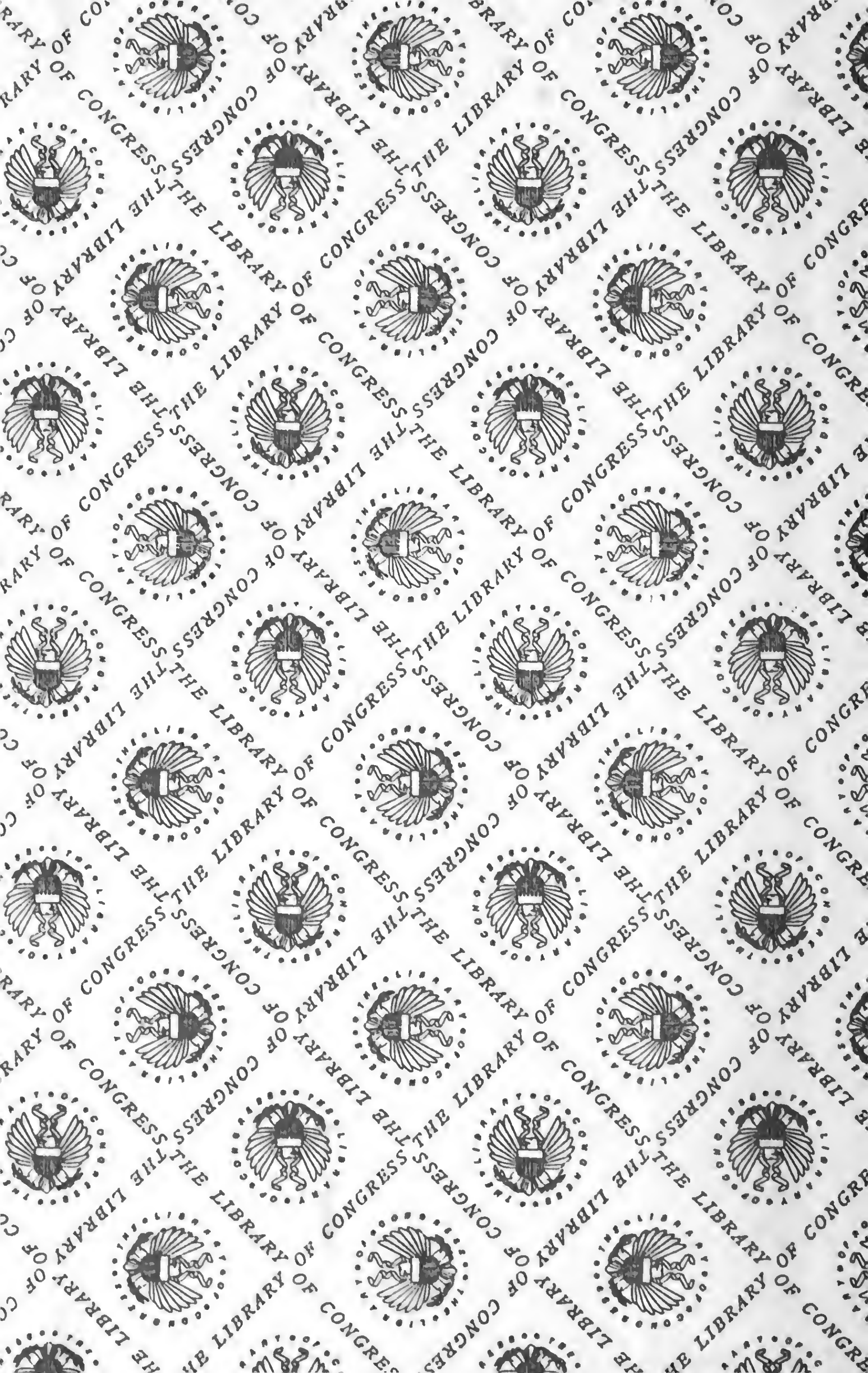

CHEMISTRY FOR LAUNDERERS

ALSO FOR

CLEANERS AND DYERS

BY

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CONTENTS.

(See Also Full Index, 183 to 189)

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CHAPTER I

INTRODUCTION

While it is impossible, or next to it, for every launderer to be a chemist, there is no reason whatever why he should not learn many valuable scraps of chemistry which will come in useful, not merely some time or other, but very frequently in his business. No doubt the time will come, and let us hope it is not very far off, when every launderer will have had a good chemical and engineering training. But that is not yet; and although one or two launderers may have found the time and energy to make a serious study of chemistry they are so few and far between as to be hardly worth considering. The average launderer has started with little technical knowledge, and what he does possess has been gained in the hard school of experience and paid for on the high scale of fees that are in vogue in that school. It is not as a rule until he has got over his initial difficulties and settled down into a nice comfortable paying business that he can spare sufficient time from the pressing worries of everyday routine to devote to anything else, however useful it might prove to him theoretically. By the time he is able to tear himself away from his business to this extent, he naturally feels that he has earned a long rest and is usually not at all inclined to take up the study of chemistry or anything else. Of course, there are exceptions; but that is the rule. Nevertheless there is no excuse for the launderer not giving his son who is to succeed him in the management of the business the opportunity of learning chemistry and engineering thoroughly, although for himself this may generally have been out of the question.

The serious study of chemistry requires several years of almost devoted attention in order to become even comparatively proficient in the subject, especially in analytical chemistry, which in its higher branches is almost an art or a science. Taking all this into account, however, there is no reason whatever why he should not pick up useful scraps of chemical knowledge as he does engineering knowledge; and even something more, provided always that he bears in mind the fact that they are only scraps and takes care not to fall into the many traps that stand in the path of the man with the little knowledge, proverbially such a dangerous thing.

Apparatus.

The first thing that stands in the way of the beginner who has not attended chemistry classes —and perhaps quite as much in the way of those who have—is the question of apparatus. He asks himself "Must I buy a whole outfit of apparatus before I can make use of the instruction provided?" To which I reply "No! There is very little you need buy; at all events at first." There are very few chemical experiments the launderer is likely to require which cannot be performed in an ordinary gallipot—*provided it is clean.* While it must be remembered that accuracy down to the minutest detail, and scrupulous cleanliness are the first essentials to any kind of practical chemical, or, in fact, any kind of scientific work, it must not be forgotten that all the early and most of the momentous experiments were conducted with home-made apparatus of what we should now consider the crudest description; and considering the difficulties, the results obtained were surprisingly accurate. Consequently, whenever it is necessary to buy anything more complicated than a jam pot I will duly advise the reader of the fact. The only time the launderer will require anything in the nature of accurate chemical apparatus will be when he may wish to carry out any quantitative analytical work. And although I do not recommend him to go very far in this direction without very much more thorough instruction than he can obtain from this little text book, or, for a matter of that, any other, there are certainly some simple analytical operations he might very well undertake, such as the rough valuation of samples of soap, tests for the hardness of water and so forth. When I come to this stage I will deal more fully with the apparatus which will be required.

Temperature.

In applying chemistry in the laundry, it is always of the first importance to remember that the people who have to do the practical work of the washroom and the starchroom are ordinary uneducated working people who will be pretty certain to make a painful mess of any complicated system, especially as they do not understand, in 999 cases out of a 1,000, the reasons for what they are doing. Consequently, while the manager should make full use of whatever knowledge he himself possesses, he should, when it comes to operations with which other people have to deal, get them down to the simplest basis. There is, however, one thing in which strict accuracy should be enjoined, and that is temperature. A thermometer, although it need not be used with every load of clothes that is washed, should occupy a conspicuous place in every washhouse. Temperature plays a very important part in nearly all chemical operations and most laundry operations are really chemical ones—and if the reader once understands that to get the best results it is necessary to work at the proper temperature for that operation, and no other, he will find that he will get on very much better. It may seem strange that I should insist so strongly on this question of temperature, and of buying a thermometer, but as I shall explain directly and frequently later on, the importance of this is very great. Many readers will say, ''Of course I have a thermometer!'' But there is no of course about it. A little while ago I had a letter from a querist asking whether there was not some instrument like a hydrometer by which she could tell whether the water was the right heat for flannels!

Effects of Heat.

Owing to its importance it would be well if I were to say a little more about this. Most chemical operations—or re-actions, as scientific people call them—will only go on at certain temperatures and under certain conditions. An alteration in the temperature or conditions may not only stop the re-action, but even reverse it. Chalk for instance, when strongly heated in a kiln, parts with its carbonic acid and becomes converted into lime. If, however, this lime is exposed to the air at the ordinary temperature, the action is reversed and it gradually becomes converted back again into chalk. This is only one instance out of a very large number, and while the launderer has not to deal with such extremes as the difference between the ordinary temperature of the air and that of a lime kiln, yet this question of temperature concerns him very intimately.

One of the kinds of ''dirt'' which he has to remove from the fabrics entrusted to his care consists of exudations from the skin, particles of skin itself and various other animal matters attached to the fibres. All these contain albumin or substances resembling it. Now albumin is rendered insoluble by heating it to a comparatively low temperature, so that the first operation in washing should always be to soak the garments in tepid water containing weak alkali, which assists in loosening the animal matter. Further, the fibre of flannel and woolen goods generally felts together at a high temperature, and chemical changes take place in it, so that it is most important that the temperature of the water in which flannels are washed should be kept as low as possible. The question of boiling linen and cotton goods is again worth considering.

The subject of starching is another important one in connection with changes of temperature, and I do not think this question has been nearly sufficiently studied by launderers. The temperature at which starch is dried before ironing is certainly a very important matter.

Cause and Effect.

One of the first things to learn in studying chemistry is that the same causes always produce the same effects, so that if you can once find out the exact conditions for securing the result you wish to obtain, you can always make sure of your result by employing like conditions. With this fact staring him in the face the launderer should have no excuse for allowing happy-go-lucky, rule of thumb conditions to rule in his washroom any longer. If you do not get the right result, be sure there is something wrong with your conditions, and do not rest until you have found out what is wrong and have put it right. Every launderer who has made even a moderate success of his business, knows that this success has been made by introducing and maintaining a rigid system in dealing with the various articles as they pass through the different departments. If he would introduce a similar rigid system into his washroom as regards the materials employed and the temperatures at which they are employed, he would soon find a marked improvement in the quality of the work turned out. The average washman is much too fond of using a piece "the size of a lump of chalk" instead of an accurately weighed or measured quantity, and this tendency is nearly always in need of restraint.

Scientific methods.

One of the first things to be done towards reorganizing the washroom on proper scientific lines is to keep a careful control of the stockroom. Never allow any form of either soap or alkali to be used in its crude state, but make up stock solutions and keep them in tanks in or adjacent to the washroom. Neither soap nor alkali should ever be thrown into the washing machine in the solid state as I have sometimes seen done. It destroys the goods and wastes the materials. Give distinct instructions as to the quantities to be employed, and make an occasional calculation to insure these quantities are not greatly departed from.

Another thing to be done in the way of insuring scientific accuracy, is to measure each machine and record the amount of liquor used in the wash and the approximate amount of soap and soda required for washing the different classes of articles. This should be posted up at the back of the machine for permanent reference.

All this talk about weighing and measuring may perhaps seem a little foreign to the subject in hand, but science has been defined as accurate measurement, and the first thing a student has to learn when he comes into a chemical, or any other scientific laboratory, is to weigh and measure with scrupulous exactitude. If the launderer learns nothing else from this book but to measure accurately all the materials and temperatures he uses in his washroom and starchroom he will have learned something of the greatest value.

The Nature of Things.

Like so many things in this world, material objects such as soap, soda, the fabrics which pass through the launderer's hands, in fact, everything that he can see and touch, are not so solid as they look. They are composed of very minute particles —so minute that you could not see them under the most powerful microscope—and these particles are separated from one another by quite appreciable distances—appreciable, that is to say, compared with the size of the particles themselves. The particles are always in a state of motion, the extent of the motion depending upon the temperature—the higher the temperature the more rapid the motion; consequently chemical changes take place much more rapidly as the temperature goes up. Even solid particles which are not too small to be seen under a microscope are in a state of rapid oscillatory motion; that is to say, although they do not move away from their position they swing backwards and forwards like tiny pendulums, only much more rapidly than the pendulum of a clock. This motion can be observed quite easily by rubbing down a little gamboge, or some other finely-divided solid in water and placing a drop under the microscope. This state of motion of finely-divided particles has an importance for the launderer, for it is on account of this that the cleansing of linen with water is a comparatively easy matter.

Surface Action.

There are certain other properties of matter that I must deal with before going farther, as they have an important bearing on laundering operations, as well as on cleaning and dyeing. There are probably few of my readers who have not noticed that water and some other liquids have a tendency to creep up the sides of a glass vessel in which they are contained. In a wide vessel this is not so very easy to see, but in a narrow one it is very noticeable. In such a narrow tube as is employed for thermometers, the water rises in the interior quite an appreciable distance above the level of the rest of the liquid if an open tube of this description is placed in water. If, however, a similar tube be placed in mercury, exactly the opposite effect is noticed; the mercury in the tube is depressed below the level of the rest of the liquid. In coloquial language, the water "wets" the glass, while the mercury does not. The former is attracted to the glass; while the latter is repelled from it. A greasy surface has exactly the same effect on water as the glass has on mercury—the water is repelled from the grease and consequently has no cleansing action on greasy fabrics if used alone. Soap and alkali, especially the former, quite apart from their specific action on the grease, greatly increase the tendency of water to "wet" things, and that is one of the reasons why they are so useful to the launderer. Another reason why soap is so valuable is that it greatly stimulates the movement of the solid particles referred to above and consequently enables the water to remove the dirt from the fabric by mechanical action.

Capillary Action.

There is another matter depending upon this: I referred just now to the tendency of water and certain other liquids, to creep up narrow tubes; well, all fabrics, or nearly all, consist of tiny tubular fibres, woven or felted together, and water has the power of creeping up these tiny tubes for quite a long way. If the water contains a dye, this is carried up with the water and deposited in the fabric.

Diffusion.

Yet another property of matter. If you divide a vessel in half by a vertical porous partition and place plain water on one side and water containing a dye on the other, you will find that although the liquids are exactly the same height on both sides of the partition and are kept apparently absolutely still, the coloring matter will travel or "diffuse" from one part to the other until there is the same amount of dye in all parts of the liquid. Even if by mechanical means you could put the heavier liquid containing the dye or any other soluble salts, such as soda, at the bottom of the vessel and the plain water on the top, you would find the same thing would happen. This is what happens when a washman by an unfortunate accident puts a red sock in with a load of whites, as probably many of my readers know to their cost. This property of diffusion is one of the reasons why we are able to dye goods at all.

Diffusion is not confined to liquids, but occurs even in the case of some apparent solids; while in gases, such as the air we breathe or the coal gas we burn, diffusion is far more active than in the case of liquids. Everyone knows how rapidly an escape of gas will make its presence felt, not only in the immediate neighborhood of the escape, but all over the building. This is due partly to the currents of air, but also to diffusion.. It is the same property of diffusion which causes coal gas to escape through the pores of an india-rubber tube.

Conduction and Connection of Heat.

Now, here is another point: Has it ever occurred to any of my readers to consider why they apply heat to a vessel at the bottom instead of at the top? The reason is that water is a very poor conductor of heat, and by means of suitable arrangements for heating a vessel at the top it is quite possible to have boiling water at the top of the vessel and a piece of ice at the bottom. In addition to water being a bad conductor, hot water is much lighter than cold water, so that in the experiment referred to the hot water being at the top stays there and is very little affected by the heavier cold water underneath. The Gulf Stream forms an excellent example of this; here you have a river of warm water running for hundreds of miles on the top of cold water and hardly mixing with it. When you apply heat at the bottom of a vessel the heated water being lighter, rises to the top through the middle of the liquid, while the heavier, cold water pours down the sides to adjust the balance, and a constant circulation is set up, so that the water is heated evenly throughout. This has a very practical application for the launderer in the case of boilers. In a badly constructed boiler or one in which scale is heavily deposited in some parts, it is quite possible for there to be quite large differences in the temperature of the water in the different parts of the boiler. Consequently an enormous strain is set up, which causes leakages and rapid deterioration of the shell.

Radiation, Reflection and Conduction.

While upon this subject I will explain the difference between radiation, reflection, and conduction of heat. Every launderer probably knows the different effect of opening a steam valve with a bright gun metal wheel and one of iron painted over. In the first place it will be so hot he can hardly touch it; while in the latter he can turn the valve without any inconvenience. The reason is that the heat from the steam in the pipe flows much more easily along the copper than along the iron and especially along the paint; that is to say, copper is a much better conductor of heat than iron. Again, if the hand be held close to a bright copper vessel on a cooking stove a much smaller sensation of heat will be felt than if it be held at the same distance from a black iron one; the heat radiated from the latter being much greater. The rule is that substances which are good reflectors, such as bright copper or white paint, are bad radiators. Consequently steam and hot water pipes should always be painted white or covered with that new metallic paint.

Light.

Light again cannot be left out of account in the introduction to notes on chemistry. In the first place it will be found that many chemical substances if placed in the light undergo important changes, which render them unfit for the purpose for which they were intended. Hydrogen peroxide, for example, decomposes rapidly if exposed to bright light, and everyone is familiar with the strong effect of sunlight upon moist linen hung out of doors; the effect of sunlight on fugitive dyes is even better known. Light is a particular form of force which is transmitted from a luminous body like waves traveling over the surface of the sea and certain kinds of light waves produce curious chemical effects in many substances. As already partly explained matter consists of tiny particles separated from one another by comparatively appreciable distances, and these light waves have the power of making some of these particles vibrate in time with themselves, just as the bricks of which a church is built will rock or vibrate in response to the sound waves from the large pipes of an organ. In the case of the light waves I have just been considering, the rocking or vibration of the particles under the influence of the waves of light often becomes so great that the complicated chemical compound falls to pieces and becomes something simpler. This is what happens in the case of a fugitive dye exposed to the sunlight, or of a piece of stained linen hung out in the open air.

CHAPTER II

CHEMICAL ARCHITECTURE

Before going any farther it will be necessary to say some more about the tiny particles of which material substances are made up, as the chemical nature of a body depends quite as much upon the way these particles are arranged as upon the differences in the nature of the particles themselves. When a metallic casting or forging is made, the particles are set in certain directions which in the relation of the particles to one another gives the metal sufficient strength to bear the strains put upon it. If, however, it be subjected to continuous vibration, such as a railway car gets in traveling at a high speed over the metals, or if the material be continually heated and cooled, as happens to the metal forming the bed of an ironing machine, the vibration causes the particles to set themselves all in the same direction and a large proportion of the strength of the material is lost; consequently it becomes unable to bear the strain, and some fine day, without any warning, the railway car axle or the bed of the ironing machine gives way. This property of metals to get "tired" so to speak, is well known to engineers, and is spoken of as the "fatigue" of metals. This peculiarity is very noticeable in working metals, such as hammering copper or drawing wire; after a short time the metal becomes brittle and has to be reheated or "annealed" before the work can proceed. In making a casting, there is always an outer "skin" to the metal, which possesses much greater tensile strength than the body of the metal inside, so that if, for example, some of the surface be planed off a calender bed to make it fit the roller better, the bed is appreciably weakened, not because of the comparatively small amount of metal that is removed, but because the "skin"—the strongest part—has been planed off. These are only a few instances, and many more might be given if space permitted.

The Composition of Water.

Now for something about the chemical properties of the particles. It is convenient to commence with the study of water, because it is one of the commonest substances, and make a good starting point into the bargain. If we pass an electric current through a liquid it apparently causes the particles composing the liquid to move, half of them with the current, and the other half against the current, so that at the terminals, that is to say, where the current enters and leaves the liquid, the particles are given off in the free state. In the case of water, we shall find if we try the experiment, that bubbles of gas are given off from each terminal plate, and if we collect the bubbles we shall find that twice as much gas is given off from the negative plate, that is to say, where the current leaves the liquid, as from the positive plate, where the current enters. We shall find also that the gas given off at the negative end will burn with a blue flame; while that given off from the other end will cause a glowing match to burst into flame. The former gas is known as hydrogen, and the latter as oxygen. We have seen that there are two volumes or two particles of hydrogen given off for every one of oxygen; consequently a particle of water appears to be made up of two particles or atoms of hydrogen and one of oxygen; or, to put it graphically, thus:

$$H—O—H$$

A large number of careful experiments made in different ways show that this is the case. It must be clearly understood that the particles or atoms are not mixed together like sand and sugar, but are very closely combined more like the links in a chain, and could not be separated by any ordinary mechanical means. This state is known as "chemical combination" as distinguished from the "mechanical mixture" of the sand and sugar.

Let us take another of the commonest things in the world, namely, the air we breathe. This contains oxygen among other things and there are several ways in which we can remove it, one of the easiest of which is by means of the pyrogallic acid and soda used for developing photographic plates; another method being by passing the air over red-hot copper filings. Suppose we do pass a measured quantity of air over red-hot copper, or, through this photographic developing solution, we shall find that about one-fifth of it has disappeared—this is the oxygen. The other four-fifths consist of a gas called nitrogen, besides very small quantities of other things which need not concern us for the moment.

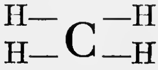
Ammonia.

Now suppose we take some of the hydrogen from our first experiment, mix it with the nitrogen just obtained and pass the electric discharge through it. We shall find that after a short time the mixture smells strongly of ammonia and further examination would show us that the nitrogen and the hydrogen had combined to form ammonia gas, one of nitrogen combining with three of hydrogen; so that we see that ammonia is:

$$\mathrm{N}\begin{matrix}-\mathrm{H}\\-\mathrm{H}\\-\mathrm{H}\end{matrix}$$

Marsh Gas.

If we were to collect some of the bubbles of gas which arise from stagnant marshy water containing decaying vegetable matter which we often see in ponds by the roadside, we should find, if we had the proper means of analyzing it, that is to say, splitting it up into its component parts, that it was made up of one part of carbon (charcoal, black lead, anthracite, etc., are more or less pure forms of carbon) and four parts of hydrogen, or to put it graphically

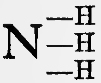
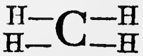


$$\begin{matrix}H-\\H-\end{matrix}C\begin{matrix}-H\\-H\end{matrix}$$

Similarly there are other compounds which contain even more particles of hydrogen, combined with one particle of the substance in question, but these will not concern us much at present.

Chlorine.

We have now before us the following types:—

Water.	Ammonia.	Marsh Gas.
$H—O—H$	 $N\begin{matrix}-H\\-H\\-H\end{matrix}$	 $\begin{matrix}H-\\H-\end{matrix}C\begin{matrix}-H\\-H\end{matrix}$

There is yet one more type necessary to complete the set, namely, that in which the particle of hydrogen combines with only one particle of another substance and we get that in hydrochloric acid (known in its impure forms as muriatic acid or spirits of salt). If we take a few drops of this acid or rather the solution of it which is sold commercially and add two or three drops of nitric acid to it, a greenish yellow gas will be given off with a very choky irritating smell. This gas is called chlorine and is the basis of all the chlorine bleaching agents. It combines with hydrogen so violently that if we mix the two gases and expose the mixture to sunlight an explosion will occur, and the resulting substance, known as hydrochloric acid, contains one of hydrogen united to one of chlorine, thus:

$$\mathrm{H—Cl}$$

We now have our types complete; hydrogen combining with chlorine one to one; with oxygen two to one; with nitrogen three to one; and with carbon four to one.

CHAPTER III

Alkalies

Going back to the beginning again, we find by experiment that water was made up of two particles of hydrogen to one of oxygen, thus:

$$H—O—H$$

Suppose we take a small piece of the metal called sodium, which at ordinary temperature is quite soft like cheese, although when freshly cut it has a bright metallic surface; cut pieces about the size of a small pea off it and drop them into a little basin of water, and we shall see that they cause great commotion in the liquid, flying about over the surface as if they were alive; while a stream of whitish matter is left as a trail, like the sparks from the tail of a rocket. When the pieces of sodium have come to the end of their course and disappeared in the water, we shall find that it has a soapy taste and will turn red litmus paper blue. Moreover, if we had applied a light to the particles of sodium we should have found that an inflammable gas was being given off, which would light and continue to burn so long as the action lasted.

This gas was hydrogen and what was happening was that the sodium was turning out part of the hydrogen from the water and taking its place, thus:—

H—O—H	Water.
Sodium—O—H	Caustic Soda.

forming caustic soda. If we continued to add sodium until all the water were decomposed we should get a solid mass of pure white caustic soda.

Sodium Oxide.

If we went on adding sodium after all the water had been converted into caustic soda and applied heat, a further action would take place, in which the remainder of the hydrogen would be turned out, forming:—

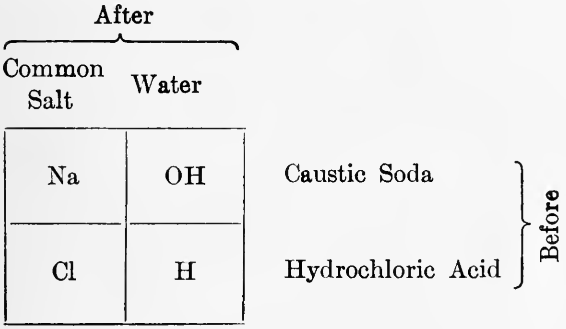
Sodium—O—Sodium

or sodium oxide with no hydrogen in it at all.

Alkalies, Acids and Salts.

The caustic soda, which we succeeded in making just now is a typical alkali. And we discovered, it had a soapy taste and would turn litmus paper blue. It has another property also: if we add dilute acid to it, say, the hydrochloric acid we were speaking of above, we shall find that if we add it little by little we shall arrive at a point when litmus paper ceases to be turned blue;

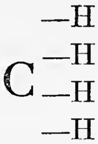
neither is it turned red. This is the neutral point when the acid and the alkali have extinguished one another, so to speak, by combining to form something else; in this case sodium chloride or common salt. In putting it graphically we find it convenient to write sodium and we cannot use the letter "S," for that is used to designate sulphur, so that in chemistry we employ the first two letters of its Latin name (natrium); consequently the action between the caustic soda and the hydrochloric acid may be put graphically thus:—



From the diagram we see that when the acid and the alkali act upon one another, salt and water are formed. In this particular case the salt formed is common salt—sodium chloride; but in every case where an alkali and an acid come together a salt of some kind and water is the result. For example, when oleic acid—the waste fatty matter from the candle factory—is mixed with caustic soda, sodium oleate and water are formed. Sodium oleate is olive oil soap; so that soap, although in some ways a complicated substance, is similar in its construction to common salt or sodium chloride; but of that more later.

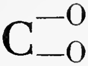
Sodium Carbonate.

For our next experiment, suppose we arrange a series of vessels connected together by tubing (quite an easy matter to do in a laboratory where we have the necessary appliances) so that we can burn a piece of charcoal in the first vessel and pass the products of combustion through some caustic soda solution in another vessel. If before the experiment we weighed the piece of charcoal and the vessel containing the caustic soda (to which, by the way, would have to be attached another vessel containing a substance which would retain any water lost by the caustic soda solution and carried forward by the current of air) we should find that the caustic soda had increased in weight by considerably more than the weight of the charcoal. As a matter of fact, determined by a large number of experiments, it has been found that in burning the charcoal, one particle of carbon, to use the chemical term, combines with two particles of oxygen to form a gas known as carbonic acid gas, and this gas is absorbed by the caustic soda to form sodium carbonate, which accounts for the increase of weight we observed. To go back to graphic diagrams we have marsh gas:—



$$\mathrm{C}\begin{matrix}-\mathrm{H}\\-\mathrm{H}\\-\mathrm{H}\\-\mathrm{H}\end{matrix}$$

Now we remember that oxygen combines with two of hydrogen to form water, that is to say, one of oxygen is equivalent to two of hydrogen. Consequently, if carbon combines with oxygen instead of hydrogen it will only require half the number of particles of the latter, and we should expect to find that carbonic acid gas is constructed according to the diagram:—

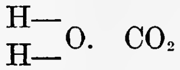


$$\mathrm{C}\begin{matrix}-\mathrm{O}\\-\mathrm{O}\end{matrix}$$

which experiment shows to be the case. For the sake of convenience this is written CO_2; the marsh gas referred to above being CH_4; water H_2O, and so on.

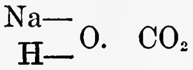
Sodium Carbonate and Bicarbonate.

There are two combinations of caustic soda with carbonic acid—the ordinary carbonate which we made just now, and the bicarbonate, these being formed according to the amount of carbonic acid present. The latter does not become a true acid until it is dissolved in water, so that carbonic acid proper is H_2O, CO_2, the two carbonates of sodium just referred to being:—



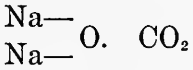
$$\begin{matrix} H— \\ H— \end{matrix} O.\ CO_2$$

Carbonic Acid



$$\begin{matrix} Na— \\ H— \end{matrix} O.\ CO_2$$

Sodium Bicarbonate



$$\begin{matrix} Na— \\ Na— \end{matrix} O.\ CO_2$$

Sodium Carbonate

Soda Crystals.

The last, or $Na_2 CO_3$, to put it in more convenient form, is the ordinary carbonate, with which launderers are so well acquainted under the forms of washing soda, soda crystals, 58 per cent. alkali, and soda ash, the differences between them being due to the amount of water they contain. If we take a solution of sodium carbonate, made by dissolving up any of the forms referred to above, and evaporate the water away by heating the solution in a glass or porcelain vessel, we shall see that when a certain amount of water has been driven off, the solution will begin to crystallize if allowed to stand. These crystals, however, are not pure sodium carbonate; in crystallizing a certain definite proportion of water becomes entangled in the crystals, and many crystals, which to all appearances are quite dry and hard, contain quite a large proportion of water combined with the substance in question. In the case of soda crystals or washing soda which is what we have just secured by allowing our concentrated solution to crystallize, the crystals contain no less than ten particles of water to each particle of sodium carbonate; so that when we buy our sodium carbonate in this form we are buying a large amount of water as well. The dry powdered alkali so much in use is practically pure dry sodium carbonate and is the most convenient and economical form to employ.

Potash.

Wood ash, known commercially as ''potashes'' and in a more refined state as ''pearlash,'' is very similar in composition to washing soda, the difference being that a metal called potassium replaces sodium. This metal resembles sodium very closely. When thrown upon water it turns out the hydrogen even more violently than the sodium does and the heat produced is so great that the gas usually takes fire of its own accord, burning with a bright violet flame in strong contrast to the yellow flame of the sodium. Not only caustic potash and caustic soda and the carbonates above referred to, but all the compounds of these two metals resemble one another very closely. At one time potash, obtained from wood ash and the ashes of seaweed was the common form of alkali in use, and it is only comparatively recent that the progress of chemical science has brought into use methods for obtaining the compounds of sodium from common salt. Consequently the alkaline materials obtained from sodium are now very much cheaper than the corresponding potassium compounds. As the letter "P" is used to denote phosphorus in chemical notation the first letter "K" of the Latin name of potassium (Kalium) is used as its symbol, so that the carbonates of potassium are written in chemical shorthand as:—

$KHCO_3$	Potassium Bicarbonate.
K_2CO_3	Potassium Carbonate (potashes, pearlash, barilla, etc.).

Unlike sodium carbonate, however, which, as just explained, crystallizes with ten parts of water, carbonate of potassium crystallizes with only two parts. Nevertheless, while ordinary washing soda will keep dry in an open vessel for any length of time, carbonate of potash attracts moisture from the air if not kept covered, and becomes sloppy.

Caustic Ammonia.

Curiously enough ammonia although it is a compound of nitrogen and hydrogen (see page 26) behaves just as if it were a metal like sodium or potassium and forms a compound with water—

ordinary liquor ammoniæ—and a series of salts. These do not greatly concern the launderer; except as a matter of general interest. Liquor ammoniæ, that is to say the solution of ammonia gas in water, which is in general use, corresponds chemically to caustic soda and caustic potash.

Just as potassium and sodium hydrates (caustic potash and caustic soda) have the composition

KOH and
$NaOH$

so ammonia gas when passed into water combines with it to form ammonium hydrate or caustic ammonia.

$$NH_4OH$$

Although it behaves so much like caustic soda and caustic potash, ammonia does not possess the same destructive action on fibres. Consequently it possesses many advantages for laundry use, as it can be used for washing flannels and delicate fabrics, where caustic potash or soda or even washing soda would be out of the question. It must be remembered, however, that ammonia turns white silk yellow and has the same tendency on white flannels; so that in spite of its advantage over the "fixed" alkalies, ammonia must be used with caution. Besides ordinary caustic ammonia, that is to say, the liquor ammoniæ just referred to, ammonia forms carbonates, just like sodium and potassium. They are not used, at all events to any extent, in the laundry, as the liquid ammonia is more convenient.

Borax.

This is a suitable place to refer to another alkaline substance which is largely used in laundries, namely, borax. This is a compound of soda with boracic acid. Like carbonic acid, boracic acid is a very weak acid and soda is a very strong alkali. Consequently the compound of the acid and alkali results not in a neutral salt, as would be the case of the compound of soda with hydrochloric acid, but in an alkaline salt. Borax acts very much like weak carbonate of soda and while it will soften water, neutralize acids, and act as a mild detergent has very little injurious action on fabrics.

Too Much Alkali.

Before leaving the subject of alkalies for the present, it would be well to say a word or two about one of the commonest—perhaps *the* commonest—fault of the launderer, namely, the use of an excess of alkali in the washing process. This is not only wasteful, but is one of the most usual causes of bad color and deterioration of linen. Careful experiments have shown that the habitual use of a hot solution of alkali, even when weak, has a destructive effect on the fibres of linen and cotton, especially the former. In most cases the use of an excess of alkali in the washer is due to either habit or ignorance, but some launderers of a scientific turn of mind may argue that because the mercerizing process, in which the cotton fibre is exposed to the action of strong alkali, actually strengthens the fibre, therefore the use of alkali in the wash water can have no injurious effect. It must be remembered, however, that the conditions are totally different; in the case of the mercerization, the alkali, although strong, is used cold, and is thoroughly rinsed out of the fibre when the action is complete; while in the washing process, the alkali, although comparatively weak, is used hot and the last traces are not always removed in the rinsing. Furthermore, there is a danger of the concentration of the alkali under the heat of the iron, if not completely rinsed out, and its action on the fibre at the high temperature of the iron would be considerable. Recent experiments show that even such a weak wash water as that containing 0.1 per cent. of sodium carbonate, that is to say, 1 lb. in 100 gallons of water, has an appreciable effect on the fibre if used repeatedly, as it would be in the ordinary round of the weekly wash, especially in yellowing it. I cannot point out too strongly the inadvisability of employing the excess of alkali, which is so dear to the heart of the average washman; it is remarkable how difficult it is to correct a bad practice which has gone on so long that it has become habitual. Carbonate of soda is bad, but caustic soda, which is so largely used in America, is very much worse. I shall, however, deal with this matter more fully in the chapter on the "Chemistry of the Washroom."

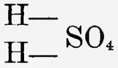
The Action of Alkalies on Wool.

Injurious as alkali is to linen and cotton, it is infinitely more so to wool and silk. So great is the injury done to these fabrics by alkali that the use of the fixed alkalies in washing woolens and silks should be rigorously excluded, ammonia being substituted. Potash salts are found occurring naturally to a considerable extent in wool, and carbonate of potash (pearlash) is therefore less injurious than carbonate of soda, but in spite of that it is not safe to use it; ammonia is much more suitable. It is very advisable also to employ ammonia instead of soda when washing delicate linen or cotton goods, and especially in the case of colored fabrics. If the color happens to be affected by alkali, as is not infrequently the case, it is much more readily restored when ammonia is used than when a fixed alkali is employed. A fixed caustic alkali, such as caustic soda or caustic potash, is most destructive to woolen or silk fabrics, and even the carbonated alkalies, if used in even weak solutions, have a tendency to render woolen fabrics harsh to the feel. While the greasiest woolens can be cleaned by a neutral soap solution (given sufficient time for it to act), yet where it is necessary to employ an alkali, weak ammonia should be used. Even ammonia has a deteriorating action on silk, and where an alkali is necessary, weak borax, say ½-lb to 10 gallons of wash water is the safest to employ.

CHAPTER IV

ACIDS

So much for alkalies. Acids do not concern the launderer very much directly, but they do occasionally, and in any case it is necessary to understand something about acids, as it is essential to the proper comprehension of many other things. I explained above that in the case of one acid —hydrochloric—its composition was made up of one particle of hydrogen and one particle of another gas called chlorine, that is to say, hydrochloric acid is chloride of hydrogen, just as common salt is chloride of sodium. It is the distinguishing feature of all acids without exception that they are salts of hydrogen. Thus sulphuric acid is hydrogen sulphate; phosphoric acid, hydrogen phosphate; acetic acid, hydrogen acetate; oxalic acid, hydrogen oxalate; and so on. This is equally true of the fatty acids which combine with alkalies to make soap, as we shall see later on; oleic acid, for example, is hydrogen oleate. Where an acid is of simple composition, like hydrochloric acid, only one kind of salt is possible, but where the composition is less simple, as in the case of sulphuric acid (oil of vitriol), two kinds of salts are possible. In chemical shorthand, sulphuric acid, or hydrogen sulphate, is written



$$\begin{matrix} H\text{—} \\ H\text{—} \end{matrix} SO_4$$

or, for convenience, H_2SO_4 and it will be seen from this, to compare it with hydrochloric acid,

$$H\text{—}Cl$$

that there are two hydrogens which can come into operation to form salts. Thus:

HCl	Hydrochloric acid.
$NaCl$	Sodium Chloride.
H_2SO_4	Sulphuric acid.
$NaHSO_4$	Acid Sodium Sulphate.
Na_2SO_4	Normal Sodium Sulphate.

Similarly:

H_2CO_3	Carbonic acid (solution in water $H_2O\text{—}CO_2$)
$NaHCO_3$	Sodium Bicarbonate.
Na_2CO_3	Sodium Carbonate (normal carbonate, washing soda, soda crystals, etc.).

Strong and Weak Acids.

What, to use a convenient term, is known as a strong acid, can turn out a weak acid and take its place as a rule in a chemical combination. For instance, carbonic acid is comparatively a weak acid, and if a carbonate such as washing soda (carbonate of soda) or chalk (carbonate of lime) be brought into contact with a strong acid, such as sulphuric acid, the carbonic acid is turned out and escapes as gas with much effervescence, while the sulphuric acid takes its place to form sulphate of soda or sulphate of lime as the case may be. This is useful to the launderer in many ways. If he is using unsoftened water containing lime salts, this is very likely to be deposited in the linen, causing not only bad color, but actually destroying the fibre. Acid will remove this and, after rinsing, the fibre will be entirely free from deposits of lime.

Lime and Lime Soap.

This is such an important point that it would be well to say a little more about it. The most familiar form of carbonate of calcium, or carbonate of lime, as it is perhaps more usually called, is chalk, which, although apparently formless, is not really so; under the microscope it will be seen to be composed of minute shells of tiny beings which are still found living in enormous quantities in the waters of the Atlantic and other oceans. When they die their shells fall to the bottom and form an ooze, which afterward becomes consolidated by pressure and forms chalk. There are, however, many well-known crystalline forms of carbonate of lime, such as marble and calc spar. When a hard water is softened in a washing machine by means of soda or some other alkali, as it usually is in laundries which do not possess a water softener, the lime salts are thrown out of solution as carbonate of lime. While a good deal of this is in a loose, formless, powdery condition suspended in the water, an appreciable amount of it is deposited as tiny sharp crystals in the fibres of the linen, and when dry has a most destructive action in cutting to pieces and wearing away the fibres. Much of the apparently unaccountable rapid wear on linen goods is due to this cause, which very few launderers take into account. By giving the linen a soaking in weak acid after the first rinse, these lime crystals are dissolved and rendered harmless, being entirely removed in the last rinse. If this is not done, a fresh deposit of crystals takes place in each wash of the garment, so that although in a single wash the quantity of carbonate of lime deposited is hardly appreciable, it increases rapidly until finally it becomes a most serious agent in the destruction of the goods.

There is another matter also in connection with this lime question, deserving of the most serious consideration; I refer to deposit of lime soap. As I explained some little time ago soap is a salt just in exactly the same way that common salt (sodium chloride) is a salt; instead of a combination between hydrochloric acid and soda, soap is formed by a combination between soda and a vegetable fatty acid, such as oleic acid—the principal fatty acid found in olive oil; so that olive oil soap is sodium oleate, just as washing soda is sodium carbonate.

We have seen that when washing soda and a lime salt come together, carbonate of lime is formed; an exactly similar thing happens when a lime salt and soap, the olive oil soap just referred to for instance, come into contact; instead of the carbonate of lime, oleate of lime—lime soap—is formed. This is an insoluble pasty material which causes a launderer no end of trouble. It forms the well-known deposit in his washing machine; it forms objectionable streaks and marks on his clean linen, and also the black specks which are not infrequent in the shirt fronts in some laundries using hard water; and last, but not least, an habitual deposit of this lime soap, together with lime salts referred to above, cause the linen to possess a dull leaden color, instead of the pearly whiteness it ought to have.

The easiest way to remove all this trouble is to put in a water softener, but without that, the acid bath after the first rinse will come to the launderer's rescue. Its action upon the deposit of carbonate of lime has already been explained; its action upon lime soap is very similar; the acid, being stronger, so to speak than the olive or other fatty acid of the soap, throws it out of combination, taking its place to form a salt with the lime. It is necessary to use the acid bath or acid rinse, hot, like the first rinse, otherwise the free fatty acid might form streaks of fatty matter on the linen, but if the water be hot, the globules of fatty matter are kept melted and carried off with the water.

The Use of Acetic Acid.

The next question arises as to which is the best acid to use for the acid rinse. Hydrochloric acid is not suitable, as in the hot water it would be somewhat volatile, and moreover the cheaper commercial forms of the acid contain iron, which would possibly help to discolor the linen. Sulphuric acid is very suitable if used in proper proportion, but it is essential that it should be *thoroughly* rinsed out; otherwise, if only quite a minute quantity of the acid be left in the fabric, it will concentrate when dry and char the fibres. Oxalic acid has many advantages and is largely used to follow the bleach, which seems to be an integral part of the average washing process in America, but this also, if not thoroughly removed, has an injurious action on fabrics. The best is acetic acid (known in the dilute state as vinegar). It is volatile, and any trace which may have been left in the goods will be completely driven off in the drying room; moreover, it possesses no injurious action on the fibres. For ordinary work a quarter of a pint of the commercial acid should be used to each 10 gallons of water in the washing machine. After the acid rinse can come the ordinary cold rinse with blue.

Acetic Acid.

Commercial acetic acid is obtained from the distillation of wood, being known as pyroligneous acid. After purification it becomes acetic acid and is used for various commercial purposes, one of the most important being the adulteration of vinegar. In commerce it is usually sold in casks, and has a strength of about 40 per cent. This is the material the launderer should use. Glacial acetic acid is practically pure acid and possesses the property of crystallizing below a certain temperature. It is much more expensive than the ordinary commercial form and there is no advantage in employing it.

Souring.

In addition to its use, which I have just described, for removing lime after washing, acetic acid is usually employed for "souring" after bleaching, in England, but oxalic acid is most favored in America—probably on account of convenience of carriage. I will describe the action that takes place, when I come to bleaching.

CHAPTER V

SOAPS

It has already been explained that a soap is as much a salt as common salt. The latter is formed by a combination of soda with hydrochloric acid, while a soap is a compound of soda or some other alkali with what is known as a fatty acid. Just as soda is not the only alkali which can form a chloride, so it is not the only alkali which can form a soap. Nearly every metal, such as calcium (lime), lead or copper, forms a chloride, and similarly these metals are quite as capable of forming soaps; although nearly all these soaps are insoluble in water. The animal and vegetable fats, of which there are a very large variety, resemble one another very closely; all are compounds of glycerine with one or other of the fatty acids. These, while they vary a good deal in composition, are very similar in their broad characteristics; the free acids, from which the glycerine has been separated, being greasy, water repelling, and having in appearance, feel, taste and smell, nearly all the characters of the complete fats. Practically all fats can be used for soap making, and are, except where their cost is prohibitive. In addition to the ordinary well-known fats and oils, such as tallow, olive oil, linseed oil, rape oil, cotton seed, palm and other vegetable oils, a large number of oils now obtained from tropical trees find their way to the soapmaker. Moreover, fish oils are used for making the cheaper kinds of soft soap, their evil odor being disguised by the more powerful one of nitrobenzol, which gives the smell and flavor of almonds.

Leaving fish oils out of the question as being quite unsuitable for laundry purposes on account of the evil smell they would inevitably leave behind, the value of a fat or oil for industrial purposes depends largely on its melting point, that is to say, on the amount of the fat known as stearin the oil contains. This fat on account of its hardness and high melting point is greatly valued for candle making, all the best candles, apart from wax candles, being made largely or wholly of this substance. As it has an important bearing on the subject I must devote a few more words to candlemaking before I deal with soapmaking itself. The first thing a candle maker does after cleaning the fat, is to separate the glycerine by treatment with steam at a high pressure, and thus secure the free fatty acid, or rather acids, for all natural oils and fats consist of a mixture of several fatty acids, the most common being oleic acid (the predominant acid in olive oil), palmitic acid (the principal acid in palm oil), and stearic acid (the chief constituent of tallow and the heavy animal fats). By processes which I need not describe here, the heavy fatty acids are then separated from the lighter ones, the former being used for candles, while the latter are employed for soapmaking and for manufacturing purposes, such as lubricating worsted during spinning. This light fat or oil consists very largely of oleic acid, and is known commercially as "red oil" on account of its color. I shall have occasion to refer to it again later.

Oils Used in Soapmaking.

As might be expected the character of the soap —I am referring now to "hard" soaps—depends very much upon that of the oils or fats employed in its manufacture. A soap made from tallow which consists largely of stearin will be hard and solid, and will possess a high lathering power; while one made from olive oil will be comparatively soft and will give a lighter lather. Although the lathering capabilities of a soap form one of the principal guides of the washman, yet this is a somewhat deceptive characteristic. Although an oil soap gives a comparatively poor lather it may be doing its work in the machine just as well as the mottled soap with a fine head of froth upon it.

Moreover, some vegetable oils which are not necessarily any better in their cleansing capabilities, give a very much stronger lather than others. Cotton seed oil, for example, when made into soap gives a good lather, while sesame oil, used very largely in making what are known as "olive" oil soaps gives a comparatively poor lather.

Mineral Oils.

To prevent confusion I may here say that the mineral oils, such as paraffin and petroleum, are not oils at all in the sense in which we have been using the word. Their composition is entirely different; they contain no glycerine and no fatty acid; they are what chemists call hydro-carbons, like coal gas or naphtha, and it is quite impossible to make soap from them. It is true they are sometimes incorporated with soap in small quantities with a view to increasing its detergent properties, but this matter will be dealt with later.

Hard and Soft Soaps.

Not so very many years ago when chemical manufacture was in its infancy, the alkali for soapmaking was not soda, but potash, and was obtained from the ash of seaweed and other plants, but with the invention of processes for making soda from common salt, soda rapidly replaced potash for this purpose. Soaps made from soda are comparatively solid, and are known as "hard" soaps; while potash soaps are quite soft at ordinary temperatures and are known as "soft" soaps. A temporary soap can be made with ammonia, but this can only be used in solution. Nevertheless, it forms a very useful soap and I shall describe it later. "Yellow" soap is somewhat different from ordinary hard soap and contains rosin, which replaces a certain proportion of fat.

Soaps are made by two main processes, the "boiled" and the "cold" process. In the latter the caustic soda and the oils are mixed cold, or but little heated, and the heat produced by the chemical action is sufficient to carry out the process. This method is, however, only used on a very small scale by perfumers and small toilet soap vendors and has the disadvantage that the resulting soap always contains an appreciable amount of free alkali.

Boiled soaps constitute well over 90 per cent of those on the market and are the only ones that need occupy the attention of the launderer. Soap-making now is conducted on an enormous scale, huge pans capable of making 20 to 30 tons of soap at a time being employed. Each pan is heated by two steam coils, one closed for heating purposes only and the other perforated, so that live steam can be blown direct into the liquid. This serves not only to supply heat, but to keep the mixture agitated while the operation is in progress.

Boiled soaps are essentially of two kinds—''curd'' soaps and ''fitted'' soaps. The best example of the latter is yellow soap. The first operation in making curd soap is to run in the requisite amount of melted fat, which may consist entirely of tallow, or of tallow mixed with other fats. A weak solution of caustic soda is then run in and steam turned on. It is necessary to begin with a weak solution, as saponification will not commence with strong alkali. As soon as saponification is proceeding satisfactorily, more and stronger alkali or ''lye'' as the soapmaker calls it, is run in, and the operation is allowed to continue until nearly the whole of the fats are converted into soap.

While soap is soluble in water it is not soluble in brine, and the next step is to throw into the pan, quantities of salt, which causes the soap to crystallize out at the top, the solution of the brine containing all the glycerine and impurities being at the bottom. This is now run off and is a valuable asset to the soapmaker, as the lye is run over to the glycerine plant, where it is recovered and purified. The demand for glycerine—chiefly for making dynamite—is very great, and the sale of the glycerine, which used at one time to be thrown away with the waste lyes, is now the most profitable part of soapmaking.

When the lye has been run off, fresh strong alkali is added, and the soap is boiled up again to insure complete saponification. After this the soap is allowed to settle and is run off into large moulds or "frames" as the soapmaker calls them, where it cools and solidifies. The sides of the frame are then taken away, the solid block of soap being left, which is cut up into bars.

Curd Mottled Soap.

The fats used for making a good curd soap should contain not less than 60 per cent of tallow. On account of the process of manufacture, it always contains a certain amount of free alkali, but for ordinary laundry purposes this is no drawback. Nevertheless, it forms an important reason why curd soap should not be used for washing flannels, woolens, colored goods or delicate fabrics. Mottled soap is, or should be, a curd soap. In the old days when chemical manufacture was in a crude state, the alkali employed contained several impurities including iron, which, when the soap was run out into the frames, settled out to form the well-known streaks or mottling. Nowadays the alkali contains no impurities of this kind to form the coloring matter, so that it has to be added artificially. Curd, mottled soap, is perhaps the safest soap for the average launderer to purchase for general use, as no means have yet been found for adulterating it. The proper mottling cannot be obtained unless a pure soap is employed, and the launderer should notice the character of the mottling and see that the "strike" is sharp and not dirty.

Soap Chips.

A form of soap which is very popular in America is known as soap chips, which contains very little water, and 70 per cent or more of fatty acid. Its great advantage is that there is practically no carriage to pay on water—a very important matter considering the enormous distances it sometimes had to travel. One of the drawbacks of this soap, however, is that a considerable separation of free fatty acid takes place on dissolving it, necessitating the addition of alkali to resaponify the fat and keep it dissolved. I shall deal further with this soap in the chapter on the washroom.

Yellow Soap.

Nearly all of the other soaps are fitted soaps, including yellow soap above mentioned. One of the principal constituents of this soap is rosin, which combines with alkali and acts very much after the manner of soap. For this reason, if present in proper proportion, the rosin should not be regarded as an adulterant. Nevertheless, the quantity employed should not exceed 20 per cent of the amount of fat. The process of making a fitted soap is very similar to that just described up to the point when the lye containing the glycerine is run off. The soap made thus is cleansed by adding water and boiling with steam. Strong brine is then run in and another boil given. When the correct point is reached, which requires a good deal of experience to determine, the brine is run off, a little water added, the whole is boiled with closed steam and the soap is run into frames to cool.

Adulterations.

This is the stage when the art of the sophisticator is brought into play. As soon as the soap is run into the frames, and before it has begun to cool—a process which takes place rather slowly—adulterants, such as silicate of soda, Glauber's salt, carbonate of soda, and—most important of all—water, can be added and "crutched" into the soap. The object of adding the other adulterants is to disguise the addition of water and make the soap appear strong and solid, when as a matter of fact it contains a large proportion of water. It is indeed remarkable how much water soap can be made to hold, if added under proper conditions, and still appear solid. Some of the soaps on the market are little better than water standing upright. A great fillip [smart blow] to the manufacture and sale of this class of soap was given a few years ago, by the increased importation of cocoanut oil, which has a remarkable capacity for holding water and yet appearing solid.

Most of the quick washer soaps—"quick waster" soaps would perhaps be a better name—are made from a mixture of cocoanut and cotton seed oils. The mixture of these oils makes a very good soap, but the temptation to lower the price by the addition of water and so attract the unsuspecting public is very great. This cocoanut-cotton-seed oil and water soap dissolves readily and lathers very freely, but is exceedingly wasteful. Our German friends describe it by the very appropriate name of "schwindel" soap. One drawback to the use of cocoanut oil for soapmaking is that clothes washed with it always possess a somewhat unpleasant smell, and the well-known odor of washing-day is mostly due to the use of cocoanut oil soap. I will describe later how the launderer can estimate approximately the value of the soap he is buying and guard himself from the frauds most usually practiced.

Oil Soaps.

Olive oil makes excellent soap and it was probably the first oil used in soapmaking. Marseilles and Castile soaps were made originally from olive oil, but nowadays sesame oil, made from the grain of that name, is largely employed for making so-called olive oil soaps. These soaps are very good and are largely used in the laundry, where they possess many advantages. One drawback is that they do not lather very freely and do not possess such strong detergent powers as tallow soaps, but as these soaps contain very little stearin it is very much easier to rinse the soap out of the goods than is the case with tallow soaps. Moreover, partly for the same reason oil soaps are very suitable for washing flannels, colored goods and finery. They should contain no free alkali, and that is another important reason why they should be employed for the purposes just mentioned.

Soft Soaps.

Soft soaps are made in a very similar manner to hard soaps, potash being employed instead of soda. The best soft soaps are made from olive oil, but linseed oil makes very good soap. Many other vegetable oils, also such as rape oil, are used for making soft soap. While rosin may be considered a normal constituent of yellow soap, it should be regarded as an adulterant if found in soft soap.

Special Soaps and Soap Powders.

Among special soaps I may mention first of all the soaps containing some of the lighter petroleum oil, which are now on the market. The oil is incorporated with the soap, usually at all events, by mechanical means after the soap is made. Experiments have shown that the addition of a small quantity of petroleum is a distinct help in the washing process, but, in the majority of instances, the smell of petroleum is very persistent, and even after it has apparently been completely removed will appear again on the clothes being warmed.

Another special soap is the soap powder which appears on the market in many forms. In making this the soap is first of all dried in a special machine in which the soap, which is cut up into strips, travels through the machine on a continuous wire band. This method is employed also for making soap chips. It is then ground to the finest power in a disintegrator. These powders, which usually consist of a mixture of soap and soda ash, with or without adulterants, vary very much in quality. Although there are a few good soap powders in the market, the majority are unqualified swindles. Like the little girl in the nursery rhyme "When they are good they are very, very good; but when they are bad they are horrid." Their value may be largely estimated by the amount of soap they contain.

Another soap used to some extent in laundries consists of soap dissolved in methylated spirit.

This soap is very convenient for finery and special work, as it is, or should be, neutral, carbonate of soda being insoluble in alcohol. The spirit assists the detergent action of the soap, and I have seen some beautiful results from silk washed with a soap of this description, the fabric having a particularly bright, fresh appearance.

Still another soap is the benzine soap used for dry cleaning. This soap does not contain benzine, but is dried by special means, so that it contains no water and will dissolve readily in benzine, giving a clear solution.

Ammonia Soap.

While discussing special soaps I must not forget to mention a very special soap, which launderers can make and use themselves without any difficulty. My readers will remember that I explained in a previous chapter that a soap is a compound of an alkali with a fatty acid; that the compounds of soda with fatty acids are hard soaps; while those of potash form soft soaps. Now ammonia acts almost exactly like caustic soda and caustic potash, although on account of its volatility it is not a fixed alkali. Ammonia forms compounds with free fatty acids, and although these are only of a temporary character, they are to all intents and purposes soaps and act just like soaps. By putting in his washer, oleic acid and ammonia, the launderer has a soap ready made. Oleic acid requires for saponification 6.0 per cent by weight of ammonia, that is to say, 10 lbs. of oleic acid require approximately 1½ pints of strong ammonia solution (specific gravity 0.884). In order to make quite sure that the ammonia is there in sufficient quantity, it would be advisable to add a slight excess. The detergent powers of this ammonia soap (10 lbs. oleic acid and 1½ pints of ammonia) would be equivalent to that of 13 lbs. or 14 lbs. of good oil soap. The oleic acid referred to is, as I have mentioned previously, the waste material from the candle works. and is known commercially as "red oil."

Monopol and Tetrapol Soaps.

Before I leave the subject of soaps I must not forget to mention the Monopol and Tetrapol soaps which are coming so much into use among cleaners and dyers. Monopol soap is a superfatted sulphonal castor oil soap and Tetrapol soap is a liquid soap made by mixing the above with carbon tetrachloride. The chapter on "Dyes and Dyeing" will explain a little what a sulphonated compound is. This particular soap has great advantages from the wet cleaner's point of view. It will mix with water in all proportions, does not form insoluble compounds with lime (lime soaps), has remarkable grease dissolving properties, and does not affect the most delicate colors.

Valuing Soap.

Now for some instructions as to the estimation of the value of the soap the launderer is using. Although the complete analysis of a soap is a complicated matter requiring extensive knowledge of chemistry and considerable analytical experience, it is a comparatively easy matter to arrive at a rough estimate of the value of any particular soap in a few moments. As I have explained above, the value of soap can for all practical purposes be gauged by the amount of fatty acid which it contains, and it is quite a usual thing to see a soap quoted as containing so much per cent of fatty acid. The easiest way to form a rough estimate of this amount is to have two tall glass jars of exactly the same pattern and to make up a standard solution of any well-known and thoroughly reliable soap, dissolving say, four ounces of this soap in water and making it up to exactly a quart.

When it is desired to test the value of a new consignment or new sample of soap, half an ounce should be carefully weighed out from the middle of the bar, and dissolved in water and placed in one of the tall jars. At the same time 5 fluid ounces (¼ pint) of the standard solution should be placed in the other jar and sufficient dilute sulphuric acid added to each jar to decompose the soap and throw down the fatty acid, which will immediately appear as a thick white, flocculent [wooly] precipitate. When this has been done, plain water must be added to each jar until the liquid in both jars is exactly the same height. After standing for, say ten minutes for the precipitate to settle, a glance will show how the amount of fatty acid in the two soaps compares. If a soap contains its proper proportion of fatty acid it is not likely to have much the matter with it in other respects. Fuller instructions for the analysis of soap will be found in the chapter on "Practical Chemical Works."

Warnings.

In valuing soap and soap powders there are certain things for which the launderer should always keep a watch. If he is buying a mottled soap, for example, he should see that he gets a "curd" mottled soap and not a "fitted" soap, which is only an imitation, being usually made from oil instead of principally from tallow. The difference in the appearance of the mottling between a real and a sham mottled soap should be enough to warn any observant launderer as to what he is dealing with. It is not necessarily that the sham mottled soap is a bad soap; it may have its full allowance of fatty acids, and yet, as the value of the oil from which it is made is so much less than that of the tallow from which it ought to have been made, the launderer may have a very bad bargain in buying it. If he purchases an oil soap as an oil soap, well and good, but if he purchases it as a curd soap he is probably not getting his money's worth.

Secondly, never buy a watered soap. You always get much better value if you buy a pure soap. It is not worth anybody's while to pay carriage, maker's profit and traveller's commission on water.

Thirdly, take care that the soap you use for your flannels and colored goods is neutral. The test for this will be found on another page.

Fourthly, I have seen it stated that "yellow" or rosin soaps gradually cause a brown color in linen. I have considerable doubt about the truth of this in practice, as I have seen linen which has been washed over and over again with yellow soap, still have an excellent color.

Fifthly, keep a careful watch on the smell of the soap you are using. Any unpleasant odor, however slight, has an inconvenient way of lingering in the clean linen and there is nothing more likely to cause adverse comment on the laundry and its methods than sending home clean linen with an unpleasant smell in it. For this reason it is never safe to use petrol or benzine or any soap containing petroleum in any form in the washroom, except possibly for some particularly dirty articles washed under exceptional circumstances. Even if the smell does not appear to be present when cold it will often reappear as soon as the article is warmed.

Lastly, take care not to use a soap or washing compound containing silicate of soda. I am continually receiving, for advice, specimens of table linen which have been absolutely ruined with washing compounds of this description.

CHAPTER VI

BLEACHING

Bleaching should not be a regular part of the laundry process, as, if the washing is properly carried out, bleaching should not be necessary, except in the case of certain articles which are stained, such as table linen, or articles which have been badly washed at other laundries and are properly treated for the first time. Where, as is unfortunately so often the case, excess of alkali is used in washing and the linen becomes yellow, it is necessary to bleach it frequently; otherwise its bad color becomes very objectionable. Also where shirts, collars and body linen have been badly washed, and the organic stains fixed in the fabrics by heat applied too soon, it is necessary to remove these stains by bleaching.

The Nature of Bleaching.

Before describing the different materials and methods used for bleaching, it would be well for the reader to understand the essence of the process. In the first place a colored substance is produced by a definite chemical combination and if that combination can be destroyed, the color will be destroyed too. Many dyes, for example, such as phenolphthalein, are colored only in the presence of alkalies or of acids as the case may be, and in nearly all instances further oxidation will form a compound which is colorless. This is not always so, for some colors, such as those produced by the naphthol dyes, cannot be destroyed by oxidation. In these cases the opposite course must be pursued, and instead of attempting to destroy the color by adding oxygen to the compound, oxygen must be taken away from it; that is to say, to use chemical language, it must be reduced. Bleaching with chlorine or its compounds is an instance of oxidation, and bleaching with burnt sulphur or hydradite or titanous chloride is an instance of reduction. An even simpler and more understandable method of oxidation is bleaching by means of hydrogen peroxide and I propose to take this first.

Hydrogen Peroxide.

Water, as explained previously, is a compound of one particle of oxygen with two of hydrogen, thus: H—O—H. By certain chemical means, which I need not enter into here, it is possible to work in another atom of oxygen, so that a compound such as this is formed: H—O—O—H which contains two atoms of oxygen instead of one. This extra atom is held very loosely, and if any readily oxidizable substance be present that substance takes up the extra atom and becomes oxidized at once, while the chemical compound in question, which is known as hydrogen peroxide, returns to the condition of ordinary water. Thus bleaching with hydrogen peroxide is a case of oxidation in its simplest form.

Hydrogen peroxide is usually sold in two strengths, known as 12 volume and 20 volume, which signifies that, say, a pint of 12 volume hydrogen peroxide is capable of giving off 12 pints of oxygen when decomposed, or 20 pints in the case of the 20 volume. As may be supposed, on account of its composition, neither form is very permanent, but the 12 volume, which is proportionately cheaper in price, is much more permanent than the 20 volume, and is best for the launderer's purpose. For general use in taking stains out of flannels, blankets, or finery of any kind, a 10 per cent solution of the 12 volume strength may be used just as it is. In order to make the peroxide keep better a small quantity of acid—usually phosphoric acid—is added, as this renders the solution much more permanent. When using it for laundry purposes it is a good plan to add a pinch of chalk or whitening to neutralize this acid.

Sodium Peroxide.

Just as sodium will replace the H's in water, so it will in hydrogen peroxide, and sodium peroxide (Na_2O_2) is formed. It is a well-known commercial product, and possesses the advantage over the liquid peroxide in being much more permanent. When dissolved in water and treated with acid it acts in exactly the same manner as hydrogen peroxide.

Nascent Oxygen.

One of the reasons to which hydrogen peroxide is believed to owe its strong oxidizing properties is that the oxygen is set free from the peroxide exactly at the spot where it is to be used and is in what chemists call the "nascent" condition, that is, the oxygen atoms have not formed any combinations among themselves, so that all their energies are available. It must always be remembered when bleaching or taking stains out of any fabric, that the oxygen atoms are no respectors of persons, so to speak, and will oxidize anything that is open to attack, whether it be the stain you want removed or the coloring matter with which the garment is dyed. Nevertheless, the majority of dyes are less readily open to attack as a rule than the matter which causes the stain, so that if the launderer proceeds judiciously he can generally succeed in removing the one without interfering much with the other. The important thing in applying all bleaches and stain removers is to confine their actions as closely as may be to the spot where the stain rests, and to rinse them out directly their work is accomplished, before they have time to turn their attention to the coloring matter in the garment.

Sodium Perborate.

Quite recently a new and most valuable oxidizing substance has appeared upon the market. Sodium perborate has been known for some time in the laboratory, but has only just become cheap enough to make it available for general use. It is by far the best and most convenient bleaching agent yet introduced for laundry purposes. It is a white powder and bears the same relation to ordinary borate, (borax) as sodium peroxide does to sodium oxide, the extra proportion of oxygen being directly available for stain removing. Sodium perborate, if kept dry and in a cool place, is quite permanent and all that has to be done to make it ready for use, is to dissolve it in water. When it has given up its oxygen, it goes back to ordinary borax, which is almost innocuous even to silks and flannels and can be used for removing stains from these fabrics as well as from cotton and linen goods. Its value is being so widely recognized that a number of compounds containing it are being placed upon the market under fancy names.

Chlorine Bleaches.

I now come to describe the chlorine bleaches, and it will be interesting to note that the active agent in the bleaching here again is oxygen, which is set free by the action of the chlorine. But before proceeding further I must give a short description of chlorine itself. If a drop of strong hydrochloric acid be placed in a test tube, two or three drops of strong nitric acid be added, and the mixture be warmed, the tube will be filled with a yellowish-green, intensely irritating, suffocating gas. This gas, which is chlorine, is a simple substance, like hydrogen or oxygen. It has a great affinity for hydrogen, and if a mixture of the two be brought into strong light they will unite with explosive force. It is this tendency to combine with oxygen (forming hydrochloric acid HCl) which is the essence of its use in bleaching. When brought into contact with moisture, chlorine gradually decomposes it, forming hydrochloric acid, and setting the oxygen free. It is this oxygen which exerts the bleaching action. Chlorine itself is too corrosive and dangerous to use for commercial purposes, except in special instances, so that some of its compounds, known as hypochlorites, are usually employed.

Bleaching Powder.

The best known of the bleaching agents which have chlorine as their active constituent is chloride of lime, or bleaching powder, which is made by passing chlorine gas over slaked lime in brick chambers, special precautions being taken to keep the temperature as low as possible; for, if the temperature be allowed to rise, a considerable amount of chlorate of lime is formed, which is quite useless for bleaching purposes, and if present in large excess might possibly be dangerous.

Bleaching powder varies very much in quality, the best powder being almost dry and powdery and containing about 38 per cent available chlorine. Poorer qualities may contain much less chlorine, and are frequently quite moist and full of large lumps. Solutions of bleaching powder, which by the way, is a hypochlorite of lime, are sometimes used in the laundry, and if employed, great care must be taken to obtain a clear solution free from any suspended lime. Bleaching powder always contains a certain amount of free caustic lime, and if this gets on to any fabric, the results will be disastrous. If solution of bleaching powder be employed, it must be a very weak one, a 2 per cent solution being quite strong enough.

For general laundry purposes, however, it is usually more convenient to employ the compound known as hypochlorite of soda, which a launderer can buy in strong solution, or make for himself from bleaching powder. In the latter case, a solution of ordinary washing soda or dry alkali is mixed with the proper proportion of bleaching powder previously worked up into a fine state with water, condensed or distilled if possible. The soda and the lime change places, forming carbonate of lime and hypochlorite of soda, which can be put into a tank or other suitable vessel and kept for use as wanted. As, however, the quantity of bleaching solution required in a laundry is, or should be, very small, the launderer will usually find it more convenient to buy his bleaching solution ready made, as it saves him a good deal of trouble. He can then dilute the strong solution as he requires it. The chemical way of writing sodium hydrochlorite is $NaClO$, and when this comes in contact with any substance which is readily oxidizable, the compound parts with its oxygen, becoming converted into ordinary sodium chloride or common salt—$NaCl$.

Chlorine bleaches do not interfere with the action of the soap, and the diluted bleaching solution may be put in the machine with the second soap. It is always found that it works much better after the excess of dirt and grease have been removed by the first wash. The bleaching should be followed by an acetic acid bath in the second rinse, as this helps greatly to get rid of any traces of bleaching material still left in the goods and to improve the color. As a matter of practice, the action of all chlorine bleaches is found to prove destructive, even to cotton fibres, if used upon them much, the chemical action not being really quite so simple as it is usually represented in text books, or for the sake of convenience in explaining matters to learners. Although the dirt stains are first attacked by the bleaching solution, this soon proceeds to attack the fibres and also to oxidize them. For this reason, bleaching should only be resorted to in case of absolute necessity, and not as a regular part of the laundry process. Most of the chlorine bleaches on the market are made by passing chlorine into a solution of caustic soda which is kept cool to prevent the wasteful formation of chlorate.

Electrolytic Bleaches.

The principle of producing a bleaching liquor by electrolysis, is, by passing an electric current through sea water or a solution of common salt. It is only quite recently that a practical apparatus has been placed upon the market. The effect of the passing of the current is to break up the salt into its elements sodium and chlorine. The sodium reacts with the water, to produce caustic soda, and the chlorine to produce hypochlorous acid, $HClO$. This unites more or less with the caustic soda to form sodium hypochlorite, $NaClO$, but I am inclined to think there is always a large quantity of hypochlorous acid in the free state. It is the best chlorine bleaching agent, and is comparatively harmless, besides being a very powerful antiseptic and deodorant.

Reduction.

While I am writing of bleaching, it would perhaps be well to say a few words of the opposite process. Bleaching with chlorine or with hydrogen peroxide is, as I have already explained, a process of oxidation. Now while the majority of natural coloring matters will yield to this process and become decolorized, there are a good many dyes in use upon which oxidizing compounds produce little or no effect, and if it should so happen that white goods become stained pink or any other color through contact with fabrics dyed with the substances referred to, the launderer will find it quite impossible to remove the color with any of the ordinary bleaching substances in general use. In order to get rid of the dye he must use the opposite method; instead of endeavoring to give the dye more oxygen, he must take oxgyen away from it, and there are two or three ways of doing this.

Most launderers are more or less familiar with the burnt sulphur process, used so largely for blankets and straw hats. In this case the articles are suspended in a chamber filled with the fumes of burnt sulphur, which has exactly the opposite effect to chlorine bleaches or hydrogen peroxide. While these are perfectly ready and anxious to part with their oxygen to any other substance which wants it, burnt sulphur—known chemically as sulphur dioxide or sulphurous acid—is itself hungering for oxygen, and is prepared to rob any other body of it where possible.

Consequently when a launderer fails to remove a stain with the other bleaches he should try sulphurous acid. This must not be confused with sulphuric acid, which is a different substance altogether. The sulphur dioxide can be obtained liquefied under pressure in syphons, just like soda water, and this form has its conveniences, but, generally speaking, the launderer will find it most convenient to make his sulphurous acid himself from sodium sulphite, which is a compound of soda with sulphurous acid. If another acid, such as dilute sulpuric acid be added to a solution of sodium sulphite, sulphurous acid is set free. Sodium sulphite can be obtained at any photographic dealers for a few cents a pound. After the stain has been removed it is only necessary to rinse the article in hot water, as sulphurous acid is easily removed.

There is a class of substances, known as stable hydrosulphites. These have a similar but better action than sulphurous acid and are largely used by cleaners and dyers. They go under various trade names, such as hydraldite, ronalite, etc.

An even more powerful reducing agent, that is to say, a substance which will take up oxygen, is titanous chloride, which is sometime sold under the name of ''stripping salts.'' Colors are discharged by it with great rapidity, and it has no injurious action on fabrics. On account of its scarcity, however, this substance is very expensive, and can only be used for removing stains or doing special work. Solution of titanous chloride is so useful for stain removing that it should be kept in every laundry ready for emergencies.

CHAPTER VII

STAINS, AND THEIR REMOVAL

Judging from the queries I receive, stains and their removal offer one of the most serious problems with which the launderer has to deal, and the consideration of the subject comes in its natural place after treating of the different kinds of bleaching reagents. As a general rule, to which, however, there are a few important exceptions, the principal difficulty, from a chemical point of view, is not the removal of the stain, but the finding out the nature of the stain. When once this is known, the task of removal proceeds on perfectly well known lines, except in those cases where the stain can only be removed by removing the fabric as well.

The first thing which should always be done when a stained fabric has to be dealt with, is to endeavor to ascertain the nature of the stain; and the experiments should always be conducted on a small portion of the stained area, and, whenever possible, on that portion which is least likely to attract the attention of the observer when the article is in use. What the launderer frequently does, is to try, first one thing and then another on the whole of the fabric, instead of proceeding by making little tests as just recommended. The consequence of this is that if his methods are not almost immediately successful, as not infrequently happens, he runs the risk of doing considerable damage to the fabric.

There are so many ways in which stains may occur, and so many different kinds of fabrics—white and colored—upon which the stains may be, that more often than not, the satisfactory removal of a stain requires the services of an expert, properly-trained chemist; but by carefully following out instructions, taking care to mix as much brains as possible with the chemicals, there is no reason why a launderer should not achieve a satisfactory amount of success in dealing with stains.

For testing purposes, the launderer should possess at least the following:—

Dilute hydrochloric acid, the strong, pure acid diluted 1 to 10 parts of water; hydrogen peroxide, or sodium perborate—the latter for preference—methylated spirit; solution of methyl orange (dye); chloroform; benzine; bleaching powder; sodium sulphite; potassium ferrocyanide solution; stripping salts. Most of these chemicals are required not only for making the tests, but for removing the stains also.

Acids and Alkalies.

In making the tests, the first thing to do is to ascertain whether the stain is acid, alkaline or neutral. Dip the stained portion in a little distilled water in a saucer, and add one or two drops of the solution of methyl orange. If the color changes to yellow, alkali is present; if to red, acid is there. A test can, of course, be made with litmus paper, but the test just indicated is much more delicate. The quantity of acid or alkali discoverable in the fabric, even if it had been brought in contact with considerable quantities in the first instance, would probably be very small, and might not seem to change the color of litmus paper. The dye known as phenol-phthalein is very useful as a test for alkali; in neutral or acid solutions it is quite colorless, but the least trace of alkali develops a very marked rose color. If it is found that acid is present, it should be removed by ammonia or weak carbonate of soda (washing soda). If the stain be alkaline, it may yield to acetic acid, but in all probability it will be necessary to bleach it with bleaching powder solution, hypochlorite of soda, hydrogen peroxide or sodium perborate, according to whether the material is linen (or cotton) or wool.

Aniline Dyes.

If the stain be of a pink or other marked bright color, it is probably due to either a fruit stain or to an aniline dye. In the former case, it should be removed by sodium perborate or bleaching powder, which will also in many cases remove aniline dyes. If it will not yield to this treatment, try sulphite of soda dissolved in water, to which is added some hydrochloric acid. The proportions required would be 1 ounce of sulphite, half an ounce of hydrochloric acid or oxalic acid, if hydrochloric is not available, ½ gallon of water. If this fails, try titanous chloride solution. As a preliminary to these operations it is always well in the case of pink or other stains, which appear to be due to fruit or a dye, to try the effect of alcohol. This will sometimes remove them by itself, and in the case of fruit stains the alcohol, even if it will not remove the stain, will dissolve the sugar and gummy or resinous substances present, and thus render the subsequent task of removing the color easier.

Green Stains.

Green stains, due to leaves, will very often come out with alcohol. This should be followed by a little peroxide or perborate.

Chloroform is often of considerable assistance in removing stains of the characters just described. This used with alcohol will take out a great many vegetable stains and many dyes.

Walnuts.

Stains on table linen are sometimes caused by walnuts, either fresh or pickled, and are due to tannin. They are best destroyed by the mixture of acid and sulphite of soda described above.

Photographic Stains.

Photographic stains are of a very similar character to those caused by walnuts, and can usually be removed by the mixture of acid and sulphite. Sometimes, though not often nowadays, photographic stains are due to silver nitrate, in which case they must be treated in the same manner as marking ink (which see).

Iron Stains.

Iron stains frequently trouble the launderer. They may be due to various causes, the iron being derived either from the water, the outer case of a metal washing machine, a galvanized tank, which has been allowed to go rusty, or from the steam pipes, etc. More than one case has come under my notice where many of the goods washed at the beginning of the week or in a particular washing machine have been badly stained with iron. This was eventually traced to the condensed water in the steam pipe, which had been lying over the week-end and contained a considerable amount of iron rust. As soon as steam was turned on, this water with the iron was blown into the washer and stained the linen badly. Quite a considerable proportion of the stained articles submitted to me contain iron.

The test for iron is a very simple one; the material is treated with a few drops of dilute hydrochloric acid to dissolve the supposed iron (which is nearly always present as oxide or hydrate) and then one or two drops of solution of potassium ferrocyanide are added. If iron be present, a blue color (Prussian blue) will be produced. The removal of iron stains is effected by means of acid. If reasonably fresh, they will come out with acetic acid or oxalic acid (1 in 20), but if long standing and thoroughly boiled into the goods, the stains are not at all easy to remove. In such a case, hydrochloric acid must be resorted to, care being taken to rinse out the acid as soon as it has done its work. One of the advantages of the acetic acid bath in the second rinse, is that it will remove any fresh iron stains as well as lime, and prevent any likelihood of serious trouble from this cause.

Copper Stains.

Copper stains sometimes occur in the laundry. They usually consist of copper soap off some copper vessel used in the laundry, and I had a case recently of some window curtain blinds, which had been washed with the brass rings on, and the copper soap formed in the washer had stained the fabric badly in the neighborhood of the rings. The best way to remove it is with hydrochloric acid (1 in 10) taking care to remove the acid, after the stain has been destroyed, by thorough rinsing. If it is not known for certain that the stain is due to copper, but its presence is only suspected, the best test is to dissolve a little of the stain in hydrochloric acid and add a few drops of potassium ferrocyanide; if copper be present a reddish brown precipitate, looking rather like red current jelly, will be produced, or if only in very small quantity, a red coloration.

Writing Ink.

Among the most common stains in a laundry are those of writing ink. This liquid is made by mixing an infusion of galls with solution of sulphate of iron or green vitriol. So long as it is preserved from the air, this solution is practically colorless, but as it combines with oxygen, it gradually turns black. The consequence of this is that the manufacturers are obliged to add a coloring matter to the ink, known as a "provisional coloring matter" and this consists usually of aniline dye, from which the inks derive their name of blue-black, violet-black, etc., according to the nature of the dye employed. When the ink dries and is exposed to the air jet, black tannate of iron is formed in the course of a day or two. A fresh ink stain can almost be washed out, the remaining coloring matter, which consists almost entirely of the aniline dye, being readily removed by solution of bleaching powder or sodium hypochlorite, or perborate. Long standing ink stains will frequently yield to this treatment also. Another method is to dissolve the stain with solution of oxalic acid (1 in 10) neutralizing the acid with sodium carbonate (washing soda) or ammonia directly the stain has been removed, to insure that any acid not rinsed out shall not act upon the fibres. If any iron still remains on neutralizing, a brown spot will probably appear, which must be removed by a further treatment with acid and again neutralizing. The spot should always be well rinsed after treatment. It should be remembered that many writing inks, if allowed to remain long, have a very bad effect upon the fibres and such spots are always liable to go into holes.

Marking Ink (Silver).

Marking ink stains form another frequent problem for the launderer, and a very difficult problem, too. The essential portion of marking ink, as in the case of the writing ink just referred to, is colorless in most cases, consisting of a solution of a silver compound which darkens on exposure to light, forming within the fibres an insoluble black pigment, and the coloring matter which is present in fresh marking ink is due to suspended carbon, which enables the person using it to see what he is writing, the actual silver pigment appearing later as described. This silver pigment is of a very permanent character, and very difficult to remove; in many cases it is practically impossible to move it without destroying the fibre as well. In most cases, the task of removing marking ink is one of such difficulty that it can only be attempted with success by an expert analytical chemist. One method of removing marking ink is to treat the stain, first of all, with solution of iodine, which, if it acts, changes the silver into iodide, and then to remove this with cyanide of potassium solution. This substance is frightfully poisonous, and is dangerous "to have about the house" if it can be avoided. Another method, which is always a last resource, is to treat the stain with strong hydrochloric acid, which converts the silver into chloride, and to treat this immediately with strong ammonia, which dissolves it. In most cases marking ink stains are best left alone, as attempts to eradicate them as a rule only make matters worse.

Grease Stains.

Grease stains which will not come out in the ordinary process of washing are best removed with carbon tetrachloride, a heavy, volatile, colorless liquid, which is an excellent solvent for grease, and possesses the advantage over benzine that it is not inflammable. As it is much more poisonous than chloroform, however, great care must be taken in using it. In taking out grease stains it must be remembered that candle grease nowadays, except in the best candles which are made of stearin or rarely of wax, consists largely or wholly of paraffin, which is quite unaffected by soap and water, but dissolves readily in carbon tetrachloride.

Many people in using a solvent for the removal of grease take some of the liquid on a pad of some material and rub the spot with it. This is quite the wrong way to go to work. If the stains are small in area, the best way is to place a pad of blotting paper under the stained spot and drop the solvent on the top. If the stain is extensive, put a little of the solvent in a basin and dip the stained portion of the fabric in it; then squeeze it out and dip again until the stain is removed, giving the spot a final rinse with some fresh, clean solvent.

Paint Stains.

Paint usually consists of some insoluble coloring matter, such as barytes or umber, mixed with a vegetable drying oil, usually linseed. When the oil is exposed to the air, it "dries," that is to say, becomes oxidized into a hard varnish, which not only fixes the coloring matter in its place, but acts as a protective covering to the wood or iron work upon which it is spread. In order to remove paint stains, it is necessary to use a solvent, such as carbon tetrachloride or benzine, to dissolve this dried oil. On account of the nature of the material, it is necessary to rub the stain with a pad of cloth dipped in the solvent. Comparatively fresh paint stains come out fairly easily, but when they are long standing they are not at all easy to move. Strong ammonia is a distinct help in the removal of paint, oil and grease stains.

In removing tar or heavy grease stains, it is a great help to rub the stain with a soft fat, like butter or cocoanut oil, and then remove the two together with carbon tetrachloride or benzine.

Printing Ink.

Printing ink is an oil varnish, containing lamp black, or some other coloring matter, and must be treated in the same way as an ordinary oil paint.

Blood and Albuminous Stains.

Blood and albuminous stains, that is to say all stains from the human body, are removed in much the same manner, namely, by soaking in cold or very lukewarm water with a little weak alkali.

Albumen is coagulated by heat at quite a moderate temperature, and when once it has reached this stage it is not at all easy to remove. The yellow stains which frequently appear on collars and cuffs are due to rubbing against the skin, and are of an albuminous nature. Where they have been boiled into the linen the only way to remove them is by bleaching with a hypochlorite. Strong ammonia is of great assistance in removing all stains of this nature. Blood stains due to venous blood usually come away quite easily by soaking in tepid water with ammonia or other alkali, but arterial blood appears to form some compound with the fibres, and is much more difficult to remove. Ammonia is the best solvent, and even obstinate blood stains can usually be removed by prolonged treatment, followed by a little oxalic acid and thorough rinsing. Old blood stains, whether venous or arterial, require prolonged soaking in water before any other treatment is applied.

CHAPTER VIII

SOLVENTS

I now come to the consideration of the various solvents used in the laundry and cleaning and dyeing industries. The most important is naturally water, in regard to which I must point out in passing that its solvent powers increase rapidly with its purity. Consequently, soft water is far better for all cleaning purposes than hard water. It is, however, with the other solvents that I wish to deal now. With the exception of benzine and solvent naphtha, solvents other than water are only used in very small quantities for the local treatment of spots and stains, and among them may be included alcohol, ether, chloroform, carbon tetrachloride, carbon bisulphide, turpentine and other essential oils.

Benzine.

In the first place, benzine must not be confounded with benzene. The former is obtained from petroleum, and the latter from coal tar oil. Benzine, which is also known as petrol, benzoline, petroleum spirit and petroleum ether, is obtained by the distillation of crude petroleum. This substance, obtained from oil wells in America, the Caucasus, Borneo, and other parts of the earth, consists mainly of a series of very similar compounds called paraffins, of which methane, or marsh gas, is the lowest term. The composition of this is one particle of carbon combined with four of hydrogen, and every step up the series is made by substituting one atom of carbon combined with three of hydrogen for one particle of hydrogen, thus:—

CH_4	methane.
$CH_3—CH_3$	ethane
$CH_3—CH_2—CH_3$	propane.
$CH_3—CH_2—CH_2—CH_3$ ...	butane.
$CH_3—CH_2—CH_2—CH_2—CH_3$	pentane.

and so on, as simple as A B C.

Different Paraffins.

All the different products of petroleum in the market are mixtures of these substances. The lowest, such as methane, are gaseous, and are found in abundance in the gases given off from the petroleum wells; next come the very light volatile oils, such as petrol and benzine, then the burning oils used in the household lamps, then solar distillates used in gas works to enrich coal gas, then the lubricating oils and vaseline, and lastly, solid paraffin wax. These are all contained in the crude petroleum, and are separated from one another by distillation in the same way that whisky is separated from water. Each fraction, as it is called, however, does not consist of one paraffin only, but of several, generally four or five. Consequently, if we warm benzine, for example, the lowest of the series which happens to be present will begin to volatilize, although it may be there in comparatively very small quantity, and the point of volatilization of the next one present may be very much higher. This vapor, with the air, will form an explosive mixture, and if it comes in contact with a light will explode and fire back, and set the whole of the benzine alight. This shows the reason for the elaborate precautions employed in dry cleaning work, and the necessity for the greatest care to be observed by any launderer employing small quantities of benzine for any purpose in the laundry.

It must be remembered that, in spite of its volatility, benzine vapor is much heavier than air, and will travel along the bench or the floor for several feet, and if a light happens to be at that distance away a catastrophe is almost inevitable. As an illustration of this, I remember an accident which occurred some years ago in a works where I was engaged at the time. Some workmen were told by the manager to empty a cask containing a gallon or two of heavy oil residues, and they proceeded to empty it into the coke about ten feet or more away from the boiler fire. The vapor in the cask, however, traveled to the fire, and a serious explosion resulted.

Sulphur Compounds.

Among the other hydrocarbons contained in the crude petroleum, for it does not consist entirely of the paraffins, are a certain proportion of sulphur compounds, some of which, like thiophene ($C_4 H_4 S$) are well known, but there are a number of others not so clearly defined, and it is to these that the unpleasant smell is due. Benzine which has been thoroughly purified from sulphur compounds has a much more ethereal odor than the liquid in common use. The smell which remains in the goods after the dry cleaning process, is caused by the more heavy of these sulphur compounds, which remain in the goods, and require long "stoving" to drive them off.

Solvent Action of Benzine.

Benzine is an excellent solvent for all oils and fats, and as a good deal of dirt is attached to the fibres of garments by means of grease, a considerable proportion of it will come away as soon as the grease is removed by the benzine. Where it is necessary to deal with specially dirty garments, or portions of garments, in the dry cleaning process, it is necessary to employ an anhydrous soap, that is to say, a soap which is very nearly free from water. Benzine is sometimes added in small quantities to soap used for ordinary wet washing, and some launderers make a practice, with very dirty loads, of adding a pint or so of benzine to the first wash. Benzine used in this way does certainly assist considerably in cleansing, not probably so much by dissolving grease as by increasing the surface action of the soap. There is a certain amount of danger in using benzine in this way, as a case occurred not long ago, when the vapor issuing from the gland of the machine caught fire.

Benzene.

Benzene, benzole, and solvent naphtha are all names for the light tar oil obtained from the tar produced in gas-making by subsequent distillation of the oil. Commercial benzene contains other substances besides that known chemically as benzene, such as toluene and xylene, although this does not affect to any extent its usefulness for cleaning purposes. Benzene is quite as good a solvent as benzine, and the reason why it is not used much for cleaning purposes is on account of its increased cost. Benzene, and other substances of the same order, found in coal-tar oil, form the starting-point of nearly all the dyes used in modern industrial operations.

Alcohol.

Alcohol is a good solvent for sugar, and many stains of an organic nature caused by fruit, grass, or leaves, the alcohol dissolving the resinous matter which frequently accompanies them and renders then difficult to remove. Generally speaking, however, ether is better for removing green stains caused by grass or leaves. Fresh ink stains will frequently yield to alcohol. For the benefit of those who are interested in the chemistry of the different substances they are using, I may remark that an alcohol is a hydrate of a hydrocarbon, in almost the same way that sodium hydrate is a hydrate of sodium.

CH_4	methane.
$Na. OH$	sodium hydrate.
$CH_3\ OH$	methyl alcohol.
C_2H_6	ethane.
$C_2H_5\ OH$	ethyl alcohol (ordinary alcohol).

Amyl Alcohol, Glycerine and Ether.

Besides these alcohols, there are several others, known as the "higher alcohols," all formed on exactly the same plan. One of them is amyl alcohol, which is sometimes used for removing spots. Another alcohol of a rather different kind is glycerine, which, combined with fatty acids of different kinds, forms the whole of our oils and fats. Ether stands in the same position to alcohol as sodium oxide does to sodium hydrate. It forms an excellent solvent for oils and fats, and is largely used for this purpose in the laboratory. It is, however, extremely volatile. Ether is very useful for dissolving stains caused by leaves and fruit juices, being better than alcohol for this purpose. One drawback to the use of ether is its extreme volatility.

Carbon Tetrachloride.

Carbon tetrachloride is an excellent solvent for fats, and possesses the advantage of being non-inflammable; in fact it forms a very good fire-extinguisher. It is, however, more volatile than benzine; consequently in a mixture of carbon tetrachloride and benzine, the former, when the mixture is exposed to the air, evaporates first, and the proportion of benzine gets higher and higher until the mixture consists practically entirely of benzine. The notion, therefore, that a mixture of carbon tetrachloride and benzine can be safely considered non-inflammable is fallacious. Carbon tetrachloride is very similar in composition to methane, consisting, as its name indicates, of one atom of carbon united to four of chlorine, thus:—

CH_4 ... methane.
CCl_4 ... carbon tetrachloride.
$CHCl_3$ ... chloroform.

The drawback to its general use is that it is distinctly poisonous.

Chloroform, Turpentine and Carbon Disulphide.

Chloroform belongs to the same series as carbon tetrachloride, and is three parts of the way between methane and the last-named substance. It is a very powerful solvent, dissolving fats and oils with ease. It forms also an excellent solvent for many dyes. Turpentine, which is obtained by distilling the juice that exudes from certain pine-trees when an incision is made in the stem, is the type of all essential oils. These substances are found in varying but usually very minute quantities in flowers and other parts of plants. They usually have a very pleasant and powerful odor, and possess strong solvent properties for oily and waxy matters. Carbon disulphide is used as little as possible on account of its very unpleasant smell. It is a very good solvent for fats and oils, and sulphur dissolves in it very readily. It forms also one of the best solvents for india-rubber.

CHAPTER IX

STARCHES AND OTHER STIFFENING AGENTS

Crystalloids and Colloids.

I must now say a few words about two important groups of substances which are distinguished in chemistry by the names of crystalloids and colloids. My readers so far have only been introduced to the former in earlier chapters, but I shall now have to consider the latter class also. Salt, soda, borax and sugar are good examples of crystalloids; while starch, glue, and animal membranes are examples of colloids. Crystalloids form definite crystals when a solution containing them is concentrated; and these crystals, although they may differ in size and even to some extent in shape, always present definite angles, and these angles are always the same for the same substance. They are soluble in water in the true sense of the term and readily diffuse through animal membranes; that is to say, if a bladder partly filled with a solution of common salt, for example, be floated on clean water, the salt will "diffuse" through the bladder into the water outside until the strength of the salt in the water and in the solution in the bladder is the same. Colloids, on the other hand, such as gelatine and starch, do not dissolve in water in the proper sense of the term, they only absorb it or mix with it, and when the water is evaporated off they do not crystallize. In some cases where they appear to do so, microscopical examination shows that these are not really crystals. Then again, they possess none of the properties of diffusion, such as crystalloids have, and if, for example, a starch paste were to be placed in a bladder and floated on water as in the last experiment, the starch would still remain in the bladder for as long as you like to leave it floating.

Starches.

Starch is a typical colloid; it mixes with or swells up in water, does not form crystals, and even the so-called soluble starches are not soluble in the same sense that common salt is soluble. Starch grains, which are obtained from the seeds or roots of plants, possess, as a rule, very characteristic shapes, but these forms do not grow in the same way that a crystal does, but layer by layer like the bricks on a wall. All starches possess the same chemical composition, but probably the internal arrangement of the particles of which they are made up varies in some way, so that, although their percentage composition is the same, their mechanical properties differ a good deal, as every launderer knows. It must, however, be perfectly clearly understood that these are not chemical differences, as we understand the word at present, but mechanical ones. When once a starch is dissolved or mixed with water, its structure is changed in some way, and it is not possible to get back the original starch grains if the water is driven off, only a horny mass remaining behind, which in most cases, at all events, will not redissolve.

Forms of Starch Granules.

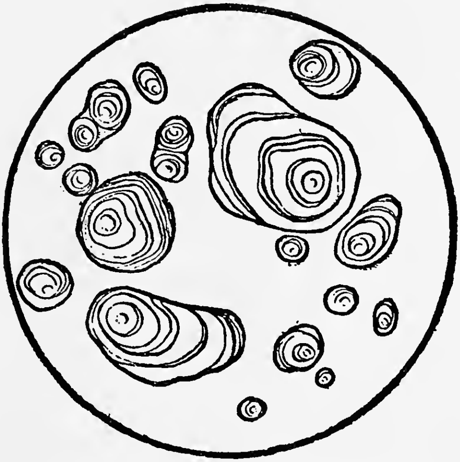
On the following pages are illustrated the forms as they appear under the microscope of the principal starches used in the laundry industry. As will be seen, they are very characteristic and differ considerably from one another both in size and shape. Potato starch, or farina, as it is frequently termed in the laundry industry, is the largest of all the starches, and rice starch is the smallest. The manner of growth of the starch granule is very well shown in the case of potato starch. In every granule will be found a spot or hilum whence the growth starts, and the starch is piled on this layer on layer. In maize starch the hilum shows as a cross, and in rice starch the hilum, if present, is too small to be noticeable. The granules in sago starch are large, although somewhat smaller than potato starch granules. In making the drawing from the microscope, I think I have drawn them just a little larger than they really are. Wheat starch consists of a number of more or less circular granules of comparatively large size, as well as a number of tiny ones.

Properties of Starch.

Each granule of starch appears to be inclosed in an envelope composed of substance known as starch cellulose, which very closely resembles the starch substance composing the mass of the granule. If the starch is placed in cold water, it does not dissolve unless this outer protective covering is broken. The granule will absorb water and swell up, but will not distribute itself through the water at all. If, however, the granules are crushed so as to break this envelope, the contents swell very much, and by repeated washing with cold water the whole of the interior can be dissolved, leaving the envelope behind. The main substance of the starch is colored blue by a solution of iodine in potassium iodide; while the envelopes are colored a dull yellow by the same reagent. If boiled in water, however, the starch cellulose is converted into ordinary soluble starch.

Gelatinized Starch.

As every launderer knows, a remarkable change occurs when raw starch is heated in water; the granules swell up and burst, and the starch matter soon becomes evenly distributed through the water as a gelatinous mass. This paste can be diluted by adding more water, and the starch, if properly mixed, will still remain evenly distributed through the solution, which simply becomes thinner in proportion to the dilution. If a few drops of solution of iodine in potassium iodide be added, the deep blue color, already referred to, is produced, and this forms a most delicate test for the presence of starch. Some starches offer a much greater resistance to the gelatinizing action of hot



Potato Starch (Farina).

water than others, rich starch being much the most resistant. According to one observer, the following are the temperatures at which gelatinization occurs for the different kinds of starches:—

Starch.	Temperature at which gelatinization occurs.
Potato (Farina)	149 deg. Fahr.
Wheat	158 ” ”
Maize	167 ” ”
Rice	194 ” ”

The different granules in the same sample of starch do not break up all at once, those most newly formed going first, while the oldest are the most resistant. The following are the temperatures at which the most resistant granules gelatinize:—

Starch.	Temperature.
Potato (Farina)	149 deg. Fahr.
Wheat	158 ” ”
Sago	165 ” ”
Maize	171 ” ”
Rice	194 ” ”

Starch Paste.

In its natural position in the plant, starch represents stored up energy, ready for use when the young growing plant requires it, and one of the first things that happens when a seed germinates is for the starch to be converted, by means of a ferment called diastase, into sugar, which the plant uses partly as a building material and partly as fuel, so to speak, to supply the energy required for cell formation. The sugar being soluble can be transferred at once in the juices of the plant to where it is required. The stages through which the starch passes are first soluble starch, then two or three different forms of dextrin, and then sugar. When barley is moistened and kept in a warm place, as it is in a malt house, the embryo plant in the seed immediately begins to grow, sending out a miniature stem and rootlet and at the same time producing diastase which acts upon the starch in the manner just described. If some malt extract, which contains diastase, be mixed with starch paste, the changes which take place can be readily followed by taking samples at intervals of say five or ten minutes, and testing them with a drop of iodine dissolved in potassium iodide. At first the starch gives the well-known deep blue color with the iodine; then this color changes to brown as the starch is converted into dextrin, and finally no color is produced on adding iodine, the complete change into sugar having taken place. Dextrin, by the way, is made on the commercial scale by baking starch in an oven, and is used for such purposes as coating the backs of postage stamps.

Malt Extract and Diastafor.

Some launderers use malt extract for dissolving the old starch out of the shirts and collars, the diastase in the malt converting the starch into sugar which dissolves in the breakdown water and is thus easily removed. When the old starch comes away, most of the dirt and yellow stains come with it, so that the washing process then becomes quite easy. There is no reason whatever why this process should not be a regular part of the washroom system. The action of ferments, or enzymes, as they are called, such as diastase, are not thoroughly understood. They are capable of promoting such an action as the union of starch and water in enormous quantities, quite out of proportion to their own mass.

Starch paste made in the ordinary way consists of a mixture of starch and what is known as soluble starch. This material is thrown out of solution, if mixed with alcohol, as a white powder, but under the microscope it can be seen that, like unaltered starch, it consists of small granules without any structure. The amount of soluble starch in the paste in the ordinary way depends a good deal upon the length of time the starch has been boiled; and that is one reason why, in working the boiled starch process, good results depend so much upon accuracy of manipulation. It will be obvious, also, from the previous description of the modifications through which the starch passes, that very important changes must take place in the boiled starch when the goods are subjected to the high temperature of the drying room.

The Viscosity of Starch.

The proportion of soluble starch to ordinary starch in starch paste varies not only with the different forms of starch, but with the process of manufacture and also the viscosity of the starch varies as well. It is necessary to free the crude starch from albuminous matter; and this is done either by treatment with dilute alkali and acid or by fermentation, and the properties of the starch obtained by the two methods vary considerably. The methods used in drying the starch have an even more important influence upon its character, as the following experiments will show:—

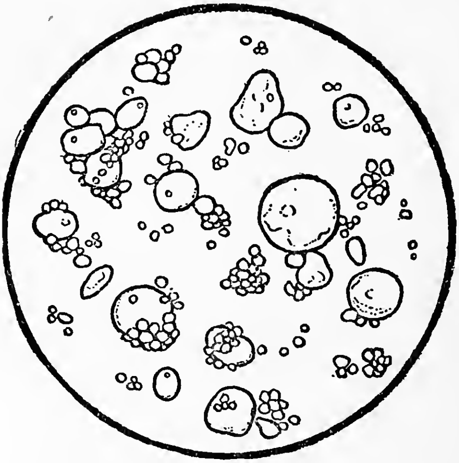
Starch No. 1 was dried while very moist at 122 deg. Fahr. and afterwards dried at 212 deg. Fahr. for 24 hours.

Starch No. 2 was dried while very moist, under reduced pressure, at the ordinary temperature of the air and then for 24 hours at 212 deg. Fahr.

Starch No. 3 was dried at a reduced pressure and finished at a temperature below 86 deg. Fahr.

Comparing them by finding what weight was required to make a small disc of glass sink through the paste, and taking the viscosity of No. 1 as 1·0, the relative viscosity was:—

No. 1...	1,000
No. 2...	2,306
No. 3...	3,288



Wheat Starch.

The Manufacture of Starch.

The starch granules, as they are formed in the cells of the plants, lie embedded in the proteid matter of the cell, as well as entangled in the network of the cells themselves, and the principal problem in the manufacture of starch is to free the granules from the glutinous and cellular matter with which they are mixed.

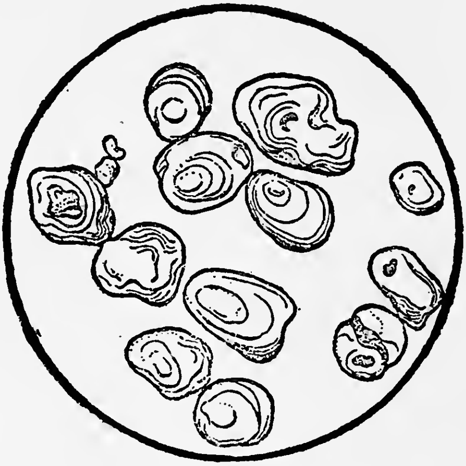
With some starches, this is a comparatively easy matter, but with others—notably rice starch—the problem presents considerable difficulties. In the first instance, the starch grains are washed out of the cellular matter by water and are then freed from adhering foreign matter either by fermentation or by the action of alkalies and acids.

Potato starch is the easiest of all to prepare, as the grains come away so freely from the cellular entanglement; the tubers are first washed, then rasped by machinery, and the pulp is subjected to various washing processes to remove the granules from the cells.

In preparing wheat starch, the grain is first separated by fermentation or by Martin's process, in which the starch granules are washed away from the gluten.

In the case of maize starch, the grain is softened with water and fermentation is allowed to commence before it is ground; or, by another method, the fermentation is omitted and hot water is employed. The pulp thus formed is washed through sieves, which permit the grains to pass through, while the albuminous matter is retained.

Sago is obtained from the pith of a palm tree, which is felled and cut up into lengths, from which the pith is extracted, the starch being removed simply by washing. This product is known as sago flour and is subsequently purified after importation into this country.



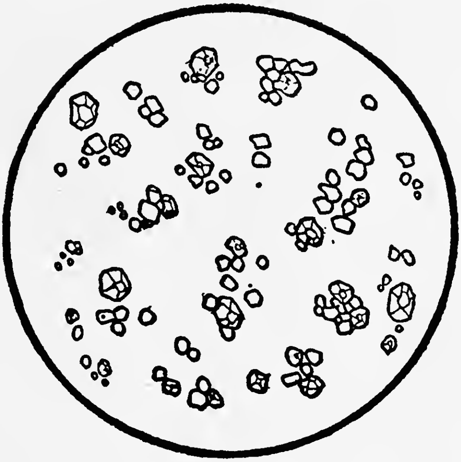
Sago Starch.

Rice starch, the most important of all the starches from the launderer's point of view, is, as already stated, by far the most troublesome to free from glutinous matter and it is necessary to employ caustic soda for the purpose, either with or without fermentation.

Attention has already been called to the important influence of the temperature and other conditions on the drying of the starch. In many starches, considerable loss occurs through the formation of dextrin on the outside of the masses of the starch.

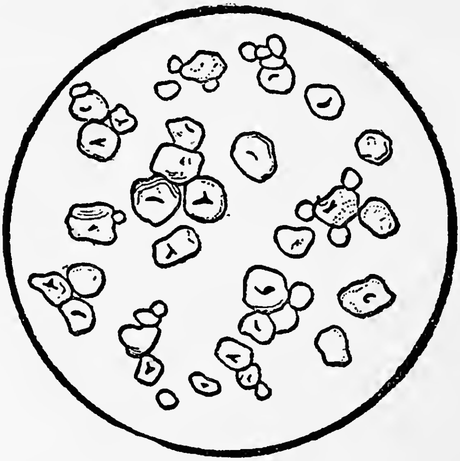
Action of Alkali and Acid on Starch.

Diluted alkali is without action on the starch, but if any be present in starch paste it helps to clear the solution by dissolving the starch cellulose it causes no alteration in the viscosity of the starch. If the alkali be neutralized with acid, the starch still remains transparent, while the viscosity is unaltered. If, however, a slight excess of acid be added and the starch paste be boiled, it is gradually converted into sugar. Dilute ammonia has no action on starch or starch paste, but strong ammonia acting upon starch for several



Rice Starch.

days converts it into soluble starch. Strong alkalis cause raw starch granules to swell up, and, as in the case of gelatinization, potato starch is the most readily attacked, while rice starch is the most resistant. If raw potato starch be treated with dilute hydrochloric acid for some days, it is converted direct into soluble starch without going through the paste stage. Glycerine dissolves starch completely.



Maize (Corn) Starch.

Lime has a curious effect on starch, entering into some kind of combination, and when in this state, the starch cannot be detected by any of the usual chemical tests, iodine showing no blue color. Consequently, starch should always be made up with softened or condensed water.

Thick and Thin Boiling Starches.

When ordinary "thick boiling," that is to say unaltered, starch is acted upon by acid, important changes take place; resulting ultimately, as stated above, in the formation of sugar. The intermediate stages, however, deserve careful attention from the launderer. The chemical difference between starch and sugar is the addition of water to the starch group of atoms.

$$\underset{\text{Starch.}}{C_{12}H_{20}O_{10}} + 2H_2O = \underset{\text{Grape Sugar.}}{C_{12}H_{24}O_{12}}$$

The first action of the acid is to hydrolyze, that is to say, to add water to the starch cellulose forming the outer coating of the starch granule; the next important step is the formation of dextrin, the intermediate product between starch and sugar; and, finally, sugar itself. As the conversion gradually takes place, the starch paste gets thinner, until finally it is converted completely into a crystalline substance, and the solution becomes perfectly clear. By regulating the proportion and action of the acid, the process can be stopped at any required stage.

The old way of making thin boiling starch was to add a considerable amount of acid, and when its action had gone far enough, to remove it by washing the starch. The present method, however, is to add a very little acid, and when its action is finished, to neutralize it with borax or some other alkali. The suspended starch is mixed with 0.2 to 0.4 per cent of acid, usually sulphuric acid; the liquid portion is removed by allowing the starch to settle centrifugally, and then heated at about 150° Fahr. until a solution of the starch becomes sufficiently thin. The acid is then neutralized and the starch dried. By varying the conditions, thin boiling starches can be obtained, varying from ordinary thin boiling starch used at the proportion of 1 lb. to 1½ lbs. per gallon of water, up to thin boiling starches in which as much as 5 to 6 lbs. per gallon still gives a clear solution.

Acetates of Cellulose and Feculose.

Cellulose enters into several combinations with acetic acid to form acetates, either by the action of glacial acetic acid or acetyl chloride. Cellulose tetra-acetate is a beautiful product, and films deposited from a solution in chloroform are most brilliant, colorless and very strong. These products are finding considerable application now in the manufacture of artificial silk. They should be watched by launderers with care. One of the cellulose acetate products is now on the British market under the name of "Feculose." It is obtained by the partial action of glacial acetic acid on starch; and, owing to the clearness and brilliancy of the film it deposits on fabrics, especially colored ones, with which it is brought in contact, it bids fair to be of great service to the laundry industry.

Other Stiffening Agents.

In addition to starch, several other colloid, that is to say, gluey substances are used upon fabrics to impart stiffness to them. Ordinary gelatin is used considerably for stiffening silks and finery, as ordinary starch makes such articles too stiff on the one hand and has a tendency to give a nasty, shiny surface on the other. Gelatin and some of the gums are used instead.

Gum Tragasol.

A somewhat remarkable product obtained from the locust bean, common in countries bordering on the Mediterranean and largely used as the basis of most of the patent foods for cattle and horses, is now attracting great attention. An exceedingly tough jelly known as "gum tragasol" is obtained from the kernel of these beans, and, either alone or combined with starch, is already on the market for laundry purposes. This gum is extraordinarily tough and pliable, and can be used either by itself or in combination with starch or with weighting agents, such as china clay, for filling or strengthening fabrics. It seems to be quite an ideal substance to use for table linen and napery; while for delicate articles, such as muslins and similar finery, it should prove very valuable for stiffening them without destroying their pliability.

Borax in Starch.

As borax is so frequently used in starch, it would not be out of place to say something further about it here (see also page 38). It has often puzzled me why launderers use it at all in their starch except to neutralize any lime which may be present in the water employed for making up the starch. As far as I am aware, it can serve no other purpose, except possibly to keep the iron from sticking. In the first place, soft water should always be employed wherever possible for starching, and especially for making up the starch in the first instance before diluting. In the second place I feel sure that even if it be an assistance, launderers use a very great deal too much borax, and this excess of borax in the starch is the cause of many of their troubles, especially the cracking of collars.

CHAPTER X

FUELS

Considering what a very important item the fuel bill is in the laundry, it is well worth the while of the launderer to get a thorough understanding of the nature of fuel and combustion. In the first place, the only portions of the fuel, of whatever kind it may be, which are combustible and therefore useful for producing heat, are carbon and hydrogen, and their combinations with one another. In the process of combustion, the carbon and hydrogen enter into chemical combination with the oxygen of the air, a large part of the chemical energy which runs down, so to speak, being converted into heat. The hydrogen burns into water and the carbon into carbonic acid gas. The heat of combination of the hydrogen with the oxygen is more than four times as much as that of carbon, weight for weight, but as hydrogen in the gaseous form is only one-twelfth of the weight of carbon, a gas rich in carbon, such as good coal gas, is far more valuable as a fuel in, say, the gas engine, than a gas which contains a much larger proportion of hydrogen. I will, however, refer to the different varieties of gaseous fuel later.

Carbonic Acid and Carbon Monoxide.

Hydrogen burns direct into water straight away without any intermediate stage, and if a cold piece of metal, for example, be placed for a few seconds over a gas flame, it will be found covered with little drops of water. Carbon, however, burns in two stages, forming a combination of one part of carbon to one part of oxygen—carbon monoxide or carbonic oxide (CO), and then a second compound of one part of carbon to two of oxygen—carbon dioxide or carbonic acid gas (CO_2). The former is exceedingly poisonous, as it enters into combination with the red coloring matter of the blood, even if present in the air in only small quantity, and the blood is consequently unable to take up oxygen. Moreover, in cases of partial poisoning with carbon monoxide, the blood takes a long time to get back to its normal condition. To breathe air containing a considerable proportion of carbon monoxide for any length of time means almost certain death from suffocation, and it is this gas remaining in the passages of a coal mine after a gas explosion which usually causes far more deaths than the actual explosion itself.

The Dangers of Carbon Monoxide.

From this the reader will see the importance of stopping at once any leaks of gas, however small, and of carrying away by means of efficient ventilation, or in some special manner, the burnt gases from gas irons and gas-heated ironing machines, for it must be noted that coal gas contains from 8 per cent. to 12 per cent. of carbon monoxide. To habitually breathe air containing even a very small amount of carbon monoxide causes chronic headaches and general lowering of health, so that if it is only for the sake of keeping the workers efficient, this matter should receive careful attention.

The Composition of Coal.

I have already referred to some of the compounds of carbon and hydrogen known as the paraffins, although this is only one series out of many. Nevertheless, ordinary paraffin oil, which, as I have stated in a previous chapter, is a mixture of many "paraffins," will serve as an example to commence with. If a small quantity of paraffin oil be thrown upon a hot fire, part of it will burst into flame, while another part will be broken up by the heat, a large amount of soot being set free. Now this is exactly what happens when a bituminous or "gassy" coal is thrown upon the fire. The best way to get an idea of the composition of coal is to study what happens when coal is distilled at a gas works for the purpose of making coal gas. The coal is placed in a retort or D-shaped vessel, made of clay, and kept red-hot by a fire underneath. Various gases are given off, and coke, consisting principally of carbon and mineral ash, is left behind. A good deal of tar and tarry oils condense on passing out of the retort, as well as ammonia compounds; while other substances, such as sulphur compounds and more ammonia, are removed in the purifying processes, leaving finally the coal gas, as we know it, to be sent into the mains.

When the two principal products of this operation—that is to say, the gas and the coke—are burned separately, they burn with practically no smoke, and yet we have seen that when burned together, by throwing the coal on a fire, they produce a good deal of smoke. It is obvious that it cannot be the fault of the coke, and our experiment with paraffin oil confirms the deduction that the smoke is due to the imperfect combustion of the other part of the coal. Consequently, if a launderer wishes to avoid a smoky chimney, he must do one of two things: he must either burn coke, or anthracite (which is a sort of natural coke), or he must so adjust his boiler fire and the draught of air as to burn the gaseous part of his coal completely.

With a mechanical stoker, which feeds finely broken coal continuously and distributes it over the fire, the difficulty is solved, because the coal falls upon the fire in such small quantities at a time that it does not cool it appreciably, and the gases given off are readily burned; but where, as in a laundry boiler furnace, the coal has to be placed on the fire in considerable quantities at a time, the problem is a different one. It is impossible to prevent the smoke being produced, or, on account partly of the local cooling of the fire and partly of the large quantity of air which would be required at that particular spot, to burn it immediately. The important thing is to keep half the fire bright, and then the carbonic acid produced by the hot fire will form carbon monoxide with the carbon of the smoke, and this again will be completely burnt further up the flue, so that the resulting gases will be smokeless.

The Ash in Coke.

In considering the relative merits of coal and coke, it must always be borne in mind that the coke contains practically the whole of the ash in the original coal. Roughly, thirteen cwt. of coke are obtained from one ton of coal, so that if a particular coal contained 8 per cent. of ash, the coke made from it at the gasworks would contain roughly 12 per cent. of ash. Moreover, the greater part of the sulphur will remain in the coke.

Valuing Coal.

In purchasing coal, one of the first things to take into consideration is the amount of ash it contains. Not only is the ash useless in itself, but the fuel has to heat up the ash as well as itself, and all this heat is wasted; also, there is all the trouble of removing the ash from the furnace. It is important also to notice the character of the ash, whether it is of a powdery nature, or whether it is inclined to fuse together in the furnace and cause a large amount of clinker, which will choke the fire and give more work to the fireman. The quantity of sulphur in the ash is also important, as sulphur products deteriorate the metal of the boiler flues. The most important thing of all, however, is the calorific, or heat-giving value of the coal. Every large launderer, on entering into a coal contract, should secure a price on a guaranteed calorific value of so many thermal units. A determination of calorific value will be made by a good analyst for quite a small fee, and as coal, even from the same mine, varies very much in quality, it is important to have some check upon the value of the fuel supplied.

Producer and Suction Gas.

As the gas known as ''producer'' gas and ''suction'' gas is coming so much into vogue, it would be well to devote a few lines here to explaining the principles upon which it is made. These two gases are really the same from a chemical point of view, so that I will treat them as one. If steam be passed through red-hot fuel, it is broken up with production of hydrogen and carbon monoxide, thus:—

$$HOH + C = CO + H_2$$

This gas is known as water gas, and is, by some gas companies, mixed with the coal gas they supply to the public, the difference in illuminating value being made up by the addition of a certain amount of oil gas of high illuminating value. The natural effect, however, of blowing steam into red-hot fuel is to rapidly bring down its temperature, so that, in making water gas the operation has to be interrupted at the end of a few minutes to turn on an air blast to get the fuel up to the proper heat again.

In making ''producer'' or ''suction gas,'' these two operations—that is to say, the ''run'' and the ''blow''—are combined. When the fuel has once been got up to the right heat, a mixture of steam and air is passed through the fuel continuously. The steam is broken up by the fuel into hydrogen and carbon monoxide, and the air, which, by the way, is insufficient for complete combustion, instead of burning the fuel to carbonic acid, only burns it to carbon monoxide, so that the whole process results in the production of a mixture of carbon monoxide and hydrogen. The heat-giving properties of this gas are not nearly so great as those of ordinary coal gas, so that it is necessary to use a proportionately larger quantity of it in the gas engine, or gas irons, or ironing machines, in order to produce the same power or heat, as the case may be. Except for the danger of the escape of unburnt producer gas into the air, there is no more danger in its use than in that of coal gas, as, when once burnt, the gases are equally harmless. Producer or suction gas is remarkably economical, and I have very little doubt that before long it will be used for driving and heating in many power laundries.

CHAPTER XI

FABRICS

In the chapter on Starches, I have already mentioned starch cellulose, and I now come to a very important class of substances, all of which are modifications of the substance called cellulose. This is very similar in chemical composition to starch, and from it, or from different variations of it, all vegetable fibres—linen, cotton, jute, bast, hemp, etc.—as well as wood, are constructed. Cotton wool, for example, is practically pure cellulose. Although cellulose and its compounds, of which more directly, do not give the resistance to compression of steel, yet the tensile strength of a linen fibre or a thread of such a substance as cellulose tetra-acetate, is quite remarkable.

Cellulose is affected by strong acids and rapidly by weak acids, and it is acted upon by alkalies far more easily than is generally supposed. If acid be used upon vegetable fibers for removing stains or other purposes, care should be taken to rinse very thoroughly, for it must always be remembered that, except in the case of a volatile acid, such as acetic acid, the acid concentrates as water of dilution evaporates, and may leave the acid in certain parts of the fabric in comparatively large proportion. This is equally true of alkalies, and it must always be borne in mind that any injurious action the alkali may have upon the fabric may—and probably will—be greatly increased when a hot iron is passed over it, or when, in the case of flat work, it is passed through the calender. When comparatively strong alkali, such as 25 per cent caustic soda, acts upon a vegetable fibre, it causes it to contract, at the same time becoming much thicker with an increased tensile strength. A cotton fibre treated in this way is completely altered. Instead of presenting, under the microscope, a flat, twisted, ribbon-like appearance, it has, after treatment, a thick, rounded aspect. This process is known as "Mercerization," from the name of the discoverer, John Mercer.

Mercerized Cotton.

Mercerized cotton is now an important article of commerce, and it is all made in this way, or in some modification of it. There is hardly any lustre in mercerized cotton if it is allowed to contract to its full extent under the action of the alkali, but if the cotton be stretched and thus prevented from contracting when the alkali acts upon it, the surface has a most beautiful lustre, which is used in many ways. Mercerized cotton has a much higher affinity for dyes than ordinary cotton, and this again is a valuable property. Bleached cotton fibres will take a much higher degree of lustre than when unbleached, so that the first step in mercerization is to bleach the hanks of cotton, which, by the way, are selected from the Egyptian or Georgian long-stapled fibre in preference to the short-stapled American product. After bleaching, the hanks are washed, stretched on rollers, and passed through the mercerizing solution. There are various modifications of this process, some of which are distinctly injurious to the fibre. The fibres may be injured in the bleaching or may be over-stretched in mercerizing, or the bleaching and mercerizing process is sometimes combined to the injury of the fabric. Consequently, in many cases, a fabric is produced by mercerizing, which, instead of being stronger than ordinary cotton, is materially weaker, as the launderer knows to his cost.

The Action of Alkalies.

It would seem that, as such a strong alkali as caustic soda has a strengthening process on the fibres in the mercerization process, there can be no harm in using plenty of alkali in the washing machine; but the conditions are not similar. In the first place, mercerization is carried on in the cold, or, if a higher temperature be employed, care has to be taken to exclude air; while in the washing process the fabric is boiled with a hot solution of alkali, which is continuously aerated by the rotation of the machine. Also, instead of only happening once in the mercerizing process, this boiling with hot alkali in the washing process happens repeatedly. As a matter of practice, it is found that washing with a large proportion of alkali has a very injurious effect, causing the fibres to swell and disintegrate, giving them at the same time an unpleasant yellowish color, which can only be whitened by bleaching. Of all the fixed alkalies, caustic soda (or potash) has the most, and borax the least, injurious action on fibres.

Linen and Cotton.

Although essentially the same in chemical composition, the fibres of linen and cotton possess very distinct physical characters. In the first place, their origin is very different, linen being derived from the long and very strong stem fibres of the flax plant; while cotton consists of the seed hairs of the cotton plant, the fibres being comparatively short. They differ very much in appearance under the miscroscope. The cotton fibre presents the appearance of a flat twisted ribbon thickened at the edges, and it is not easy to see the partitions between the cells which make up the fibre. In the linen fibres the separate cells can be easily distinguished, the fibre being thickened where the two cells join. It is these thickenings which make linen fibre easy to spin, as the fibres readily attach themselves to one another; in cotton an artificial twist has to be given to join the fibres together. On account of the much greater length and strength of the linen fibre, it is much less liable to "fluff" in the washing process than cotton. On the other hand, cotton goes through the calender [ironing machine] with much less damage than linen.

Gun Cotton.

Cellulose readily forms compounds with nitric acid, the best known one being gun cotton, which is cellulose tri-nitrate. This is made by acting upon cotton wool with a mixture of nitric and sulphuric acids. The same substance mixed with camphor forms celluloid, which accounts for its dangerous inflammable character. Nitro-cellulose also is used for some artificial silks.

Cellulose Acetates.

By acting upon cotton wool with a substance known as acetyl chloride, a very beautiful compound is produced, known as cellulose tetra-acetate. This forms a most beautiful transparent colorless film, and the substance is used in the production of an artificial silk.

Cellulose is readily dissolved by cuprammonium solution (sulphate of copper to which ammonia has been added to precipitate the hydrate, which redissolves again in the excess of ammonia), and advantage is taken of this in the manufacture of Willesden paper—a thick waterproof paper used for roofing and similar purposes.

Zinc chloride also rapidily dissolves cellulose. A good method of separating cotton and wool is by means of dilute sulphuric acid. The fabric is dipped in the acid, and then dried and heated. This concentrates the acid, which chars the cotton, leaving the wool practically untouched. By shaking and rubbing the cloth, the charred cotton can be all removed, leaving the wool behind.

Wool.

Wool is just as easily dissolved by caustic alkali as cotton is by zinc chloride, and the wool can be removed from a cotton-wool fabric with the greatest ease, although it cannot be recovered. All varieties of wool, hair, etc., used for textile fabrics, although they may differ considerably in mechanical structure, are very similar in composition. The peculiarity of wool is that the fibre is made up of small sections fitted into one another, and at each join, so to speak, there is a rough expanded serrated edge. These edges, when the fibres are woven, lock into one another, and every movement of the fabric caused by changes of temperature, etc., causes these serrations to interlock closer and closer, so that a woolen fabric always has a tendency to shrink when washed. Consequently, it is important that in the washing process wool should be exposed to as few changes of temperature as possible, and that the washing process should be carried through quickly. High temperature causes the fibres to move very much, so that they "felt" together with considerable shrinkage.

Acids have comparatively slight action on the fibre, although, as stated above, wool is rapidly destroyed and dissolved by strong caustic alkalies. Even weak alkalies have a most injurious effect on the wool fibre, and all woolen goods should be washed in a neutral soap solution at about 90 deg. Fahr. If it is necessary to use alkali, weak borax—or, better, ammonia—is the best to employ, although it must not be forgotten that ammonia has a tendency to turn white woolen goods yellowish.

Silk.

Silk, obtained from the cocoons of various kinds of silkworm, is somewhat similar in composition to wool, the most important substance present in silk being known as serecine. More will be said about its properties in the chapter on "Dyes and Dyeing." Silk in the laundry requires to be treated very much the same as wool, and if similar methods are employed, the silk will come to no harm. If the launderer or cleaner and dyer only had pure silks to deal with, he would be able to accomplish his work without much difficulty, but the terrible adulteration practiced in silk weaving of late years has made his task an extremely difficult one.

It has been found that silk will take up very large quantities of tin, barium, and other mineral oxides without any apparent change in lustre or appearance, and consequently a very considerable proportion of the silk in the market is adulterated to an enormous extent. By repeated treatment with chloride of tin (stanic chloride), silk can be loaded so that it contains only about 20 per cent of genuine silk.

Although improvements in the methods of weighting have rendered this weighted silk less fragile than it used to be, it is rapidly acted upon by light and by perspiration; a very small percentage of common salt, which is a normal constituent of perspiration, rapidly disintegrating weighted silk. Various unaccountable spots and stains often occur in weighted silk. Consequently weighted silk, although it may look quite sound, very often tears under the arm-pits or falls to pieces when placed in water. When it is remembered that mere exposure to light in the linen-draper's window is quite sufficient to ruin the fabric, it is needless to add that the launderer must be on his guard against it.

Other Adulterations.

Cotton and linen goods are usually more or less adulterated with filling and sizing materials, such as glue, starch, gum tragasol, etc., on the one side, and china clay on the mineral side. Woolens, besides being adulterated with cotton, are loaded also, and when washing new blankets or new woolen goods, care must be taken to get out the dressing before proceeding to wash the article.

Chlorinated Wool.

There are a considerable number of woolen garments on the market, known as "unshrinkable," and these have in most cases been treated with chlorine (or, rather, hypochlorous acid) which has the effect of removing the serrations on the fibres which cause them to interlock and shrink in the ordinary way.

CHAPTER XII

DYES AND DYEING

Dyeing lies somewhat ouside the business of the average launderer and is really quite a special subject requiring a large amount of study and a very considerable knowledge of chemistry—far more than could be obtained from an elementary manual—so that in this chapter I only propose to touch upon the subject sufficiently to give the reader what small insight is possible into the main principles of dyeing. If he wishes to go farther, he will find it necessary to study some larger work, and at the same time to secure some practical instruction in the matter, to attempt dyeing with only a book knowledge of the subject would be disastrous. In the first place it may be stated that dyeing is quite a different thing from mere staining of the fabric. If a piece of sugar be placed resting in some colored fluid, the color will be sucked up by capillary action until the sugar appears to have been regularly stained throughout. In the same way a piece of cotton will take up a stain if part of it is resting in a colored solution, and if dried the stain will remain in it, but the colored appearance is purely temporary, and is as readily removed as it is taken up. By dyeing, we understand a much closer relationship between the coloring matter and the fibre, than the instance we have just discussed. Some coloring matters can be dyed direct on to the fabric and remain permanently fixed, and the reason for this will be discussed subsequently; but in the majority of instances the dyeing operation is by no means so simple as this.

Theories About Dyeing.

There are various theories to account for the dyeing action of colors on fabrics, but none of these appear to cover the whole ground. In the majority of cases the dyeing action appears to be in the nature of a chemical relationship between the fibre and the coloring matter; while in others, the coloring matter appears to be deposited in the fibre in a purely mechanical manner. The latter is undoubtedly the case with metallic pigments, such as chrome yellow, and with indigo dyed on the vat system, in which the reduced indigo is deposited in the fabric and is afterwards oxidized to develop the color. In any case the structure of the fibre does not appear to be altered in any way, and where the coloring matter can be conveniently removed, the fibre, when examined subsequently, appears to be entirely unaltered.

Wool, silk, and animal substances generally behave in a very similar manner towards dyes, and this is what might be expected from a knowledge of their chemical nature. They are all very much more readily dyed than cotton and other vegetable fibres, which in the majority of cases require much more drastic treatment to get them to take up the dye. In fact it is usually necessary to introduce an intermediary, if it may be termed so, in the shape of a mordant, the nature of which will be explained later.

Those who consider the action of dyeing to be a mechanical one, compare the action of the fibre on the dye to the solvent action of ether on an aqueous solution of a dye. In most instances the ether, if shaken up with the other solution, will absorb all the color, and it is thought that the action of the vegetable fibre at all events is similar. On this supposition the differences observed with different fibres are considered to be due to variations in the pores of the fibre. Whatever may be the exact case in regard to vegetable fibres, it is pretty clear that in the dyeing of animal fibre a genuine chemical combination takes place between some substance in the fibre and the coloring material.

My readers will remember that a salt is produced by the union of an acid and an alkali or base, and the same thing appears to take place in the dyeing of certain animal fibres. In some cases the fibre appears to act as the base, and in others as the acid, and it is very courious that wool and silk can be dyed with plain, colorless rosaniline, which is a substance bearing a chemical resemblance to ammonia, only much more complicated. If the hydrochloride or combination of rosaniline base with hydrochloric acid is used, the whole of the hydrochloric acid will be found left in the solution, indicating that the fibre takes its place in the combination with the rosaniline. It is interesting to note that in the case of wool, silk and other animal matters, the dye appears to completely permeate the substance; while in the case of cotton, the dye lies more or less on the surface.

Classes of Dyes.

Dyeing substances may be divided roughly into two classes, namely, those which act more or less after the manner of pigments, that is to say, possess a strong coloring themselves, and only give shades of the same color under all circumstances, and those which are only lightly colored, or sometimes colorless in themselves, but produce strong dyes in combination with a mordant or its equivalent. Moreover, the coloring matters of the second class vary very much in the shade they produce according to the mordant with which they are combined. As instances of the first class I may mention magenta, indigo, and azo-scarlet. These are applied by steeping the fabric in hot solution of the dye, to which has been added an acid, an alkali, or a salt, such as Glauber's salt, as the case may be. As instances of the second class, alizarine (madder), cochineal and brazilein, yield different colors according to the mordant with which they are used. It is important to note in this connection that magenta, while it will dye wool and silk directly, needs a mordant with cotton.

Another very important—one of the most important from the dyer's point of view—difference between coloring matters, is the division into acid and basic coloring matters. The two classes combine with substances of the opposite chemical character to yield a dye. For example, in the case of alizarine red, which is an acid color, this is dyed with alizarine—a base resembling rosaniline or ammonia already referred to, and alumina—another base—as a mordant; while rosaniline, being a basic color, requires hydrochloric acid as a mordant.

Direct Dyes and Mordants.

A direct dye, such as magenta, will dye the fabric without any assistance; but there are many dyes which require the aid of what is known as a mordant. The substances most commonly employed for this purpose are metallic oxides, such as alumina, iron, hydrate of copper or chromium, and so on, which are usually deposited first on the fibre, and then, when the dyeing process proper is carried out, the dye combines with the mordant, or with the mordant and the fibre, and remains permanently fixed. When the action is at an end, the mordant—and in the case of wool and silk the fibre itself—have combined with the coloring matter to form an insoluble substance, which is quite fast to the action of water, but not to that of light.

As a good example of the action of a mordant, it is an interesting experiment to mix an acid color with sulphate of alumina and carbonate of soda in solution; the alumina will carry down the whole of the coloring matter, leaving a clear colorless solution. Mordants consisting of metallic salts are of a basic character and are employed with acid colors, and it is interesting to note how very sensitive these basic metallic salts are. In many cases it is only necessary to dilute a solution of a metallic salt to obtain the basic salt, which commences to precipate at once.

Wool is mordanted by boiling with dilute solutions of metallic salts, but these are usually mixed with organic acids such as formic acid, or acid salts, such as cream of tartar, to assist in keeping the mordant in solution. While the boiling proceeds, the metallic salt in contact with the fibre, dissociates, forming a basic compound with the fibre. When the mordanting is complete, the fabric is transferred to a vat containg the dye. The composition of silk is very similar to that of wool, and it is mordanted in a similar manner by boiling with metallic salts, or by steeping for a certain number of hours in a more or less basic solution, and it is then dyed in the usual way.

Cotton and all vegetable fibers require quite different treatment to wool and silk, as they contain no active chemical substance such as that existing in the first named. On account of the absence of any active substance, cotton is not able to break up and combine with any basic salt. The most common mordants employed with cotton are the metallic acetates. These decompose comparatively readily, leaving the basic salt deposited on the cotton fibre. Acid mordants are very commonly used with cotton, the most common being tannic acid.

Classes of Dyes.

Owing to the exceedingly complicated chemical structure of most of the organic dyes now so largely used, it would only be possible to go into their composition after a large preliminary volume on organic chemistry. Consequently, I can only give a very rough indication of the classes of dyes which exist.

First of all there are metallic dyes, such as chrome yellow, which are very much in the nature of a pigment.

Next, there are the aniline dyes proper, of which magenta is a well-known member. These bear a distant resemblance to ammonia and its salts.

Then there are the important groups of which alizarine is the best known. These, like the last, are all derived from benzole (benzene), or coal tar naphtha, or substances resembling benzene. Unless combined with other substances they are basic dyes.

Again, there is the nitro-group, of which picric acid—the nitrate of phenol, or carbolic acid, as it is commonly called—is a good example. These are acid colors, and can be used for direct dyeing without a mordant.

Further, there is the very important group of sulphonic dyes, which are obtained by the action of sulphuric acid on benzene and similar compounds. The sulphuric acid is broken up, an atom of oxygen and one of hydrogen being removed by the action of benzine. These colors can be dyed direct on to wool, silk, and cotton, and are, perhaps, the most valuable dyes the garment dyer possesses.

Direct Wool, Silk and Cotton Dyes.

In speaking of direct dyes, it must always be remembered that dyes which are direct on wool and silk, are not necessarily so on cotton; in fact, although direct cotton dyes are not so scarce as they used to be, there are not nearly so many direct cotton dyes as direct wool dyes. The reason for this is that the animal fibre takes a very active part in the dyeing process; while the vegetable fibre is passive, and in many cases, so to speak, takes up the dye under protest. These important differences in the behavior of the fibres in the presence of dyes makes it distinctly difficult for the dyer to deal with mixed fabrics of wool and cotton, although there is now a fairly numerous list of dyes which will dye both wool and cotton direct in the same bath. With such dyes, temperature plays a most important part. The dye will usually go on to the wool when it is hot and the cotton when it is cold, and it will even leave the cotton to go on to the wool when hot so that much care and judgment is required.

Natural Dyes.

Although naturally occuring dyes, such as indigo, logwood, fustic, catechu, etc., are still of considerable importance to the piece dyer, they are little used in garment dyeing. They possess the advantage of being very fast to light and the washing process, and probably a large quantity of fabrics dyed with them pass through the washroom every week.

Laundry Blues.

A few words on blues used in the laundry may very well come in here. The blue used originally was indigo, or rather a soluble compound with sulphuric acid, but, except perhaps in domestic washing, indigo is now very little employed for laundry purposes. Prussian blue is ued to some extent. This is a ferrocyanide of iron, is rather apt to have a greenish cast, and is credited with leaving an iron stain in the goods when they are re-washed. Ultramarine is employed a good deal. This coloring matter is formed by roasting together a mixture of china clay, charcoal and sulphate or carbonate of soda. Its composition and color vary considerably from a greenish to a dark blue shade, and, as is always the case with pigments, the depth of color and value depends as much or more upon the fineness of the grinding, as upon the original color. Ultramarine is quite insoluble in water, and although it appears to dissolve, it is really only in a state of suspension. It is really somewhat of the nature of powdered glass, and is quite unaffected by weak acids and alkalies. Other blues which are largely employed, shade, from violet blue to greenish blue. These are aniline blues, which can be obtained in any are true dyes, soluble in water, and must be used with care, because the fabric is actually dyed, and if excess of blue be employed, it cannot be removed except by some reducing agent, such as hydraldite or titanous chloride (stripping salts). It is very important in selecting a blue, to use one with a slight violet shade; on no account should a greenish blue be employed, as the object of the blue is to cover up the natural yellowish color of the cotton or linen fibre.

CHAPTER XIII

WATER

As water is the most important article, the finest washing compound, so to speak, that the launderer uses, it certainly deserves a chapter to itself. I have already dealt with its chemical structure, and what I specially propose to deal with in this chapter is the composition, purification and general properties of the natural waters which the launderer has to use in practice.

In the first place the action of water is far more than a purely mechanical one. Water wets things and other liquids do not. Benzine, for example, although it may saturate a fabric, does not "wet" it. It has been found that most chemical reactions, in which apparently water is in no way concerned, will not proceed in the absence of water; so that water must possess some action peculiar to itself which is not yet thoroughly understood.

The Universal Solvent.

Water probably approaches closer to the universal solvent that the ancients dreamed of, than most people suppose. There are very few things which will not dissolve to some extent in water, and distilled or rain water, which is free from any dissolved mineral matter, possesses remarkable solvent powers. If placed in a glass or earthenware vessel, it rapidly attacks the glass or the glaze of the earthenware, dissolving out the alkali. If placed in metal vessels or pipes, the metal, if it be iron, lead or zinc, is quickly attacked by the water with probably the help of the dissolved air which it contains. This powerful solvent action of what is commonly called "soft" water, is alone a good reason for the launderer to use it as much as possible.

Another effect of this powerful solvent tendency of soft water is that as it passes through the soil, carrying, in addition to its own solvent powers, some carbonic acid from the air and some of the humic acid from the decomposing vegetable matter in the soil, both of which help it to attack the rocks, it dissolves out a large variety of mineral substances. The most common are sodium chloride (common salt), magnesium chloride and calcium chloride, calcium sulphate (gypsum), magnesium sulphate and calcium carbonate (chalk and limestone). In addition, some waters contain peaty matter derived from bog moss on the hills, and iron, of which more later.

Lime in Water.

All or any of the substances just mentioned are undesirable in the washing machine, as, with the exception of the peaty matter, they combine with the fatty acid of the soap, rendering it useless from the launderer's point of view, and thereby causing a large waste, as well as the bad color, streaks and other blemishes due to the lime soap already referred to. Another objection to the presence of lime in the water used in the washing machine is that, although most of it goes into combination with the soap or is thrown out in a loose form by the soda, yet an appreciable amount very frequently is deposited in a crystalline form in the fibres of the linen, where it accumulates with every wash until the amount present is quite appreciable. These sharp crystals of carbonate of lime rapidly assist the ordinary process of wear and tear, and the life of the article becomes exceedingly short.

Hardness.

Chloride of calcium and magnesium, and sulphate of calcium (gypsum), and magnesium are soluble in water in the ordinary way, and if the water be boiled, the only effect is to concentrate them until you get them so concentrated that they begin to crystallize out. These salts constitute what is known as the "permanent hardness" of water. The carbonate of calcium is kept in solution only by virtue of the carbonate acid present in the water; it is really a bicarbonate (see page 33), and if the extra carbonic acid can be removed, the carbonate of calcium will fall to the bottom. Boiling the water has the effect of removing this carbonic acid, so that the hardness produced by carbonate of calcium or carbonate of lime, as it is often called, is known as "temporary." Instead of boiling the water we can remove the carbonic acid by adding either solution of lime, or milk of lime, or caustic soda. Thus:—

$$\overset{\text{Calcium bicarbonate.}}{CaCO_3\,H_2O\,CO_2} + \overset{\text{Slaked lime}}{CaO\,H_2O}$$

$$= \overset{\text{Calcium Carbonate.}}{2\ CaCO_3} + \overset{\text{Water}}{2\ H_2O}\ ;$$

or—

$$CaCO_3\ H_2O\ CO_2 + \overset{\text{Caustic Soda.}}{2\ NaOH}$$

$$= CaCO_3 + \overset{\text{Carbonate of Soda.}}{Na_2CO_3} + 2\ H_2O.$$

Similarly, the permanent hardness can be removed by treatment with carbonate of soda, thus—

$$\overset{\substack{\text{Calcium}\\ \text{sulphate.}}}{CaSO_4} + \overset{\substack{\text{Carbonate}\\ \text{of soda.}}}{Na_2CO_3} = CaCO_3 + \overset{\substack{\text{Sulphate}\\ \text{of soda.}}}{Na_2SO_4}.$$

In softening water for laundry or other industrial uses, a combination of these two processes is employed, so that all, or nearly all, the temporary and permanent hardness is removed. On account of the powerful solvent action of perfectly soft water, to which I have already referred, it is not advisable to make the water perfectly soft, as it would then be unsuitable for use in the boiler.

The hardness of water is usually stated in analytical reports as parts per 100,000 or grains per gallon, that is to say, per 70,000 and one degree of hardness corresponds to one grain of carbonate of calcium per gallon. Consequently, a water certified to contain 5 degrees of permanent hardness and 16 degrees of temporary hardness would contain 16 grains per gallon of carbonate of lime as temporary hardness and the equivalent of 5 grains of carbonate of lime as permanent hardness. Hardness is estimated by means of what is known as Clark's Soap Test, full particulars of which will be given in the last chapter. A definite quanity of water is taken, and a standard solution of soap is added, a little at a time, until a permanent lather is obtained on shaking the liquid.

Iron can usually be removed from natural water by aerating it. If water containing iron be thoroughly aerated, and allowed to stand, the iron will usually fall to the bottom; or it can be removed more quickly by passing it through one of the usual filters employed in water softening. The materials used in the ordinary water softening process will remove the iron at the same time as the lime.

CHAPTER XIV

The Chemistry of the Washroom

All of the subsequent processes of starching, ironing, and so forth, depend for their success upon the article being properly washed in the first instance, so that the proper conduct of the washroom is of vital importance to the whole establishment. The theory of the washroom has already been dealth with more or less, but there will be no harm whatever in recapitulating.

There are three kinds of "dirt" the launderer has to contend with, namely, albuminous animal dirt, caused by exudations from the skin, particles of epidermis and animal stains generally; next there is greasy matter, which, together with the first, helps to keep the mineral dirt or general dust stuck to the fabric; lastly, in starched garments, there is old starch.

Each of these kinds of dirt requires different treatment for its removal. In the first place albuminous matter is readily coagulated by heat and rendered permanently insoluble; consequently it is necessary to remove this before the temperature is allowed to rise to any extent, the best plan being to soak the linen for as long as conveniently possible in plain water containing a little alkali, which helps to render the albuminous matter soluble. The next step with this albuminous matter is to wash the articles with soap and soda, in warm water only, which removes a good deal of the loose dirt and most of the albuminous matter; finally the articles are boiled with soap and soda, and here I must emphasize the necessity of having a good lather in the machine.

If there is no lather in the machine it shows that the quantity of soap is insufficient; that some substance present, be it lime or manufacturer's dressing, or whatever it may be, has taken up the fatty acid of the soap and that more is required. So long as there is no lather there is no free soap present. Where this happens as a matter of practice you are quite as likely to boil the dirt into the clothes as to boil it out, and working in this manner is a frequent source of bad color. Moreover, in the case of a hard water, the deposition of lime soap in the goods is certain to be greatly increased where they are washed without sufficient soap.

The action of the soap and alkali in the first wash—I am dealing here with body linen—and the boil, is to emulsify the grease and the loose dirt, having nothing now to hold it on to the fabric, comes away. In addition to removing the dirt, boiling, possibly due to the action of the steam causing the production of ozone—the active form of oxygen—or in some way connected with the aeration of the goods in the revolving machine at that temperature, has a great effect in whitening and sweetening the goods. Moreover, it must be remembered, that exposure to boiling temperature for any length of time causes the destruction of all disease germs.

Rubbers.

Rubbers, on account of the very miscellaneous nature of the dirt which they contain, require somewhat similar treatment to body linen, although the preliminary breakdown can be omitted. Nevertheless, it is a good plan to run them in plain water for a few minutes to wet them thoroughly, and to remove any loose dirt before commencing to wash.

Sheets and Table Linen.

Sheets, as a general rule, require very little washing compared to other goods, and are easy to deal with, and there should be no great difficulty in washing table linen, for, apart from fruit and wine stains, and occasional iron mould, the principal dirt is grease, which comes out readily enough. As a rule, launderers keep these articles much too long in the machine, probably because so many insist upon using too much alkali and not enough soap. This tendency is at the bottom of half the launderer's troubles.

Shirts and Collars.

The washing of shirts and collars raises the question of old starch. If this be not removed, it is fatal to any satisfactory results afterwards. Here again there is not much object in an extended breakdown. The first wash with soap and soda in warm water only, not hotter than the hand can bear, should loosen the animal matter; while a thorough good boil should get rid of the starch. In regard to the wear and tear of shirts and collars, however, it is well worth while considering whether malt extract might not be used to advantage to free shirts and collars from old starch by simple fermentation, thus securing freedom from old starch with very little washing. In the case of colored starched articles, malt extract is simply invaluable.

Washing Materials.

Before considering silks and flannels, it would be well to deal briefly with washing materials. Of the hard soaps there are curd, mottled, yellow or pale, and oil soaps. Of the soft soap there are various makes, all more or less similar in character. For general washroom use, the inexperienced launderer is certainly safest with a good curd mottled soap. It cannot be adulterated, and he is certain of good results in the washing machine. It has the disadvantage, however that goods washed with it require more thorough rinsing than with any other soap. Also it is alkaline, and must not be used on colored goods. The yellow soap is said to give in time, a brownish tinge to linen washed with it; but I have not noticed it, and excellent results certainly can be obtained with it. Like curd soap, it is made largely from animal fats, and requires thorough rinsing. It is, or should be, neutral. Oil soap is made from olive, sesame or other oils, and very often from the waste oils of the candle factory. It is an excellent soap—neutral, and easily rinsed out of the goods. For that reason it is very suitable for colored goods or other articles which are not boiled, and which cannot be rinsed with hot water. Some oil soaps, however, leave a peculiar smell in the goods, and this must be guarded against. The odor of all the soaps used in the washroom must be carefully watched. Soft soaps are excellent for flannels and blankets.

Alkalies.

Alkalies in use in the washroom are washing soda or soda crystals, 58 per cent alkali, and various proprietary compounds, some good and some bad, including in this category those which contain sodium silicate. 58 per cent alkali is practically pure carbonate of soda; while washing soda or soda crystals (see page 34) contain a large proportion of water. The equivalent quantities to use, if you are changing from one alkali to another, will be found on page 179. Alkali in any form should never be put into the machine in the solid state, but always dissolved in water. For general use it is a good plan to add the alkali to the soap solution; or, rather, the other way round, dissolving the alkali first and then the soap, instead of putting them in the machine separately. The reason for this is that a neutral soap is very much inclined to dissociate to some extent when dissolved, and the free fat is probably the cause of many unexplained troubles.

Soap Solution.

Soap chips containing something over 70 per cent of fatty acids are largely used in America, and it is necessary to use some form of alkali in order to dissolve the whole of the fatty acid, which would otherwise separate out. Instead of having two tanks in the wash room, one for soap and the other for alkali, as is often done, I prefer to use only one tank. Add the alkali first, turn on steam, and then add the soap. This prevents any separation of insoluble fatty acid which would be almost sure to occur if the alkali were added after the soap. By working in this manner, the quantity of alkali can be reduced. Caustic soda should not be used in the laundry at all, except in the water softener. It has a most injurious action on fibres, and is quite unnecessary. Ordinary alkali or sodium carbonate is quite strong enough, and most launderers use a great deal too much of that. The theoretical quantity of alkali required for soft, or even for hard water, is very small compared with that generally in use. This is probably too little for practical purposes, but I should regard 4 ozs. of actual sodium carbonate as a maximum for a 100-shirt machine. No pains should be spared to keep down the excessive use of alkali in the washroom, as it causes rapid wear in the linen and a yellow color to boot.

Rinsing.

A few words now about rinsing. Where softened water is in use, as it should be everywhere for washing, the rinse which follows the last wash should be with hot soft water; then should follow a second rinse with hot soft and cold hard water mixed, and a last rinse with cold hard water. Where soft water alone is used it is difficult to get rid of the last traces of soap, and there is a tendency for the goods to feel sticky, but the least trace of lime in the water gets over this difficulty.

Where soft water is not to be had, and washing with hard water is unavoidable, it is an excellent plan to add acetic acid—in the proportion of, say, half a pint of commercial acid to a 100-shirt machine—to the second rinse. This decomposes any lime soap or lime salts there may be in the goods, so that they are washed out, and the goods keep a good color and wear better.

Bleaching.

Indiscriminate bleaching or insufficient care in the use of bleaching materials is the cause of any amount of trouble. A very large number of the articles which are sent to me in holes, for opinion on the cause of the trouble, are due to the use of chlorine bleaches, and the rest, to the use of excess of alkali. While it may be necessary to use a chlorine bleach to remove stains from table linen, this should be done with all possible care, and only the actual stained portions bleached, unless they are too numerous or too extensive, when the whole cloth must be treated. Collars should be bleached at very rare intervals, if at all, and there should be nothing else which requires this treatment, except in the case of actual stains. On account of the danger of allowing any form of chlorine bleach in the hands of the average washman, some launderers prefer to let the stains in table linen go unremoved, or to treat them only at the special request of the owner.

There are many reliable made up chlorine bleaches on the market, but where the launderer thinks it best to make his own, a good method is to take 5 lbs. of bleaching powder (chloride of lime), dissolve in a bucket with water, and add 5 lbs. of carbonate of soda (58 per cent. alkali), or its equivalent in soda crystals. Allow it to stand all night to settle, and then strain through muslin into a 5 gallon jar of water. Use one pint of this to 15 gallons of water. (Note.—The strength of this is approximately 0.03 per cent. available chlorine.)

Souring.

After bleaching, the goods should have a bath in dilute acetic acid of a strength of one pint of the commercial acid in 40 gallons of water. The effect of this is to decompose the sodium hypochlorite with production of hypochlorous acid—a very powerful bleaching agent, and easily removable. On account of its greater convenience, oxalic acid is usually employed in America, but acetic is greatly to be preferred on account of the absence of injury to the goods.

Iron Mould.

An indispensable reagent in the washroom is oxalic acid for the removal of iron mould. A convenient strength is about 10 per cent. It should be used warm, and steeping for a few minutes usually suffices to remove the stain. The article should be well rinsed afterwards, as the acid has an injurious action on the fibre. It is not generally known that warm oxalic acid will remove mildew stains.

Silks and Flannels.

I must now deal, in a few words, with the washing of silks and flannels. There are two essential things to be observed here, namely, that the temperature of washing should not exceed 90° Fahrenheit, and that the wash water should be neutral. A good soft soap is the best for washing silks and flannels, and the only alkalies that should be used are ammonia or weak borax. The latter is, perhaps, the better of the two, as ammonia is inclined to turn white silks or flannels yellow. The use of alkalies, such as carbonate of soda or potash, upon flannels or silks, is most dangerous, and many articles have been submitted to me which have been ruined in this way. In connection with this it must always be remembered that curd soap is alkaline, and consequently it should not be used for flannels.

It is most important that the temperature, in washing flannels, should be kept as constant as possible, that is to say, all the wash waters and rinse waters should be at a temperature of 90° Fahr.; while the drying-room for flannels, if they are dried indoors, should be about 100° Fahr. By keeping the temperature constant, the shrinkage of flannels, due to the serrations of the fibres interlocking or felting as the fibres move under the change of temperature, is prevented. It is also very important that as much water as possible should be wrung out of the garment before hanging out to dry, as the evaporation of this water, especially if hung in a cold wind in the open air, is very liable to cause shrinking, for the reason just mentioned.

Colored Goods.

Colored cotton or linen goods are best washed with a neutral oil soap in lukewarm water. If a color shows a tendency to "bleed," a bath in acetic acid will usually stop it, besides helping to brighten the color.

CHAPTER XV

SOME SIMPLE ANALYTICAL WORK

In analyzing a substance, that is to say, dividing it up into its component parts, there are two things to be done: first, to find out what are the components; secondly, how much of each of them is present. In some cases it is sufficient to know what substances are present in the material you are dealing with; while it is not important to know exactly how much of each of them is there; as, for example, if an article is yellow in color, you are satisfied with knowing that it is due to the presence of iron, and it would not be of any particular advantage to know how much iron. In other cases you can determine not only whether a particular substance is present, but also exactly how much is there at the same time.

For simply finding out what substances are present you will not require apparatus for accurate measurement, but for determining quantities, accurate weighing and measuring of everything used is essential. I will refer to the different apparatus, which will only be what is absolutely required, as I pass along, and will give a summary at the end of the chapter for the guidance of those who wish to purchase an outfit for doing a little simple analytical work.

In the first place you will find it necessary to get a few glass stirring rods, a few glass or porcelain vessels in which to conduct your operations, and a few bottles in which to contain your chemicals. Supposing these have been obtained, with the necessary chemicals (see list on page 176), I will get to work.

Tests for Alkalies.

1. If in solution take up a drop on a clean stirring-rod and put the drop on a piece of red litmus paper. It will be turned blue if an alkali is present.

2. Add one or two drops of solution of phenol-phthalein to the solution. It will turn red in the presence of alkali.

3. Add one or two drops of solution of methyl-orange to the solution. If alkaline it will turn yellow.

4. Alkalies in Fabrics.—Boil a piece of the fabric, if cotton or linen, in clean distilled water in a clean dish for two or three minutes, and add one or two drops of phenol-phthalein. If alkaline it will turn red.

Note.—In connection with this it must always be remembered that soap insufficiently rinsed out may appear as alkali in this test. If the fabric be wool or silk the water used for dissolving out the supposed alkali must only be warm.

5. Alkali in Soap.—In order to test whether a soap contains free alkali, the easiest way is to make a shallow hole in the soap about as large as a sixpence, and allow two or three drops of phenol-phthalein to fall into it. If the soap is alkaline a pink color will be produced.

Test for Acid.

6. If a solution is being tested, take a drop on a clean stirring-rod, and place it upon a piece of blue litmus paper. If acid be present it will turn red.

7. Add one or two drops of solution methyl-orange to the solution. If acid it will turn red. Phenol-phthalein under like conditions would be colorless.

When a fabric is being tested it can be treated in exactly the same way as for alkalies.

Test for Presence of Chlorine Bleach.

8. Immerse a portion of the fabric in warm water for five minutes, squeeze the excess out of the fabric so that it mixes with the rest and add some solution, or, better, two or three crystals of potassium iodide. If chlorine be present the solu-

tion will turn yellowish. The adition of a few drops of starch solution will turn it from yellow to deep blue.

Test for Iron.

9. If a fabric is being tested, moisten the stained portion with 10 per cent. hydrochloric acid and add a drop of potassium ferrocyanide solution. If iron be present it will turn blue. The color will easily come out with ordinary carbonate of soda solution.

10. If a water is being tested, the best way is to concentrate it by boiling down, say, a pint, nearly to dryness, in a white porcelain dish. Then add hydrochloric acid and one or two drops of potassium ferrocyanide.

Test for Copper.

11. Copper sometimes causes a stain on a fabric. Moisten the stain with hydrochloric acid and add a drop or two of potassium ferrocyanide. If copper is present it will turn red.

Test for Old Starch.

12. Moisten the collar, or whatever it may be, with warm water and add one or two drops of solution of iodine in potassium iodide. If there is

any starch present an intense blue color will be produced. As this test is very delicate the color will be produced by a very minute quantity of starch. The test solution is made by dissolving, say, 10 grams or ½ oz. of potassium iodide in 100 c. c., or 4 ozs. of distilled water, and adding a few crystals of idodine.

Test for Lime Soap.

13. Dark stains and bad color are often produced by lime soap in the fabric. Soak part of the stained portion for a few minutes in a dish containing 10 per cent hydrochloric acid and then see if the stain is removed. Also see if there are any globules of fat from the soap decomposed by the acid floating in the solution.

The Fastness of Dyes.

14. In testing the fastness of dyes on a fabric the best way is to cut a small portion from a hem or some turned in part of the garment, place it in a small porcelain dish and try (*a*) the effect of neutral soap and water in the cold; (*b*) when warmed to whatever temperature it is proposed to wash at; (*c*) the effect of water rendered alkaline with one or two drops of 10 per cent caustic soda.

The Valuation of Soap.

15. Although the complete analysis of a soap is a complicated matter requiring extensive knowledge of chemistry and considerable analytical experience, it is a comparatively easy matter to arrive at a rough estimate of the value of any particular soap in a few moments. As I have explained above the value of soap can, for all practical purposes, be gauged by the amount of fatty acid which it contains, and it is quite a usual thing to see a soap quoted as containing so much per cent of fatty acid. The easiest way to form a rough estimate of this amount is to have two tall glass jars of exactly the same pattern, and to make up a standard solution of any well-known and thoroughly reliable soap, dissolving, say, four ounces of this soap in water and making it up to exactly a quart.

When it is desired to test the value of a new consignment or new sample of soap, half an ounce should be carefully weighed out from the middle of the bar, and dissolved in water and placed in one of the tall jars. At the same time 5 fluid ounces (¼ pint) of the standard solution should be placed in the other jar, and sufficient dilute sulphuric acid added to each jar to decompose the soap and throw down the fatty acid, which will immediately appear as a thick, white, flocculent [wooly] precipitate. When this has been done, plain water must be added to each jar until the liquid in both jars is exactly the same height. After standing for, say, ten minutes for the precipitate to settle, a glance will show how the amount of fatty acid in the two soaps compares. If a soap contains its proper proportion of fatty acid it is not likely to have much the matter with it in other respects.

A More Complete Analysis of Soap.

For the benefit of those who wish to go more thoroughly into the matter and make a complete analysis, I will explain as simply as possible how this can be accomplished satisfactorily with the appliances the launderer is likely to have ready to hand. The first thing that will be required is a pair of scales, such as the amateur photographer uses, and also the equally necessary weights. If a launderer does propose to do work of this kind it will be well worth his while to purchase a set of weights on the metric system, which can be obtained for a few pence, as the calculation of the results is so much simplified; nevertheless, the work can be done equally well using grain weights instead of grams, if the launderer does not possess the latter. I shall give the figures that follow on the metric system, but in case the reader wishes to use grains he must remember that roughly speaking 15 grains go to the gram, and instead of weighing out 5 grams of soap, as I am about to suggest, he will find it convenient to weigh out 100 grains.

Sampling Soap.

Before going any farther, I must say a few words about sampling soap. If the latter be supplied in the form of powder or shreds, as is sometimes done, the sampling is easy enough, all that is required being to take the sample some little distance away from the outside of the package; but in the case of bar soap, the sampling is not quite so easy. Soap, even the best laundry soap, contains an appreciable amount of water, varying from about 25 per cent in the case of the best soaps, to a very much larger amount in the case of inferior soaps. Directly this soap is exposed to the air, it commences to lose moisture, and the rate of shrinkage in a bar of soap, on keeping, is one excellent test of the value of the soap. A really good soap will not lose its shape appreciably, but while shrinking a little will get much harder and darker in color on the outside; while a poor watery soap will shrink in the most noticeable way, the bar frequently curling up and losing its shape altogether. In consequence of this loss of water on exposure to the air, it is very important, when taking a sample from a bar of soap, to cut it in half and take the sample as fairly as possible from the middle.

The Analysis.

In making the extended analysis, weigh out first of all about 5 grams in a porcelain dish; it is too tedious a process to get an exact 5 grams, so you get somewhere about that amount, making an accurate record of the weight taken. Suppose in this instance the weight was 5.4 grams. After weighing, place the dish containing the soap in a double saucepan or porridge pot, and keep it boiling until the soap (and dish) are found not to lose any more weight. Let us suppose that the fresh weight is 4.1 grams. This means that the soap, in drying, has lost 1.3 grams of water, and the soap is now dry. A piece of filter paper or blotting paper is now placed in a glass funnel and the dry soap carefully brushed into it with a camel hair brush, taking care that none is lost. Alcohol (rectified methylated spirit) is poured slowly over the soap until all is dissolved, and the filter is quite clear of soap, the alchol with the dissolved soap being received in a glass vessel underneath. This now contains an alcoholic solution of soap, any mineral matter, such as carbonate of soda or silica, being left in the filter. If it is desired to estimate this, the filter can be placed in a dish, burnt to an ash and weighed; but with most modern soaps the impurities of this kind are trifling, and the launderer need not trouble himself much about them. The next step is to boil the alcoholic solution carefully in order to drive off the alcohol, and the remainder is then made up to a definite convenient bulk and divided into two equal parts. To one of these portions dilute sulphuric acid (say 10 per cent) is added, to decompose the soap and throw out the fatty acid, and the whole is passed through another filter, which has been previously weighed. When the fatty acid is all on the filter, it is carefully washed down with hot water to bring the fatty acid towards the centre of the filter and at the same time remove any traces of sulphuric acid, which would char the filter if allowed to dry upon it, and thus affect the weight. The glass funnel with the filter is now placed in a warm place to dry, and when sufficiently so, the filter is carefully removed from the funnel, placed on a porcelain dish, and put to dry properly in the double saucepan kept at boiling point. This must be weighed and re-weighed until it ceases to lose any more weight, as the fatty acid has a tendency to retain the last portions of moisture. The final weight gives you the amount of fatty acid in half the total amount of soap weighed out. Let us suppose that this weight, less the filter and the dish, is 1.8 grams, which represents 3.6 grams on the original soap.

Having obtained these figures, we will see how they work out. It was found that the weight of the water in the soap was 1.3 grams. To obtain the percentage composition, we multiply by 100 and divide by the original weight of the soap, namely 5.4, which gives us 24.1 per cent of water.

Again is was found that the weight of the fatty acid was 3.6 grams. Multiply by 100 and divide by 5.4 gives 66.7 per cent of fatty acid.

It is not difficult to estimate the alkali present, but as this requires a knowledge of chemistry, which most of my readers will not possess, and the amount of alkali is not an essential thing to know, I will not explain here how it should be done. In the soap under consideration, the alkali combined with the fatty acid would be about 6.2 per cent.

To return to the first operation when the soap was dissolved in alcohol and the mineral residue left upon the filter. This can either be burnt to an ash and weighed, in which case I will suppose it weighs 0.12 grams, or it can be tested to see what the impurities on the filter consist of. In the former case, the result must be multiplied by 100 and divided by 5.4, as before, thus 0.12 multiplied by 100, divided by 5.4 equals 2.2 per cent mineral matter.

Unless there is some very marked amount of impurity present on the filter, it is hardly worth while to make a test, but where there is a considerable quantity, it is comparatively easy to ascertain what it is composed of. In the first place, we can add a drop or two of dilute acid, and if it effervesces this will indicate that the matter on the filter consists of carbonate of soda; if it dissolves without effervescence it is probably Glauber's salt; if it does not dissolve at all it is either powdered talc, silica or starch (farina). A simple test will show whether it is the latter; it must be boiled in water for a few minutes and a drop of iodine solution added; if farina or any other starch be present it will be turned deep blue. Farina is not often used to adulterate hard soaps, but it is used for soft soaps.

In the soap under consideration, the mineral residue is small and can be burnt to an ash as directed. Putting together all the figures obtained, the composition of the soap will be found to be as follows:—

Water	24.1	per cent.
Fatty Acid	66.7	” ”
Combined Alkali ...	6.2	” ”
Mineral Matter ...	2.2	” ”
Glycerine and other Substances not estimated	.8	” ”
	100.0	per cent.

The Hardness of Water.

16. In estimating the hardness of water, the first step is to estimate the total hardness; then to boil another portion of the water, thus removing the temporary hardness, due to carbonate of lime, filter off the precipitated carbonate, and estimate the permanent hardness, which is now left. By subtracting this from the total, the amount of the temporary hardness is obtained. The test employed is known as Clark's Soap Test, a standard solution of soap, made up so that when the test is made so many cubic centimetres correspond to one grain per gallon (70,000 grains), or, by calculation, so many parts per 100,000. In making the test, a clean stoppered or corked bottle is taken, capable of holding, say 250 c.c. and 50 c.c. of the water to be tested is placed in it. The standard soap solution is then run in from a burette, a little at a time, the bottle being shaken vigorously after each addition. As soon as a lather which will remain for five minutes is obtained, the amount of standard solution used is read off and by comparing with the table (see page 179) the figure for the total hardness is secured. A fresh portion of 50 c. c. is then taken and boiled in a beaker flask for five or six minutes to expel the carbonic acid gas; the precipitated carbonate of lime is filtered off; the filtrate being allowed to run into the same

bottle used for the first test, which has been made clean in the meanwhile, the liquid which saturates the paper in the filter being washed into the estimating bottle with distilled or condensed water. The hardness is then estimated in the boiled water in just the same way as before and the amount of soap solution used compared with the table. This gives the permanent hardness, due to sulphate and chloride of calcium (lime) and magnesium. By subtracting the figures for the permanent, from that for the total hardness, the figure for the temporary hardness is obtained. Many other analytical operations can be carried out with the chemicals and apparatus, but too much space would be required to explain the *modus operandi* and methods of calculating results. Those who wish to go further into this matter should consult Sutton's Volumetric Analysis and other text books on analytical chemistry.

Apparatus and Methods.

The apparatus which would be required to start with for doing simple analytical work would be:

	Price.		
	s.	d.	
1. Six beaker flasks (assorted)...	2	6	$ .60
2. Six test tubes (a "nest") and a small test-tube stand ...	1	0	.24

3.	Three glass stirring rods	0	6	.12
4.	Two burettes and a burette stand	8	6	2.04
5.	Six porcelain basins	1	3	.30
6.	A small gas ring	3	0	.72
7.	An iron tripod stand	0	7	.14
8.	A piece of wire gauze and asbestos millboard	1	0	.24
9.	A simple balance and weights from 50 grm. to 0.01 grm.	7	0	1.68
10.	Two glass funnels and filter paper	1	0	.24
11.	100 c. c. graduated vertical measure	1	10	.44
12.	Two graduated pipettes up to 10 c. c.	2	0	.48
13.	Dropping bottle for phenolphthalein solution	0	4	.08
14.	One doz. N. M. bottles	4	0	.96

Chemicals.

Hydrochloric Acid (pure)	1 W.Q.*	1	8	.40
Ammonia .880	1 W.Q.	2	1	.50
Acetic Acid	1 W.Q.	1	5	.34
Sulphuric Acid	1 W.Q.	2	11	.70
Oxalic Acid	7lbs.	3	3	.78

*W.Q. stands for a Winchester Quart, holding 5lbs. to 10lbs. according to contents.

Carbon tetrachloride	1 W.Q.	7	0	1.68
Alcohol	1 Pint	0	6	.12
Potassium ferrocyanide	¼lb.	0	3	.06
Potassium Iodide	1 oz.	1	3	.30
Iodine	½oz.	0	6	.12
Standard Soap Solution	½ litre	2	9	.66
Caustic Soda	1 lb.	0	5	.10
Phenol-phthalein	50 c.c.	1	0	.24
Methyl-Orange	50 c.c.	0	6	.12
Litmus paper, six books, red and blue		0	9	.18

I have allowed much larger quantities of hydrochloric acid, ammonia, etc., than would be required for experiments, as these will be found useful for removing stains, etc.

A convenient strength for the acids and alkalies is 10 per cent. These with the exception of caustic soda and carbonate of soda, should be placed in stoppered bottles, holding, say, eight ounces. The indicators phenol-phthalein and methyl-orange, which show whether a solution is acid or alkaline, are best placed in dropping bottles, so that it is easy to place one or two drops where you want them, instead of pouring in a dozen drops.

The form of burette with a piece of rubber tubing, a pinchcock and a glass nozzle, is the cheapest, and perhaps, the most convenient. In working with a burette, it is first of all filled up nearly to the top with the standard solution, and then sufficient is run off to drive the air out of the rubber tubing where the pinchcock is; the level can then be read off.

There are two forms of pipette, one which measures only a definite quantity, say, 10 c.c.,* another which measures 10 c.c., say, when full; but is graduated all the way up, so that any quantity up to 10 c.c. can be measured with it. The liquid to be measured is drawn up with the mouth some distance above the required point, and is retained in position by placing the finger upon the orifice at the top. By slightly relaxing the pressure of the finger, the liquid is allowed to run down to any desired point.

Although a thin glass vessel containing liquid will not crack, as a rule, when placed over a naked gas flame, it is much safer to interpose a piece of wire gauze or asbestos millboard between the bottom of the vessel and the flame.

In all chemical operations, it must be borne in mind that scrupulous accuracy and cleanliness are necessary to any approach to an accurate result.

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*c.c. is an abbreviation of cubic centimeters.

APPENDIX A.

Table showing the chemically equivalent quantities of the different kinds of alkalies.

Soda Ash, 58 per cent Alkali, (Dry Carbonate of Soda.)	Washing Soda (Soda Crystals).	Caustic Soda, 70 per cent.	Pearlash (Carbonate of Potash).
1.0	2.7	1.1	1.5
0.4	1.0	0.4	0.6
0.9	2.4	1.0	0.4
0.7	1.8	0.8	1.0

Suppose you wish to change from washing soda to 58 per alkali, you see that 10 lbs. of washing soda can be replaced by 4 lbs. of 58 per cent alkali; consequently for every 10 lbs. of washing soda you have been using you must now only use 4 lbs. of 58 per cent alkali.

APPENDIX B.

Table showing the amount of alkali required to soften washing water.

Degrees of Hardness.	Amount of Dry Soda (58% Alkali or 98% Carbonate of Soda) required to soften 100 gallons in ounces Avoirdupois.	Amount of Washing Soda (Soda Crystals) required to soften 100 gallons of water in ounces Avoirdupois.
5	1¼	3¾
10	2½	7½
15	3¾	11¼
20	5	15
25	6¼	18¾
30	7½	22½

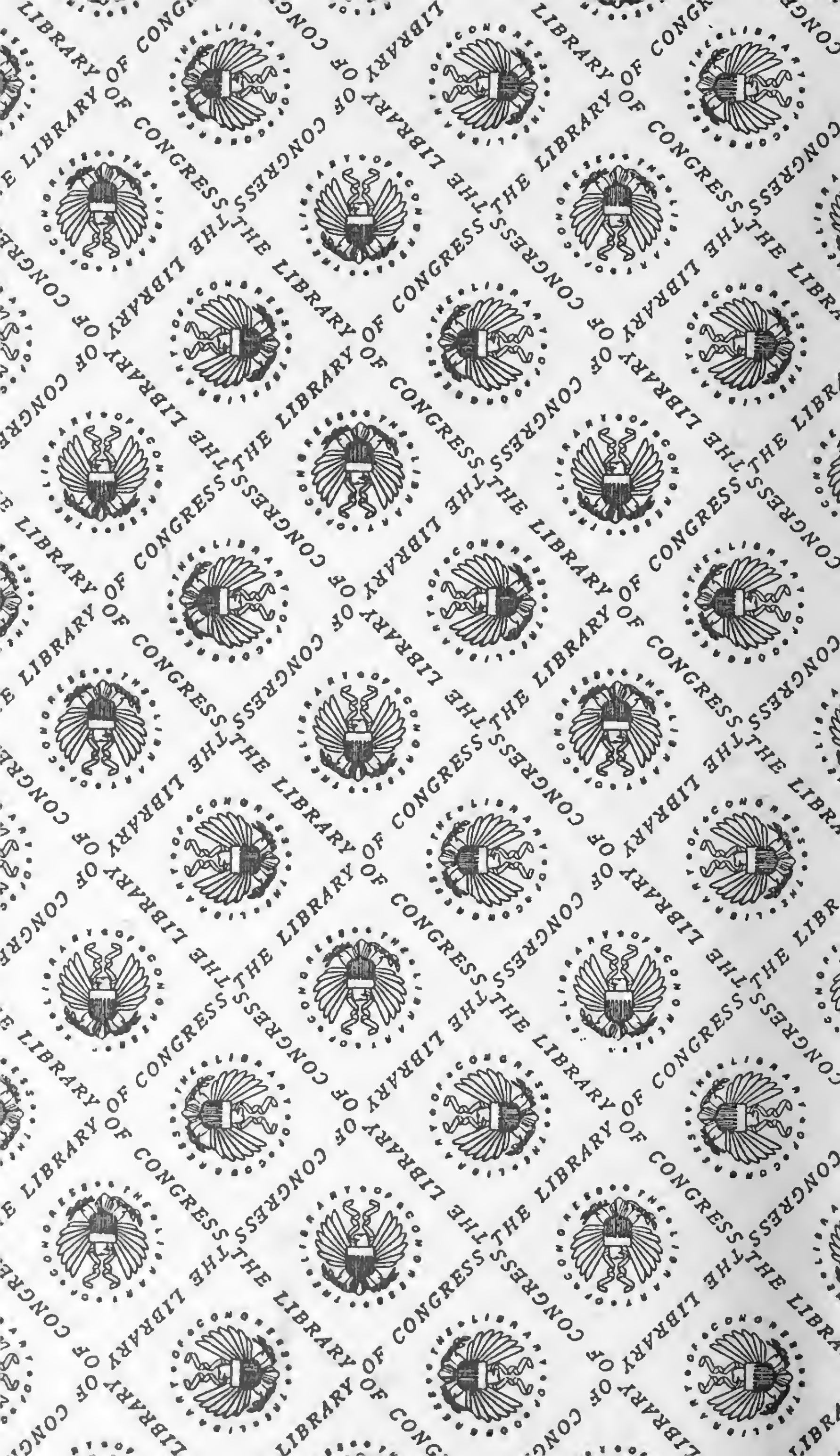
APPENDIX C.

Table showing the hardness of natural waters equivalent to the amounts of standard soap solution required to produce a permanent lather (see page 149) calculated as calcium carbonate.

C. C. Soap Soln.	Parts of Calcium Carbonate (Chalk) per 100,000.
0.7	0.0
1.0	.5
1.5	1.3
2.0	2.0
2.5	2.6
3.0	3.2
3.5	3.9
4.0	4.6
4.5	5.3
5.0	6.0
5.5	6.7
6.0	7.4
6.5	8.1
7.0	8.9
7.5	9.6
8.0	10.3
8.5	11.0

9.0	11.8
9.5	12.6
10.0	13.3
10.5	14.0
11.0	14.8
11.5	15.6
12.0	16.5
12.5	17.2
13.0	18.0
13.5	18.8
14.0	19.6
14.5	20.4
15.0	21.2
15.5	22.0
16.0	22.9

INDEX



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