulates all around the kettle.

First Process.—Saponify all the parts of the animals; take

Animal substances	200 lbs.
Caustic soda	10 "
Melted tallow	40 "

Heat the kettle, and when it begins to be warm throw in the soda, the small quantity of water it still contains is

sufficient to dissolve it; then immediately introduce the animal substances and stir well.

The heat must be gentle at the beginning. The mass is not long in melting, and the temperature is gradually raised to 167°.

During the fusion, stir the liquid until it thickens, then pour on it 40 pounds of tallow, which immediately saponifies. The hot soap can be run into the frames; it is hard and fit to use before being cold.

If the tallow does not saponify well, add to it a little warm water.

Second Process.—In this process the intestines, or soft organs, are employed; they must be well cleaned and submitted to pressure so as to separate the aqueous parts.

Take

Intestines	200 lbs.
Caustic soda at 38° or 40° . . .	10 "
Ordinary soap	20 "
Slacked lime	10 "
Flour	12 "

Throw into the kettle the intestines wet with lye; a gentle heat is sufficient to saponify the mass to which the ordinary soap is added.

A little before the fusion is complete, throw in the lime, being careful to mix it well, then let it cool a little and add the flour.

The material being entirely cool, beat it well. The object of this beating is to bleach the soap.

A few hours after, heat again up to the boiling point, and keep boiling until sufficiently concentrated. When the mass has become thick, stop off the heat and run into the frames.

Use of Bones in the Fabrication of Soap, by Mme. Dement.—Bones are treated cold, by submitting them to the

action of caustic substances. For this purpose, introduce them into a large vat, and cover them with a lye composed of a mixture of water, soda, and lime, heated to 80°. After 15 or 20 days, they are completely changed to a white fatty substance of a soapy consistency. This product is then separated from the lye, and a paste is obtained which is used in the fabrication of soap. Before mixing it, it is well pressed so as to render it perfectly uniform and consistent.

The inventor begins then a new series of operations: after manufacturing an ordinary soap of soda with olive oil by the process generally adopted, a certain quantity of it is placed in a kettle heated by steam, and before boiling, the above paste in the proportion of 39 of paste for 67 of soap is thrown in; the mixture is stirred until the union is perfect, and it is then run into the frames. Next day the soap is very hard, whiter than the one generally used and of a better quality.

Oil and Sirup of Soap—New Soft Soap.—1. Prepare the fatty bodies by steam or by very limpid lime-water, and boil with weak lyes; two hours after add from ten to twelve per cent. of resinous substances, continuing the saponification with stronger lyes; evaporate by increasing the heat, and when the material is reduced to a smaller volume, add clear water and boil at a good heat for one hour.

Second Process.—Finish the coction with strong beer and boil one hour.

Third Process.—By reducing the oils with water, sirups are obtained, and by reducing these sirups, new soft soaps until now unknown are produced.

Modified Soft Soap.—This soap is obtained by the application of the different processes described above, and by using substances which contain the most stearin with

the above mixture, or without it, according to the kind of soap to be manufactured.

Soap by Machinery.—1st. Beat the fatty bodies in diluted hydrochloric acid mixed with clarified lime-water. Decant, beat with pure water, and separate. Mix one part of fatty body with one part of caustic soda at 20°, beat for some time, and whilst tepid, let the whole rest; when cold beat for one hour, until the mixture is perfect.

2d. By using liquid fatty bodies, the lye and fatty substance in equal quantities are run together in a receiver, where they are beaten without stopping, and the mixture is pressed between two cylinders.

3d. Mix two parts of lye with one of fat prepared as above, and beat for several hours. When the mixture is homogeneous, melt at a gentle heat.

Soap Made with Gelatin, by M. J. B. Aubonnet.—The substance used in this new soap is gelatin in a more or less concentrated state, according to the kind of soap to be manufactured. One-fourth in weight of caustic lye at 30° is added to the gelatin, and when by evaporation the mixture has the consistency of honey the heat is stopped off; it is then poured into moulds or barrels.

Sometimes from 15 to 20 per cent. of grease, oils, rosins, or any other saponifiable material, are added to the gelatin. Argillaceous substances may also be incorporated with the soap to give it more density.

To apply gelatin to soaps manufactured with greases, oils, or rosins, melt the gelatin with a fourth of its weight of caustic lye at 30°, in a kettle heated by steam, and after evaporation, pour into it soap already prepared in quantity about equal to that of the gelatin; heat and stir until the whole forms a homogeneous paste of the consistency of honey; add the essential oils and run into the frame.

Toilet Soap, by M. P. Guerlain.—The use of cetine in the fabrication of toilet soaps has the advantage of giving a perfectly odorless product, which may receive, without alteration, the most delicate perfumes, and affords a paste with the whiteness of spermaceti.

As this substance is very difficult to saponify, it is mixed with a very small proportion of almond oil, and this compound is treated by liquid potash.

To answer the wants of certain consumers, this soft soap is transformed into hard soap, by treating the paste by salt.

The quantities used are the following :—

Pure cetine	40 lbs.
Oil of almonds	10 "
Lye of potash at 36°	25 "

Saponify as usual.

To transform this soft paste of soap into hard soap, dissolve the paste in 30 quarts of water and boil; add then little by little, as fast as absorbed, 18 lbs. of salt dissolved in 12 quarts of water. This solution is prepared beforehand, and clarified by settling. After this addition, keep up the heat until the soap is entirely boiled, which is ascertained when the lye of chloride of potassium formed reaches a specific gravity of 1.15 to 1.16; then turn off the heat, and let rest for 24 hours, covering the kettle carefully. This soap is perfumed with the oils of lavender, thyme, rosemary, caraway, rose, vervain, or others, according to taste.

Soap of Turpentine, by M. W. Marley.—The object of this invention is to produce, with crude turpentine, a resinous soap, which may be used either alone or in combination with soaps made from fatty substances.

Melt by steam 100 parts of crude turpentine, and add

to it 400 parts of a solution of soda, containing 33 per cent. of pure dry soda. The addition of soda has for its object to neutralize the acids and set free the essential oil contained in the rosin. To separate the latter, add to the saponified mass a solution of common salt; the vessel which contains it is connected with a condensing apparatus. Heat is then applied, and the oil condenses in the receiver, the soap floats on the surface of the saline solution.

Another process which succeeds well, consists in using a lye not so strong as that indicated above, but at 20° B., and adding at first only half of the necessary quantity, and introducing the balance during the distillation.

A solution of pearlash may also be used, but much care must be taken, because a large quantity of carbonic acid gas is disengaged. Two pounds of caustic soda, or carbonate, containing 50 per cent. of pure soda, are sufficient to saponify eight pounds of turpentine.

To free the soap from the coloring matter, it is washed with a solution of common salt.

A good article slightly colored may be obtained by mixing 100 lbs. of good tallow soap with 200 lbs. of the above rosin soap.

Palm and Coco Oils Soaps, E. Junot's Process.—Palm oil has a dark yellow color, and furnishes soaps strongly colored. M. Junot is the first who decolorized this oil, and the soap he manufactured from it was equal in whiteness to the finest olive oil soaps. His process is as follows :—

The palm oil is melted in a kettle by means of an injection of steam at the bottom of the kettle. When the oil is melted, and when it has remained in this state for some time in contact with the steam, the outlet cock is opened, and the melted oil falls into a pipe pierced with

holes, similar to those used by wax makers, and from which it runs into a tank full of cold chlorine water.

As the oil contracts by cooling, it is removed to let it drain, then melted again in a lead vessel, with an addition of a very small quantity of sulphuric acid, and boiled one hour; afterwards, a proportional quantity of water is added to separate the acid. After decantation, the oil is run anew into the tank, and drained in the air. The next day the oil is perfectly white and makes very fine soaps.

Coco oil is extremely thick, and the facility with which it dissolves in alkalies renders its treatment very difficult. It is employed only to make soaps by the cold process, which gives only imperfect products. M. Junot succeeded in obtaining very hard soaps by the following process :—

A very concentrated lime-water is prepared, to which is added a small proportion of chlorine; then introduce into the kettle about one-fourth of the proportion of oil to be treated, and raise the temperature to the boiling point. In this state add the oil gradually, and as fast as the substance rises, introduce successively and alternately lime-water similar to the first, and alkaline lye until the quantity is equal to that of the oil used. When the paste acquires a gelatinous appearance, that is, after an ebullition of one and a half hours, pour into the kettle powdered sulphate of alumina, and give a good boil; then pour the whole into a tub filled to one-third with cold caustic lye, and let it rest until cold. Then draw off all the liquid part which has separated from the paste, melt the cake of soap to complete the liquefaction, as for other soaps, and run it into the frames.

Palm Oil Soap, by M. F. Violet.—This soap, which this perfumer calls *orangine*, is prepared with concrete palm oil.

After melting about 100 lbs. of oil at 95°, he adds 12½

ounces of nitric acid and stirs the whole for 15 minutes, he then introduces 12 gallons of warm water, stirs well, and lets it rest.

This operation being completed, the oil is washed three times.

The oil thus prepared is saponified by lyes of soda ash, rendered caustic by one-third of its weight of lime, and marking 8°, 10°, and 15°. The weakest lyes are employed at the beginning, etc.

The operation is continued in the same manner as for other toilet soaps, only after a perfect coction the lyes are entirely decanted and the grained soap is dissolved with lemon juice. After settling, the product is run into the frame.

The proportions employed are the following :—

Concrete oil	66 parts
Soda	6
Water	20 "
Lemon juice	5 "
Essential oil of Portugal . . .	3 "

White Palm Oil Soap, by M. C. Vallée.—The decoloration and even complete bleaching of palm oil, is due to the oxidizing action of bichromate of potash dissolved in water, with the addition either of sulphuric acid, or hydrochloric acid, or any other acid having the same properties.

The proportions vary according to the degree of whiteness to be obtained.

Generally, for a complete operation, it requires for 100 lbs. of palm oil, 1 lb. of bichromate dissolved in water and mixed with 4 lbs. of sulphuric acid, or 8 lbs. of hydrochloric acid; or the same quantity of bichromate may be mixed with 2 lbs. of sulphuric acid, and 4 lbs. of hydrochloric acid.

Heat the oil to about 212°, dissolve the bichromate in a sufficient quantity of water (1 bichromate, 10 of water), and afterwards pour the acid into the solution.

The liquor thus obtained is thrown into the melted oil, stir the whole, and in ten or fifteen minutes the bleaching is finished. Decant the oil which floats on the surface of the liquor, and transform it into soap by the ordinary processes.

CHAPTER LIX.

IMPROVEMENTS IN THE FABRICATION OF SOAPS.

Improved Soap, by M. Rotch.—This manufacturer introduces a small quantity of soap and water into a kettle, and mixes them together, so as to make a soapy compound; then he adds a little tallow, or grease, or oil, being careful to incorporate them well with the first mixture; he adds afterwards, as much caustic lye as the substance will absorb, without decomposition. He continues to add fatty matters and lye until the kettle is full, gradually increasing the doses, and carefully stirring the whole; the soap is then run into moulds.

Improved Soaps, by M. J. Davis.—This process consists in adding to the soap, fuller's earth, clay, soda, or potash. These substances after being calcined are allowed to cool, then reduced to a fine powder, and mixed with the melted soap. This soap may be indifferently used with salt or soft water, and is very detersive. The soap used in woollen factories, and which is entirely soluble in sea water, is composed as follows: to 124 lbs. of soap add 54 lbs. of fuller's earth, 54 lbs. of clay, and 110 lbs. of

calcined soda ash. These substances are reduced to a fine powder and passed through a sieve. The mass being well stirred is run into the frames.

When the soap is to be used for washing cotton cloth in sea water, the fuller's earth is omitted, and to 118 lbs. of yellow soap, add 110 lbs. of calcined clay, and 94 lbs. of powdered soda ash.

The following proportions are used when the soap is to be employed in soft water: 110 lbs. of soap, 27 lbs. of dry clay, and 34 lbs. of powdered calcined soda ash.

Soap to take out Stains.—Take good white soap and cut it into very thin shavings; for 6 lbs. of soap take one ox-gall and four whites of eggs.

Introduce all these substances into a mortar with two lbs. of calcined and powdered alum. When the whole has been well ground together, keep it in a damp place for 24 hours. If by touching the paste the mixture is found perfect, it is then worked into cakes which are kept for use. If the mixture is not perfect, keep it in a dry place until it has acquired consistency; it is then cut anew into thin slices, and ground in a mortar.

This soap is very much esteemed by scourers, who prefer it to any other.

Fabrication of Soap, by M. P. Michelin.—The following proportions enter into the composition of 1500 lbs. of marbled soap:—

Oil	400 lbs.
Starch	300 "
Soda	20 "
Potash	20 "
Silver white	20 "
Indigo	8 ounces.
Ivory black	8 "
Gum	20 lbs.

Twenty lbs. of rock alum may be added if a soap cutting dry is wanted. To this mixture add 188 gallons of water, introduce the whole into a kettle, and expose to the action of heat. When the coction is perfect run the whole into a frame.

Argillaceous Soap, by M. J. Douglas.—The principle of this invention consists in the use of any kind of clay combined with soap. The clay is thus prepared :—

Introduce the clay into a box to which heat can be applied, and pour water on it until it is reduced to a thick paste, which gives a proportion of about 25 per cent. of clay; in case a greater proportion is wanted, the consistency of the liquid will be thicker, and care must be taken to stir all the time. After the stirring, heat is applied to boil the liquid and keep it boiling, so as to incorporate the clay more thoroughly with the water; this done, add to the argillaceous liquid about a twentieth part of water saturated with salt.

The soap and the clay being in a state to be combined, it depends on the manufacturer to judge the most convenient proportions for the two substances; we must observe that it is impossible to use more than 50 per cent. of clay, and that the mixture is made gradually, by running the two substances together into the frames, being careful to stir them well during the operation.

If an excess of fatty matter is in the soap, this inconvenience may be remedied by using lye to saturate it.

The use of clay is very advantageous especially in toilet soap.

Fabrication of a Soap with Lichen, by M. J. Levat.—The considerable trade made by France with foreign countries for its extracts of odors, leaves without any use a

large quantity of very fine oils and pomades saturated with alcohol, the disagreeable odor of which prevents their employment. It is with these products that the inventor makes a soap of soda in the following manner:—

When the fatty matters, after being heated, have disengaged the greater part of the alcohol they contain, the saponification of the grease is effected with weak lyes, and the operation is continued with stronger lyes, until the soap separates and the grain has a good and strong consistency. Then comes the operation of dissolving the grain to form a smooth paste; it is then that an infusion of lichen is used to liquefy.

Numerous experiments have proved the softness that this mucilage of lichen combined with the soap gives to the skin, and that washing with it precipitates more alkali than by the ordinary process.

This soap is composed as follows:—

Fatty bodies	58 parts.
Water	34 "
Soda	6 "
Lichen	2 "

Fabrication of a Soap, by M. O. Will.—Take

Quince seeds	50 lbs.
Soapmaker's lye at 36°	50 "
Purified lard	100 "

Macerate and boil the seeds in a quantity of water sufficient to obtain after a treatment of several hours a mucilaginous decoction, equal in weight to that of the seeds used. During this time prepare the mixture of the lye with the lard, and afterwards incorporate it into the mucilaginous decoction, being careful to stir all the time the warm mixture.

When the soap is sufficiently cold and the mixture well

made, run the soap into moulds and expose it afterwards to a gentle heat until it has properly dried. This soap is perfumed according to taste; it is very light, foams abundantly, is entirely deprived of alkaline principles, and for toilet soap has the advantage of softening the skin without heating it.

Medicated Soaps, by M. Piesse.—In 1850, the inventor began to make a series of medicated soaps, such as *sulphur soap, mercurial soap, iodine soap, bromine soap, creosote soap,* and many others. These soaps are prepared by adding the medicament to curd soap, and then making into a tablet form for use. For sulphur soap, the curd soap may be melted, and flour of sulphur added while the soap is in a soft state. For antimony and mercurial soaps, the low oxides of the metals employed may also be mixed in the curd soap while in a melted state. Iodine, bromine, creasote soaps, and others containing very volatile substances, are best prepared cold by shaving up the curd soap in a mortar, and mixing the medicines with it by long beating.

In certain cutaneous diseases the author has reason to believe that they will prove of infinite service as auxiliaries to the general treatment. It is obvious that the absorbent vessels of the skin are very active during the lavatory process, and such soap must not, therefore, be used except by the special advice of a medical man. Probably these soaps will be found useful for internal application.

Juniper Tar Soap.—This soap is made from the tar of the wood of the *Juniperus communis,* by dissolving it in a fixed vegetable oil such as almond or olive oil, or in fine tallow, and forming a soap by means of a weak soda lye after the ordinary method. This yields a moderately firm and clear soap, which may be readily used by appli-

cation to parts affected with eruptions, at night, mixed with a little water and carefully washed off the following morning. This soap has lately been much used for eruptive disorders and with varying degrees of success. It is thought that the efficient element in its composition is a rather less impure hydrocarburet than that known in Paris under the name *huile de cade.* On account of its ready miscibility with water, it possesses great advantage over the common tar ointment.

CHAPTER LX.

SUBSTITUTES FOR SOAPS.

Experiment has demonstrated that several substances have a detersive property, that is, bleach tissues. There are certain species of clay of a dirty white color, which act in so advantageous a manner, that they have been called *fuller's earths.* There are also some vegetables, such as horse-chestnut, potatoes, saponaria, etc., which have similar virtues. Every one knows the effects of the chloride of soda (hypochlorite of soda) on linen. Chlorine has been applied with great success in the bleaching of linen, cotton, etc., and chloride of lime has been substituted for it; but as it does not enter into the plan of this work to speak of the preparation of these different agents, we pass immediately to the examination of the different vegetables named above.

Horse-chestnut.—This is the fruit of the horse-chestnut tree, originally from India, and actually cultivated in this country not for its fruit but for the shade it produces and because its culture is easy, and it reaches the size of

a large tree in a few years. At the end of its branches grow several boughs which carry each one several white flowers with four or five petals. To these flowers succeed fruits which are round, thorny, and which open in two or three parts, and which contain one or several chestnuts. These fruits are not good to eat, being bitter, acrid, and astringent.

Several means have been found to render them fit to feed to cattle, by preparing them like olives, that is, by impregnating them with a solution of common salt.

A great many trials have been made to use the horse-chestnut, and the most advantageous known has been to employ it as a substitute for soap.

The horse-chestnut is first peeled, and then grated as fine as possible in soft water. This is done ten or twelve hours before using it; the water is stirred from time to time, so as to dissolve the grating. A quarter of an hour before drawing off the water stir again, and leave in the bottom only the thickest part.

The water is drawn off by leaving it to run slowly. The water must be white and foamy.

To use this kind of lye, it is heated to a degree that it is not possible to keep the hand in.

Take from the fire, and throw the stuffs into it; let them soak; rub them with the hand, and wash them.

It requires very little soap to rub the parts which were too dirty to be cleaned with the horse-chestnut lye alone.

The hemp which has been thus bleached and washed, is dried in the same manner as cotton.

The residuum of the horse-chestnut is good, and may be used to feed poultry, pigs, and even cows.

Potatoes.—We must speak here of the process proposed by Cadet de Vaux, to substitute the potato for soap in the bleaching of linen, and the numerous expe-

riments which have been made on this subject. Introduce into the vat the cloths to be bleached, cover them with water, let them soak for 24 hours; then beat and squeeze them.

Cook potatoes either in water or by steam, avoiding to boil them too much, because the potatoes will be attacked to the centre. They must be two-thirds cooked, and be firm enough to resist when rubbed. They are then peeled.

The cloths are introduced into a vat full of warm water, where they are left for half an hour, and then taken piece by piece, squeezed, and put in heaps.

Take each piece separately; the dirty parts are rubbed with potatoes; they are then folded, and watered with warm water.

They are then worked with the hands, so as to impregnate well all the cloths. Beat as usual; afterwards, dip the cloths again into the kettle, and keep them boiling for three-quarters of an hour. The operation is begun again, if the cloths are not clean. In both cases the cloths are washed in cold water, well squeezed and dried.

Vegetable Soap of Jamaica.—This soap is extracted from the great American aloes. It is prepared by two processes.

The first consists in cutting the large leaves of the plant, passing them through the rollers of a mill, and collecting the expressed juice in large receivers; expose afterwards to a very hot sun the residuum which remains, and leave it until it has acquired a solid consistency; it is then made into balls, by mixing it with ashes. It may be used as well as Castile soap to bleach cloths. One advantage of this soap over others, is that it dissolves as well in salt as in soft water. The second manner of preparing this vegetable soap is to cut the

leaves in small pieces, grind them in a mortar, and express the juice, which is thicker, either by the heat of the sun, or by boiling it on the fire, and adding to it a certain quantity of ashes.

Prepared by either method it answers the purpose for washing clothes. One peculiarity of the juice of this plant is, that it cannot combine with tallow or other fatty substances, even their admixture would prevent its effects.

Soap Tree.—There exists a tree which by its nature produces the effect of soap, and which is used in many countries for washing; this is the soap tree.

It grows in firm ground, principally in the West Indies, in the Spanish islands, and in Jamaica.

Its wood is white, resinous, quite hard, but may be cut easily; it has an odor and taste similar to that of copal. In the West Indies they use the root and the fruit to produce the same effects as soap. They introduce two or three of these fruits into warm water and wash clothes in it. A large quantity of foam is produced, the water becomes whitish, detersive, and cleans very well.

This kind of soap must not be used too often with the same clothes, for it destroys and burns them.

The fruit melts little by little in the water, until nothing remains but the stones, which are very hard; this fruit is called *soap apple.*

Soapwort.—Independently of the above, they have in Europe the soapwort, *saponaria officinalis*, a plant which grows near rivers, ponds, in woods, and in certain sandy grounds.

It is cultivated in gardens, it flowers in summer, and sometimes its flowers become double; it is a beautiful plant, and has a very good odor.

The soapwort is bitter and detersive, it removes some kinds of stains on cloths in the same manner as soap.

Liquid used as a Substitute for Soap.—Take wood ashes and prepare with them a lye with a sufficient quantity of water, mixing with it one or two handfuls of fresh slacked lime.

Leave this lye to rest until clear, then decant it and keep it for use.

To employ it, pour on it of fat and common oil about three or four times as much as lye. Immediately a liquid as white as milk is formed, which, being thoroughly stirred, gives a lather proper to wash as well as a solution of genuine soap. All the liquid is poured into the wash tub and is diluted with more or less water according to the quantity of clothes to be washed; the clothes are dipped in and well rubbed, then they are squeezed and dried as usual.

If the oil mixed with the lye has a bad odor, the clothes must be washed in a pure lye, which will take off the odor.

If the mixture has a yellow color, it has to be diluted in pure water, for, without this precaution, it will dye the clothes.

Process to Render Hard-water fit for Washing.—Soda introduced into hard water renders it muddy, and precipitates the lime and magnesia.

To render such water fit to wash clothes, introduce into it an excess of carbonate of soda; the above earths are soon precipitated and the water may be used like soft water.

CHAPTER LXI.

ON THE CHANGES TO BE MADE IN THE ACTUAL PROCESSES OF SAPONIFICATION, BY M. D'ARCET.

HAVING to establish in Paris a manufactory large enough to prepare daily about 30,000 lbs. of soap, I had to reflect on the mission I had to fill, and it was not without trouble I attained the object proposed to me.

There never had been before a large soap manufactory established in Paris, and I was aware that the manufacturers in the south had not to fear the effects of cold in their different operations, nor the destructive action of frost on buildings nearly always damp; on the other hand, the high price of fuel and soda in Paris at the time, made me think that it was not prudent to establish in the north of France the fabrication of soap as conducted at Marseilles. I had therefore to establish the work according to principles, and on a plan more rational or more in accordance with the atmospheric circumstances and the industrial and commercial data, under the influence of which I had to operate.

In reflecting on what takes place during the saponification of fatty bodies by alkalies, knowing that some kinds of soap may be prepared cold, and starting from the well-known fact that a piece of tallow dipped into a caustic lye and even in a solution of an alkaline carbonate, is converted after a time into a perfect soap, at the ordinary temperature, I thought it was easy to perfect the processes of saponification, and I searched for the way.

It was then that I ascertained that it would be economi-

cal to manufacture soap on a large scale, by employing a low temperature, capable only of maintaining the fatty substances in a liquid state, and, instead of a protracted and costly boiling, by substituting mechanical means for multiplying the points of contact between liquids having densities so different.

There are two very distinct operations in the fabrication of soaps; the first has for its object to chemically combine the alkali with the fatty bodies, while in the second, the former soap must be made to contain the proper quantity of water, by the processes of liquefaction or mottling if a white soap containing 50 per cent. of water or a marbled soap containing only 33 per cent. are to be manufactured.

The first operation, called saponification, presents numerous difficulties; it is important to add to the fatty body the necessary caustic lye, little by little, and of a proper density, so that the soap when formed will not dissolve in the liquor, nor be transformed into too large and too hard grains. If the soap dissolves in the boiling lye, the whole will soon form a mass, the soap will burn at the bottom of the kettle, and the operation thus conducted will be impossible. If, on the contrary, the saponification is effected by using too much of, or a too concentrated lye, the ebullition will with difficulty bring about a sufficient contact between the fatty bodies and the lye, which will retard the saponification, and increase the expense in fuel, work, etc.

The necessity of keeping the soap during all the time of the saponification in a state of half solution in the boiling lye, presents great difficulties of execution, and renders the operation much longer and too costly.

The saponification being finished the soap is boiled down, that is, until the lye on which the soap floats is concen-

trated by evaporation to the density at which the grain contains just the necessary quantity of water. It is thus, that after the saponification the soap contains more than 50 per cent. of water, while towards the end of the coction the grain of soap contains only about 16 per cent.

This operation has for its principal object to leave in the grain of the soap only the proper quantity of lye, but it presents at the same time the advantage of completing the saponification, if this first operation had not been completely effected, and besides, of rendering the soap homogeneous in all its parts. After the coction of the soap comes its liquefaction, if it is to be converted into white, or its mottling, if it is to be manufactured into marbled soap.

The liquefaction or fitting has for its object to soften the grain of the soap, to introduce into it as much as 55 per cent. of water, instead of the 16 per cent. that the coction has left in it, to render the paste nearly liquid, and to favor thus during the cooling of the soap in the frame, the precipitation of all the foreign substances that the grains may contain, which contributes to bleach this kind of soap, and to give it much homogeneity, and a great degree of purity.

As for the marbling of the soap, it may be improved. It is true that soap has been marbled at Marseilles for many years, and when the art of soapmaking is well understood it strikes me that since the origin of the art, the manufacturers have obtained soaps more or less well marbled.

At the time of the saponification, the iron which is held in solution in the lye of sulphuretted soda combines with the fatty bodies and forms a soap of iron, and the manufacturer is obliged to add some green vitriol; on the other hand, the alumina and lime contained in the

lyes are also converted into soaps of alumina and lime, and these three soaps dissolve in the nearly liquid mixture of oil and soap submitted to the saponification.

Later, when the saponification is finished, and even at the end of the coction, the soaps of iron, lime, and alumina are so uniformly divided in the mass, that it may be said that they are in a state of true solution. They color it a blackish-blue in all its parts, if the lye on which the soap boils has not ceased to be sulphuretted; and the soap suddenly cooled and cut into thin plates, looks then like damp slate.

The soap being finished and colored as we have just stated, is too dry on account of the high density of the boiling lyes on which it floats; it must be brought back to contain at the most 36 per cent. of water. This is done by the operation called mottling, which has for its object to swell and soften the grains of soap.

When this is done, the mass of soap ought to be evenly penetrated with water throughout; the grains must be soft and voluminous, hardly separated from the warm lye on which they float, and the greater part of which is interposed between the grains of soap properly softened; the soap is then run into the frame, and the operation is finished. Let us see what takes place in the frame.

If the soap is run into a thin dish, and if a portion of the soap, taken at the time it is run into the frame, is quickly cooled down, a soap uniformly colored blue like damp slate is obtained; the soap then is not marbled at the time; the mixture of the soaps of iron, alumina, and lime, colored by sulphydric acid, is still in solution in the mass, but by degrees, and by the progressive cooling, the soaps of alumina and lime being less

soluble and less fusible than the soap of soda, separate and divide in the mass of soap, which is white for the greater portion, but is streaked with strongly colored runs, which are formed by those portions of the soap in which has concentrated the mixture of the soaps of iron, lime, and alumina, colored blue by the action of the sulphuretted lye.

The marbling of the soap is not an effect produced by a simple mechanical mixture of two soaps, one of which is colored; the cause which controls its formation belongs to a more elevated order, for the separation of soaps having different bases, during the cooling in the frame, is effected by the action of that force which separates alloys at the time of their solidification, the effect of which is known by the name of *liquation*, and to which we attribute the formation of granites, etc., and in general, that of all the primitive crystallized rocks.

In the fabrication of the bar soap by using sulphuretted lyes, a white soap is obtained, because the liquefaction is carried to the point where the paste is fluid enough to permit the whole of the blue colored soaps of iron, alumina, and lime, to separate completely and fall to the bottom of the frame.

The mixture of soaps of iron, alumina, and lime, dissolved in ordinary soap, and colored by the action of the sulphuretted lye, quickly loses its color in the air under the influence of water and the excess of alkali the soap contains; the blue color by disappearing leaves a yellow trace, so much darker when there is more iron in the soap, which is due to this, that the mixture of the soaps of iron, alumina, lime, and soda, being desulphuretted, is colored only by the iron soap which has an ochreous yellow color. These yellow lines are not wanted by the consumer, and they constitute a loss to the soapmaker.

It is required that the soap shall have a marbling of a fine dark blue, and that the part of the soap thus shaded shall become white in the air.

In conclusion, for the marbling of soap, the following conditions have to be fulfilled :—

1. To have in the mass the quantity of iron soap necessary to give the required degree of coloration.

2. That the iron soap shall be combined with a sufficient quantity of soap of lime and alumina, so as to produce a transparent, homogeneous, and properly shaded marbling.

3. To have all the time, but especially at the end of the coction, a proper excess of sulphuretted lye in contact with the soap.

4. That the cooling in the frame is managed in such a manner as to produce the required marbling.

Instead of saponifying with weak lyes, and in deep and conical kettles, I operate in large sheet iron vats being three times as long as they are wide, heated below only by the waste heat of the ordinary kettles, and I use strong caustic lyes containing a little common salt, instead of using weak lyes, and gradually increasing their density.

The heat communicated to the vats is not above 122°, and may be sufficient only to keep the fatty body perfectly liquid.

Instead of stirring the mixture by ebullition, I use a mechanical stirrer conveniently fixed, which multiplies more economically than the ebullition, the points of contact between the fatty body and the lye. The stirring is continued until the chemical combination which constitutes the soap is completed, which is ascertained by the strength of the lye, which must remain the same, and the complete solubility of the soap in boiling water. The

soap is then converted into small round grains without adherency, and swimming on the excess of caustic lye; the saponification is then finished.

The vat in which this operation takes place has its edges elevated about three feet above the large, deep, and conical kettle in which the coction is finished. A wooden gutter is used to transfer the soap from the vat into the kettle; the old lye remaining in the bottom of the vat, is drawn off, and a new operation may be begun. As for the soap in grains which has been introduced into the large kettle with new lye, its saponification is completed, and the coction is conducted as usual; it is also converted into white or marbled soap.

To manufacture white soap, it is not necessary to add coloring matter; but for the marbled soap, the mass must be colored in the vat at the beginning of the saponification.

This coloration is managed as follows:—

In a kettle, I prepare a mixture of soaps of alumina, lime, and lead, by decomposing in the order indicated below, by an excess of soap dissolved in water, solutions of acetate of lead, chloride of calcium, and alum. The mixture obtained is kept under water, and is used to color marbled soap, which is done by adding at the beginning of the operation enough of the mixture to give to the mass the proper shade. The sulphuretted lye used in the saponification quickly gives to the soap of lead the blackish-blue color necessary to color the marbling, and consequently, it is easy by different trials to obtain the required shade.

What I have said of the marbling of soap, proves that there is an obligatory relation between the beauty or the perfection of the marbling of the soap, and the quantity of water it contains. A well-marbled soap cannot

contain more than 33 to 34 per cent. of water, while white soap may receive more without losing its good appearance, and it is even whiter when it contains more water. To manufacture white soap, containing like the marbled soap, 33 per cent. of water, lyes without sulphydric acid must be used, which increases the expense of fabrication. I have noticed this fact, because it is generally believed that the preference given to marbled soap is ridiculous and without foundation, while on the contrary, this preference is the result of a long experience.

SECTION IX.

ANALYSIS AND ASSAYS OF 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 a potash 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:—

Table of the Quantities of Soap obtained from Three Pounds of Oil, Saponified with Carbonate 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 " "	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 yel-

low. By associating these oils with proportionate quantities of suet, mixtures will be formed of which soaps of proper quality and consistency can be made.

The soaps made from *poppy oil* are of a dirty gray, without any disagreeable odor, of a medium consistency, 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 the 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 consistency, 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.

Soaps 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.

Coconut 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.

Table of the Quantities of Soap given by Three Pounds of Oils, Saponified by means of Commercial Soda, and by the same process.

Names of the oils or fats.	Quantity obtained as taken from the frame.	Weight of the soap two months after.
Olive	6 lbs. 10 oz.	4 lbs. 15 oz.
Sweet almonds	5 " 8 "	4 " 8 "
Colza	5 "	3 " 12 "
Rapeseed	5 " 10 "	4 " 8 "
Beech-nut	5 "	4 " 10 "
Poppy	5 " 6 "	5 " 2 "
Hempseed	5 "	4 " 8 "
Nuts	4 " 12 "	4 " 8 "
Linseed	5 "	4 " 8 "
Sperm	5 "	4 " 8 "
Fish	5 "	4 " 8 "
Cod-liver	5 "	4 " 8 "

Chemically pure, soaps are real salts formed with a fatty body in combination with potash or soda, mixed with a certain quantity of water, varying according to

the nature of the soap. Besides these substances, it frequently occurs that they contain others, introduced purposely, or which are due to the impurities of the lyes or fatty bodies employed in their preparation. Sometimes also, the soaps, not being properly purified after the coction, are very alkaline, and in this state, may be injurious in the operations in which they are employed.

It is then impossible to know the real composition of a soap, and consequently its value, except by an analysis which will determine the nature and respective proportions of the different elements which constitute it. Considered in a commercial and industrial point of view, this analysis comprises four distinct operations which are :—

1. *The determination of the proportions of water.*
2. *The determination of the proportions of the fatty acids.*
3. *The determination of the proportions of alkali.*
4. *The determination of the proportions of the foreign substances.*

We shall describe these different operations in the above order.

CHAPTER LXII.

DETERMINATION OF THE PROPORTIONS OF WATER.

To determine the proportions of water contained in a soap, ascertain what quantity is taken, partly inside and partly outside of the cake or bar, and reduced into thin shavings. Weigh some of this soap, 80 grains for example ; this being done, spread the shavings on a sheet of white paper which is placed on the cover of a small cop-

per kettle containing boiling water. The temperature thus produced, heats the soap to about 202°, and determines the evaporation of the water it contains; but if the analysis is to be very precise and the temperature above 212°, the soap must be dried in a small oven with an oil bath. This oven, very often used in the laboratory, is composed of a copper box with a double envelop, provided with a door on one of the sides to introduce the substances to be dried. The space between the two envelopes is filled with a fixed oil. The oven is heated on a small furnace until the temperature at which the soap is to be dried is reached, which is easy to ascertain by means of a thermometer. The best temperature for this operation is between 248° and 266°. The soap being introduced into the oven, is left in for a few hours, and is then weighed. The difference in weight represents the evaporated water. The soap is again placed in the oven, and if after one or two hours its weight has not changed, the operation is finished. Perfectly dried soap must be instantaneously reduced to powder when triturated in a mortar.

To determine the quantity of water the soap has lost by desiccation, it is sufficient to weigh it exactly before and after desiccation. As we have said, the difference in weights will represent the quantity of water contained in the soap. Suppose the original weight of the soap to be 80 grains, the weight after it is dried 67 grains; then it follows that the soap contains $\frac{(80-67)\times 100}{80} = 16.25$ per cent of water.

This operation is very important, for the quality of a soap is in inverse proportion to the quantity of water it has lost during ths process of drying.

CHAPTER LXIII.

DETERMINATION OF THE PROPORTIONS OF FATTY ACIDS.

Soaps found in commerce contain very variable proportions of fatty acids. These proportions vary from 10 to 65, and even sometimes to 75 per cent. of the weight of the soap; it is then very important for the consumer to determine by a precise and ready process the quantity of fatty acids contained in the soap he has to use. Its real value is in proportion to the quantity of fatty acids it contains.

The process used for this analysis is founded on the decomposition of soaps by vegetable or mineral acids, which combine with the alkali and set free the fatty acids. The operation is conducted as follows: Take a piece of the soap to be tested and divide it into thin shavings, then weigh very exactly 100 grains, which are dissolved in 5 ounces of warm distilled water, or in rain water, if the distilled is not to be had.

The solution is effected in a porcelain dish heated over an alcohol lamp. When complete, pour into it gradually, stirring continually, sulphuric acid diluted with nine parts of water. To have a complete decomposition of the soap, it is essential that the acid should be in excess, which is ascertained by dipping a piece of blue litmus paper into the liquor; if the paper becomes red, it is a sign that there is enough acid to decompose the soap. Boil the mixture gently for about 15 minutes, and to facilitate the solidification of the fatty acids, add at the end of the operation a weight of white wax equal to that

of the soap. The wax ought to be very pure and dry, and as it generally contains a little water, before using it, it ought to be kept melted for a time to evaporate the water.

When the wax is entirely melted let the mixture cool. The fatty or oily substances contained in the soap unite with the wax on the surface of the liquor and acquire a solid consistency when cold. This mixture is carefully taken off, and to eliminate the small quantity of sulphuric acid it contains, it is boiled for a few minutes with half a pint of distilled water; the water removes the acid and the mixture of fatty acids and wax solidifies by cooling on the surface of the liquor. After separating the fatty substances from the liquid they are kept melted for some-time in a porcelain dish to evaporate the water; this is ascertained when the mixture ceases to decrepitate. Let it cool and weigh the fatty matters very exactly. Subtract 100 grains for the weight of the wax added during the operation; the remainder represents the quantity of fatty acids contained in the 100 grains of the analyzed soap.

The analysis of the principal kinds of commercial soaps gives:—

Marseilles marbled soap . .	62 to 65	pounds of fatty acids in 100 lbs. of soap.*
Tallow marbled soap . . .	60 " 62	
White soap of oleic acid . .	55 " 60	
" Marseilles . .	48 " 52	
Soap of tallow and rosin . .	40 " 50	
Soap of Glasgow	50 " 52	
Soap of coco oil	15 " 50	

We see by this table that the proportions of fatty acids in different kinds of soap present much difference. The

* See general table at the end of this section.

marbled soap has a more constant composition, the causes of which we have explained while speaking of its fabrication. We have demonstrated that there is a necessary relation between the beauty of the marbling and the respective proportions of the different substances which constitute it. Soaps without marbling, not being subject to such precise rules of fabrication, have a more variable composition, since we see that the proportions of the fatty acids may vary from 15 to 60 per cent. of the weight of the soap. Truly, the soaps made from coco oil are about the only ones which present such a considerable difference in their composition. The other varieties of soaps without marbling contain from 40 to 50 per cent. of fatty acids.

The above process is employed for the analysis of soaps in general; only for black or green soaps the proportion of fatty acids is less considerable. But the process is the same in both cases.

The use of the wax has for its object to solidify the fatty acids obtained by the decomposition of the soap. Stearin or spermaceti will give the same result.

Nevertheless, the use of these substances has an inconvenience which we must notice. They have no influence whatever on the results of the operation, but by the consistency they give to the fatty acids, they prevent our ascertaining the nature of the fatty body used to prepare the soap.

Indeed, if the operation is performed on an oil soap, or on a soap of tallow or grease, the fatty acids by mixing with the wax, always assume a solid consistency by cooling. When it is necessary to ascertain the nature of the fatty body which constitutes a soap, the wax or any other substance which has the property of solidifying fatty acids must be dispensed with. Thus the fatty

acids of a soap of olive oil will always have a soft and unctuous consistency, like olive oil, only more opalescent than before the saponification; those from the decomposition of a soap of tallow or grease have, on the contrary, as much solidity as those substances in their natural and original state. When the fatty acids are produced by a soap formed of a mixture of oil and tallow, or grease, they have an intermediate consistency, and are much firmer when the proportion of the concrete acids is larger, and *vice versâ*.

Lastly, the fatty acids obtained by the decomposition of a soap containing rosin or palm oil are always easily recognized by their yellow color. The intensity of the coloration varies according to the proportions in which these substances enter into the composition of the soap.

We see, by what has been said above, that if it is only necessary to determine the proportions of fatty acids existing in a soap, wax may be used without any inconvenience; but, when independently of the weight of the fatty substances, their nature has to be ascertained, the wax cannot be employed, because it has the property of forming a solid compound by its mixture with the fatty acids from the soap.

CHAPTER LXIV.

DETERMINATION OF THE PROPORTION OF ALKALI.

INDEPENDENTLY of water and fatty acids, soaps contain potash or soda as a base. To determine in what proportion the alkali exists in a soap, dissolve half an ounce in four or five ounces of warm distilled water. The solu-

tion being completed, saturate the alkali by the alkalimetric liquor in the usual manner. The quantity of alkali contained in the soap is thus obtained.

The same result is obtained by saturating a boiling solution of 1¼ drachms of soap by an excess of alkalimetric liquor. The saturation being effected, the mixture is allowed to cool and is afterwards filtered to separate the fatty acids. The limpid liquor is evaporated to dryness in a porcelain dish, the residuum calcined at a red heat, and from the weight of sulphate of potash or soda found, a calculation will give the quantity of potash or soda existing in 1¼ drachms of soap.

A less precise process, but more practical, to determine the weight of the alkali contained in a soap, consists in incinerating a certain quantity in a porcelain crucible; the residuum carefully weighed gives the quantity of carbonated alkali contained in the soap. But this process lacks precision, for the residuum may be mixed with a large proportion of foreign substances, and this is the case with soaps of inferior quality. The writer has incinerated black soaps made with tallow and rosin, which have given 22 per cent. of solid residuum, the greater part of which was formed of clay. Soaps made with coco oil have given by the same process 18 per cent. of solid substances composed of about equal parts of carbonate of soda and common salt. Consequently this process cannot be used for an exact analysis; but besides its simplicity it is advantageous in this, that it indicates the falsification of soap, by the residuum it leaves after incineration. Indeed, a well-made soap, whatever is the nature of the fatty body used to prepare it, never gives by its incineration more than 11 or 12 per cent. of residuum; whenever the residuum exceeds this weight, it is certain that the soap has been adulterated by an ex-

cess of alkali, salt, or earthy substances; but to ascertain the nature of these substances, it is necessary to analyze the residuum.*

Sometimes, and without any intention of falsification, soaps contain an excess of alkali; they have a strongly caustic taste resulting from an incomplete purification. The excess of alkali is ascertained as follows :—

For this purpose dissolve in a porcelain dish 6 ounces of soap in one quart of distilled or rain water. When the soap is melted add one quart of a solution of salt at 25° and boil the mixture gently for one or two hours. The soap is then obtained in the form of small round grains, without adherency, and swimming on the salt water, in which they are completely insoluble. These grains being separated from the liquor, it is ascertained that the liquid is alkaline by dipping into it a piece of litmus paper reddened by an acid; if the paper resumes its original blue color, the change is due to a free or carbonated alkali abandoned by the soap while boiling in the salt water.

The quantity of alkali contained in the salt water can be exactly determined by saturating about two ounces of the solution with the alkalimetric acid liquor, which by calculation will give the excess of alkali contained in the whole of the soap.

In principle, this process is based on the property pos-

* When soap is incinerated, the fatty acids are destroyed and produce carbonic acid which combines with the base to form a carbonate. As 100 parts of carbonate of soda represent 45 of carbonic acid, and 55 of soda, it is sufficient, in order to obtain the quantity of soda contained in the soap, to multiply the residuum by 0.55. But as this residuum is often mixed with foreign substances, it is necessary to submit it to an alkalimetric assay to determine exactly the quantity of real alkali.

sessed by a concentrated solution of salt to separate completely the soap from its aqueous or alkaline solution. But this solution becomes alkaline only when the soap itself contains an excess of alkali. When perfectly purified soaps are treated by this process, the solution remains neutral and does not change the color of red litmus paper.

This mode of operating may be applied to every kind of soap, hard or soft, that has potash or soda for its base. The alkalinity of the liquor after the operation always shows an excess of free alkali in the soap.

In the arts, it is sometimes useful to know if a soap is made with potash or soda, or with both. To resolve this question, calcine by a strong heat, in a porcelain crucible, one ounce of the soap to be tested. After the calcination, dissolve a part of the residuum in 5 or 6 ounces of boiling distilled water, and filter through paper, then saturate the alkali by a slight excess of nitric acid diluted with four or five parts of water.

If into one portion of the liquor a concentrated solution of chloride of platinum is poured and a yellow precipitate is formed, it indicates that the analyzed soap is made with potash. This reagent is without action on soda.

To ascertain if besides potash the soap contains soda, saturate the other portion of the liquor by perchloric acid, and treat the dried product by alcohol. If the perchlorate is insoluble in alcohol, the soap is made of potash. If a part is soluble and another insoluble in alcohol, it indicates potash and soda. Knowing the respective proportions of the perchlorates of potash and soda, it is easy to determine by calculation the quantities of each base.

CHAPTER LXV.

DETERMINATION OF THE PROPORTIONS OF FOREIGN SUBSTANCES INTRODUCED INTO SOAP.

Foreign substances are often introduced purposely into soaps. Concentrated and boiling alcohol presents a very exact and precise means of ascertaining the presence of these substances. This process is based on the property that boiling alcohol possesses of completely dissolving pure soap and leaving undissolved the substances which may have been used to adulterate it, such as alumina, chalk, lime, salt, starch, *fecula*, etc.

Proceed as follows: Take one ounce of soap, which is cut into very thin shavings, and introduce it into a bottle of the capacity of about one pint; add five ounces of alcohol at 90°, and cork the bottle slightly. This being done, heat the bottle over a water-bath, gently at first, so that the alcohol will begin to boil only after 25 or 30 minutes. Boil for about a quarter of an hour, and to facilitate the solution of the soap stir from time to time with a glass rod.

The solution being complete, stop off the heat, cork the bottle to prevent the evaporation of the alcohol, and let it rest for 15 or 20 minutes in a cool place. If after this time, the solution is perfectly limpid, and if there is only a very slight deposit at the bottom of the bottle, the soap on which the experiment was made is free from all mixture.

In the event that the soap should be mixed with earthy

substances or with fecula, or even with an excess of soda or salt, as is the case with coco oil soap, a more considerable deposit is obtained, and as much more abundant as the soap contains more foreign substances. To determine their nature, they are at first separated from the liquid soap, then washed with some boiling alcohol, which dissolves the small quantity of soap with which they are impregnated. This being done, they are dried in an oven.

If the operation has been performed on marbled soap free from all admixture, the dried deposit will not be more than 0.1 per cent. of the weight of the analyzed soap. This soap always contains a certain quantity of insoluble soaps of manganese, alumina, and iron, which are the coloring principle of the marbling.

Purified white soaps, when pure, leave an unappreciable deposit. Thus, when the dried deposit weighs more than 0.1 per cent of the soap, it is evident that foreign substances have been introduced into them. These substances are generally feculæ, alumina, lime, clay, chalk, salt, etc. The deposit is divided into two parts. One is treated by half an ounce of cold water which dissolves the soluble salts, the potash and soda. Cold water has no action on feculæ, nor on the earthy substances which may be contained in the deposit.

The clear solution is separated by filtration or decantation and divided into three parts. If in one of these parts, on pouring a few drops of a solution of chloride of platinum a yellow precipitate is obtained, the deposit contains potash. If into another part, by adding nitrate of silver an abundant white precipitate is formed, it indicates the presence of salt. Lastly, the third part of the liquid treated by perchloric acid, gives a perchlorate insoluble in concentrated alcohol, if potash alone is in the deposit.

To ascertain if the soap contains starch or fecula, take the deposit insoluble in cold water and treat it by a small quantity of boiling water. The solution will form a more or less thick paste, according to the proportions of amylaceous substances it contains. To be certain that this thickening is due to the presence of starch or fecula, pour into it a few drops of a solution of iodine, which, in this case, will give a violet coloration to the liquor. This reagent does not cause any coloration if there is no fecula present.

Let us suppose that the soap contains at the same time alumina and lime either free or carbonated, that is, in the form of chalk. To detect these two bases, take that part of the deposit which is insoluble in cold and hot water, and dissolve it in nitric acid diluted with three or four parts of water. Heat gently in a porcelain dish to facilitate the reaction. The solution being complete, which is ascertained when the mixture reddens litmus paper, add one ounce of distilled water, stir, and filter.

To determine separately the alumina and lime, divide the filtered liquor into two parts. If to one a few drops of liquid ammonia are added, and a white precipitate is immediately formed, this precipitate indicates alumina, then the soap has been mixed with this base. A distinctive characteristic of alumina is that the precipitate ought to dissolve in a slight excess of nitric or hydrochloric acid. The aluminous earths generally introduced into the soap are kaolin and ordinary white clay.

Pour into the other part of the filtered liquor a concentrated solution of an alkaline carbonate, or, what is better, a few drops of oxalate of ammonia; with the first reagent, an insoluble carbonate of lime is formed, and with the second an oxalate of the same base, if the liquor contains lime. It is easily ascertained if the soap has been

adulterated with chalk, if the deposit effervesces with acids; quicklime dissolves without effervescence.

The processes indicated in the above chapters will give a general rule for the analysis of soaps, but some of them are somewhat slow and complicated. We shall now indicate a few special methods which give results quite as accurate as the above, and have besides the advantage of quickness and more ease in the manipulations.

CHAPTER LXVI.

SPECIAL METHODS OF ANALYZING SOAPS.

Process of M. Rampal—Process of M. C. Cailletet.

Rampal's Process.

In 1857, the *Société Industrielle de Mulhouse* proposed for the subject of a prize a process for readily determining the value of a soap. This prize was awarded to M. Rampal, who proposed the following process for the analysis of soaps :—

I. The analysis of soaps does not present any more difficulty, and may be done in as little time and with as much precision as that of alkalies.

II. There is no necessity for analyzing marbled soap, for it *cannot be adulterated ;* too much water precipitating the marbling, and the introduction of foreign substances preventing its formation.

III. For the white or unicolored liquefied soaps, *i.e.*, manufactured according to the Marseilles method, the quantity of water is determined by the usual process.

The soap in thin shavings is submitted to a tempera-

ture of 212°. The soap is weighed before drying and afterwards; the difference in weight gives the proportion of water. One drachm dissolved in two ounces of hot water, indicates by the limpidity of the solution, if the soap has been manufactured by *liquefaction.*

If the solution is muddy, this effect is due to the presence of rosin. Liquefied soaps do not require further analysis, for they can contain neither insoluble nor inert substances.

IV. Unicolored, white, or other liquefied soaps, mixed with rosin, manufactured by saponification and evaporation, always produce muddy solutions.

The method for ascertaining the quantity of rosin will be described hereafter.

V. To ascertain the presence and quantity of insoluble substances contained in a soap, the process is simple and easy.

In a small glass tube closed at one end introduce a few grains of soap, and heat it with about ten times its weight of alcohol. The solution is soon completed if there is no insoluble impurity; if, on the contrary, a deposit is left, it is washed several times with alcohol, and weighed after desiccation. Its weight indicates the quantity of insoluble substances contained in the soap.

When the proportions of water and insoluble substances have been ascertained, the operator has approximately determined the value of the soap. Indeed, if the soap has given 30 to 34 per cent. of water, and 1 to 2 per cent. of insoluble substance, it is certain that the soap contains 6 per cent. of alkali, and 60 per cent. of fatty acids, which are the constant proportions of the marbled and pure white liquefied soaps. If, on the contrary, the proportions of water exceed 35 per cent., or the insoluble substances 2 per cent., it is a certain proof

that the soap has been adulterated. In either case it is useless to determine the proportions of fatty and inert substances that the soap contains.

By burning a small quantity of soap and assaying the residuum in the same manner as by the alkalimetric process, the real quantity of alkali and inert substances is determined at the same time. The alkalimetric assay is not necessary; indeed, when soap is burned the residuum obtained contains all the fixed principles of the soap, but instead of having the soda in a *caustic state* as in the soap, it exists in this residuum as a carbonate.

VI. To ascertain the value of a soap as to the proportions of fatty acids and base it contains, the following is recommended:—

To determine the quantity of fatty acid in a soap, a given weight is decomposed by a soluble acid; the fatty acids float on the surface of the liquid, and it is easy to collect them and determine their weight. When they do not collect easily, they are mixed with a known weight of wax, which causes their solidification. A kind of cake is thus obtained which by cooling solidifies on the surface of the solution, and is weighed after being dried. When wax is used its weight is subtracted from that of the cake.

To obtain the proportion of alkali contained in a soap, calcine a certain quantity of it in an iron spoon; all the soda is transformed into carbonate, and the real quantity of alkali is determined by the alkalimetric process.

D'Arcet combines the two operations into one, that is, he dissolves 2½ drachms of soap in two ounces of water, and adds from 1 to 2½ drachms of pure dried white wax. The mixture is heated, and when the wax is melted and the soap dissolved, he decomposes it by normal sulphuric

acid in the same manner as in the ordinary alkalimetric process; after cooling, the quantity of fatty acids is determined.

Then by separating the fatty acids by means of pressure, the solid and liquid acids are ascertained by their consistency, odor, etc.

If the different processes described above are little known, forgotten, or not well understood, by making them known and explaining them more clearly, we believe that we have rendered a good service. But as our object is not to propose several processes, but a single one, the following is that which we use in our own practice.

In a little glass jar fixed over a water-bath, introduce 2 ounces of water, and 2½ drachms of soap.

When the solution is made, remove the jar from the water-bath, and decompose the soap with a sufficient quantity of diluted sulphuric acid.

After cooling, if the fatty acids are solid, dry and weigh them.

If they have but little consistency, melt them with 2½ drachms of dried white wax. Let the mixture cool, and weigh it, deducting the weight of the wax used.

The operation is then finished.

The results of this assay are:—

1. If the solution of soap is limpid, it indicates that the soap has been liquefied. If muddy, it contains rosin.

2. By resting a few minutes, if a deposit is formed, the soap contains an excess of insoluble matters.

3. If the decomposition produces fatty acids easily solidified, it is a sign that fatty bodies of animal origin predominate in the soap.

4. If the use of wax is necessary, it is a proof that liquid vegetable oils are abundant.

5. By the quantity of fatty acids obtained, the quan-

tity of alkaline base with which they are combined is easily determined.

Indeed, soaps being composed in *definite proportions*, the quantity of the fatty acids determines that of the soda they ought to contain. As we have seen that the soda in soaps equals the tenth of the weight of the fatty acids, by increasing one-tenth the weight of the fatty acids obtained, we know that the loss is composed of water and insoluble and inert substances.

For example : If we operate on a soap which has given

6.00 of fatty acids, we know immediately that it contains
0.60 of alkali, and
3.40 of water and foreign substances.

In all 10.00

And this soap is to be considered as well manufactured, for the proportions of its composition are normal. If, on the contrary, the soap gives a less proportion of fatty acids, that of the soda will still be equal to the tenth of their weight, and the balance above or below 3.40 is a sign that the soap is more or less adulterated.

As for the rosin, its quantity is determined by the following process :—

One ounce of soap is decomposed by an excess of sulphuric acid. The fatty acids obtained, after cooling, are washed with slightly acidulated water, then with pure water. The cake of fatty acids is divided into small pieces and well dried. A certain quantity is dissolved in five or six times its weight of alcohol at 90°. When the solution is made, boiling water is added to it; the proportion of water must be larger than that of the alcohol; an immediate separation takes place, and the fatty acids float on the surface of the liquor, which becomes limpid

if the soap does not contain rosin, and, on the other hand, becomes milky if rosin is present.

After the solidification of the fatty acids by cooling, the cake is divided again into pieces, dried and weighed.

The difference in weight from that of the acids before the treatment by alcohol, gives the proportion of rosin contained in the soap.

M. Sutherland has lately proposed a new method to determine rosin in soaps. It is said to give perfect results.

Three hundred grains of soap cut into small pieces are introduced into a capsule and covered with concentrated hydrochloric acid, the contents are gently boiled till the soap is dissolved and entirely decomposed; four ounces of hot water are added, and the capsule is set aside to cool. When cold, the cake of fatty acids and rosin is removed and washed several times with warm water. After cooling it is dried and gently remelted and kept for a few minutes at 212° to evaporate all traces of water.

This cake containing the fatty acids and the rosin is carefully weighed.

One hundred grains of the mixture are placed in a capsule and covered with strong nitric acid, and the temperature raised to the boiling point; a powerful reaction takes place with violent evolution of nitrous vapors. The heat is withdrawn till the violence of the action subsides, and is again applied to maintain a gentle ebullition for a few minutes. Small portions of nitric acid are successively added till no further distinctly appreciable quantity of nitrous acid is given off. The fatty acids are now allowed to cool and are removed from the acid solution strongly colored by terebic acid. The cake is then washed by melting it in a further quantity of nitric acid.

When cold it is dried and melted at a gentle heat till acid fumes cease to be given off. The resulting cake is the pure fatty acid freed from rosin, the latter being indicated by the loss. It will be observed that a correction must be made to obtain the exact relative proportions of fat and rosin originally put into the soap pan, as fats on being decomposed lose about 4½ per cent. of their original weight. Hence, in making the calculation a proportionate addition must be made to the fatty acid before dividing its weight by that of the rosin indicated. This process may be also used to determine rosin in beeswax.*

Cailletet's Process.

In 1858, the *Société Industrielle de Mulhouse* proposed a silver medal for practical instructions, giving the means of ascertaining the good quality of a soap without weighing. M. Cailletet, to whom the medal was awarded, treated the question with skill, and proposed a process entirely new to ascertain the proportion of fatty acids, alkali, and water; the whole required only to weigh once 10 grammes of the soap.

We think it will interest the manufacturer to read the details of this process, which we give in full from the *Bulletin de la Société Industrielle de Mulhouse* (No. 144, vol. xxix. p. 8).

Characteristics of the Aqueous Solutions of Soaps, Normal Acid, and Alkaline Liquor.—The soaps used in industry are formed of fatty acids, of soda and potash, and water. These acids, which are solid or liquid at the ordinary temperature, are extracted from fatty substances of animal or vegetable origin.

The soap of oleic acid often contains rosin.

* Art of Manufacturing Soap and Candles. By A. Ott.

The white soap obtained by the Marseilles process is formed of:—

60 to 64 of fatty acids.
30 to 36 of water.
6 of soda.

Some white soaps are met with in the trade which contain from 40 to 50 per cent. of water.

The marbled soap cannot contain more than thirty-four per cent.

When the soap separates from a saturated saline solution it is formed of:—

Fatty acids	77
Soda	7
Water	16

When anhydrous the same soap contains:—

Fatty acids	91
Soda	9

In certain industries, soaps are used in which there enters more than six per cent. of soda. These soaps by their excess of alkali, and according to their mode of fabrication, may be hydrated enough to contain from 50 to 60 per cent. of water.

The fatty substances which enter into the composition of soaps are generally oleic, margaric, stearic, and palmitic acids. The more or less consistency of the aqueous solution of a soap is due to the presence of solid fatty acids, or to an excess of alkali.

To prepare an aqueous solution of soap, take ten grammes of the soap to be tested, introduce it into a wide mouthed bottle and add 90 grammes of cold distilled water, and dissolve over a water-bath. Introduce this solution into a test tube of a capacity of 100 cubic centimetres, and one hour after, examine the consistency.

Hard soaps generally give a solution which by cooling forms an opalescent mass, in which crystallizations are often seen after it has been prepared for some time. Diluted with cold water, this solution divides into an acid salt which deposits, and an alkaline salt which remains in solution.

The acid salt sometimes deposits in the form of a flaky substance, without consistency; it is ordinarily richer in solid acids than in liquid; sometimes, as with a solution of soap of coco oil diluted with its volume of water, the acid salt which deposits assumes a crystalline form, and remains attached to the edges of the vessel in which the mixture has been kept.

A warm solution of ten grammes of soap of olive oil, and 90 grammes of distilled water, is transparent as long as the solution is warm, but as soon as it cools down it becomes more and more opalescent, and lastly, when cold, it is entirely opaque. Its consistency has some analogy with that of the white of eggs; it can be drawn in threads, and after a few days of preparation it has lost some of its consistency.

If in the soap which has been dissolved, there have entered fatty acids due to a mixture of sesame and olive oils, olive oil and earth-nut oil, etc., the solution is less opaque and has not so much consistency as that produced with olive oil soap alone. If in the composition of this latter there enters coco oil, the solution resembles an emulsion partly curded.

A solution of soap of coco oil diluted with its volume of water produces, after a rest of twelve hours, an abundant and crystalline precipitate; the liquor is colorless.

Generally, a solution made with 10 grammes of soap and 90 grammes of distilled water gives, by cooling, a

solution as much more opalescent and with more consistency, when it contains more solid acids and alkali.

Soaps manufactured with solid fatty acids give a solution which is solid. Thus 3 grammes of soap of tallow, and 97 grammes of water, produce a solid solution.

Soaps in which liquid fatty acids predominate give generally a colorless solution at a temperature of 185° to 212°. When the fatty acids predominate, as in the tallow soap, the solution looks flocculent. If the soap contains rosin, the solution at 185° to 212° is very opaque, and after being prepared a few hours it separates into three parts. The upper part, which is nearly transparent, contains very little rosin and much alkali; the middle part is entirely opaque; the lower part is formed with a white substance which has deposited and which looks like pure rosin combined with very little alkali.

All soaps are heavier than water; they do not act in the same manner when in contact with warm water. If a piece of soap weighing ten grammes is introduced into a wide mouthed bottle containing 90 grammes of cold distilled water, and if the whole is heated over a water-bath, the soaps manufactured with olive oil, palm oil, tallow, oleic acid, etc., will float on the surface and become transparent from the circumference to the centre; soon by their contact with warm water, their transparency is complete. The contrary takes place, if the soaps have been manufactured with coco oil or rosin; they remain at the bottom of the vessel and dissolve very easily.

The soaps of olive oil, tallow, etc., retain their transparency all the while they are in contact with warm water. If this transparent soap is taken from the warm water, it will retain its transparency for some time; but if the soap is half out of the water and is allowed to

cool, the part in contact with the liquid becomes white and opalescent, while the other remains transparent.

Soap in contact with warm water loses at first a part of alkali, water, and fatty substance; it becomes richer in solid acids and is less aqueous. Its transparency is as much greater as it contains less water and alkali; afterwards its solution in warm water will be slower if it contains more stearic than margaric acid, and more of this latter than oleic acid.

Lastly, each kind of soap by its solubility in warm water, by the transparency and consistency of its aqueous solution, presents to the observer shades more easy to see by the aid of a comparative examination.

After studying the characteristics of the aqueous solution of a soap, it is very easy to determine its composition by the following method: This process, which consists in measuring the constituent principles of a soap to ascertain its weight, is called *saponimetry*, by which the manufacturer may, in half an hour, test several specimens of soap, compare them, and select the best for his use.

To operate according to this method, it is necessary to prepare beforehand two liquors, one which is acid, the other alkaline. These two liquors ought to be kept in ground-stoppered bottles.

Preparation of the Acid Liquor called Normal.

Take

Monohydrated sulphuric acid (66°) .	189.84 grammes
Distilled water	same quantity

and add, after the cooling of the liquor, enough water to make *one litre* at the temperature of 59°.

10 cubic centimetres of normal acid contain 1.8984 grammes of monohydrated sulphuric acid, and are equi-

valent, in forming a neutral salt, to 1.2 grammes of soda, or 1.825 grammes of potash.

The equivalent of monohydrated sulphuric acid is 612.5 (SO^3,500+HO,112.5=612.5).

The equivalent of soda is 387.17.

The weight of sulphuric acid necessary to form a neutral salt with soda 1.2 grammes, is known by

NaO	SO^3HO	NaO	SO^3HO
387.17 :	612.5 ::	1.2 :	= 1.8984

The weight of this acid, which has to be mixed with a sufficient quantity of water to form one litre of acid liquor, is known by

$$\frac{1.8984 \text{ grm.} \times 1000 \text{ c. c.}}{10 \text{ c. c.}} \quad x = 189.84 \text{ grammes.}$$

To prepare 50 cubic centimetres of acid liquor, we have

$$\frac{1.8984 \text{ grm.} \times 50 \text{ c. c.}}{10 \text{ c. c.}} \quad x = 9.492 \text{ grammes.}$$

Preparation of the Alkaline Liquor.

Pure and dry carbonate of soda .	41.046 grammes.
Distilled water	enough to

dissolve the carbonate and obtain one litre of alkaline liquor at a temperature of 59°.

50 cubic centimetres of this liquor ought to contain 1.2 grammes of soda, a weight represented by 2.0523 grammes of carbonate of soda.

To ascertain the weight of the dry carbonate of soda which ought to represent 1.2 grammes of soda to saturate 1.8984 grammes of monohydrated sulphuric acid contained in 10 cubic centimetres of normal acid, knowing that 612.5 of monohydrated acid saturates 662.17 of carbonate of soda (NaO 387.17+CO^2 275=662.17) we have

SO^3HO	NaO,CO^2	SO^3HO	$NaOCO^2$
612.5 :	662.17 : :	1.8984 :	$x=$ 2.0523

We find 2.0523 grammes of carbonate of soda *without water*, representing 1.2 grammes of soda which, dissolved in a sufficient quantity of water ought to give 50 c. c. of alkaline liquor at a temperature of 59°.

The weight of carbonate to dissolve in a sufficient quantity of distilled water to obtain one litre of alkaline liquor is known by

$$\frac{2.0523 \text{ grms.} \times 1000 \text{ c. c.}}{50 \text{ c. c.}} = x = 41.046 \text{ grammes.}$$

Saponimetry.

Soaps Composed of Solid and Liquid Fatty Acids.—The normal acid and the alkaline liquor being prepared, the question is to determine with rapidity the weight of the fatty matter, the alkali, and the water, without being obliged to use the balance.

To obtain this result, take a graduated glass tube of a capacity of 50 cubic centimetres divided into 100 parts, (alkalimetre) to which a cork is adapted. Introduce into it 10 c. c., of normal acid. This acid must be carefully measured. Afterwards, add to it 20 c. c. of spirit of turpentine carefully measured; then weigh 10 grms. of soap divided into very thin shavings which is introduced into the tube; cork the tube; stir for a few minutes until the soap is dissolved and then let it rest. A quarter of an hour is sufficient to have a complete separation of the turpentine, of the dissolved fatty matter, and of the water.* The heaviest part, which is

* The solution of the fatty matter in the turpentine takes place without dilatation or contraction of the volume; it is the same for the mixture of the normal acid with the water.

water, sulphate of soda, and sulphuric acid, falls rapidly to the bottom of the tube; the lightest part formed with turpentine and fatty matter occupies the upper part; lastly, a layer formed of an albuminous or animal matter occupies the middle. This latter layer, which is neither fatty matter nor water, is sometimes voluminous enough to occupy the whole of the capacity of the tube containing the normal acid. A slight agitation is sufficient to collect it into a very thin layer. In this state it is between the normal acid and the turpentine. When the soap contains rosin, this substance partly separates from the fatty matter, and forms a layer between the turpentine and the acid, but it preserves its volume whatever is done to unite it into a smaller space.

The volume of the turpentine with the fatty substance must be diminished by about ½ a division, or ¼ of a c. c., and the volume of the water ought to be increased by that diminution. This correction must be made, because the water attaches itself to the edges of the tube and diminishes its diameter, which causes the lightest volume to be increased a little, and the heaviest to be diminished.

If soap made with olive oil is tried, the total volume is about 79.5 divisions; if the trial is made with oleic acid soap, the total volume is from 80 to 81; if the soap is made with greases or heavy oils, the volume is below 79.5 div. These volumes are very variable, because the soaps may contain more or less water, and the fatty substances may have a greater or less weight.

Let us suppose that by the trial of a white soap from olive oil the volume was 79.5 div., and the volume of the normal acid and water contained in the 10 grammes of the soap was 26 divisions, we have :—

Total volume . .	79.5 div.
Less the volume of the acid and water . . .	26.0 div.
For the correction . .	0.5 "
Which gives . .	53.0
Less the volume of the turpentine . .	40.0
Balance . . .	13.0 $= \frac{13 \text{ c.c.}}{2} = 6.5$ c. c.

As there has been used 10 c. c. = 20 divisions of normal acid according to the composition of the soap, the volume of the acid water is 26.5 div., we have :—

$$\frac{26.5 \text{ c. c.}}{2} = 13.25 \text{ c. c.} - 10 \text{ c. c.} = 3.25 \text{ c. c.}$$

Which make

Fatty matter	6.50 c. c.
Water and soda	3.25 "
	9.75

The soap being heavier than water, the volume 9.75 c. c. in soap represents the weight of 10 c. c. of water.

To know the weight of the cubic centimetre of the fatty matter contained in various soaps, we remember that there has been introduced into the tube 10 c. c. of normal acid, 20 c. c. spirit of turpentine, and 10 grammes of soap. After the decomposition of the soap, the height of the total volume of the spirit, fatty matter, and acid water being exactly taken, has been of 79.5 div., the volume of the aqueous part being 26 div. By making the correction spoken of before, 10 grammes of the soap contain in volume :—

Fatty matter	6.50 c. c.
Water and soda . . .	3.25 "

} = 9.75 c. c.

On the other hand, the author has dissolved in a porce-

lain dish 10 grammes of the same soap in a sufficient quantity of water, to which, afterwards, was added a sufficient quantity of normal sulphuric acid; after the separation of the fatty acids 10 grammes of dried white wax were added, which after fusion became incorporated with the fatty substance; and after cooling the cake was dried and weighed. The total weight was 15.97 grammes. From this weight, if we subtract that of the wax, which is 10 grammes, the balance 5.97 grammes represents the volume 6.5 c. c. found by the turpentine. To ascertain the weight of a cubic centimetre of the fatty matter contained in Marseilles soap, we have :—

$$\frac{5.97 \text{ grms.}}{6.5 \text{ c. c.}} \quad x = 0.91846 \text{ gramme.}$$

The weight of the cubic centimetre of the fatty matter contained in several specimens of Marseilles soap made by different manufacturers was 0.91846, 0.91875, 0.91921; the average of which is 0.91880 gramme.

The weight of the cubic centimetre of fatty substances from coco oil soap is 0.940. gramme.

From palm oil soap 0.922.

From tallow soap 0.9714.

From oleic acid soap 0.9003.

The weight of the fatty matter being known, we have to analyze the soda and water.

Add to the tube which contains the mixture a sufficient quantity of distilled water to raise the level of the turpentine; this substance and the fatty matter are removed, the tube is corked and well stirred to dissolve the acid sulphate of soda which may have crystallized, and the acid mixture is poured into a test glass. Pour a little more water into the tube so as to wash well the last portions of acidulated water, and add it to the first acid solution. Put into this solution a few drops of tincture of

litmus, and in the graduated tube introduce 50 c. c. of the alkaline liquor; pour little by little a sufficient quantity of this liquor into the glass containing the acid, mixing the whole with a glass rod until the litmus passes to the onion peel *color*. The liquor has to be tried from time to time with litmus paper, and when this paper does turn red, the addition of the alkaline liquor is stopped and its volume measured.

Let us suppose that the $\frac{30}{100}$ of the alkaline volume have been necessary to saturate the acid.

The alkaline liquor contains in 50 c. c. 1.2 grammes of soda. This weight forms a neutral salt with the sulphuric acid contained in the 10 c. c. of normal acid used to decompose the soap. If the operator has only used the $\frac{30}{100}$ of 50 c. c. of alkaline liquor, it is evident that the soap contains the $\frac{70}{100}$ of 1.2 grammes of soda. Then the volume of the alkaline liquor which is not used contains exactly a weight of soda equal to that which is found in the 10 grammes of the soap.

To apply this process, if the operator has used the $\frac{30}{100}$ of the alkaline volume for the saturation of the acid, the soap contains the $\frac{70}{00}$ of 1.2 grammes of soda, or 0.84 gramme, or 8.40 per cent.; if the volume used has been $\frac{50}{100}$ the soap contains 0.6 grm. of soda, or six per cent.

If the analysis of a soft soap has to be made, what is left of the alkaline volume not used will represent the proportional equivalent of the potash contained in the soap. The equivalent of the soda being 1.2 grammes, that of the potash is 1.825 grammes. If the volume not used is $\frac{70}{100}$, it is evident that the soap contains in the 10 grms. $\frac{70}{100}$ of 1.825 grms. of potash; if the volume not used is $\frac{50}{100}$, it is manifest that the soap contains $\frac{50}{100}$ of 1.825, or 9.125 per cent. of potash.

The weight of the soda or potash being determined, it has to be subtracted from the water.

The analysis of a soap giving in volume

Fatty matter	6.50 c. c.
Water and soda	3.25 "

If the weight of the soda is 0.60 gramme, we have :—

Fatty substance 6.5 c. c. × 0.91846 grm. = .	5.9699 grms.
Soda	0.6000 "
Water found by difference	3.4301* "
Soap	10.0000

If the soap contains glycerin, this substance remains in solution in the normal acid; if it contains flour, talc, clay, all these substances fall immediately to the bottom of the tube.

Soap of Oleic Acid and Rosin.—If 10 grammes of rosin soap are treated by 10 c. c. of normal acid, and 20 c. c. of spirit of turpentine, the latter hardly dissolves any of the rosin. If a certain quantity of Marseilles soap, for example, enters into the weight of 10 grammes of rosin soap, all the fatty matter of the Marseilles soap is dissolved by the turpentine, and the rosin is dissolved only in the proportion of about the $\frac{1.5}{100}$ of a cubic centimetre; it forms a voluminous layer below the turpentine.

This easy separation of the rosin ought to be attributed to a special state it acquires while in presence of the

* If we take 10 c. c. of distilled water, and 5 grammes of potash, the volume of the solution at 60° is 11.75 c. c. Supposing that soda gives the same result as potash, we have to know the volume of 0.6 gramme of soda :—

KO	Vol.		NaO	Vol.
5 grms.	: 1.75 c. c.	: :	0.60	: x=0.21 c. c.

Which gives for the volume of the water :—

3.25 c. c.—0.21 c. c.=3.04 c. c. of water.

water when separated from its combination with potash or soda by sulphuric acid.

These results are described in the two following experiments :—

First Experiment.—10 grammes of olive soap containing very little water have given for the volume of the fatty matter 8.25 c. c.

Second Experiment.—8 grammes of the same soap and 2 grammes of rosin soap have given a volume of fatty matter and dissolved rosin equal to 6.75 c. c.

To know the volume from the 8 grammes of olive soap we have :—

10 grms. : 8.25 c. c. : : 8 grms. : x = Vol. 6.60 c. c.

If from the volume of 6.75 c. c. we subtract vol. 6.60, the balance 0.15 indicates that the turpentine has dissolved only the $\frac{15}{100}$ of a c. c. of rosin.

In some woollen cloth manufactories, they use a black soap made with oleic acid and rosin. Let us suppose that 10 grammes of this soap have given by the wax process a weight of fatty matter and rosin = 6.45 grammes ; that by the treatment with the turpentine the volume of fatty matter and dissolved rosin = 6.25 c. c. and that by saturating the normal acid the volume of alkaline liquor employed $\frac{32}{100}$.

Subtract from the volume 6.25 c. c. the volume 0.15, which gives for the oleic acid 6.25—0.15 = 6.10 c. c., we have :—

Oleic acid 6.10 c. c. × 0.9003 grm. . .	= 5.49183	grms.
Rosin by difference (6.45 *grms.*—5.49183) .	—0.95817	"
Soda 1.2 *grms.* × $\frac{68}{100}$	0.81600	"
Water by difference	2.73400	"
Soap of oleic acid and rosin . . .	10.00000	

The weight of the wax will give that of the fatty mat-

ter and rosin; the volume x c. c. of the fatty matter—the volume 0.15 of the rosin multiplied by 0.9003 weight of a c. c. of oleic acid will give the weight of that volume. By difference the weight of the rosin will be known; the volume of the alkaline liquor not used, will give the weight of the soda or potash; lastly, by difference, the weight of the water is obtained.

Mixtures of Potash and Soda.—In some soaps there is a mixture of potash and soda. The weight of each alkali is known by the following method.

Burn x grammes of soap. Weigh the ashes and treat them by boiling distilled water; filter, wash the filter with a little warm water, and add the washings to the alkaline solution; then burn the filter, deduct the known weight of its ash from the total weight of the ashes, and by difference we have the weight of the potash and soda mixed in the state of carbonates.

Let us suppose that the mixture weighs 3 grammes.

The volume of normal acid necessary to saturate 3 grammes of the mixture is found by a direct experiment. Then the volume of normal acid necessary to saturate 3 grammes of carbonate of potash, and 3 grammes of carbonate of soda is found by calculation. The volume of normal acid by which the three grammes of the mixture have been saturated will be intermediary between the volumes which ought to saturate 3 grammes of carbonate of potash and 3 grammes of carbonate of soda. By a proportional division, we shall have fractions of potash and soda to compose the weight of the mixture examined.

Let us suppose that the volume of normal acid used directly for the saturation of the 3 grammes of the mixture to be 13 c. c.

The volume of normal acid to saturate 3 grammes of

carbonate of potash and 3 grammes of carbonate of soda, are to be ascertained; knowing that 10 c. c. of normal acid contain 1.8984 grammes of monohydrated sulphuric acid, and that its equivalent is 612.5

For the carbonate of soda we have :—

NaO,CO^2	SO^3,HO	NaO,CO^2	SO^3,HO
662.17	: 612.5 ::	3	: x=2.774 grms.

To know the volume of normal acid which contains 2.774 grammes of monohydrated acid, we have :—

SO^3,HO	Vol.	SO^3,HO	Vol.
1.8984 grms.	: 10 c. c. ::	2.774 grms.	: x=14.612 c. c.

In the same manner we ascertain the weight of monohydrated acid and afterwards the volume of normal acid which contains the weight of monohydrated acid necessary to saturate 3 grammes of carbonate of potash. We have :—

KO,CO^2	SO^3,HO	KO,CO^2	SO^3,HO
863.93	: 612.5 ::	3	: x=2.126 grms.

SO^3,HO	Vol.	SO^3,HO	
1.8984 grms.	: 10 c. c. ::	2.126 grms.	: x=11.198 c. c.

of normal acid, which contains 2.126 grammes of monohydrated acid.

By experiment 13 c. c. of normal acid have been employed to saturate the alkalies found in the ashes of the calcined soap.

It is evident that if the weight of alkali found in the ashes is formed only of carbonate of soda, the volume used should be 14.612 c. c. of normal acid; if, on the contrary, the 3 grammes are only formed of carbonate of potash, the volume used should be 11.198 c. c. of normal acid.

But as the volume of normal acid used has been 13 c. c., this volume alone indicates a mixture of carbonate of potash and soda.

By a proportional division we have the weight of the carbonate of soda proportional to a fraction of the volume 14.612 c. c. of normal acid ; we have also the weight of the carbonate of potash proportional to a fraction of the volume 11.198 c. c. of normal acid.

To establish this division, we have :—

1. *The gain that the volume* 11.198 *ought to make to give volume* 13 *c. c., which is* 1.802.

2. *The loss that the volume* 14.612 *c. c. ought to make to give* 13 *c. c, which is* 1.612.

Which gives :—

$$\left.\begin{array}{ll} \textit{Gain} \ldots\ldots & 1.802 \\ \textit{Loss} \ldots\ldots & 1.612 \end{array}\right\} = 3.414$$

To compose the volume 13 c. c. we take

1. *The* $\frac{1802}{3414}$ *of the volume* 14.612 *c. c. corresponding to the* $\frac{1802}{3414}$ *of* 3 *grammes of carbonate of soda.*

2. *The* $\frac{1612}{3414}$ *of the volume* 11.198 *c. c. corresponding to the* $\frac{1612}{3414}$ *of* 3 *grammes of carbonate of potash.*

We obtain :—

x=carb. of soda	1.5834 grms.	corr. to soda	0.9258 grms.	corr. to vol. of acid. 7.7126 c. c.
y " " pot.	1.4165	" pot.	0.9656	" " " " 5.2873 "
$x+y$=mixture	2.9999 " both		1.8914	for volume found 12.9999

In this analysis, the following method due to Gay-Lussac cannot be well used, because too much soap would have to be burned so as to operate on 50 grms. of mixed chlorides.

Operate as follows :—

Transform the two carbonates into chlorides and calcine to evaporate the excess of acid ; take 50 grammes of the mixture which is finely powdered, introduce this mixture into a bottle weighing 185 grammes, and containing 200 grammes of water, stir with a glass rod, and observe the falling of the temperature produced by the solution of the salt in water.

The chloride of potassium produces a falling of temperature of 11.4° C. Common salt in the same conditions produces a falling of 1.9° C.

If we suppose that the thermometer marking 15° C, falls by the effect of the dissolution of the saline mixture to 10° C., we have a falling of 5° C.

By proportionally dividing 11.4° and 1.9° to give 5° C, we have : 1st, a fraction of 11.4° corresponding to a fraction of 100 grammes of chloride of potassium; 2d, a fraction of 1.9° corresponding to a fraction of 100 grammes of chloride of sodium. Therefore :—

1. Gain 5 —1.90=3.10 } 9.50
2. Loss 11.4—5.00=6.40 }

Which gives :—

1. *The* $\frac{3\,1\,0}{9\,5\,0}$ *of* 11.4° *corresponding to the* $\frac{3\,1\,0}{9\,5\,0}$ *of* 100 *grammes of chloride of potassium.*

2. *The* $\frac{6\,4\,0}{9\,5\,0}$ *of* 1.9° *corresponding to the* $\frac{6\,4\,0}{9\,5\,0}$ *of* 100 *grammes of chloride of sodium.*

The results are :—

Chloride of potassium	32.63	corresp. to temp.	3.72°
Chloride of sodium	67.37	" "	1.28°
Total	100.00	falling of temp.	5.00°

CHAPTER LXVII.

DIFFERENT METHODS OF DETERMINING THE COMMERCIAL VALUE OF SOAP.

A. Muller's Process—Dr. Buchner's Process—R.. Grœger's Remarks on the Value of Soaps.

A. Muller's Process.*

In consequence of the tedious process by which the fatty acids are determined in one sample of the soap, and the alkali by the incineration of another, I consider that the following method is not unworthy of publication, because it appears to afford quicker and more correct results by reason of the greater simplicity of the manipulation. It is available principally for soda soaps which are the most common, but it may also be employed with corresponding alterations for soaps which have other bases.

A piece of soap weighing two or three grammes is dissolved in an accurately weighed beaker glass of about 160 cubic centimetres capacity, with 80 to 100 cubic centimetres of water in a water-bath, and then three or four times the quantity of diluted sulphuric acid, or as much as is necessary to decompose the soap, added from a *burette*. When, after repeated agitation, the fatty acids have separated into a transparent clear stratum from the aqueous solution, it is allowed to cool, and then the con-

* Journal für praktische Chemie.

tents of the beaker glass are placed in a moistened filter which has been previously dried at 212° and weighed. The contents of the filter are washed until all acid reaction disappears. In the meanwhile the beaker glass is placed in a steam bath, so that it being already dry, it may support the washed and partly dry filter, which is laid on the mouth of the glass as if it were in a funnel. The fatty acids soon pass through the paper, and for the most part flow ultimately to the bottom of the beaker glass, the increase of weight of which, after cooling, and the subtraction of the weight of the filter gives the quantity of fatty acids present in the soap. A second drying and weighing is not necessary, if on the cold sides of the interior of the glass no moisture is observed, which is occasioned by a trace of water still present. If the quantity of oxide of iron added to marble the soap is considerable, it may be easily found by incinerating the filter and determining the weight of the residue.

The fluid which runs from the fatty acids on the filter, which, with the washings, has been preserved in a sufficiently large beaker glass, is colored with tincture of litmus and decomposed with a test alkaline solution until the blue color appears. The difference of the quantity of alkali required to neutralize the sulphuric acid, and the quantity of sulphuric acid used in the first instance, allows a calculation to be made as to the quantity of effective alkali in the soap, for example :—

23.86 grms. of soap (partly coco nut oil soap) give :—
17.95 " fatty acids with filter.
4.44 " filter (to be deducted).

13.51 grms. of hydrates of fatty acid = 56.62 per cent.

28.00 cub. cent. of the diluted sulphuric acid applied for the decomposition of the soap, of which 100 cub. cent. represent 2.982 grms. of carbonate of soda.

17.55 cub. cent. of alkaline test liquor which were used for the saturation of the above acid, and of which 100 cub. cent. saturate an equal quantity of that acid.

10.45 cub. cent. of the sulphuric acid necessary for the alkali contained in the soap, representing 0.1823 grm. of soda = 7.34 per cent.

A determination of the alkali as a sulphate, afforded in another portion of soap 9.57 per cent. of soda, because the sulphate of soda and chloride of sodium present in the soap gave up their alkali.

The alkaline fluid applied by me was a saccharine solution of lime, which can be naturally replaced by a solution of soda, and must be if the chloride of sodium and sulphate of soda mixed with the soap shall be determined in the following way :—

The fluid again exactly neutralized with alkali is evaporated to dryness, and the residue gently heated to redness. As in the above manipulation the fluid was not heated to the boiling point; the original chloride of sodium and sulphate of soda are contained in the weighed residue, besides the soda of the soap and that which has been added with the sulphuric acid, forming sulphate of soda. A second exposure to a red heat with sulphuric acid converts the whole residue into sulphate of soda, and from the increase of weight by a comparison of the equivalents of NaCl and NaO,SO^3, the quantity of the former may be determined. According to the equivalents which Kopp furnished in 1850, the increase of weight to the chloride of sodium is as 1 : 4.68. The original sulphate of soda must be, lastly, found by the subtraction of the same salt formed plus the calculated chloride of sodium from the first heated residue.

In practice, it is seldom necessary to proceed with the determination of the chloride of sodium and sulphate of soda except with stirred and coco-nut oil soaps; certainly less of the truth is seen if, after the above determination of the fatty acids and the effective alkali, the absent percentage of water is introduced into the calculation, than if the water is reckoned, which is never completely separated from the soap, even technically prepared at 302° F., and another determination made of the fatty acids, or alkali, *en bloc*, the fatty acids, or even the alkaline contents.

The method here given partakes of the usual imperfections, that the fatty acids as well as the unsaponified soaps are equally estimated, and the mixed hydrate or carbonate of the alkali as well as the combined alkali. The presence of the carbonate can be easily recognized by the foaming of the soap solution upon the addition of the sulphuric acid. These imperfections, however, are of little importance.

It must be granted that the minutely correct determination of the constituent parts of soap must always be yielded up to those who are technically conversant with this department of chemistry, as, for instance, the estimation of free alkali and unchanged fat which certain kinds of soap may contain.

Further, a considerable excess of one or another ingredient soon betrays itself by a corresponding departure, by the soap, from the characteristic properties of a good product; a small excess may be judged with sufficient exactness from the proportion of the alkali, which, supposing soda present, should not amount to more than 13 per cent. with a pure coco oil soap, and not less than 11.5 per cent. with a tallow soap; but with palm oil and mixed soaps the proportions vary between the above limits.

Buchner's Process.*

Dr. Buchner gives a method by which the amount of hard soap in a specimen may be calculated from the amount of fatty acid obtained, when a given amount of the specimen is decomposed by a strong acid. The author makes use of a flask, the neck of which is graduated into cubic centimetres; into this flask, half full of water, he puts half an ounce of soap and dissolves it. He then adds the acid, either commercial hydrochloric, or dilute sulphuric acid, and warms the mixture, whereupon the fatty acids are set free. He now puts sufficient water to allow the reading of the number of cubic centimetres the acids measure in the neck of the flask. The fatty acids from different sources differ slightly in sp. gr., but the author found that the average weight of a cubic centimetre is 0.93 gramme, which is near enough to the truth for practical purposes. As the acids are combined with $\frac{1}{16}$ of glycerin, it is easy, knowing the weight of the acids, to calculate the weight of the fat used; and as on the average 100 lbs. of fat give 155 lbs. of good hard soap, the weight of the real soap can be calculated when the weight of the fat is known. These calculations may be made by the use of a table which the author has constructed, from which we extract the important parts. The results are not to be considered scientifically accurate, but are near enough to the truth for ordinary business purposes. The process requires only one weighing, is executed in a few minutes, and is so simple that it can be performed by a common workman.

* Polytechnisch. Centralblatt, 1860.

I. Cubic centimetres of fat acids separated from half an ounce of soap.

II. Percentage of water, lye, glycerin, etc., in the specimen.

III. Percentage of good hard soap.

I.	II.	III.
½	97	3
5	69	31
6	63	37
7	57	43
8	51	49
9	44	56
10	38	62
11	32	68
12	26	74
13	20	80
14	13	87
15	7	93

R. Grœger's Remarks on the Value of Soaps.*

Complaints of consumers in regard to the value, or rather efficacy of samples of soap which, to the best of the manufacturer's knowledge, have been well prepared, are not uncommon. It is very probable that the usual explanation which is offered whenever a soap fails to fulfil the expectations of its consumer, viz., that it contains too much water, may be in many cases exact. Admiting this, and various other contingencies which are of importance in deciding upon the value of a soap, there appears to be another obvious reason why different soaps containing equal amounts of water may still possess different degrees of efficacy.

It is evident, from the different equivalent weights of

* Bœttger's Polytechnisches Notizblatt.

the various fatty acids, that the amounts of caustic alkali taken up by them in the formation of soap must be of unlike magnitude.

If it be true that the detergent power of soap is entirely dependent upon the amount of alkali which it contains, of course it follows that those soaps which contain the largest proportion of alkali, or, in other words, those containing a fatty acid, the equivalent weight of which is small, must be the most efficacious.

Since the difference between the equivalents of the common fatty acids are not large, these considerations are perhaps of little or no importance, in so far as concerns the consumption of soap in household economy. In a manufacturing establishment, however, where thousands of pounds of soap may be used in the course of a year, differences which cannot be deemed insignificant must exhibit themselves.

For example, the equivalent weights of several soaps (regarded as anhydrous) in common use are as follows :—

Oleic acid soap	=3800.95
Palm oil soap	=3588.85
Tallow soap	=3300.95
Coco-oil soap	=3065.45

Calculating from these weights how much of each of the other soaps would be required to replace 1000 lbs. of tallow soap, the following quantities will be found :—

Pounds of		Per cent.
1151 *oleic acid soap*	i. e.	15.1 *more than tallow soap.*
1087 *palm oil soap*	"	8.7 " " "
928 *coco oil soap*	"	7.2 *less* " " "

Differences like these must certainly be of importance in practice, and could doubtless, be detected by direct experiment, if any one would undertake a comparison of the various kinds of soap—a research which would not be easy however.

The annexed table presents the composition of different kinds of soaps.

HARD SOAPS.

Names.	Fatty acids.	Oil.	Pasty fat.	Suet.	Rosin.	Fat and rosin.	Coco oil.	(Salt) chloride sodium.	Lime and insoluble residue.	Soda.	Potash.	Water.	Analyst.
Castile soap (genuine)....	..	76.5	..	..	..	..	..	..	..	9.0	..	14.5	Ure.
" " (imitation)..	..	..	75.2	..	..	..	..	..	..	10.5	..	14.3	"
Perfumer's white soap...	..	..	..	75.0	..	..	..	..	..	9.0	..	16.0	"
Glasgow white soap.....	..	..	..	60.0	..	..	..	..	..	6.4	..	33.6	"
" brown rosin 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 " "	..	..	..	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" " "	..	..	..	..	..	36.2	..	5.25		5.2	..	51.9	"
Holt's yellow "	..	..	..	..	..	74.0	..	..	..	7.08	..	18.92	Kent.
American Soap Co.'s soap	..	..	..	..	..	35.0	..	..	40.0	5.00	..	20.0	"
Soap from hazelnut oil...	64.0	..	..	..	..	..	..	1.0	..	..	7.0	28.0	Abendroth.
Marbled tallow soap, prepared from potash, and kept several years.....	81.25	..	..	..	..	..	..	..	..	8.55	1.77	8.43	Heeren.
Manchester palm oil soap	76.0	..	..	..	..	..	..	..	..	7.0	..	17.0	Ure.

SOFT SOAPS.

Common 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 "	..	36.0	..	..	..	..	..	..	..	..	7.0	57.0	"
Scotch soft "	..	..	47.0	..	..	..	..	..	..	..	8.0	45.0	"
Rapeseed oil "	..	51.6	..	..	..	..	..	..	..	..	10.0	38.3	"
Gallipoli soft "	..	48.0	..	..	..	..	..	..	..	..	10.0	42.0	"
Fulling soap (semi-hard).	..	..	..	62.0	..	..	..	..	..	..	11.5	26.5	Verviers.
Good green soap.....	34.0	..	..	..	..	..	..	..	..	..	9.0	57.0	Ure.
Manchester soft soap.....	42.0	..	..	..	..	..	..	..	..	..	8.25	47.0	O'Neill.
" " "	37.5	..	..	..	..	..	..	..	..	..	8.81	44.0	"
" " "	36.75	..	..	..	..	..	..	..	..	..	9.57	47.75	"

APPENDIX.

SOAPS AS SHOWN IN THE UNIVERSAL EXPOSITION, PARIS, 1867.

*Extracts from the Reports of the International Jury.**

SOAPS.

By M. Fourcade:

1. General Considerations.

The Universal Exposition of 1867, confirms the two points already signalized in the remarkable report of M. Balard, in 1855, to wit, that this industry continues to exhibit an increase in the number of manufactories, but that it does not present any important progress. These two circumstances, which seem to be the negative the one of the other, may be explained as follows: the first by the constant increase of the consumption, the second by the nature itself of the limited elements which constitute this fabrication. As a business, it is one of those which utilizes the most capital, which gives rise to the most numerous and most important transactions; as an industry, on the other hand, it is one of those which present the least openings for improvement.

Fatty bodies can produce at the present day no more nor less than in the past, and no one will pretend that the addition of foreign matters with which soaps are so frequently loaded, are an improvement. To try to keep salt water in the paste, to introduce into it talc, sulphate of baryta, argillaceous and ochreous earths, various feculæ, &c., so as to increase the weight, or to

* "Rapports du Jury International, publiés sous la direction de M. Michel Chevalier, Membre de la Commission Impériale," 13 vols. 8vo. Paris, 1868.

obtain a fallacious cheapness, is a fraud and not an industrial process, and many times it has been regretted that such operations remain unpunished.

No one will admit as an improvement the use of coco oil for the soaps by the "cold process," which, instead of supporting as the soaps made with oils, tallows, and greases, from 28 to 35 per cent. of water, may contain as much as 70 per cent., and thus permit the addition to them of any or all of the above mixtures, therefore deceiving the consumer. An improvement, however, made a short appearance a few years ago, which was the process of Mège-Mouriès, on the subject of which numerous discussions have taken place in scientific publications and in industry. Although the result of the first experiments has given place to failures which caused this process to be abandoned, we must not hasten to condemn it, for like many ingenious indications, which have given results only after being worked again and abandoned several times, this process will, probably, at a future day, be the prelude to a great change which some new discoveries by science or practice may determine. We make this conjecture after having examined the articles exposed by Mr. Bignon, of Lima (Peru).

2. Marseilles Soap.

Marseilles soap continues to keep the first rank in the industry of soaps. We remarked in the cases of the exhibitors very fine specimens of pale blue and white soaps with olive oil. If all the manufacturers of Marseilles had always worked thus, the unicolored soap with oleic acid, while taking a large place in the trade, would not be so sought for as it now is.

The superiority of the Marseilles soap has been generally, acknowledged, but we must here express regret that the peculiar standard which has made the reputation of the soap, begins to be an exception. Manufacturers have a tendency to abandon it by adding to their working mixtures all kinds of greases and inferior oils, without doubt under the stimulus of competition and the pressure of necessity. Why is it that a great industry, in its own land, forgets that it is the respect of good traditions

which has given to the soaps of Marseilles the universal reputation which has not been the work of one day? It is a sure way to encroach on it, to furnish the trade with a product deprived of its traditional merit. Such a practice cannot be allowed in great manufactures, and it is to be hoped, in their interest, if the former standard cannot be universally kept up at Marseilles, on account of the scarcity of choice oils, at least to banish from its manufactories those soaps filled with water, barytes, talc, &c., with or without these last names, which conceal in reality soaps containing inert bodies in various proportions. There are, however, at Marseilles, several manufacturers who stand by the old mark.

* * * * * * * * * *

3. Unicolored Soaps.

The consumption of soap increasing in an enormous proportion, the present exposition has revealed to us the existence of an innumerable quantity of soap manufactories disseminated all over the world, the principal ones employing all kinds of fatty matters, and principally oleic acid, when it is possible to obtain the latter; the others utilizing the substances they have at their disposal. In the exposition of South America, where the alkali is often missing, we remark some soap manufacturers who produce their alkali by extracting it from certain plants they have at their command.*

The fabrication of unicolored soap, principally that with oleic acid for basis, predominates in the exposition. M. Chevreul, we must not forget it, in giving to France the industry of stearic acid which has been propagated all over the world, has acquired a double right to the gratitude of all, not only by substituting the stearic candle for the wax and common candle, but also by giving to the industry of soap, oleic acid which has become the

* In a subsequent part of this report the following statement is made:—

"In the show case of Peru we found soaps of a Frenchman, M. Bignon, of Lima, the processes for the fabrication of which, in a country deprived of alkali, are the result of learned researches, and are published with the most perfect disinterestedness."

most precious element, the most choice, regular, and convenient material for the fabrication of unicolored soaps.

This manufacture has been much benefited by it, for its products only acquire a larger place in the market, supported besides, as they are, by their excellent qualities, when they come from manufacturers who respect themselves.

* * * * * * * * * *

After remembering that it is to M. Chevreul, that the industry of soaps of oleic acid is indebted for this precious material, it is but justice to state here the name of M. de Milly, who was the first not only to utilize the oleic acid obtained from his manufactory of candles "de l'Etoile" (the star) for making soap, but also to put into practice the useful mode of giving to commerce boxes containing 100 cakes of soap, having each a constant weight of 500 grammes.

The fabrication of unicolored soap is well represented in France by important manufactories. The oldest is that of l'Etoile (the star), to which, the same M. de Milly gives every day a greater extension, seconded by the incontested reputation of the soap which bears its mark. Among the products exhibited by this manufacturer, we remark a new soap manufactured with oleic acid obtained by sulphuric saponification. The brown color which distinguishes it is not favorable; but it is to be presumed that the trade will accept it, and it will be a new service rendered by M. de Milly.

* * * * * * * * * *

A certain number of manufacturers of candles, operating by lime saponification, have exhibited in their cases full of candles, soaps of their fabrication which generally appear well made, but which have not that style which the real soap-maker knows how to give to his products.

Commendable efforts have been made by M. Leroy-Durand, of Gentilly, and by MM. Petit Brothers, of Grenelle, near Paris, to use in their own factory, the oleic acids furnished by the distilling apparatus which they use to manufacture candles. They had to conquer difficulties inherent in the poor quality of their oils, but, nevertheless, by obtaining from them a good soap, they have rendered indirectly a service to the consumers, for

the distillation of the fatty bodies keeps down the price of candles when the oleic acid obtained from them finds a good employment.

ALUMINATE OF SODA.

This substance may be employed as a substitute for caustic soda in the manufacture of soap, and according to the Polytech. Central Blatt, 1865, s. 1452, the alumina presents certain advantages. Pure neutral soap gives but little soapsuds or lather, and, in fact, removes coarse rough dirt but slowly; Bonamy, of St. Germain, near Paris, has found that when freshly precipitated alumina, for instance, from the cryolite factories, is added to the soap, its capacity for cleansing is greatly increased. This object is obtained in the easiest manner by using, instead of the ordinary lye, the solution of aluminate of soda from cryolite for saponifying the soap."

Aluminate of soda is manufactured from different materials, the two principal of which are bauxite, and cryolite. The bauxite is an aluminate of iron, which being calcined with soda ash gives the aluminate of soda, separated afterwards from the oxide of iron by a methodic lixiviation. By evaporation of the liquors, a dry commercial aluminate of soda is obtained which has the following composition:—

Soda	43
Alumina	40
Water and impurities from the soda ash employed	9
	100

The other crude material, cryolite, comes "from Greenland's icy mountains," and is a double fluoride of sodium and aluminum, the formula of which is Al^2Fl^3 3NaFl, and the composition:—

2 equivalents of	aluminum	. . .	12.94
3 "	sodium	. . . .	32.72
6 "	fluorine	. . . .	54.34
			100.00

By boiling the finely powdered cryolite with six equivalents of lime, a decomposition takes place, by which insoluble fluoride of calcium is formed and the alumina becomes dissolved in the excess of caustic soda. This reaction may be expressed by the formula $Al^2Fl^3NaFl+6CaO=Al^2O^3NaO+2NaO+6FlCa$. A further addition of lime will precipitate the alumina, leaving therefore caustic soda alone in the solution.

Such is the process which soap-makers may use for making for themselves the aluminate of soda directly from cryolite, instead of buying the dry product found in the trade.

Another process consists in calcining in reverberatory furnaces the mixture of cryolite and lime, and lixiviating afterwards, but we believe that the former boiling process is better adapted to the requirements of the soap factory.

The Pennsylvania Salt Manufacturing company, whose works are at Natrona, on the Alleghany River, about thirty miles from Pittsburg, manufacture on a very large scale the various products which can be extracted from cryolite, and among them caustic soda and aluminate of soda for soap-makers. Their aluminate of soda, sold under the name of *Natrona refined saponifier*, is put up in paper boxes, and is a white dry substance having the following composition:—

Soda	44
Alumina	24
Water	32
	100

We insert here the directions given by the Pamphlet of the Penna. Salt Manufacturing Company, for making soap with their aluminate of soda. "To make soap without using scales, weights or measures, cut out one end of this box, empty its contents into a pan, fill the box three times with cold water, and pour it on the saponifier, stirring until it is all dissolved; then pour

this same box five times full of rendered grease or fat into another pan; now pour the dissolved saponifier into the rendered fat, stirring for a few minutes until thoroughly mixed, let it stand till next day, then cut into small pieces, and pour in two more boxes of water; put it on the fire, and stir till the soap is all dissolved and becomes free from lumps; take it off the fire, and when cool cut into bars or cakes. In very cold weather the water should be warmed a little; the rendered grease should be about as thick as honey, and not very warm. For soft soap, see directions inside; using four boxfuls of grease in place of three and a half pounds."

It is also recommended to use pure grease, say one-half suet and one half lard, the heat being only that necessary for keeping the grease fluid enough to mix with the alkaline solution. Indeed, in many cases, soap-makers would find it more advantageous to use less heat than they do generally; the combination of the fatty substances with the alkalies is often promoted by a temperature much below the point of ebullition.

COTTON SEED OIL.

This oil which is now being manufactured in the Southern States in large quantities, finds a useful application in the manufacture of soap. In the crude state it is colored, somewhat viscous, but when refined it is clear. Nevertheless, the crude oil being much cheaper is preferred by soap-makers. It does not appear to make a very good hard soap when used alone, but mixed with other fatty substances in the proportion of about one-third of this oil, it produces a very good soap.

There are some peculiar difficulties in the employment of cotton seed oil for soap-making which are not yet fully understood. When the proportion of cotton seed oil is considerable the usual separation by common salt does not take place readily, but is helped by adding pure water in the kettle. Part of the color of the soap may be removed, by boiling the saponified mixture over spent lyes holding carbonated alkali, similar to those lyes indicated in this treatise under the name of *lyes of coction*. These remarks are designed more for the purpose of calling the

attention of soap-makers to this new fatty substance than with any idea of giving them perfected rules which have been fully tested.

MECHANICAL STIRRER.

Many kinds of apparatus have been devised and patented for stirring the contents of the soap kettle. One which we think would be very serviceable to the soap maker is the stirrer employed by many coal oil refiners. It consists of an upright shaft, resting on a step at the bottom of the kettle or tank, its upper part being supported by a collar and provided with suitable gearing. At the lower part of the shaft is fixed a helix with blades, similar to those of a propeller. By this arrangement a powerful stirring may be produced, which may be slackened or stopped off at will with proper gearing. This apparatus is simple in construction, easily cleaned, and the helix being in that part of the apparatus where the lye remains when all is still, does not present any obstacle to the decanting or ladling off of the soap. It may be employed successfully where one or several substances, liquid or rendered fluid, require to be stirred with other substances liquid or in powder. We hope and believe that this application of this well-known apparatus has not been patented, nor a patent applied for. We cordially give this *so-called new invention* to the public at large, satisfied with the idea of being a *public benefactor!*

WEIGHTS AND MEASURES.

APOTHECARIES' WEIGHT, U. S.

Pound.		Ounces.		Drachms.		Scruples.		Grains.
℔ 1	=	12	=	96	=	288	=	5760
		℥ 1	=	8	=	24	=	480
				ʒ 1	=	3	=	60
						℈ 1	=	gr. 20

The imperial standard Troy weight, at present recognized by the British laws, corresponds with the apothecaries' weight in pounds, ounces, and grains, but differs from it in the division of the ounce, which, according to the former scale, contains twenty pennyweights, each weighing twenty-four grains.

AVOIRDUPOIS WEIGHT.

Pound.		Ounces.		Drachms.		Troy Grains.
℔ 1	=	16	=	256	=	7000.
		oz. 1	=	16	=	437.5
				dr. 1	=	gr. 27.34375

Relative Value of Troy and Avoirdupois Weights.

Pound.		Pounds.		Pound.	Oz.	Grains.
1 Troy	=	0.822857 Avoirdupois	=	0	13	72.5
1 Avoirdupois	=	1.215277 Troy	=	1	2	280.

DUBLIN WEIGHTS.

Pound.		Ounces.		Drachms.		Scruples.		Grains.
℔ 1	=	16	=	128	=	384	=	7000
		℥ 1	=	8	=	24	=	437.5
				ʒ 1	=	3	=	54.68
						℈ 1	=	18.22

WINE MEASURE, U. S.

Gallon.		Pints.		Fluidounces.		Fluidrachms.		Minims.		Cubic Inches.
Cong. 1	=	8	=	128	=	1024	=	61440	=	231
		O 1	=	16	=	128	=	7680	=	28.875
				f℥ 1	=	8	=	480	=	1.8047
						f ʒ 1	=	♏ 60	=	0.2256

IMPERIAL MEASURE.

Adopted by all the British Colleges.

Gallon.		Pints.		Fluidounces.		Fluidrachms.		Minims.
1	=	8	=	160	=	1280	=	76800
		1	=	20	=	160	=	9600
				1	=	8	=	480
						1	=	60

Relative Value of Apothecaries' and Imperial Measures.

APOTHECARIES' MEASURE.		IMPERIAL MEASURE. Pints.	Fluidozs.	Fluidrms.	Minims.
1 gallon	=	6	13	2	23
1 pint	=		16	5	18
1 fluidounce	=		1	0	20
1 fluidrachm	=			1	2.5
1 minim	=				1.04

IMPERIAL MEASURE.		APOTHECARIES' MEASURE. Gallon.	Pints.	Fluidoz.	Fluidrms.	Minims.
1 gallon	=	1	1	9	5	8
1 pint	=		1	3	1	38
1 fluidounce	=				7	41
1 fluidrachm	=					58
1 minim	=					0.96

Relative Value of Weights and Measures in Distilled Water at 60° Fahrenheit.

1. Value of Apothecaries' Weight in Apothecaries' Measure.

				Pints.	Fluidoz.	Fluidr.	Minims.
1 pound	=	0·7900031 pints	=	0	12	5	7.2238
1 ounce	=	1.0533376 fluidounces	=	0	1	0	25.6020
1 drachm	=	1·0533376 fluidrachms	=	0	0	1	3.2002
1 scruple	=			0	0	0	21.0667
1 grain	=			0	0	0	1.0533

2. Value of Apothecaries' Measure in Apothecaries' Weight.

				Pounds.	Oz.	Dr.	Sc.	Gr.	Grains.
1 gallon	=	10.12654270 pounds	=	10	1	4	0	8.88 =	58328.886
1 pint	=	1.26581783 pounds	=	1	3	1	1	11.11 =	7291.1107
1 fluidounce	=	0.94936332 ounces	=	0	0	7	1	15 69 =	455.6944
1 fluidrachm	=	0.94936332 drms.	=	0	0	0	2	16.96 =	56.9618
1 minim	=	0.94936332 grains	=						0 9493

3. Value of Avoirdupois Weight in Apothecaries' Measure.

				Pints.	Fluidozs.	Fluidrms.	Minims.
1 pound	=	0.9600732 pints	=	0	15	2	53.3622
1 ounce	=	0.9600732 fluidounces	=	0	0	7	40.8351

4. Value of Apothecaries' Measure in Avoirdupois Weight.

1 gallon	=	8.33269800 pounds.
1 pint	=	1.04158725 pounds.
1 fluidounce	=	1.04158725 ounces.

5. Value of Imperial Measure in Apothecaries' and Avoirdupois Weights.

Imperial Measure.		Apothecaries' Weight.					Avoirdupois Weight.			Grains.		Cubic Inches.
1 gallon	=	12 ℔	1 ℥	6 ʒ	2 ℈	0 gr.	=	10 ℔	0 ℥	70,000	=	277.27384
1 pint	=	1	6	1	2	10	=	1	4	8,750	=	34.65923
1 fluidounce	=			7	0	17.5	=		1	437.5	=	1.73296
1 fluidrachm	=				2	14.69	=			54.69	=	0.21662
1 minim	=									0.91	=	0.00361

In converting the weights of liquids heavier or lighter than water into measures, or conversely, a correction must be made for specific gravity. In converting weights into measures, the calculator may proceed as if the liquid was water, and the obtained measure will be to the true measure *inversely* as the specific gravity. In the converse operation, of turning measures into weights, the same assumption may be made, and the obtained weight will be to the true weight *directly* as the specific gravity.

TABLES

SHOWING THE

RELATIVE VALUES OF FRENCH AND ENGLISH WEIGHTS AND MEASURES, &c.

Measures of Length.

Millimetre	=	0.03937	inch.
Centimetre	=	0.393708	"
Decimetre	=	3.937079	inches.
Metre	=	39.37079	"
"	=	3.2808992	feet.
"	=	1.093633	yard.
Decametre	=	32.808992	feet.
Hectometre	=	328.08992	"
Kilometre	=	3280.8992	"
"	=	1093.633	yards.
Myriametre	=	10936.33	"
"	=	6.2138	miles.
Inch ($\frac{1}{36}$ yard)	=	2.539954	centimetres.
Foot ($\frac{1}{3}$ yard)	=	3.0479449	decimetres.
Yard	=	0.91438348	metre.
Fathom (2 yards)	=	1.82876696	"
Pole or perch ($5\frac{1}{2}$ yards)	=	5.029109	metres.
Furlong (220 yards)	=	201.16437	"
Mile (1760 yards)	=	1609.3149	"
Nautical mile	=	1852	"

Superficial Measures.

Square millimetre	=	$\frac{1}{645}$	square inch.
" "	=	0.00155	" "
" centimetre	=	0.155006	" "
" decimetre	=	15.50059	" inches.
" "	=	0.107643	" foot.
" metre or centiare	=	1550.05989	" inches.
" " "	=	10.764299	" feet.
" " "	=	1.196033	" yard
Are	=	1076.4299	" feet.
"	=	119.6033	" yards.
"	=	0.098845	rood.
Hectare	=	11960.3326	square yards.
"	=	2.471143	acres.
Square inch	=	645.109201	square millimetres.
" "	=	6.451367	" centimetres
" foot	=	9.289968	" decimetres.
" yard	=	0.836097	" metre.
" rod or perch	=	25.291939	" metres.
Rood (1210 sq. yards)	=	10.116775	ares.
Acre (4840 sq. yards)	=	0.404671	hectare.

Measures of Capacity.

Cubic millimetre	=	0.000061027	cubic inch.
" centimetre or millilitre	=	0.061027	" "
10 " centimetres or centilitre	=	0.61027	" "
100 " " " decilitre	=	6.102705	" inches.
1000 " " " litre	=	61.0270515	" "
" " " " "	=	1.760773	imp'l pint.
" " " " "	=	0.2200967	" gal'n.
Decalitre	=	610.270515	cubic inches.
"	=	2.2009668	imp. gal'ns.
Hectolitre	=	3.531658	cubic feet.
"	=	22.009668	imp. gal'ns.
Cubic metre or stere or kilolitre	=	1.30802	cubic yard.
" " "	=	35.3165807	" feet.
Myrialitre	=	353.165807	" "

Cubic inch	=	16.386176	cubic centimetres.
" foot	=	28.315312	" decimetres.
" yard	=	0.764513422	" metre.

American Measures.

Winchester or U.S. gallon (231 cub.in.)	=	3.785209	litres.
" " bushel (2150.42 cub. in.)	=	35.23719	"
Chaldron (57.25 cubic feet)	=	1621.085	"

British Imperial Measures.

Gill	=	0.141983	litre.
Pint ($\frac{1}{8}$ gallon)	=	0.567932	"
Quart ($\frac{1}{4}$ gallon)	=	1.135864	"
Imperial gallon (277.2738 cub. in.)	=	4.54345797	litres.
Peck (2 gallons)	=	9.0869159	"
Bushel (8 gallons)	=	36.347664	"
Sack (3 bushels)	=	1.09043	hectolitre.
Quarter (8 bushels)	=	2.907813	hectolitres.
Chaldron (12 sacks)	=	13.08516	"

Weights.

Milligramme	=	0.015438395	troy grain.
Centigramme	=	0.15438395	" "
Decigramme	=	1.5438395	" "
Gramme	=	15.438395	" grains.
"	=	0.643	pennyweight.
"	=	0.0321633	oz. troy.
"	=	0.0352889	oz. avoirdupois.
Decagramme	=	154.38395	troy grains.
"	=	5.64	drachms avoirdupois.
Hectogramme	=	3.21633	oz. troy.
"	=	3.52889	oz. avoirdupois.
Kilogramme	=	2.6803	lbs. troy.
"	=	2.205486	lbs. avoirdupois.
Myriagramme	=	26.803	lbs. troy.
"	=	22.05486	lbs. avoirdupois.

Quintal metrique = 100 kilog. = 220.5486 lbs. avoirdupois.
Tonne = 1000 kilog. = 2205.486 " "

VALUES OF FRENCH AND ENGLISH

Different authors give the following values for the gramme:—

Gramme = 15.44402 troy grains.
" = 15.44242 "
" = 15.4402 "
" = 15.433159 "
" = 15.43234874 "

AVOIRDUPOIS.

Long ton = 20 cwt. = 2240 lbs.	=	1015.649	kilogrammes.
Short ton (2000 lbs.)	=	906.8296	"
Hundred weight (112 lbs.)	=	50.78245	"
Quarter (28 lbs.)	=	12.6956144	"
Pound = 16 oz. = 7000 grs.	=	453.4148	grammes.
Ounce = 16 dr'ms. = 437.5 grs.	=	28.3375	"
Drachm = 27.344 grains	=	1.77108	gramme.

TROY (PRECIOUS METALS).

Pound = 12 oz. = 5760 grs.	=	373.096	grammes.
Ounce = 20 dwt. = 480 grs.	=	31.0913	"
Pennyweight = 24 grs.	=	1.55457	gramme.
Grain	=	0.064773	"

APOTHECARIES' (PHARMACY).

Ounce = 8 drachms = 480 grs.	=	31.0913	gramme.
Drachm = 3 scruples = 60 grs.	=	3.8869	"
Scruple = 20 grs.	=	1.29546	gramme.

CARAT WEIGHT FOR DIAMONDS.

1 carat = 4 carat grains = 64 carat parts.
" = 3.2 troy grains.
" = 3.273 " "
" = 0.207264 gramme
" = 0.212 "
" = 0.205 "

Great diversity in value.

Proposed Symbols for Abbreviations.

M—myria — 10000	Mm	Mg	Ml	
K—kilo — 1000	Km	Kg	Kl	
H—hecto — 100	Hm	Hg	Hl	Ha
D—deca — 10	Dm	Dg	Dl	Da
Unit — 1	metre—m	gramme—g	litre—l	are—a
d—deci — 0.1	dm	dg	dl	da
c—centi — 0.01	cm	cg	cl	ca
m—milli — 0.001	mm	mg	ml	

Km = Kilometre. Hl = Hectolitre. cg = centigramme. c. cm = $\overline{cm}^3$ = cubic centimetre. $\overline{dm}^2$ = sq. dm = square decimetre. Kgm = Kilogrammetre. Kg° = Kilogramme degree.

Celsius or Centigrade.	Fahrenheit.	Réaumur.
— 15°	+ 5°	— 12°
— 10	+ 14	— 8
— 5	+ 23	— 4
0 melting	+ 32	ice 0
+ 5	+ 41	+ 4
+ 10	+ 50	+ 8
+ 15	+ 59	+ 12
+ 20	+ 68	+ 16
+ 25	+ 77	+ 20
+ 30	+ 86	+ 24
+ 35	+ 95	+ 28
+ 40	+104	+ 32
+ 45	+113	+ 36
+ 50	+122	+ 40
+ 55	+131	+ 44
+ 60	+140	+ 48
+ 65	+149	+ 52
+ 70	+158	+ 56
+ 75	+167	+ 60
+ 80	+176	+ 64
+ 85	+185	+ 68
+ 90	+194	+ 72
+ 95	+203	+ 76
+100 boiling	+212	water + 80
+200	+392	+160
+300	+572	+240
+400	+752	+320
+500	+932	+400

$1° \text{ C.} = 1°.8 \text{ Ft.} = \frac{9}{5}° \text{ Ft.} = 0°.3 \text{ R.} = \frac{4}{5}° \text{ R.}$

$1° \text{ C.} \times \frac{9}{5} = 1° \text{ Ft.}$ $\quad 1° \text{ Ft.} \times \frac{5}{9} = 1° \text{ C.}$ $\quad 1° \text{ R.} \times \frac{9}{4} = 1° \text{ Ft.}$

$1° \text{ C.} \times \frac{4}{5} = 1° \text{ R.}$ $\quad 1° \text{ Ft.} \times \frac{4}{9} = 1° \text{ R.}$ $\quad 1° \text{ R.} \times \frac{5}{4} = 1° \text{ C.}$

Calorie (French) = unit of heat
= kilogramme degree } English.

It is the quantity of heat necessary to raise 1° C. the temperature of 1 kilogramme of distilled water.

Kilogrammetre = Kgm = the power necessary to raise 1 kilogramme, 1 metre high, in one second. It is equal to $\frac{1}{75}$ of a French horse power. An English horse power = 550 foot pounds, while a French horse power = 542.7 foot pounds.

Ready-made Calculations.

No. of units.	Inches to centimetres.	Feet to metres.	Yards to metres.	Miles to Kilometres.	Millimetres to inches.
1	2.53995	0.3047945	0.91438348	1.6093	0.03937079
2	5.0799	0.6095890	1.82876696	3.2186	0.07874158
3	7.6199	0.9143835	2.74315044	4.8279	0.11811237
4	10.1598	1.2197680	3.65753392	6.4373	0.15748316
5	12.6998	1.5239724	4.57191740	8.0466	0.19685395
6	15.2397	1.8287669	5.48630088	9.6559	0.23622474
7	17.7797	2.1335614	6.40068436	11.2652	0.27559553
8	20.3196	2.4383559	7.31506784	12.8745	0.31496632
9	22.8596	2.7431504	8.22945132	14.4838	0.35433711
10	25.3995	3.0479450	9.14383480	16.0930	0.39370790

No. of units.	Centimetres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.	Square inches to square centimetres.
1	0.3937079	3.2808992	1.093633	0.6213824	6.45136
2	0.7874158	6.5617984	2.187266	1.2427648	12.90272
3	1.1811237	9.8426976	3.280899	1.8641472	19.35408
4	1.5748316	13.1235968	4.374532	2.4855296	25.80544
5	1.9685395	16.4044960	5.468165	3.1069120	32.25680
6	2.3622474	19.6853952	6.561798	3.7282944	38.70816
7	2.7559553	22.9662944	7.655431	4.3496768	45.15952
8	3.1496632	26.2471936	8.749064	4.9710592	51.61088
9	3.5433711	29.5280928	9.842697	5.5924416	58.06224
10	3.9370790	32.8089920	10.936330	6.2138240	64.51360

No. of units.	Square feet to sq. metres.	Sq. yards to sq. metres.	Acres to hectares.	Square centimetres to sq. inches.	Sq. metres to sq. feet.
1	0.0929	0.836097	0.404671	0.155	10.7643
2	0.1858	1.672194	0.809342	0.310	21.5286
3	0.2787	2.508291	1.204013	0.465	32.2929
4	0.3716	3.344388	1.618684	0.620	43.0572
5	0.4645	4.180485	2.023355	0.775	53.8215
6	0.5574	5.016582	2.428026	0.930	64.5858
7	0.6503	5.852679	2.832697	1.085	75.3501
8	0.7432	6.688776	3.237368	1.240	86.1144
9	0.8361	7.524873	3.642039	1.395	96.8787
10	0.9290	8.360970	4.046710	1.550	107.6430

No. of units.	Square metres to sq. yards.	Hectares to acres.	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.
1	1.196033	2.471143	16.3855	0.02831	0.76451
2	2.392066	4.942286	32.7710	0.05662	1.52902
3	3.588099	7.413429	49.1565	0.08494	2.29354
4	4.784132	9.884572	65.5420	0.11325	3.05805
5	5.980165	12.355715	81.9275	0.14157	3.82257
6	7.176198	14.826858	98.3130	0.16988	4.58708
7	8.372231	17.298001	114.6985	0.19819	5.35159
8	9.568264	19.769144	131.0840	0.22651	6.11611
9	10.764297	22.240287	147.4695	0.25482	6.88062
10	11.960330	24.711430	163.8550	0.28315	7.64513

No. of units.	Cubic centimetres to cubic inches.	Litres to cubic inches.	Hectolitres to cubic feet.	Cubic metres to cubic feet.	Cubic metres to cubic yards.
1	0.06102	61.02705	3.5317	35.31659	1.30802
2	0.12205	122.05410	7.0634	70.63318	2.61604
3	0.18308	183.08115	10.5951	105.94977	3.92406
4	0.24411	244.10820	14.1268	141.26636	5.23208
5	0.30514	305.13525	17.6585	176.58295	6.54010
6	0.36617	366.16230	21.1902	211.89954	7.84812
7	0.42720	427.18935	24.7219	247.21613	9.15614
8	0.48823	488.21640	28.2536	282.53272	10.46416
9	0.54926	549.24345	31.7853	317.84931	11.77218
10	0.61027	610.27050	35.3166	353.16590	13 08020

No. of units.	Grains to grammes.	Ounces avoir. to grammes.	Ounces troy to grammes.	Pounds avoir. to kilogrammes.	Pounds troy to kilogrammes.
1	0.064773	28.3375	31.0913	0.4534148	0.373096
2	0.129546	56.6750	62.1826	0.9068296	0.746192
3	0.194319	85.0125	93.2739	1.3602444	1.119288
4	0.259092	113.3500	124.3652	1.8136592	1.492384
5	0.323865	141.6871	155.4565	2.2670740	1.865480
6	0.388638	170.0250	186.5478	2.7204888	2.238576
7	0.453411	198.3625	217.6391	3.1739036	2.611672
8	0.518184	226.7000	248.7304	3.6273184	2.984768
9	0.582957	255.0375	279.8217	4.0807332	3.357864
10	0.647730	283.3750	310.9130	4.5341480	3.730960

No. of units.	Long tons to tonnes of 1000 kilog.	Pounds per square inch to kilogrammes per square centimetre.	Grammes to grains.	Grammes to ounces avoir.	Grammes to ounces troy.
1	1.015649	0.0702774	15.438395	0.0352889	0.0321633
2	2.031298	0.1405548	30.876790	0.0705778	0.0643266
3	3.046947	0.2108322	46.315185	0.1058667	0.0964899
4	4.062596	0.2811096	61.753580	0.1411556	0.1286532
5	5.078245	0.3513870	77.191975	0.1764445	0.1608165
6	6.093894	0.4216644	92.630370	0.2117334	0.1929798
7	7.109543	0.4919418	108.068765	0.2470223	0.2251431
8	8.125192	0.5622192	123.507160	0.2823112	0.2573064
9	9.140841	0.6324966	138.945555	0.3176001	0.2894697
10	10.156490	0.7027740	154.383950	0.3528890	0.3216330

No. of units.	Kilogrammes to pounds avoirdupois.	Kilogrammes to pounds troy.	Metric tonnes of 1000 kilog. to long tons of 2240 pounds.	Kilog. per square millimetre to pounds per square inch.	Kilog. per square centimetre to pounds per square inch.
1	2.205486	2.6803	0.9845919	1422.52	14.22526
2	4.410972	5.3606	1.9691838	2845.05	28.45052
3	6.616458	8.0409	2.9537757	4267.57	42.67578
4	8.821944	10.7212	3.9383676	5690.10	56.90104
5	11.027430	13.4015	4.9229595	7112.63	71.12630
6	13.232916	16.0818	5.9075514	8535.15	85.35156
7	15.438402	18.7621	6.8921433	9957.68	99.57682
8	17.643888	21.4424	7.8767352	11380.20	113.80208
9	19.849374	24.1227	8.8613271	12802.73	128.02734
10	22.054860	26.8030	9.8459190	14225.26	142.25260

HYDROMETERS.

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. 81 and 82; 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.

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 instru-

ment again plunged into ninety parts of distilled water, holding in solution ten parts of previously dried chloride of sodium or

Fig. 81.

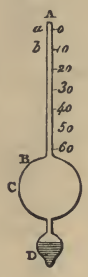
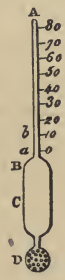


Fig. 82.



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. 82. The instrument should be sufficiently heavy in ballast to sink in a saline solution of ten parts of dried chloride of sodium in ninety parts distilled water to the bottom of its stem *a*, to be marked as the zero of the scale.

Now, when it is again placed in distilled water alone, it floats or sinks to a point somewhere about *b*, which is to be the ten degree mark. The rest of the stem is then to be accurately divided into as many ten degree intervals as its length will permit, and each subdivision into ten uniform smaller degrees or intervals.

As it would be troublesome, and with many impracticable, to estimate the specific gravities of their liquids in a scientific way, these little instruments are a great convenience, for by taking

out a portion of the fluid to be tested, and placing it in a glass cylinder, Fig. 83, 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 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 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.

Fig. 83.

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	1.7807
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	0.7556
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. 84 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

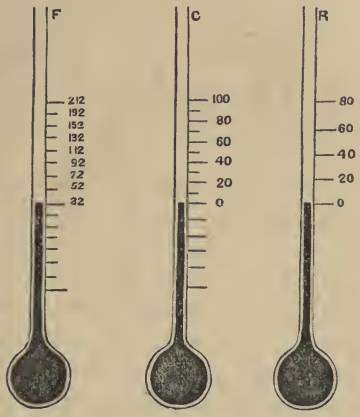
an alteration, or, in other words, upon their expansion." As it is necessary, in the construction of thermometers, that the material used to measure the change of temperature, shall be of uniform expansion, and with a very distant interval between its freezing and boiling point, as fulfilling these requisites 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. 85. 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. 84.

In the graduation of the scale, it is only necessary to have two fixed determinate temperatures, and for these the boiling and freezing points of water are universally chosen. The scales can be extended beyond either of these points, by continuing the graduation. Those degrees below zero or 0° have the minus (—) prefixed, to distinguish them from those above; thus, 55° F., means fifty-five degrees above zero, Fahrenheit's scale, and —9° C., nine degrees below zero, Centigrade scale. The thermometers for general use very seldom, however, extend either

way beyond the boiling and freezing points of water, but for manufacturers' use, they are graduated sometimes to 400° or 600°. The figure represents one ranging as high as 240°.

Fig. 85.



The following table shows at a glance the corresponding value of each scale.

Table of Corresponding Degrees of Fahrenheit's, Reaumur's, and the Centigrade Thermometers.

Fah.	Reau.	Centig	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.
600	252.4	315.5	569.7	239	298.7	540	225.7	282.2	510.8	212.8	266
599	252	315	569	238.6	298.3	539.6	225.6	282	510	212.4	265.5
598	251.5	314.4	568.4	238.4	298	539	225.3	281.6	509	212	265
597.2	251.2	314	568	238.2	297.7	538.2	225	281.2	508	211.5	264.4
597	251.1	313.8	567.5	238	297.5	538	224.9	281.1	507.2	211.2	264
596.7	251	313.7	567	237.7	297.2	537.8	224.8	281	507	211.1	263.8
596	250.3	313.3	566.6	237.6	297	537	224.4	280.5	506.7	211	263.7
595.4	250.4	313	566	237.3	296.6	536	224	280	506	210.6	263.3
595	250.2	312.7	565.2	237	296.2	535	223.5	279.4	505.4	210.4	263
594.5	250	312.5	565	236.9	296.1	534.2	223.2	279	505	210.2	262.7
594	249.7	312.2	564.8	236.8	296	534	223.1	278.8	504.5	210	262.5
593.6	249.6	312	564	236.4	295.5	533.7	223	278.7	504	209.7	262.2
593	249.3	311.6	563	236	295	533	222.6	278.3	503.6	209.6	262
592.2	249	311.2	562	235.5	294.4	532.4	222.4	278	503	209.3	261.6
592	248.9	311.1	561.2	235.2	294	532	222.2	277.7	502.2	209	261.2
591.8	248.8	311	561	235.1	293.8	531.5	222	277.5	502	208.9	261.1
591	248.4	310.5	560.7	235	293.7	531	221.7	277.2	501.8	208.8	261
590	248	310	560	234.6	293.3	530.6	221.6	277	501	208.4	260.5
589	247.5	309.4	559.4	234.4	293	530	221.3	276.6	500	208	260
588.2	247.2	309	559	234.2	292.7	529.2	221	276.2	499	207.5	259.4
588	247.1	308.8	558.5	234	292.5	529	220.9	276.1	498.2	207.2	259
587.7	247	308.7	558	233.7	292.2	528.8	220.8	276	498	207.1	258.8
587	246.6	308.3	557.6	233.6	292	528	220.4	275.5	497.7	207	258.7
586.4	246.4	308	557	233.3	291.6	527	220	275	497	206.6	258.3
586	246.2	307.7	556.2	233	291.2	526	219.5	274.4	496.4	206.4	258
585.5	246	307.5	556	232.9	291.1	525.2	219.2	274	496	206.2	257 7
585	245.7	307.2	555.8	232.8	291	525	219.1	273.8	495.5	206	257.5
584.6	245.6	307	555	232.4	290.5	524.7	219	273.7	495	205.7	257.2
584	245.3	306.6	554	232	290	524	218.6	273.3	494.6	205.6	257
583.2	245	306.2	553	231.5	289.4	523.4	218.4	273	494	205.3	256.6
583	244.9	306.1	552.2	231.2	289	523	218.2	272.7	493.2	205	256.2
582.8	244.8	306	552	231.1	288.8	522.5	218	272.5	493	204.9	256.1
582	244.4	305.5	551.7	231	288.7	522	217.7	272.2	492.8	204.8	256
581	244	305	551	230.6	288.3	521.6	217.6	272	492	204.4	255.5
580	243.5	304.4	550.4	230.4	288	521	217.3	271.6	491	204	255
579.2	243.2	304	550	230.2	287.7	520.2	217	271.2	490	203.5	254.4
579	243.1	303.8	549.5	230	287.5	520	216.9	271.1	489.2	203.2	254
578.7	243	303.7	549	229.7	287.2	519.8	216.8	271	489	203.1	253.8
578	242.6	303.3	548.6	229.6	287	519	216.4	270.5	488.7	203	253.7
577.4	242.4	303	548	229.3	286.6	518	216	270	488	202.6	253.3
577	242.2	302.7	547.2	229	286.2	517	215.5	269.4	487.4	202.4	253
576.5	242	302.5	547	228.9	286.1	516.2	215.2	269	487	202.2	252.7
576	241.7	302.2	546.8	228.8	286	516	215.1	268.8	486.5	202	252.5
575.6	241.6	302	546	228.4	285.5	515.7	215	268.7	486	201.7	252.2
575	241.3	301.6	545	228	285	515	214.6	268.3	485.6	201.6	252
574.2	241	301.2	544	227.5	284.4	514.4	214.4	268	485	201.3	251.6
574	240.9	301.1	543.2	227.2	284	514	214.2	267.7	484.2	201	251.2
573.8	240.8	301	543	227.1	283.8	513.5	214	267.5	484	200.9	251.1
573	240.4	300.5	542.7	227	283.7	513	213.7	267.2	483.8	200.8	251
572	240	300	542	226.6	283.3	512.6	213.6	267	483	200.4	250.5
571	239.5	299.4	541.4	226.4	283	512	213.3	266.6	482	200	250
570.2	239.2	299	541	226.2	282.7	511.2	213	266.2	481	199.5	249.4
570	239.1	298.8	540.5	226	282.5	511	212.9	266.1	480.2	199.2	249

Fah.	Reau.	Centig	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.
480	199.1	248.8	448.2	185	231.2	416	170.6	213.3	384.8	156.8	196
479.7	199	248.7	448	184.9	231.1	415.4	170.4	213	384	156.4	195.5
479	198.6	248.3	447.8	184.8	231	415	170.2	212.7	383	156	195
478.4	198.4	248	447	184.4	230.5	414.5	170	212.5	382	155.5	194.4
478	198.2	247.7	446	184	230	414	169.7	212.2	381.2	155.2	194
477.5	198	247.5	445	183.5	229.4	413.6	169.6	212	381	155.1	193.8
477	197.7	247.2	444.2	183.2	229	413	169.3	211.6	380.7	155	193.7
476.6	197.6	247	444	183.1	228.8	412.2	169	211.2	380	154.6	193.3
476	197.3	246.6	443.7	183	228.7	412	168.9	211.1	379.4	154.4	193
475.2	197	246.2	443	182.6	228.3	411.8	168.8	211	379	154.2	192.7
475	196.9	246.1	442.4	182.4	228	411	168.4	210.5	378.5	154	192.5
474.8	196.8	246	442	182.2	227.7	410	168	210	378	153.7	192.2
474	196.4	245.5	441.5	182	227.5	409	167.5	209.4	377.6	153.6	192
473	196	245	441	181.7	227.2	408.2	167.2	209	377	153.3	191.6
472	195.5	244.4	440.6	181.6	227	408	167.1	208.8	376.2	153	191.2
471.2	195.2	244	440	181.3	226.6	407.7	167	208.7	376	152.9	191.1
471	195.1	243.8	439.2	181	226.2	407	166.6	208.3	375.8	152.8	191
470.7	195	243.7	439	180.9	226.1	406.4	166.4	208	375	152.4	190.5
470	194.6	243.3	438.8	180.8	226	406	166.2	207.7	374	152	190
469.4	194.4	243	438	180.4	225.5	405.5	166	207.5	373	151.5	189.4
469	194.2	242.7	437	180	225	405	165.7	207.2	372.2	151.2	189
468.5	194	242.5	436	179.5	224.4	404.6	165.6	207	372	151.1	188.8
468	193.7	242.2	435.2	179.2	224	404	165.3	206.6	371.7	151	188.7
467.6	193.6	242	435	179.1	223.8	403.2	165	206.2	371	150.6	188.3
467	193.3	241.6	434.7	179	223.7	403	164.9	206.1	370.4	150.4	188
466.2	193	241.2	434	178.6	223.3	402.8	164.8	206	370	150.2	187.7
466	192.9	241.1	433.4	178.4	223	402	164.4	205.5	369.5	150	187.5
465.8	192.8	241	433	178.2	222.7	401	164	205	359	149.7	187.2
465	192.4	240.5	432.5	178	222.5	400	163.5	204.4	368.6	149.6	187
464	192	240	432	177.7	222.2	399.2	163.2	204	368	149.3	186.6
463	191.5	239.4	431.6	177.6	222	399	163.1	203.8	367.2	149	186.2
462.2	191.2	239	431	177.3	221.6	398.7	163	203.7	367	148.9	186.1
462	191.1	238.8	430.2	177	221.2	398	162.6	203.3	366.8	148.8	186
461.7	191	238.7	430	176.9	221.1	397.4	162.4	203	366	148.4	185.5
461	190.6	238.3	429.8	176.8	221	397	162.2	202.7	365	148	185
460.4	190.4	238	429	176.4	220.5	396.5	162	202.5	364	147.5	184.4
460	190.2	237.7	428	176	220	396	161.7	202.2	363.2	147.2	184
459.5	190	237.5	427	175.5	219.4	395.6	161.6	202	363	147.1	183.8
459	189.7	237.2	426.2	175.2	219	395	161.3	201.6	362.7	147	183.7
458.6	189.6	237	426	175.1	218.8	394.2	161	201.2	362	146.6	183.3
458	189.3	236.6	425.7	175	218.7	394	160.9	201.1	361.4	146.4	183
457.2	189	236.2	425	174.6	218.3	393.8	160.8	201	361	146.2	182.7
457	188.9	236.1	424.4	174.4	218	393	160.4	200.5	360.5	146	182.5
456.8	188.8	236	424	174.2	217.7	392	160	200	360	145.7	182.2
456	188.4	235.5	423.5	174	217.5	391	159.5	199.4	359.6	145.6	182
455	188	235	423	173.7	217.2	390.2	159.2	199	359	145.3	181.6
454	187.5	234.4	422.6	173.6	217	390	159.1	198.8	358.2	145	181.2
453.2	187.2	234	422	173.3	216.6	389.7	159	198.7	358	144.9	181.1
453	187.1	233.8	421.2	173	216.2	389	158.6	198.3	357.8	144.8	181
452.7	187	233.7	421	172.9	216.1	388.4	158.4	198	357	144.4	180.5
452	186.6	233.3	420.8	172.8	216	388	158.2	197.7	356	144	180
451.4	186.4	233	420	172.4	215.5	387.5	158	197.5	355	143.5	179.4
451	186.2	232.7	419	172	215	387	157.7	197.2	354.2	143.2	179
450.5	186	232.5	418	171.5	214.4	386.6	157.6	197	354	143.1	178.8
450	185.7	232.2	417.2	171.2	214	386	157.3	196.6	353.7	143	178.7
449.6	185.6	232	417	171.1	213.8	385.2	157	196.2	353	142.6	178.3
449	185.3	231.6	416.7	171	213.7	385	156.9	196.1	352.4	142.4	178

Fah.	Reau.	Centig.	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.
352	142.2	177.7	320	128	160	288	113.7	142.2	255.2	99.2	124
351.5	142	177.5	319	127.5	159.4	287.6	113.6	142	255	99.1	123.8
351	141.8	177.2	318.2	127.2	159	287	113.3	141.6	254.7	99	123.7
350.6	141.6	177	318	127.1	158.8	286.2	113	141.2	254	98.6	123.3
350	141.3	176.6	317.7	127	158.7	286	112.8	141.1	253.4	98.4	123
349.2	141	176.2	317	126.6	158.3	285.8	112.8	141	253	98.2	122.7
349	140.9	176.1	316.4	126.4	158	285	112.4	140.5	252.5	98	122.5
348.8	140.8	176	316	126.2	157.7	284	112	140	252	97.9	122.2
348	140.4	175.5	315.5	126	157.5	283	111.5	139.4	251.6	97.6	122
347	140	175	315	125.7	157.2	282.2	111.2	139	251	97.3	121.6
346	139.5	174.4	314.6	125.6	157	282	111.1	138.9	250.2	97	121.2
345.2	139.2	174	314	125.3	156.6	281.7	111	138.7	250	96.9	121.1
345	139.1	173.8	313.2	125	156.2	281	110.6	138.3	249.8	96.8	121
344.7	139	173.7	313	124.8	156.1	280.4	110.4	138	249	96.4	120.5
344	138.6	173.3	312.8	124.8	156	280	110.2	137.7	248	96	120
343.4	138.4	173	312	124.5	155.5	279.5	110	137.5	247	95.5	119.4
343	138.2	172.7	311	124	155	279	109.7	137.2	246.2	95 2	119
342.5	138	172.5	310	123.5	154.4	278.6	109.6	137	246	95.1	118.9
342	137.7	172.2	309.2	123.2	154	278	109.3	136.6	245.7	95	118.7
341.6	137.6	172	309	123.1	153.7	277.2	109	136.2	245	94.6	118.3
341	137.3	171.6	308.7	123	153.6	277	108.8	136.1	244.4	94.4	118
340.2	137	171.2	308	122.6	153.3	276.8	108.8	136	244	94.2	117.8
340	136.9	171.1	307.4	122.4	153	276	108.4	135.5	243.5	94	117.5
339.8	136.8	171	307	122.2	152.7	275	108	135	243	93.8	117.2
339	136.4	170.5	306.5	122	152.5	274	107.5	134.4	242.6	93.6	117
338	136	170	306	121.7	152.2	273.2	107.2	134	242	93.3	116.6
337	135.5	169.4	305.6	121.6	152	273	107.1	133.8	241.2	93	116.2
336.2	135.2	169	305	121.3	151.6	272.7	107	133.7	241	92.9	116.1
336	135.1	168.8	304.2	121	151.2	272	106.6	133.3	240.8	92.8	116
335.7	135	168.7	304	120.9	151.1	271.4	106.4	133	240	92.4	115.5
335	134.6	168.3	303.8	120.8	151	271	106.2	132.7	239	92	115
334.4	134.4	168	303	120.4	150.5	270.5	106	132.5	238	91.5	114.4
334	134.2	167.7	302	120	150	270	105.7	132.2	237.2	91.2	114
333.5	134	167.5	301	119.5	149.4	269.6	105.6	132	237	91.1	113.9
333	133.7	167.2	300.2	119.2	149	269	105.3	131.6	236.7	91	113.7
332.6	133.6	167	300	119.1	148.9	268.2	105	131.2	236	90.6	113.3
332	133.3	166.6	299.7	119	148.7	268	104.8	131.1	235.4	90.4	113
331.2	133	166.2	299	118.6	148.3	267.8	104.8	131	235	90.2	112.7
331	132.9	166.1	298.4	118.4	148	267	104.4	130.5	234.5	90	112.5
330.8	132.8	166	298	118.2	147.7	266	104	130	234	89.7	112.2
330	132.4	165.5	297.5	118	147.5	265	103.5	129.4	233.6	89.6	112
329	132	165	297	117.7	147.2	264.2	103.2	129	233	89.3	111.6
328	131.5	164.4	296.6	117.6	147	264	103.1	128.9	232.2	89	111.2
327.2	131.2	164	296	117.3	146.6	263.7	103	128.7	232	88.9	111.1
327	131.1	163.9	295.2	117	146.2	263	102.6	128.3	231.8	88.8	111
326.7	131	163.7	295	116.9	146.1	262.4	102.4	128	231	88.4	110.5
326	130.6	163.3	294.8	116.8	146	262	102.2	127.7	230	88	110
325.4	130.4	163	294	116.4	145.5	261.5	102	127.5	229	87.5	109.4
325	130.2	162.7	293	116	145	261	101.7	127.2	228.2	87.2	109
324.5	130	162.5	292	115.5	144.4	260.6	101.6	127	228	87.1	108.9
324	129.7	162.2	291.2	115.2	144	260	101.3	126.6	227.7	87	108.7
323.6	129.6	162	291	115.1	143.8	259.2	101	126.2	227	86.6	108.3
323	129.3	161.6	290.7	115	143.7	259	100.8	126.1	226.4	86.4	108
322.2	129	161.2	290	114.6	143.3	258.8	100.8	126	226	86.2	107.8
322	128.8	161.1	289.4	114.4	143	258	100.4	125.5	225.5	86	107.5
321.8	128.8	161	289	114.2	142.7	257	100	125	225	85.7	107.2
321	128.4	160.5	288.5	114	142.5	256	99.5	124.4	224.6	85.6	107

Fah.	Reau.	Centig	Fah.	Reau.	Centig	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.
224	85.3	106.6	191.7	71	88.7	160	56.8	71.1	127.4	42.4	53
223.2	85	106.2	191	70.6	88.3	159.8	56.8	71	127	42.2	52.7
223	84.9	106.1	190.4	70.4	88	159	56.4	70.5	126.5	42	52.5
222.8	84.8	106	190	70.2	87.8	158	56	70	126	41.8	52.2
222	84.4	105.5	189.5	70	87.5	157	55.5	69.4	125.6	41.6	52
221	84	105	189	69.7	87.2	156.2	55.2	69	125	41.3	51.6
220	83.5	104.4	188.6	69.6	87	156	55.1	68.9	124.2	41	51.2
219.2	83.2	104	188	69.3	86.6	155.7	55	68.7	124	40.9	51.1
219	83.1	103.9	187.2	69	86.2	155	54.6	68.3	123.8	40.8	51
218.7	83	103.7	187	68.9	86.1	154.4	54.4	68	123	40.4	50.5
218	82.6	103.3	186.8	68.8	86	154	54.2	67.7	122	40	50
217.4	82.4	103	186	68.4	85.5	153.5	54	67.5	121	39.5	49.4
217	82.2	102.7	185	68	85	153	53.7	67.2	120.2	39.2	49
216.5	82	102.5	184	67.5	84.4	152.6	53.6	67	120	39.1	48.9
216	81.7	102.2	183.2	67.2	84	152	53.3	66.6	119.7	39	48.7
215.6	81.6	102	183	67.1	83.9	151.2	53	66.2	119	38.6	48.3
215	81.3	101.6	182.7	67	83.7	151	52.9	66.1	118.4	38.4	48
214.2	81	101.2	182	66.6	83.3	150.8	52.8	66	118	38.2	47.7
214	80.9	101.1	181.4	66.4	83	150	52.4	65.5	117.5	38	47.5
213.8	80.8	101	181	66.2	82.7	149	52	65	117	37.7	47.2
213	80.4	100.5	180.5	66	82.4	148	51.5	64.4	116.6	37.6	47
212	80	100	180	65.7	82.2	147.2	51.2	64	116	37.3	46.6
211	79.5	99.4	179.6	65.6	82	147	51.1	63.9	115.2	37	46.2
210.2	79.2	99	179	65.3	81.6	146.7	51	63.7	115	36.9	46.1
210	79.1	98.9	178.2	65	81.2	146	50.6	63.3	114.8	36.8	46
209.7	79	98.7	178	64.9	81.1	145.4	50.4	63	114	36.4	45.5
209	78.6	98.3	177.8	64.8	81	145	50.2	62.7	113	36	45
208.4	78.4	98.0	177	64.4	80.5	144.5	50	62.5	112	35.5	44.4
208	78.2	97.8	176	64	80	144	49.7	62.2	111.2	35.2	44
207.5	78	97.5	175	63.5	79.4	143.6	49.6	62	111	35.1	43.9
207	77.7	97.2	174.2	63.2	79	143	49.3	61.6	110.7	35	43.7
206.6	77.6	97	174	63.1	78.8	142.2	49	61.2	110	34.6	43.3
206	77.3	96.6	173.7	63	78.7	142	48.9	61.1	109.4	34.4	43
205.2	77	96.2	173	62.6	78.3	141.8	48.8	61	109	34.2	42.7
205	76.9	96.1	172.4	62.4	78	141	48.4	60.5	108.5	34	42.5
204.8	76.8	96	172	62.2	77.7	140	48	60	108	33.8	42.2
204	76.4	95.5	171.5	62	77.5	139	47.5	59.4	107.6	33.6	42
203	76	95	171	61.7	77.2	138.2	47.2	59	107	33.3	41.6
202	75.5	94.4	170.6	61.6	77	138	47.1	58.8	106.2	33	41.2
201.2	75.2	94	170	61.3	76.6	137.7	47	58.7	106	32.9	41.1
201	75.1	93.9	169.2	61	76.2	137	46.6	58.3	105.8	32.8	41
200.7	75	93.7	169	60.8	76.1	136.4	46.4	58	105	32.4	40.5
200	74.6	93.3	168.8	60.8	76	136	46.2	57.7	104	32	40
199.4	74.4	93	168	60.4	75.5	135.5	46	57.5	103	31.5	39.4
199	74.2	92.7	167	60	75	135	45.8	57.2	102.2	31.2	39
198.5	74	92.5	166	59.5	74.4	134.6	45.6	57	102	31.1	38.9
198	73.7	92.2	165.2	59.2	74	134	45.3	56.6	101.7	31	38.7
197.6	73.6	92	165	59.1	73.9	133.2	45	56.2	101	30.6	38.3
197	73.3	91.6	164.7	59	73.7	133	44.9	56.1	100.4	30.4	38
196.2	73	91.2	164	58.6	73.3	132.8	44.8	56	100	30.2	37.7
196	72.8	91.1	163.4	58.4	73	132	44.5	55.5	99.5	30	37.5
195.8	72.8	91	163	58.2	72.7	131	44	55	99	29.7	37.2
195	72.4	90.5	162.5	58	72.5	130	43.5	54.4	98.6	29.6	37
194	72	90	162	57.7	72.2	129.2	43.2	54	98	29.3	36.6
193	71.5	89.4	161.6	57.6	72	129	43.1	53.9	97.2	29	36.2
192.2	71.2	89	161	57.3	71.6	128.7	43	53.7	97	28.9	36.1
192	71.1	88.8	160.2	57	71.2	128	42.6	53.3	96.8	28.8	36

Fah.	Reau.	Centig	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.	Fah.	Reau.	Centig.
96	28.4	35.5	66.2	15.2	19	38	2.6	3.3	9.5	—10	—12.5
95	28	35	66	15.1	18.8	37.4	2.4	3	9	—10.2	—12.7
94	27.5	34.4	65.7	15	18.7	37	2.2	2.7	8.6	—10.4	—13
93.2	27.2	34	65	14.6	18.3	36.5	2	2.5	8	—10.6	—13.3
93	27.1	33.9	64.4	14.4	18	36	1.7	2.2	7.2	—11	—13.7
92.7	27	33.7	64	14.2	17.7	35.6	1.6	2	7	—11.1	—13.9
92	26.6	33.3	63.5	14	17.5	35	1.3	1.6	6.8	—11.2	—14
91.4	26.4	33	63	13.7	17.2	34.2	1	1.2	6	—11.5	—14.4
91	26.2	32.7	62.6	13.6	17	34	0.9	1.1	5	—12	—15
90.5	26	32.5	62	13.3	16.6	33.8	0.8	1	4	—12.4	—15.5
90	25.7	32.2	61.2	13	16.2	33	0.4	0.5	3.2	—12.8	—16
89.6	25.6	32	61	12.9	16.1	32	0	0	3	—12.9	—16.1
89	25.3	31.6	60.8	12.8	16	31	—0.4	— 0.5	2.7	—13	—16.2
88.2	25	31.2	60	12.4	15.5	30.2	—0.8	— 1	2	—13.3	—16.6
88	24.9	31.1	59	12	15	30	—0.9	— 1.1	1.4	—13.6	—17
87.8	24.8	31	58	11.5	14.4	29.7	—1	— 1.2	1	—13.7	—17.2
87	24.4	30.5	57.2	11.2	14	29	—1.3	— 1.6	0.5	—14	—17.5
86	24	30	57	11.1	13.8	28.4	—1.6	— 2	0	—14.2	—17.7
85	23.5	29.4	56.7	11	13.7	28	—1.7	— 2.2	— 0.4	—14.4	—18
84.2	23.2	29	56	10.6	13.3	27.5	—2	— 2.5	— 1	—14.6	—18.3
84	23.1	28.9	55.4	10.4	13	27	—2.2	— 2.7	— 1.7	—15	—18.7
83.7	23	28.7	55	10.2	12.7	26.6	—2.4	— 3	— 2	—15.1	—18.9
83	22.6	28.3	54.5	10	12.5	26	—2.6	— 3.3	— 2.2	—15.2	—19
82.4	22.4	28	54	9.7	12.2	25.2	—3	— 3.7	— 3	—15.5	—19.4
82	22.2	27.7	53.6	9.6	12	25	—3.1	— 3.8	— 4	—16	—20
81.5	22	27.5	53	9.3	11.6	24.8	—3.2	— 4	— 5	—16.4	—20.5
81	21.7	27.2	52.2	9	11.2	24	—3.5	— 4.4	— 5.8	—16.8	—21
80.6	21.6	27	52	8.9	11.1	23	—4	— 5	— 6	—16.8	—21.1
80	21.3	26.6	51.8	8.8	11	22	—4.4	— 5.5	— 6 2	—17	—21.2
79.2	21	26.2	51	8.4	10.5	21.2	—4.8	— 6	— 7	—17.3	—21.6
79	20.9	26.1	50	8	10	21	—4.9	— 6.1	— 7.6	—17.6	—22
78.8	20.8	26	49	7.5	9.4	20.7	—5	— 6.2	— 8	—17.7	—22.2
78	20.4	25.5	48.2	7.2	9	20	—5.3	— 6.6	— 8.5	—18	—22.5
77	20	25	48	7.1	8.9	19.4	—5.6	— 7	— 9	—18.2	—22.7
76	19.5	24.4	47.7	7	8.7	19	—5.7	— 7.2	— 9.4	—18.4	—23
75.2	19.2	24	47	6.6	8.3	18.5	—6	— 7.5	—10	—18.6	—23.3
75	19.1	23.8	46.4	6.4	8	18	—6.2	— 7.7	—10.7	—19	—23.7
74.7	19	23.7	46	6.2	7.7	17.6	—6.4	— 8	—11	—19.1	—23.8
74	18.6	23.3	45.5	6	7.5	17	—6.6	— 8.3	—11.2	—19.2	—24
73.4	18.4	23	45	5.7	7.2	16.2	—7	— 8.7	—12	—19.5	—24.4
73	18.2	22.7	44.6	5.6	7	16	—7.1	— 8.9	—13	—20	—25
72.5	18	22.5	44	5.3	6.6	15.8	—7.2	— 9	—14	—20.4	—25.5
72	17.7	22.2	43.2	5	6.2	15	—7.5	— 9.4	—14.8	—20.8	—26
71.6	17.6	22	43	4.9	6.1	14	—8	—10	—15	—20.9	—26.1
71	17.3	21.6	42.8	4.8	6	13	—8.4	—10.5	—15.2	—21	—26.2
70.2	17	21.2	42	4.4	5.5	12.2	—8.8	—11	—16	—21.3	—26.6
70	16.9	21.1	41	4	5	12	—8.9	—11.1	—16.6	—21.6	—27
69.8	16.8	21	40	3.5	4.4	11.7	—9	—11.2	—17	—21.7	—27.2
69	16.4	20.5	39.2	3.2	4	11	—9.3	—11.6	—17.5	—22	—27.5
68	16	20	39	3.1	3.9	10.4	—9.6	—12	—18	—22.2	—27.7
67	15.5	19.4	38.7	3	3.7	10	—9.7	—12.2	—18.4	—22.4	—28

The following tables exhibit the percentage of various substances contained in solutions of different specific gravities:—

Table showing the Quantity of Anhydrous Potash in Caustic Potash Lye.

Sp. grav.	Potash in 100.	Sp. grav.	Potash in 100.	Sp. grav.	Potash in 100.	Sp. grav.	Potash in 100.
1.3300	28.290	1.2268	20.935	1.1308	13.013	1.0478	5 002
1.3131	27.158	1.2122	19.803	1.1182	11.822	1.0369	3 961
1.2966	26.027	1.1979	18.671	1.1059	10.750	1.0260	2.829
1.2805	24.895	1.1838	17.540	1.0938	9.619	1.0153	1.697
1.2648	23.764	1.1702	16.408	1.0819	8.487	1.0050	0.5658
1.2493	22.632	1.1568	15.277	1.0703	7.355		
1.2342	21.500	1.1437	14.145	1.0589	6.224		

Gerlach's Table showing the Quantity of Carbonate of Soda in its solution.

Per cent.	Sp. weight.	Per cent.	Sp. weight.	Per cent.	Sp. weight.	Per cent.	Sp. weight.
1	1.00914	14	1.13199	27	1.26787	40	1.41470
2	1.01829	15	1.14179	28	1.27893	41	1.43104
3	1.02743	16	1.15200	29	1.28999	42	1.44338
4	1.03658	17	1.16222	30	1.30105	43	1.45573
5	1.04572	18	1.17243	31	1.31261	44	1.46807
6	1.05513	19	1.18265	32	1.32417	45	1.48041
7	1.06454	20	1.19286	33	1.33573	46	1.49314
8	1.07396	21	1.20344	34	1.34729	47	1.50588
9	1.08337	22	1.21402	35	1.35885	48	1.51861
10	1.09278	23	1.22459	36	1.37082	49	1.53135
11	1.10258	24	1.23517	37	1.38279	50	1.54408
12	1.11238	25	1.24575	38	1.39476	51	1.55728
13	1.12219	26	1.25681	39	1.40673	52	1.57048

Table showing the Quantity of Caustic Soda in Soda Lye.

Sp. grav.	Per cent.	Sp. grav.	Per cent.	Sp. grav.	Per cent.	Sp. grav.	Per cent.
1.4285	30.220	1.3198	22.363	1.2392	15.110	1.1042	7.253
1.4193	29.616	1.3143	21 884	1.2280	14.506	1.0948	6.648
1.4101	29.011	1.3125	21.894	1.2178	13 901	1.0855	6.944
1.4011	28.407	1.3053	21.154	1.2058	13.297	1.0764	5.540
1.3923	27.802	1.2982	20.550	1.1948	12.692	1.0675	4.835
1.3836	27.200	1.2912	19.945	1.1841	12.088	1.0587	4.231
1.3751	26.594	1.2843	19.341	1.1734	11.484	1.0500	3.626
1.3668	25.989	1.2775	18 730	1.1630	10.879	1.0414	3.022
1.3586	25.385	1.2708	18.132	1.1528	10.275	1.0330	2.418
1.3505	24.780	1.2642	17.528	1.1428	9.670	1.0246	1.813
1.3426	24.176	1.2578	16.923	1.1330	9.066	1.0163	1.209
1.3349	23.572	1.2515	16.349	1,1233	8.462	1.0081	0.604
1.3273	22.967	1.2453	15.814	1.1137	7.857	1.0040	0.302

Schiff's Table, showing the Quantity of Crystallized and Anhydrous Soda in Solution of Carbonate of Soda.

Specific weight.	Percentage of crystalliz'd soda.	Percentage of anhydrous soda.	Specific weight.	Percentage of crystalliz'd soda.	Percentage of anhydrous soda.
1.0038	1	0.370	1.1035	26	9.635
1.0076	2	0.741	1.1076	27	10.005
1.0114	3	1.112	1.1117	28	10.376
1.0153	4	1.482	1.1158	29	10.746
1.0192	5	1.853	1.1200	30	11.118
1.0231	6	2.223	1.1242	31	11.488
1.0270	7	2.594	1.1284	32	11.859
1.0309	8	2.965	1.1326	33	12.230
1.0348	9	3.335	1.1368	34	12.600
1.0388	10	3.706	1.1410	35	12.971
1.0428	11	4.076	1.1452	36	13.341
1.0468	12	4.447	1.1494	37	13.712
1.0508	13	4.817	1.1536	38	14.082
1.0548	14	5.188	1.1578	39	14.453
1.0588	15	5.558	1.1620	40	14 824
1.0628	16	5.929	1.1662	41	15.195
1.0668	17	6.299	1.1704	42	15.566
1.0708	18	6.670	1.1746	43	15.936
1.0748	19	7.041	1.1788	44	16.307
1.0789	20	7.412	1.1830	45	16.677
1.0830	21	7.782	1.1873	46	17.048
1.0871	22	8.153	1.1916	47	17.418
1.0912	23	8.523	1.1959	48	17.789
1.0953	24	8.894	1.2002	49	18.159
1.0994	25	9.264	1.2045	50	18.530

Table of Dumas, giving the relative proportions of Hydrate of Soda, Dry Carbonate of Soda, and Crystallized Carbonate of Soda, corresponding to each per cent. of anhydrous Caustic Soda.

Anhydrous soda, NaO.	Hydrated soda, NaO,HO.	Anhydrous carbonate of soda, NaO,CO^2.	Crystallized carbonate of soda, NaO,CO^2+10HO.	Anhydrous soda, NaO.	Hydrated soda, NaO,HO.	Anhydrous carbonate of soda, NaO,CO^2.	Crystallized carbonate of soda, NaO,CO^2+10HO.
1	1.29	1.71	4.61	51	65.81	87.19	235.26
2	2.58	3.42	9.23	52	67.10	88.90	239.87
3	3.87	5.13	13.84	53	68.39	90.61	244.48
4	5.16	6.84	18.45	54	69.68	92.32	249.10
5	6.45	8.55	23.06	55	70.97	94.03	253.71
6	7.74	10.26	27.68	56	72.26	95.74	258.32
7	9.03	11.97	32.29	57	73.55	97.45	262.94
8	10.32	13.68	36.90	58	74.84	99.16	267.55
9	11.61	15.39	41.52	59	76.13	100.87	272.16
10	12.90	17.10	46.13	60	77.42	102.58	276.77
11	14.19	18.81	50.74	61	78.71	106.00	281.40
12	15.48	20.52	55.35	62	80.00	107.71	286.01
13	16.77	22.23	59.97	63	81.29	109.42	290.62
14	18.06	23.93	64.58	64	82.58	111.13	295.24
15	19.35	25.64	69.19	65	83.87	112.84	299.85
16	20.64	27.35	73.80	66	85.16	114.55	304.46
17	21.93	29.16	78.42	67	86.45	116.26	309.08
18	23.22	30.77	83.03	68	87.74	117.97	313.69
19	24.52	32.84	87.64	69	89.03	119.68	318.30
20	25.81	34.19	92.26	70	90.32	120.68	322.90
21	27.10	35.90	96.87	71	91.61	121.39	327.52
22	28.34	37.63	101.48	72	92.90	123.10	332.13
23	29.68	39.32	106.10	73	94.19	124.81	336.74
24	30.97	41.03	110.71	74	95.48	126.52	341.36
25	32.26	42.74	115.32	75	96.77	128.23	345.97
26	33.85	44.45	119.94	76	98.06	129.94	350.58
27	34.84	46.16	124.55	77	99.35	131.64	355.20
28	36.13	47.87	129.16	78	100.64	133.35	359.81
29	37.42	49.58	133.78	79	101.93	135.07	364.41
30	38.71	51.29	138.39	80	103.25	136.77	369.03
31	40.00	53.00	143.00	81	104.51	138 48	373.64
32	41.29	54.71	147.61	82	105.80	140.19	378.26
33	42.58	56.92	152.23	83	107.09	141.90	382.87
34	43.87	58.13	156.84	84	108.38	143.61	387.48
35	45.16	59.84	161.45	85	109.67	145.32	392.09
36	46.45	61.55	166.07	86	110.96	147.03	396.71
37	47.74	63.26	170.68	87	112.25	148.74	401.32
38	49.03	64.97	175.29	88	113.55	150.45	405.43
39	50.32	66.68	179.90	89	114.84	152.16	410.55
40	51.61	68.39	184.51	90	116.13	153.87	415.16
41	52.90	70.10	189.13	91	117.41	155.58	419.77
42	54.19	71.81	193.74	92	118.70	157.29	424.34
43	55.48	73.52	198.35	93	119.49	159.00	429.00
44	56.77	75.23	202.97	94	121.28	160.71	433.61
45	58.06	76.94	207.58	95	122.57	162.42	438.21
46	59.35	78.65	212.19	96	123.86	164.13	442.84
47	60.64	80.35	216.81	97	125.15	165.83	447.45
48	61.93	82.06	221.42	98	126.45	167.54	452.06
49	63.22	83.77	226.03	99	127.74	169.25	456.68
50	64.52	85.48	230.64	100	129.03	170.97	461.29

Table of Tünnermann, giving the per cent. of Carbonate of Potash contained in a solution of this alkali.

Specific gravity.	Degrees, Baumé.	Per cent. of carbonate of potash.	Specific gravity.	Degrees, Baumé.	Per cent. of carbonate of potash.
1.4812	47	40.504	1.2282	26	19.580
1.4750	46.5	40.139	1.215	25	18.601
1.4626	45.6	39.160	1.202	24	17.622
1.4504	44.7	38.181	1.1892	23	16.643
1.4384	44	37.202	1.1766	21	15.664
1.4265	43	36.223	1.1642	20	14.685
1.4147	42	35.244	1.1520	19	13.706
1.4030	41.2	34.265	1.1400	17.7	12.727
1.3915	40.5	33.286	1.1282	16	11.748
1.3803	39.7	32.307	1.1166	15	10.769
1.3692	38.9	31.328	1.1052	14	9.790
1.3585	38	30.349	1.0940	12	8.811
1.3480	37	29.36	1.0829	11	7.832
1.3378	36	28.391	1.0719	10	6.853
1.3277	35	27.412	1.0611	8	5.874
1.3177	34	26.432	1.0505	7	4.895
1.3078	33.5	25.454	1.0401	6	3.916
1.298	33	24.475	1.0299	4	2.934
1.2836	32	23.496	1.0108	1.5	1.958
1.2694	30	22.517	1.0098	1	0.979
1.2554	29	21.538	1.0048	0.5	0.489
1.2417	28	20.539			

Table of Tünnermann, giving the per cent. of Carbonate of Soda in a solution of this alkali.

Specific gravity.	Degrees Baumé	Per cent. of anhydrous carbonate of soda.	Specific gravity.	Degrees Baumé.	Per cent. of anhydrous carbonate of soda.
1.1816	22	14.88	1.0847	11	7.44
1.1748	21	14.508	1.0802	10.7	6.768
1.1698	20.9	14.136	1.0757	10	6.396
1.1648	20.5	13.764	1.0713	9.5	6 324
1.1598	19.8	13.392	1.0669	8.8	5.972
1.1549	19	13.020	1.0625	8.2	5.58
1.1500	18.8	12.648	1.0578	7.4	5.208
1.1452	18	12.276	1.0537	7	4.836
1.1404	17.7	11.904	1.0494	6.9	4.464
1.1356	17	11.532	1.0452	6.5	4.092
1.1308	16.6	11.160	1.0410	5.6	3.72
1.1261	16	10.788	1.0368	5	3.348
1.1214	15.5	10.416	1.0327	4.2	2.976
1.1167	15	10.044	1.0286	4	2.504
1.1120	14.3	9.672	1.0245	3.4	2.232
1.1074	14	9.3	1.0204	2.9	1.85
1.1028	13.1	8.928	1.0163	1.4	1.488
1.0982	12	8.556	1.0121	1.5	1.116
1.0937	11.5	8.184	1.0081	1.1	0.744
1.0892	11.1	7.812	1.0040	0.6	0.372

Table giving the relative proportions of Hydrate of Potash and Carbonate of Potash, corresponding to each per cent. of Anhydrous Caustic Potash.

Anhydrous potash, KO.	Hydrated potash, KO,HO.	Carbonate of potash, KO,CO^2.	Anhydrous potash, KO.	Hydrated potash, KO,HO.	Carbonate of potash, KO,CO^2.
1	1.19	1.47	43	51.2	63.07
2	2.38	2.93	44	52.39	64.54
3	3.58	4.40	45	53.58	66
4	4.76	5.87	46	54.77	67.47
5	5.95	7.33	47	55.96	68.94
6	7.14	8.8	48	57.15	70.4
7	8.33	10.27	49	58.34	71.87
8	9.52	11.73	50	59 53	73.34
9	10.72	13.2	51	60.72	74.8
10	11.91	14.67	52	61.91	76.27
11	13.10	16.13	53	63.10	77.74
12	14.29	17.6	54	64.29	79.2
13	15.48	19.07	55	65.48	80.67
14	16.67	20.53	56	66.67	82.14
15	17.86	22	57	67.86	83.6
16	19.05	23.47	58	69.05	85.07
17	20.24	24.93	59	70.25	86.54
18	21.43	26.4	60	71.44	88
19	22.62	27.87	61	72.63	89.47
20	23.81	29.33	62	73.82	90.94
21	25	30.8	63	75	92.4
22	26.19	32.27	64	76.20	93.87
23	27.38	33.73	65	77.39	95.34
24	28.57	35.2	66	78.58	96.8
25	29.76	36.67	67	79.77	98.27
26	30.96	38.13	68	80.96	99.74
27	32.15	39.6	69	82.15	101 43
28	33.34	41.07	70	83.34	102.90
29	34.53	42.53	71	84.53	104.37
30	35.72	44	72	85.72	105.84
31	36.91	45.49	73	86.91	
32	38.10	46.97	74	88.1	
33	39.29	48.4	75	89.29	
34	40.48	49.87	76	90.49	
35	41.67	51.34	77	91.68	
36	42.86	52.8	78	92.87	
37	44.05	54.27	79	94.06	
38	45.24	55.74	80	95.25	
39	46.43	57.2	81	96.44	
40	47.62	58.67	82	97.63	
41	48.81	60.14	83	98.82	
42	50	61.6	84	100.01	

Table of Tünnermann, giving the per cent. of Anhydrous Caustic Potash in a lye at 15° C. of this alkali, and the quantity of mixed fats which it will saponify.

Specific gravity.	Approximate value in degrees Baumé.	Per cent. of anhydrous caustic potash.	Quantity (in weight) of mixed fats which may be saponified by 100 parts (in weight) of these lyes.
1.3300	36	28.290	170
1.3131	34	27.158	163
1.2966	33	26.027	156
1.2803	32	24.895	150
1.2648	30	23.764	142
1.2493	28	22.632	136
1.2342	27	21.5	129
1.2268	26	20.935	125
1.2122	25	19.803	119
1.1979	23	18.671	112
1.1839	22	17.54	105
1.1702	21	16.408	98
1.1568	19	15.277	92
1.1437	18	14.145	85
1.1308	17	13.013	78
1.1182	15	11.882	71
1.1059	14	10.750	64
1.0938	12	9.619	58
1.0819	11	8.487	51
1.0703	10	7.355	43
1.0589	7	6.214	37
1.0478	6	5.022	30
1.0369	5	3.961	24
1.0260	3	2.829	17
1.0153	2	1.697	10
1.0050	1	0.5658	3.4

Table of Dalton and L. Mehrens, giving the per cent. of Alkali in a Caustic Lye of Potash, and the quantity of mixed fats which may be saponified by it.

(This table differs about 2 per cent. from that by Tünnermann.)

Specific gravity.	Degrees Baumé.	Per cent. of potash.	Quantity (in weight) of mixed fats which may be saponified by 100 parts (in weight) of these lyes.
1.68	58	51.2	307
1.60	54	46.7	280
1.52	49	42.9	258
1.47	46	39.9	240
1.44	44	36.8	222
1.42	43	34.4	206
1.39	40	32.4	194
1.36	38	29.4	176
1.32	35	26.3	157
1.28	31	23.4	140
1.23	27	19.5	117
1.19	23	16.2	97
1.15	19	13	78
1.11	14	9.5	57
1.06	8	4.7	26

1 equivalent of fat . . . . . = 860
860 parts of fat unite with 3 equivalents of potash = 141
100 " " " " " = 16.4
1 " " " " " = 0.164

Therefore 1 part of pure caustic potash saponifies $\frac{100}{16.4}$ = 6.1 parts of fat.

Table of Dalton, giving the per cent. of Alkali in a Caustic Lye of Soda, and the quantity of mixed fats which may be saponified by it.

Specific gravity.	Degrees Baumé.	Per cent. of soda.	Quantity (in weight) of mixed fats which may be saponified by 100 parts (in weight) of these lyes.
2.60	70	77.8	720
1.85	66	63.6	596
1.72	60	53.8	498
1.63	56	46.6	431
1.56	52	41.2	381
1.50	48	36.8	340
1.47	46	34	314
1.44	44	31	287
1.40	41	29	268
1.36	38	26	240
1.32	35	23	212
1.29	32	19	175
1.23	27	16	148
1.18	22	13	121
1.12	16	9	85
1.06	8	4.7	43

1 equivalent of fat . . . . . = 860
860 parts of fat unite with 3 equivalents of soda = 93
100 " " " " " = 10.8
1 " " " " " = 0.108

Therefore 1 part of pure caustic soda saponifies $\frac{100}{10.8}$ = 9.26 parts of fat.

Table of Tünnermann, giving at the temperature of 15° C. the per cent. of Soda in a Caustic Lye, and the quantity of mixed fats which may be saponified by this lye.

Specific gravity.	Degrees Baumé.	Per cent. of soda.	Quantity of mixed fats which may be saponified by 100 parts of these lyes.	Specific gravity.	Degrees Baumé.	Per cent. of soda.	Quantity of mixed fats which may be saponified by 100 parts of these lyes.
1.4285	43	30.22	279	1.2392	27	15.11	139
1.4193	42.5	29.616	274	1.228	26	14.506	134
1.4101	42	29.011	270	1.2178	25	13.901	128
1.4011	41	28 407	263	1.2058	24.5	13.297	122
1.3923	40.5	27.802	257	1.1948	23	12.692	117
1.3836	39.7	27.2	251	1.1841	22	12.088	111
1.3751	39	26.594	246	1.1734	21	11.484	105
1.3668	38.5	25.489	240	1.163	20	10.879	100
1.3686	38	25.385	235	1.1528	19	10.275	95
1.3505	38	24.78	229	1.1428	18	9.67	89
1.3426	36.7	24.176	224	1.133	17	9.066	83
1.3349	36	23.572	217	1.1233	16	8.462	78
1.3273	35	22.967	212	1.1137	15	7.857	72
1.3198	34.5	22.363	206	1.1042	13.5	7.253	66
1.3143	34.2	21.894	202	1.0948	12	6.648	61
1.3125	34	21.758	201	1.0855	11	6.044	55
1.3053	33.5	21.154	195	1.0764	10	5.44	50
1.2982	33	20.55	190	1.0675	9	4.835	44
1.2912	32.4	19.945	184	1.0587	7	4.231	39
1.2843	31.6	19.341	179	1.05	6	3.626	33
1.2775	31	18.73	173	1.0414	5.6	3.022	28
1.2708	30.5	18.132	167	1.033	4.2	2.418	22
1.2642	30	17.518	162	1.0246	3	1.813	16
1.2578	29	16.923	156	1.0163	2	1.209	11
1.2515	28.5	16.319	151	1.0081	1	0.604	5.5
1.2453	28	15.714	145				

INDEX.

"Let no book lack an Alphabetical Index."—S. A. Allibone, LL. D.

"So essential did I consider an Index to be to every book, that I proposed to bring a Bill into Parliament to deprive an author who publishes a book without an Index, of the privilege of copyright, and, moreover, to subject him for his offence to a pecuniary penalty."—Lord Campbell. "*Lives of the Chief Justices*," vol. iii., preface.

THE END.

CATALOGUE

OF

PRACTICAL AND SCIENTIFIC BOOKS,

PUBLISHED BY

HENRY CAREY BAIRD,

INDUSTRIAL PUBLISHER,

No. 406 WALNUT STREET,

PHILADELPHIA.

☞ Any of the Books comprised in this Catalogue will be sent by mail, free of postage, at the publication price.

☞ This Catalogue will be sent, free of postage, to any one who will furnish the publisher with his address.

ARMENGAUD, AMOUROUX, AND JOHNSON.—**THE PRACTICAL DRAUGHTSMAN'S BOOK OF INDUSTRIAL DESIGN, AND MACHINIST'S AND ENGINEER'S DRAWING COMPANION:** Forming a complete course of Mechanical Engineering and Architectural Drawing. From the French of M. Armengaud the elder, Prof. of Design in the Conservatoire of Arts and Industry, Paris, and MM. Armengaud the younger and Amouroux, Civil Engineers. Rewritten and arranged, with additional matter and plates, selections from and examples of the most useful and generally employed mechanism of the day. By WILLIAM JOHNSON, Assoc. Inst. C. E., Editor of "The Practical Mechanic's Journal." Illustrated by 50 folio steel plates and 50 wood-cuts. A new edition, 4to. . $10 00

ARROWSMITH.—**PAPER-HANGER'S COMPANION:** A Treatise in which the Practical Operations of the Trade are Systematically laid down: with Copious Directions Preparatory to Papering; Preventives against the Effect of Damp on Walls; the Various Cements and Pastes adapted to the Several Purposes of the Trade; Observations and Directions for the Panelling and Ornamenting of Rooms, &c. By JAMES ARROWSMITH, Author of "Analysis of Drapery," &c. 12mo., cloth $1 25

BAIRD.—THE AMERICAN COTTON SPINNER, AND MANAGER'S AND CARDER'S GUIDE:

A Practical Treatise on Cotton Spinning; giving the Dimensions and Speed of Machinery, Draught and Twist Calculations, etc.; with notices of recent Improvements: together with Rules and Examples for making changes in the sizes and numbers of Roving and Yarn. Compiled from the papers of the late ROBERT H. BAIRD. 12mo. . . . $1 50

BAKER.—LONG-SPAN RAILWAY BRIDGES:

Comprising Investigations of the Comparative Theoretical and Practical Advantages of the various Adopted or Proposed Type Systems of Construction; with numerous Formulæ and Tables. By B. Baker. 12mo. $2 00

BAKEWELL.—A MANUAL OF ELECTRICITY—PRACTICAL AND THEORETICAL:

By F. C. BAKEWELL, Inventor of the Copying Telegraph. Second Edition. Revised and enlarged. Illustrated by numerous engravings. 12mo. Cloth $2 00

BEANS.—A TREATISE ON RAILROAD CURVES AND THE LOCATION OF RAILROADS:

By E. W. BEANS, C. E. 12mo. (In press.)

BLENKARN.—PRACTICAL SPECIFICATIONS OF WORKS EXECUTED IN ARCHITECTURE, CIVIL AND MECHANICAL ENGINEERING, AND IN ROAD MAKING AND SEWERING:

To which are added a series of practically useful Agreements and Reports. By JOHN BLENKARN. Illustrated by fifteen large folding plates. 8vo. $9 00

BLINN.—A PRACTICAL WORKSHOP COMPANION FOR TIN, SHEET-IRON, AND COPPER-PLATE WORKERS:

Containing Rules for Describing various kinds of Patterns used by Tin, Sheet-iron, and Copper-plate Workers; Practical Geometry; Mensuration of Surfaces and Solids; Tables of the Weight of Metals, Lead Pipe, etc.; Tables of Areas and Circumferences of Circles; Japans, Varnishes, Lackers, Cements, Compositions, etc. etc. By LEROY J. BLINN, Master Mechanic. With over One Hundred Illustrations. 12mo. $2 50

BOOTH.—MARBLE WORKER'S MANUAL:
Containing Practical Information respecting Marbles in general, their Cutting, Working, and Polishing; Veneering of Marble; Mosaics; Composition and Use of Artificial Marble, Stuccos, Cements, Receipts, Secrets, etc. etc. Translated from the French by M. L. Booth. With an Appendix concerning American Marbles. 12mo., cloth . . $1 50

BOOTH AND MORFIT.—THE ENCYCLOPEDIA OF CHEMISTRY, PRACTICAL AND THEORETICAL:
Embracing its application to the Arts, Metallurgy, Mineralogy, Geology, Medicine, and Pharmacy. By James C. Booth, Melter and Refiner in the United States Mint, Professor of Applied Chemistry in the Franklin Institute, etc., assisted by Campbell Morfit, author of "Chemical Manipulations," etc. Seventh edition. Complete in one volume, royal 8vo., 978 pages, with numerous wood-cuts and other illustrations. $5 00

BOWDITCH.—ANALYSIS, TECHNICAL VALUATION, PURIFICATION, AND USE OF COAL GAS:
By Rev. W. R. Bowditch. Illustrated with wood engravings. 8vo. $6 50

BOX.—PRACTICAL HYDRAULICS:
A Series of Rules and Tables for the use of Engineers, etc. By Thomas Box. 12mo. $2 00

BUCKMASTER.—THE ELEMENTS OF MECHANICAL PHYSICS:
By J. C. Buckmaster, late Student in the Government School of Mines; Certified Teacher of Science by the Department of Science and Art; Examiner in Chemistry and Physics in the Royal College of Preceptors; and late Lecturer in Chemistry and Physics of the Royal Polytechnic Institute. Illustrated with numerous engravings. In one vol. 12mo. . $2 00

BULLOCK.—THE AMERICAN COTTAGE BUILDER:
A Series of Designs, Plans, and Specifications, from $200 to to $20,000 for Homes for the People; together with Warming, Ventilation, Drainage, Painting, and Landscape Gardening. By John Bullock, Architect, Civil Engineer, Mechanician, and Editor of "The Rudiments of Architecture and Building," etc. Illustrated by 75 engravings. In one vol. 8vo. $3 50

BULLOCK.—THE RUDIMENTS OF ARCHITECTURE AND BUILDING:

For the use of Architects, Builders, Draughtsmen, Machinists, Engineers, and Mechanics. Edited by JOHN BULLOCK, author of "The American Cottage Builder." Illustrated by 250 engravings. In one volume 8vo. . . . $3 50

BURGH.—PRACTICAL ILLUSTRATIONS OF LAND AND MARINE ENGINES:

Showing in detail the Modern Improvements of High and Low Pressure, Surface Condensation, and Super-heating, together with Land and Marine Boilers. By N. P. BURGH, Engineer. Illustrated by twenty plates, double elephant folio, with text. $21 00

BURGH.—PRACTICAL RULES FOR THE PROPORTIONS OF MODERN ENGINES AND BOILERS FOR LAND AND MARINE PURPOSES.

By N. P. BURGH, Engineer. 12mo. . . . $2 00

BURGH.—THE SLIDE-VALVE PRACTICALLY CONSIDERED:

By N. P. BURGH, author of "A Treatise on Sugar Machinery," "Practical Illustrations of Land and Marine Engines," "A Pocket-Book of Practical Rules for Designing Land and Marine Engines, Boilers," etc. etc. etc. Completely illustrated. 12mo. $2 00

BYRN.—THE COMPLETE PRACTICAL BREWER:

Or, Plain, Accurate, and Thorough Instructions in the Art of Brewing Beer, Ale, Porter, including the Process of making Bavarian Beer, all the Small Beers, such as Root-beer, Ginger-pop, Sarsaparilla-beer, Mead, Spruce beer, etc. etc. Adapted to the use of Public Brewers and Private Families. By M. LA FAYETTE BYRN, M. D. With illustrations. 12mo. $1 25

BYRN.—THE COMPLETE PRACTICAL DISTILLER:

Comprising the most perfect and exact Theoretical and Practical Description of the Art of Distillation and Rectification; including all of the most recent improvements in distilling apparatus; instructions for preparing spirits from the numerous vegetables, fruits, etc.; directions for the distillation and preparation of all kinds of brandies and other spirits, spirituous and other compounds, etc. etc.; all of which is so simplified that it is adapted not only to the use of extensive distillers, but for every farmer, or others who may wish to engage in the art of distilling By M. LA FAYETTE BYRN, M. D. With numerous engravings. In one volume, 12mo. $1 50

BYRNE.—POCKET BOOK FOR RAILROAD AND CIVIL ENGINEERS:

Containing New, Exact, and Concise Methods for Laying out Railroad Curves, Switches, Frog Angles and Crossings; the Staking out of work; Levelling; the Calculation of Cuttings; Embankments; Earth-work, etc. By OLIVER BYRNE. Illustrated, 18mo., full bound $1 50

BYRNE.—THE HANDBOOK FOR THE ARTISAN, MECHANIC, AND ENGINEER:

By OLIVER BYRNE. Illustrated by 11 large plates and 185 Wood Engravings. 8vo. $5 00

BYRNE.—THE ESSENTIAL ELEMENTS OF PRACTICAL MECHANICS:

For Engineering Students, based on the Principle of Work. By OLIVER BYRNE. Illustrated by Numerous Wood Engravings, 12mo. $3 63

BYRNE.—THE PRACTICAL METAL-WORKER'S ASSISTANT:

Comprising Metallurgic Chemistry; the Arts of Working all Metals and Alloys; Forging of Iron and Steel; Hardening and Tempering; Melting and Mixing; Casting and Founding; Works in Sheet Metal; the Processes Dependent on the Ductility of the Metals; Soldering; and the most Improved Processes and Tools employed by Metal-Workers. With the Application of the Art of Electro-Metallurgy to Manufacturing Processes; collected from Original Sources, and from the Works of Holtzapffel, Bergeron, Leupold, Plumier, Napier, and others. By OLIVER BYRNE. A New, Revised, and improved Edition, with Additions by John Scoffern, M. B , William Clay, Wm. Fairbairn, F. R. S., and James Napier. With Five Hundred and Ninety-two Engravings; Illustrating every Branch of the Subject. In one volume, 8vo. 652 pages . $7 00

BYRNE.—THE PRACTICAL MODEL CALCULATOR:

For the Engineer, Mechanic, Manufacturer of Engine Work, Naval Architect, Miner, and Millwright. By OLIVER BYRNE. 1 volume, 8vo., nearly 600 pages $4 50

CABINET MAKER'S ALBUM OF FURNITURE:

Comprising a Collection of Designs for the Newest and Most Elegant Styles of Furniture. Illustrated by Forty eight Large and Beautifully Engraved Plates. In one volume, oblong $5 00

CALVERT.—LECTURES ON COAL-TAR COLORS, AND ON RECENT IMPROVEMENTS AND PROGRESS IN DYEING AND CALICO PRINTING:

Embodying Copious Notes taken at the last London International Exhibition, and *Illustrated with Numerous Patterns of Aniline and other Colors.* By F. Grace Calvert, F. R. S., F. C. S., Professor of Chemistry at the Royal Institution, Manchester, Corresponding Member of the Royal Academies of Turin and Rouen; of the Pharmaceutical Society of Paris; Société Industrielle de Mulhouse, etc. In one volume, 8vo., cloth $1 50

CAMPIN.—A PRACTICAL TREATISE ON MECHANICAL ENGINEERING:

Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Mechanical Manipulation, Manufacture of Steam-engines, etc. etc. With an Appendix on the Analysis of Iron and Iron Ores. By Francis Campin, C. E. To which are added, Observations on the Construction of Steam Boilers, and Remarks upon Furnaces used for Smoke Prevention; with a Chapter on Explosions. By R. Armstrong, C. E., and John Bourne. Rules for Calculating the Change Wheels for Screws on a Turning Lathe, and for a Wheel-cutting Machine. By J. La Nicca. Management of Steel, including Forging, Hardening, Tempering, Annealing, Shrinking, and Expansion. And the Case-hardening of Iron. By G. Ede. 8vo. Illustrated with 29 plates and 100 wood engravings. $6 00

CAMPIN.—THE PRACTICE OF HAND-TURNING IN WOOD, IVORY, SHELL, ETC.:

With Instructions for Turning such works in Metal as may be required in the Practice of Turning Wood, Ivory, etc. Also, an Appendix on Ornamental Turning. By Francis Campin; with Numerous Illustrations, 12mo., cloth . . $3 00

CAPRON DE DOLE.—DUSSAUCE.—BLUES AND CARMINES OF INDIGO.

A Practical Treatise on the Fabrication of every Commercial Product derived from Indigo. By Felicien Capron de Dole. Translated, with important additions, by Professor H. Dussauce. 12mo. $2 50

CAREY.—THE WORKS OF HENRY C. CAREY:

CONTRACTION OR EXPANSION? REPUDIATION OR RESUMPTION? Letters to Hon. Hugh McCulloch. 8vo. 38

FINANCIAL CRISES, their Causes and Effects. 8vo. paper 25

HARMONY OF INTERESTS; Agricultural, Manufacturing, and Commercial. 8vo., paper $1 00
Do. do. cloth . . . $1 50

LETTERS TO THE PRESIDENT OF THE UNITED STATES. Paper $1 00

MANUAL OF SOCIAL SCIENCE. Condensed from Carey's "Principles of Social Science." By KATE MCKEAN. 1 vol. 12mo. $2 25

MISCELLANEOUS WORKS: comprising "Harmony of Interests," "Money," "Letters to the President," "French and American Tariffs," "Financial Crises," "The Way to Outdo England without Fighting Her," "Resources of the Union," "The Public Debt," "Contraction or Expansion," "Review of the Decade 1857—'67," "Reconstruction," etc. etc. 1 vol. 8vo., cloth $4 50

MONEY: A LECTURE before the N. Y. Geographical and Statistical Society. 8vo., paper 25

PAST, PRESENT, AND FUTURE. 8vo. . . . $2 50

PRINCIPLES OF SOCIAL SCIENCE. 3 volumes 8vo., cloth $10 00

REVIEW OF THE DECADE 1857—'67. 8vo., paper 38

RECONSTRUCTION: INDUSTRIAL, FINANCIAL, AND POLITICAL. Letters to the Hon. Henry Wilson, U. S. S. 8vo. paper 38

THE PUBLIC DEBT, LOCAL AND NATIONAL. How to provide for its discharge while lessening the burden of Taxation. Letter to David A. Wells, Esq., U. S. Revenue Commission. 8vo., paper 25

THE RESOURCES OF THE UNION. A Lecture read, Dec. 1865, before the American Geographical and Statistical Society, N. Y., and before the American Association for the Advancement of Social Science, Boston . . . 25

THE SLAVE TRADE, DOMESTIC AND FOREIGN; Why it Exists, and How it may be Extinguished. 12mo., cloth $1 50

THE WAY TO OUTDO ENGLAND WITHOUT FIGHTING HER. Letters to the Hon. Schuyler Colfax. 8vo., paper 75

CAMUS.—A TREATISE ON THE TEETH OF WHEELS:
Demonstrating the best forms which can be given to them for the purposes of Machinery, such as Mill-work and Clock-work. Translated from the French of M. CAMUS. By JOHN I. HAWKINS. Illustrated by 40 plates. 8vo. $3 00

CLOUGH.—THE CONTRACTOR'S MANUAL AND BUILDER'S PRICE-BOOK:
Designed to elucidate the method of ascertaining, correctly, the value and Quantity of every description of Work and Materials used in the Art of Building, from their Prime Cost in any part of the United States, collected from extensive experience and observation in Building and Designing; to which are added a large variety of Tables, Memoranda, etc., indispensable to all engaged or concerned in erecting buildings of any kind. By A. B. CLOUGH, Architect, 24mo., cloth 75

COLBURN.—THE GAS-WORKS OF LONDON:
Comprising a sketch of the Gas-works of the city, Process of Manufacture, Quantity Produced, Cost, Profit, etc. By ZERAH COLBURN. 8vo., cloth 75

COLBURN.—THE LOCOMOTIVE ENGINE:
Including a Description of its Structure, Rules for Estimating its Capabilities, and Practical Observations on its Construction and Management. By ZERAH COLBURN. Illustrated. A new edition. 12mo. $1 25

COLBURN AND MAW.—THE WATER-WORKS OF LONDON:
Together with a Series of Articles on various other Water-works. By ZERAH COLBURN and W. MAW. Reprinted from "Engineering." In one volume, 8vo. . . $4 00

DAGUERREOTYPIST AND PHOTOGRAPHER'S COMPANION:
12mo., cloth $1 25

DUPLAIS.—A COMPLETE TREATISE ON THE DISTILLATION AND PREPARATION OF ALCOHOLIC AND OTHER LIQUORS:
From the French of M. DUPLAIS. Translated and Edited by M. MCKENNIE, M. D. Illustrated. 8vo. (*In press.*)

DESSOYE.—STEEL, ITS MANUFACTURE, PROPERTIES, AND USE.

By J. B. J. Dessoye, Manufacturer of Steel; with an Introduction and Notes by Ed. Graten, Engineer of Mines. Translated from the French. In one volume, 12mo. (In press.)

DIRCKS.—PERPETUAL MOTION:

Or Search for Self-Motive Power during the 17th, 18th, and 19th centuries. Illustrated from various authentic sources in Papers, Essays, Letters, Paragraphs, and numerous Patent Specifications, with an Introductory Essay by Henry Dircks, C. E. Illustrated by numerous engravings of machines. 12mo., cloth $3 50

DIXON.—THE PRACTICAL MILLWRIGHT'S AND ENGINEER'S GUIDE:

Or Tables for Finding the Diameter and Power of Cogwheels; Diameter, Weight, and Power of Shafts; Diameter and Strength of Bolts, etc. etc. By Thomas Dixon. 12mo., cloth. $1 50

DUNCAN.—PRACTICAL SURVEYOR'S GUIDE:

Containing the necessary information to make any person, of common capacity, a finished land surveyor without the aid of a teacher. By Andrew Duncan. Illustrated. 12mo., cloth. $1 25

DUSSAUCE.—A NEW AND COMPLETE TREATISE ON THE ARTS OF TANNING, CURRYING, AND LEATHER DRESSING:

Comprising all the Discoveries and Improvements made in France, Great Britain, and the United States. Edited from Notes and Documents of Messrs. Sallerou, Grouvelle, Duval, Dessables, Labarraque, Payen, René, De Fontenelle, Malapeyre, etc. etc. By Prof. H. Dussauce, Chemist. Illustrated by 212 wood engravings. 8vo. $10 00

DUSSAUCE.—A GENERAL TREATISE ON THE MANUFACTURE OF EVERY DESCRIPTION OF SOAP:

Comprising the Chemistry of the Art, with Remarks on Alkalies, Saponifiable Fatty Bodies, the apparatus necessary in a Soap Factory, Practical Instructions on the manufacture of the various kinds of Soap, the assay of Soaps, etc. etc. Edited from notes of Larmé, Fontenelle, Malapeyre, Dufour, and others, with large and important additions by Professor H. Dussauce, Chemist. Illustrated. In one volume, 8vo. $10 00

DUSSAUCE.—A PRACTICAL GUIDE FOR THE PERFUMER:
Being a New Treatise on Perfumery the most favorable to the Beauty without being injurious to the Health, comprising a Description of the substances used in Perfumery, the Formulæ of more than one thousand Preparations, such as Cosmetics, Perfumed Oils, Tooth Powders, Waters, Extracts, Tinctures, Infusions, Vinaigres, Essential Oils, Pastels, Creams, Soaps, and many new Hygienic Products not hitherto described. Edited from Notes and Documents of Messrs. Debay, Lunel, etc. With additions by Professor H. DUSSAUCE, Chemist. 12mo. press, *shortly to be issued.*) $3 00

DUSSAUCE.—PRACTICAL TREATISE ON THE FABRICATION OF MATCHES, GUN COTTON, AND FULMINATING POWDERS.
By Professor H. DUSSAUCE. 12mo. . . . $3 00

DUSSAUCE.—A GENERAL TREATISE ON THE MANUFACTURE OF VINEGAR, THEORETICAL AND PRACTICAL.
Comprising the various methods, by the slow and the quick processes, with Alcohol, Wine, Grain, Cider, and Molasses, as well as the Fabrication of Wood Vinegar, etc. By Prof. H. DUSSAUCE. 12mo. (*In press.*)

DE GRAFF.—THE GEOMETRICAL STAIR-BUILDERS' GUIDE:
Being a Plain Practical System of Hand-Railing, embracing all its necessary Details, and Geometrically Illustrated by 22 Steel Engravings; together with the use of the most approved principles of Practical Geometry. By SIMON DE GRAFF, Architect. 4to. $5 00

DYER AND COLOR-MAKER'S COMPANION:
Containing upwards of two hundred Receipts for making Colors, on the most approved principles, for all the various styles and fabrics now in existence; with the Scouring Process, and plain Directions for Preparing, Washing-off, and Finishing the Goods. In one vol. 12mo. $1 25

EASTON.—A PRACTICAL TREATISE ON STREET OR HORSE-POWER RAILWAYS:
Their Location, Construction, and Management; with General Plans and Rules for their Organization and Operation; together with Examinations as to their Comparative Advantages over the Omnibus System, and Inquiries as to their Value for Investment; including Copies of Municipal Ordinances relating thereto. By ALEXANDER EASTON, C. E. Illustrated by 23 plates, 8vo., cloth $2 00

FORSYTH.—**BOOK OF DESIGNS FOR HEAD-STONES, MURAL, AND OTHER MONUMENTS:**

Containing 78 Elaborate and Exquisite Designs. By FORSYTH. 4to. (*In press.*)

FAIRBAIRN.—**THE PRINCIPLES OF MECHANISM AND MACHINERY OF TRANSMISSION:**

Comprising the Principles of Mechanism, Wheels, and Pulleys, Strength and Proportions of Shafts, Couplings of Shafts, and Engaging and Disengaging Gear. By WILLIAM FAIRBAIRN, Esq., C. E., LL. D., F. R. S., F. G. S., Corresponding Member of the National Institute of France, and of the Royal Academy of Turin; Chevalier of the Legion of Honor, etc. etc. Beautifully illustrated by over 150 wood-cuts. In one volume 12mo. $2 50

FAIRBAIRN.—**PRIME-MOVERS:**

Comprising the Accumulation of Water-power; the Construction of Water-wheels and Turbines; the Properties of Steam; the Varieties of Steam-engines and Boilers and Wind-mills. By WILLIAM FAIRBAIRN, C. E., LL. D., F. R. S., F. G. S. Author of "Principles of Mechanism and the Machinery of Transmission." With Numerous Illustrations. In one volume. (In press.)

FLAMM.—**A PRACTICAL GUIDE TO THE CONSTRUCTION OF ECONOMICAL HEATING APPLICATIONS FOR SOLID AND GASEOUS FUELS:**

With the Application of Concentrated Heat, and on Waste Heat, for the Use of Engineers, Architects, Stove and Furnace Makers, Manufacturers of Fire Brick, Zinc, Porcelain, Glass, Earthenware, Steel, Chemical Products, Sugar Refiners, Metallurgists, and all others employing Heat. By M. PIERRE FLAMM, Manufacturer. Illustrated. Translated from the French. One volume, 12mo. (In press.)

GILBART.—**A PRACTICAL TREATISE ON BANKING:**

By JAMES WILLIAM GILBART. To which is added: THE NATIONAL BANK ACT AS NOW (1868) IN FORCE. 8vo. $4 50

GOTHIC ALBUM FOR CABINET MAKERS:
Comprising a Collection of Designs for Gothic Furniture. Illustrated by twenty-three large and beautifully engraved plates. Oblong $3 00

GRANT.—BEET-ROOT SUGAR AND CULTIVATION OF THE BEET:
By E. B. Grant. 12mo. $1 25

GREGORY.—MATHEMATICS FOR PRACTICAL MEN:
Adapted to the Pursuits of Surveyors, Architects, Mechanics, and Civil Engineers. By Olinthus Gregory. 8vo., plates, cloth $3 00

GRISWOLD.—RAILROAD ENGINEER'S POCKET COMPANION.
Comprising Rules for Calculating Deflection Distances and Angles, Tangential Distances and Angles, and all Necessary Tables for Engineers; also the art of Levelling from Preliminary Survey to the Construction of Railroads, intended Expressly for the Young Engineer, together with Numerous Valuable Rules and Examples. By W. Griswold. 12mo., tucks. $1 50

GUETTIER.—METALLIC ALLOYS:
Being a Practical Guide to their Chemical and Physical Properties, their Preparation, Composition, and Uses. Translated from the French of A. Guettier, Engineer and Director of Founderies, author of "La Fouderie en France," etc. etc. By A. A. Fesquet, Chemist and Engineer. In one volume, 12mo. (In press, *shortly to be published.*)

HATS AND FELTING:
A Practical Treatise on their Manufacture. By a Practical Hatter. Illustrated by Drawings of Machinery, &c., 8vo. $1 25

HAY.—THE INTERIOR DECORATOR:
The Laws of Harmonious Coloring adapted to Interior Decorations: with a Practical Treatise on House-Painting. By D. R. Hay, House-Painter and Decorator. Illustrated by a Diagram of the Primary, Secondary, and Tertiary Colors. 12mo. $2 25

HUGHES.—AMERICAN MILLER AND MILLWRIGHT'S ASSISTANT:
By Wm. Carter Hughes. A new edition. In one volume, 12mo. $1 50

HUNT.—THE PRACTICE OF PHOTOGRAPHY.
By ROBERT HUNT, Vice-President of the Photographic Society, London, with numerous illustrations. 12mo., cloth . 75

HURST.—A HAND-BOOK FOR ARCHITECTURAL SURVEYORS:
Comprising Formulæ useful in Designing Builder's work, Table of Weights, of the materials used in Building, Memoranda connected with Builders' work, Mensuration, the Practice of Builders' Measurement, Contracts of Labor, Valuation of Property, Summary of the Practice in Dilapidation, etc. etc. By J. F. HURST, C. E. 2d edition, pocket-book form, full bound $2 50

JERVIS.—RAILWAY PROPERTY:
A Treatise on the Construction and Management of Railways; designed to afford useful knowledge, in the popular style, to the holders of this class of property; as well as Railway Managers, Officers, and Agents. By JOHN B. JERVIS, late Chief Engineer of the Hudson River Railroad, Croton Aqueduct, &c. One vol. 12mo., cloth $2 00

JOHNSON.—A REPORT TO THE NAVY DEPARTMENT OF THE UNITED STATES ON AMERICAN COALS:
Applicable to Steam Navigation and to other purposes. By WALTER R. JOHNSON. With numerous illustrations. 607 pp. 8vo., half morocco $6 00

JOHNSON.—THE COAL TRADE OF BRITISH AMERICA:
With Researches on the Characters and Practical Values of American and Foreign Coals. By WALTER R. JOHNSON, Civil and Mining Engineer and Chemist. 8vo. . . . $2 00

JOHNSTON.—INSTRUCTIONS FOR THE ANALYSIS OF SOILS, LIMESTONES, AND MANURES.
By J. W. F. JOHNSTON. 12mo. 38

KEENE.—A HAND-BOOK OF PRACTICAL GAUGING,
For the Use of Beginners, to which is added A Chapter on Distillation, describing the process in operation at the Custom House for ascertaining the strength of wines. By JAMES B. KEENE, of H. M. Customs. 8vo. $1 25

KENTISH.—A TREATISE ON A BOX OF INSTRUMENTS,
And the Slide Rule; with the Theory of Trigonometry and Logarithms, including Practical Geometry, Surveying, Measuring of Timber, Cask and Malt Gauging, Heights, and Distances. By THOMAS KENTISH. In one volume. 12mo. . $1 25

KOBELL.—ERNI.—**MINERALOGY SIMPLIFIED:**

A short method of Determining and Classifying Minerals, by means of simple Chemical Experiments in the Wet Way. Translated from the last German Edition of F. Von Kobell, with an Introduction to Blowpipe Analysis and other additions. By Henri Erni, M. D., Chief Chemist, Department of Agriculture, author of "Coal Oil and Petroleum." In one volume, 12mo. $2 50

LAFFINEUR.—**A PRACTICAL GUIDE TO HYDRAULICS FOR TOWN AND COUNTRY;**

Or a Complete Treatise on the Building of Conduits for Water for Cities, Towns, Farms, Country Residences, Workshops, etc. Comprising the means necessary for obtaining at all times abundant supplies of Drinkable Water. Translated from the French of M. Jules Laffineur, C. E. Illustrated. (In press.)

LAFFINEUR.—**A TREATISE ON THE CONSTRUCTION OF WATER-WHEELS:**

Containing the various Systems in use with Practical Information on the Dimensions necessary for Shafts, Journals, Arms, etc., of Water-wheels, etc. etc. Translated from the French of M. Jules Laffineur, C. E. Illustrated by numerous plates. (In press.)

LANDRIN.—**A TREATISE ON STEEL:**

Comprising the Theory, Metallurgy, Practical Working, Properties, and Use. Translated from the French of H. C. Landrin, Jr., C. E. By A. A. Fesquet, Chemist and Engineer. Illustrated. 12mo. $3 00

LARKIN.—**THE PRACTICAL BRASS AND IRON FOUNDER'S GUIDE:**

A Concise Treatise on Brass Founding, Moulding, the Metals and their Alloys, etc.; to which are added Recent Improvements in the Manufacture of Iron, Steel by the Bessemer Process, etc. etc. By James Larkin, late Conductor of the Brass Foundry Department in Reany, Neafie & Co.'s Penn Works, Philadelphia. Fifth edition, revised, with Extensive additions. In one volume, 12mo. $2 25

LEAVITT.—FACTS ABOUT PEAT AS AN ARTICLE OF FUEL:
With Remarks upon its Origin and Composition, the Localities in which it is found, the Methods of Preparation and Manufacture, and the various Uses to which it is applicable; together with many other matters of Practical and Scientific Interest. To which is added a chapter on the Utilization of Coal Dust with Peat for the Production of an Excellent Fuel at Moderate Cost, especially adapted for Steam Service. By H. T. LEAVITT. Third edition. 12mo. . . . $1 75

LEROUX.—A PRACTICAL TREATISE ON THE MANUFACTURE OF WORSTEDS AND CARDED YARNS:
Translated from the French of CHARLES LEROUX, Mechanical Engineer, and Superintendent of a Spinning Mill. By Dr. H. PAINE, and A. A. FESQUET. Illustrated by 12 large plates. In one volume 8vo. $5 00

LESLIE (MISS).—COMPLETE COOKERY:
Directions for Cookery in its Various Branches. By Miss LESLIE. 58th thousand. Thoroughly revised, with the addition of New Receipts. In 1 vol. 12mo., cloth . . $1 25

LESLIE (MISS). LADIES' HOUSE BOOK:
a Manual of Domestic Economy. 20th revised edition. 12mo., cloth $1 25

LESLIE (MISS).—TWO HUNDRED RECEIPTS IN FRENCH COOKERY.
12mo. 50

LIEBER.—ASSAYER'S GUIDE:
Or, Practical Directions to Assayers, Miners, and Smelters, for the Tests and Assays, by Heat and by Wet Processes, for the Ores of all the principal Metals, of Gold and Silver Coins and Alloys, and of Coal, etc. By OSCAR M. LIEBER. 12mo., cloth $1 25

LOVE.—THE ART OF DYEING, CLEANING, SCOURING, AND FINISHING:
On the most approved English and French methods; being Practical Instructions in Dyeing Silks, Woollens, and Cottons, Feathers, Chips, Straw, etc.; Scouring and Cleaning Bed and Window Curtains, Carpets, Rugs, etc.; French and English Cleaning, etc. By THOMAS LOVE. Second American Edition, to which are added General Instructions for the Use of Aniline Colors. 8vo. 5 00

MAIN AND BROWN.—QUESTIONS ON SUBJECTS CONNECTED WITH THE MARINE STEAM-ENGINE:
And Examination Papers; with Hints for their Solution. By THOMAS J. MAIN, Professor of Mathematics, Royal Naval College, and THOMAS BROWN, Chief Engineer, R. N. 12mo., cloth $1 50

MAIN AND BROWN.—THE INDICATOR AND DYNAMOMETER:
With their Practical Applications to the Steam-Engine. By THOMAS J. MAIN, M. A. F. R., Ass't Prof. Royal Naval College, Portsmouth, and THOMAS BROWN, Assoc. Inst. C. E., Chief Engineer, R. N., attached to the R. N. College. Illustrated. From the Fourth London Edition. 8vo. . . . $1 50

MAIN AND BROWN.—THE MARINE STEAM-ENGINE.
By THOMAS J. MAIN, F. R. Ass't S. Mathematical Professor at Royal Naval College, and THOMAS BROWN, Assoc. Inst. C. E. Chief Engineer, R. N. Attached to the Royal Naval College. Authors of "Questions connected with the Marine Steam-Engine," and the "Indicator and Dynamometer." With numerous Illustrations. In one volume, 8vo. . . . $5 00

MORTIMER.—THE PYROTECHNIST'S COMPANION:
Or, a Familiar System of Recreative Fireworks. By G. W. MORTIMER. Illustrated 12mo. $1 25
CONTENTS.—Introduction. Of Gunpowder, Materials, Apparatus. Division of Fireworks, Single Fireworks, Rockets, Tables of Various Compositions, Compound Fireworks.

MARTIN.—SCREW-CUTTING TABLES, FOR THE USE OF MECHANICAL ENGINEERS:
Showing the Proper Arrangement of Wheels for Cutting the Threads of Screws of any required Pitch; with a Table for Making the Universal Gas-Pipe Thread and Taps. By W. A. MARTIN, Engineer. 8vo. 50

MILES.—A PLAIN TREATISE ON HORSE-SHOEING.
With illustrations. By WILLIAM MILES, author of "The Horse's Foot," $1 00

MOLESWORTH. POCKET-BOOK OF USEFUL FORMULÆ AND MEMORANDA FOR CIVIL AND MECHANICAL ENGINEERS.
By GUILFORD L. MOLESWORTH, Member of the Institution of Civil Engineers, Chief Resident Engineer of the Ceylon Railway. Second American, from the Tenth London Edition. In one volume, full bound in pocket-book form . . $2 00

MOORE.—THE INVENTOR'S GUIDE:
Patent Office and Patent Laws; or, a Guide to Inventors, and a Book of Reference for Judges, Lawyers, Magistrates, and others. By J. G. Moore. 12mo., cloth . . $1 25

NAPIER.—A SYSTEM OF CHEMISTRY APPLIED TO DYEING:
By James Napier, F. C. S. A New and Thoroughly Revised Edition, completely brought up to the present state of the Science, including the Chemistry of Coal Tar Colors. By A. A. Fesquet, Chemist and Engineer. With an Appendix on Dyeing and Calico Printing, as shown at the Paris Universal Exposition of 1867, from the Reports of the International Jury, etc. Illustrated. In one volume 8vo., 400 pages $5 00

NAPIER.—A MANUAL OF DYEING RECEIPTS FOR GENERAL USE.
By James Napier, F. C. S. *With Numerous Patterns of Dyed Cloth and Silk.* Second edition, revised and enlarged. 12mo. $3 75

NAPIER.—MANUAL OF ELECTRO-METALLURGY:
Including the Application of the Art to Manufacturing Processes. By James Napier. Fourth American, from the Fourth London edition, revised and enlarged. Illustrated by engravings. In one volume, 8vo. $2 00

NEWBERY.—GLEANINGS FROM ORNAMENTAL ART OF EVERY STYLE;
Drawn from Examples in the British, South Kensington, Indian, Crystal Palace, and other Museums, the Exhibitions of 1851 and 1862, and the best English and Foreign works. In a series of one hundred exquisitely drawn Plates, containing many hundred examples. By Robert Newbery. 4to. $15 00

NICHOLSON.—A MANUAL OF THE ART OF BOOK-BINDING:
Containing full instructions in the different Branches of Forwarding, Gilding, and Finishing. Also, the Art of Marbling Book-edges and Paper. By James B. Nicholson. Illustrated. 12mo., cloth $2 25

NORRIS.—A HAND-BOOK FOR LOCOMOTIVE ENGINEERS AND MACHINISTS:
Comprising the Proportions and Calculations for Constructing Locomotives; Manner of Setting Valves; Tables of Squares, Cubes, Areas, etc. etc. By Septimus Norris, Civil and Mechanical Engineer. New edition. Illustrated, 12mo., cloth $2 00

NYSTROM. — **ON TECHNOLOGICAL EDUCATION AND THE CONSTRUCTION OF SHIPS AND SCREW PROPELLERS:**
For Naval and Marine Engineers. By JOHN W. NYSTROM, late Acting Chief Engineer U. S. N. Second edition, revised with additional matter. Illustrated by seven engravings. 12mo. $2 50

O'NEILL.—**A DICTIONARY OF DYEING AND CALICO PRINTING:**
Containing a brief account of all the Substances and Processes in use in the Art of Dyeing and Printing Textile Fabrics: with Practical Receipts and Scientific Information. By CHARLES O'NEILL, Analytical Chemist; Fellow of the Chemical Society of London; Member of the Literary and Philosophical Society of Manchester; Author of "Chemistry of Calico Printing and Dyeing." To which is added An Essay on Coal Tar Colors and their Application to Dyeing and Calico Printing. By A. A. FESQUET, Chemist and Engineer. With an Appendix on Dyeing and Calico Printing, as shown at the Exposition of 1867, from the Reports of the International Jury, etc. In one volume 8vo., 491 pages. . $6 00

OVERMAN—OSBORN.—**THE MANUFACTURE OF IRON IN ALL ITS BRANCHES:**
Including a Practical Description of the various Fuels and their Values, the Nature, Determination and Preparation of the Ore, the Erection and Management of Blast and other Furnaces, the characteristic results of Working by Charcoal, Coke, or Anthracite, the Conversion of the Crude into the various kinds of Wrought Iron, and the Methods adapted to this end. Also, a Description of Forge Hammers, Rolling Mills, Blast Engines, &c. &c. To which is added an Essay on the Manufacture of Steel. By FREDERICK OVERMAN, Mining Engineer. The whole thoroughly revised and enlarged, adapted to the latest Improvements and Discoveries, and the particular type of American Methods of Manufacture. With various new engravings illustrating the whole subject. By H. S. OSBORN, LL. D. Professor of Mining and Metallurgy in Lafayette College. In one volume, 8vo. $10 00

PAINTER, GILDER, AND VARNISHER'S COMPANION:
Containing Rules and Regulations in everything relating to the Arts of Painting, Gilding, Varnishing, and Glass Staining, with numerous useful and valuable Receipts; Tests for the Detection of Adulterations in Oils and Colors, and a statement of the Diseases and Accidents to which Painters, Gilders, and

Varnishers are particularly liable, with the simplest methods of Prevention and Remedy. With Directions for Graining. Marbling, Sign Writing, and Gilding on Glass. To which are added COMPLETE INSTRUCTIONS FOR COACH PAINTING AND VARNISHING. 12mo., cloth $1 50

PALLETT.—THE MILLER'S, MILLWRIGHT'S, AND ENGINEER'S GUIDE.

By HENRY PALLETT. Illustrated. In one vol. 12mo. $3 00

PERKINS.—GAS AND VENTILATION.

Practical Treatise on Gas and Ventilation. With Special Relation to Illuminating, Heating, and Cooking by Gas. Including Scientific Helps to Engineer-students and others. With illustrated Diagrams. By E. E. PERKINS. 12mo., cloth $1 25

PERKINS AND STOWE.—A NEW GUIDE TO THE SHEET-IRON AND BOILER PLATE ROLLER:

Containing a Series of Tables showing the Weight of Slabs and Piles to Produce Boiler Plates, and of the Weight of Piles and the Sizes of Bars to produce Sheet-iron; the Thickness of the Bar Gauge in Decimals; the Weight per foot, and the Thickness on the Bar or Wire Gauge of the fractional parts of an inch; the Weight per sheet, and the Thickness on the Wire Gauge of Sheet-iron of various dimensions to weigh 112 lbs. per bundle; and the conversion of Short Weight into Long Weight, and Long Weight into Short. Estimated and collected by G. H. PERKINS and J. G. STOWE $2 50

PHILLIPS AND DARLINGTON.—RECORDS OF MINING AND METALLURGY:

Or Facts and Memoranda for the use of the Mine Agent and Smelter. By J. ARTHUR PHILLIPS, Mining Engineer, Graduate of the Imperial School of Mines, France, etc., and JOHN DARLINGTON. Illustrated by numerous engravings. In one volume, 12mo. $2 00

PRADAL, MALEPEYRE, AND DUSSAUCE.—A COMPLETE TREATISE ON PERFUMERY:

Containing notices of the Raw Material used in the Art, and the Best Formulæ. According to the most approved Methods followed in France, England, and the United States. By M. P. PRADAL, Perfumer Chemist, and M. F. MALEPEYRE. Translated from the French, with extensive additions, by Professor H. DUSSAUCE. 8vo. $10 00

PROTEAUX.—**PRACTICAL GUIDE FOR THE MANUFACTURE OF PAPER AND BOARDS.**

By A. PROTEAUX, Civil Engineer, and Graduate of the School of Arts and Manufactures, Director of Thiers's Paper Mill, 'Puy-de-Dômé. With additions, by L. S. LE NORMAND. Translated from the French, with Notes, by HORATIO PAINE, A. B., M. D. To which is added a Chapter on the Manufacture of Paper from Wood in the United States, by HENRY T. BROWN, of the "American Artisan." Illustrated by six plates, containing Drawings of Raw Materials, Machinery, Plans of Paper-Mills, etc. etc. 8vo. $5 00

REGNAULT.—**ELEMENTS OF CHEMISTRY.**

By M. V. REGNAULT. Translated from the French by T. FORREST BETTON, M. D., and edited, with notes, by JAMES C. BOOTH, Melter and Refiner U. S. Mint, and WM. L. FABER, Metallurgist and Mining Engineer. Illustrated by nearly 700 wood engravings. Comprising nearly 1500 pages. In two volumes, 8vo., cloth $10 00

REID.—**A PRACTICAL TREATISE ON THE MANUFACTURE OF PORTLAND CEMENT:**

By HENRY REID, C. E. To which is added a Translation of M. A. Lipowitz's Work, describing a new method adopted in Germany of Manufacturing that Cement. By W. F. REID. Illustrated by plates and wood engravings. 8vo. $7 00

SHUNK.—**A PRACTICAL TREATISE ON RAILWAY CURVES AND LOCATION, FOR YOUNG ENGINEERS.**

By WM. F. SHUNK, Civil Engineer. 12mo. . . $1 50

SMEATON.—**BUILDER'S POCKET COMPANION:**

Containing the Elements of Building, Surveying, and Architecture; with Practical Rules and Instructions connected with the subject. By A. C. SMEATON, Civil Engineer, etc. In one volume, 12mo. $1 50

SMITH.—**THE DYER'S INSTRUCTOR:**

Comprising Practical Instructions in the Art of Dyeing Silk, Cotton, Wool, and Worsted, and Woollen Goods: containing nearly 800 Receipts. To which is added a Treatise on the Art of Padding; and the Printing of Silk Warps, Skeins, and Handkerchiefs, and the various Mordants and Colors for the different styles of such work. By DAVID SMITH, Pattern Dyer. 12mo., cloth. $3 00

SMITH.—PARKS AND PLEASURE GROUNDS:
Or Practical Notes on Country Residences, Villas, Public Parks, and Gardens. By CHARLES H. J. SMITH, Landscape Gardener and Garden Architect, etc. etc. 12mo. . $2 25

STOKES.—CABINET-MAKER'S AND UPHOLSTERER'S COMPANION:
Comprising the Rudiments and Principles of Cabinet-making and Upholstery, with Familiar Instructions, Illustrated by Examples for attaining a Proficiency in the Art of Drawing, as applicable to Cabinet-work; The Processes of Veneering, Inlaying, and Buhl-work; the Art of Dyeing and Staining Wood, Bone, Tortoise Shell, etc. Directions for Lackering, Japanning, and Varnishing; to make French Polish; to prepare the Best Glues, Cements, and Compositions, and a number of Receipts particularly for workmen generally. By J. STOKES. In one vol. 12mo. With illustrations $1 25

STRENGTH AND OTHER PROPERTIES OF METALS.
Reports of Experiments on the Strength and other Properties of Metals for Cannon. With a Description of the Machines for Testing Metals, and of the Classification of Cannon in service. By Officers of the Ordnance Department U. S. Army. By authority of the Secretary of War. Illustrated by 25 large steel plates. In 1 vol. quarto $10 00

TABLES SHOWING THE WEIGHT OF ROUND, SQUARE, AND FLAT BAR IRON, STEEL, ETC.,
By Measurement. Cloth 63

TAYLOR.—STATISTICS OF COAL:
Including Mineral Bituminous Substances employed in Arts and Manufactures; with their Geographical, Geological, and Commercial Distribution and amount of Production and Consumption on the American Continent. With Incidental Statistics of the Iron Manufacture. By R. C. TAYLOR. Second edition, revised by S. S. HALDEMAN. Illustrated by five Maps and many wood engravings. 8vo., cloth . . . $6 00

TEMPLETON.—THE PRACTICAL EXAMINATOR ON STEAM AND THE STEAM-ENGINE:
With Instructive References relative thereto, for the Use of Engineers, Students, and others. By WM. TEMPLETON, Engineer. 12mo. $1 25

THOMAS.—THE MODERN PRACTICE OF PHOTOGRAPHY.
By R. W. THOMAS, F. C. S. 8vo., cloth . . . 75

THOMSON.—FREIGHT CHARGES CALCULATOR.
By ANDREW THOMSON, Freight Agent . . . $1 25

TURNBULL.—THE ELECTRO-MAGNETIC TELEGRAPH:
With an Historical Account of its Rise, Progress, and Present Condition. Also, Practical Suggestions in regard to Insulation and Protection from the effects of Lightning. Together with an Appendix, containing several important Telegraphic Devices and Laws. By LAWRENCE TURNBULL, M. D., Lecturer on Technical Chemistry at the Franklin Institute. Revised and improved. Illustrated. 8vo. . . . $3 00

TURNER'S (THE) COMPANION:
Containing Instructions in Concentric, Elliptic, and Eccentric Turning; also various Plates of Chucks, Tools, and Instruments; and Directions for using the Eccentric Cutter, Drill, Vertical Cutter, and Circular Rest; with Patterns and Instructions for working them. A new edition in one vol. 12mo. $1 50

ULRICH—DUSSAUCE.—A COMPLETE TREATISE ON THE ART OF DYEING COTTON AND WOOL:
As practised in Paris, Rouen, Mulhausen, and Germany. From the French of M. LOUIS ULRICH, a Practical Dyer in the principal Manufactories of Paris, Rouen, Mulhausen, etc. etc ; to which are added the most important Receipts for Dyeing Wool, as practised in the Manufacture Impériale des Gobelins, Paris. By Professor H. DUSSAUCE. 12mo. $3 50

URBIN—BRULL.—A PRACTICAL GUIDE FOR PUDDLING IRON AND STEEL.
By ED. URBIN, Engineer of Arts and Manufactures. A Prize Essay read before the Association of Engineers, Graduate of the School of Mines, of Liege, Belgium, at the Meeting of 1865—6. To which is added a COMPARISON OF THE RESISTING PROPERTIES OF IRON AND STEEL. By A. BRULL. Translated from the French by A. A. FESQUET, Chemist and Engineer. In one volume, 8vo. $1 00

WATSON.—A MANUAL OF THE HAND-LATHE.
By EGBERT P. WATSON, Late of the "Scientific American," Author of "Modern Practice of American Machinists and Engineers." In one volume, 12mo. $1 50

WATSON.—THE MODERN PRACTICE OF AMERICAN MACHINISTS AND ENGINEERS:
Including the Construction, Application, and Use of Drills, Lathe Tools, Cutters for Boring Cylinders, and Hollow Work Generally, with the most Economical Speed of the same, the Results verified by Actual Practice at the Lathe, the Vice, and on the Floor. Together with Workshop management, Economy of Manufacture, the Steam-Engine, Boilers, Gears, Belting, etc. etc. By EGBERT P. WATSON, late of the "Scientific American." Illustrated by eighty-six engravings. 12mo. . . $2 50

WATSON.—THE THEORY AND PRACTICE OF THE ART OF WEAVING BY HAND AND POWER:
With Calculations and Tables for the use of those connected with the Trade. By JOHN WATSON, Manufacturer and Practical Machine Maker. Illustrated by large drawings of the best Power-Looms. 8vo. $10 00

WEATHERLY.—TREATISE ON THE ART OF BOILING SUGAR, CRYSTALLIZING, LOZENGE-MAKING, COMFITS, GUM GOODS,
And other processes for Confectionery, &c. In which are explained, in an easy and familiar manner, the various Methods of Manufacturing every description of Raw and Refined sugar Goods, as sold by Confectioners and others . . $2 00

WILL.—TABLES FOR QUALITATIVE CHEMICAL ANALYSIS.
By Prof. HEINRICH WILL, of Giessen, Germany. Seventh edition. Translated by CHARLES F. HIMES, Ph. D., Professor of Natural Science, Dickinson College, Carlisle, Pa. . $1 25

WILLIAMS.—ON HEAT AND STEAM:
Embracing New Views of Vaporization, Condensation, and Expansion. By CHARLES WYE WILLIAMS, A. I. C. E. Illustrated. 8vo. $3 50

WOHLER.—A PRACTICAL TREATISE ON ANALYTICAL CHEMISTRY.
By F. WÖHLER. With additions by GRANDEAU and TROOST. Edited by H. B. NASON, Professor of Chemistry, Rensselaer Institute, Troy, N. Y. With numerous Illustrations. (*In press.*)

WORSSAM.—ON MECHANICAL SAWS:
From the Transactions of the Society of Engineers, 1867. By S. W. WORSSAM, Jr. Illustrated by 18 large folding plates. 8vo. $5 00

BOX.—A PRACTICAL TREATISE ON HEAT AS APPLIED TO THE USEFUL ARTS:

For the use of Engineers, Architects, etc. By THOMAS BOX, author of "Practical Hydraulics." Illustrated by 14 plates, containing 114 figures. 12mo. $4 25

BYRNE.—THE AMERICAN ENGINEER, DRAUGHTSMAN, AND MACHINIST'S ASSISTANT:

Designed for Practical Workingmen, Apprentices, and those intended for the Engineering Profession. Illustrated with 200 Engravings on wood, and 14 large Plates of American Machinery and Engine-work. By OLIVER BYRNE. 4to. Cloth . $6 00

CHAPMAN.—A TREATISE ON ROPE-MAKING,

As practised in private and public Rope-yards, with a Description of the Manufacture, Rules, Tables of Weights, etc. adapted to the Trade; Shipping, Mining, Railways, Builders, etc. By ROBERT CHAPMAN. 24mo. $1 50

SLOAN.—AMERICAN HOUSES:

A variety of Original Designs for Rural Buildings. Illustrated by 26 colored Engravings, with Descriptive References. By SAMUEL SLOAN, Architect; author of the "Model Architect," etc. etc. 8vo. $2 50

SMITH.—THE PRACTICAL DYER'S GUIDE:

Comprising Practical Instructions in the Dyeing of Shot Cobourgs, Silk Striped Orleans, Colored Orleans from Black Warps, ditto from White Warps, Colored Cobourgs from White Warps, Merinos, Yarns, Woollen Cloths, etc. Containing nearly 300 Receipts, to most of which a Dyed Pattern is annexed. Also, a Treatise on the Art of Padding. By DAVID SMITH. In one vol. 8vo. $25 00