methods of ventilation and dust removal the consumption death rate among wage earners can be reduced from 2.2 per 1,000, the rate based on the number of deaths among gainfully employed persons 10 years of age and over in the registration States in 1900, to 1.5

per 1,000, the average rate for 200 small cities, as shown in the mortality statistics of the United States census for 1901 to 1905.

Such a reduction, the author estimates, would result in an annual saving of 22,238 human lives and would

add 15.4 years of life for every death from consumption avoided by rational conditions of industrial life. Such a gain would represent a total of 342,465 years of lifetime, and by so much the efficiency of the American nation would be increased.—Iron Age.

SOME USEFUL LESSONS OF LIMEWATER.

A FEW CHEMICAL FACTS FOR THE ENGINEER.

BY CHARLES S. PALMER.

ALL that we have studied thus far is only an introduction to what that barrel of quicklime has to tell. We have seen that lime-like substances are found in hard water and that, sometimes, it is one of these same lime-like things which may be used to overcome this hardness; as though one should make one hand wash the other; or, following the old proverb, healing by "a hair of the dog that bit him." But this subject of hard water, while very real and practical, is not a separate thing by itself; it is connected with many other chemical facts and theories. We will make short excursions into some of these other fields, such as that of fire or water, or acids or alkalis.

FIRE.

In making our clearing before our imaginary cabin home, in the forest of ignorance and prejudice, one of the first things which we should know something about is the air, or the atmosphere, as it is also called. We know that the air has everything to do with burning, for if we want to make a fire burn in a stove or furnace all that is necessary is to keep the grate free from ashes, supply it with fuel, light it and give it free draft. Indeed, in some forms of power maker one can almost control the engine by regulating the doors and dampers. So it is almost self-evident that burning, in the common meaning, is dependent on the air draft.

Moreover, when coal or fuel burns there is some great change in the fuel. Most of it goes up the stack, except some 5 or 10, or, perhaps, 15 or 20 per cent of ashes; but usually from 80 to 90 per cent of the fuel vanishes in the work of furnishing heat and power. If one should look only at the fuel and the remaining ashes he would suppose that burning is a subtraction; and there was once common among scientific men a theory which called itself "phlogiston," that is, "burn stuff," and which supposed that burning is a subtraction, because they looked only at the fuel and ashes. But if we look with one eye at the fuel and the ashes and save the other eye for the waste gases which go up the chimney, then we find that burning is an addition, and not a small addition, but a great addition. This is proved by burning fuel in closed apparatus and weighing everything which comes off it. In this way it is found that one ton of hard coal will send up the chimney, when well burned, between three and four tons of burnt gas, to say nothing of wasting heat on some nine or ten tons of a gas (nitrogen) which is in the air as neutral "filler."

If your attention has never been called to these curious facts, you have a good right to be skeptical as to the correctness of the figures. They are only general, but they are approximately correct; and you begin to think that our eyes must be half blind to let such vast quantities of substances slip by us unnoticed. There are many ways of getting at these interesting things, but one of the easiest ways is to ask this simple question: Is the air about us composed of one thing, or of several things? You have heard all your life that the air is mostly made up of the two gases, nitrogen and oxygen; but if you have not taken this statement in the forceps of your careful attention, if you have not tested this statement with your own chemical apparatus, you can have but a faint notion of the wonderful meaning and the good business value which lie hidden behind the simple statement that the air is made up of nitrogen and oxygen. You know that there is more of the nitrogen than the oxygen, and yet that the oxygen is the active thing as far as burning is concerned; but you need to prove at least a part of this for yourself, in order to see what the fact is worth to you.

TWO THINGS IN THE AIR.

Take a common wash or dish pan, as shown in Figs. 1 and 2. By the way, you will be flattered to know that your wash dish is serving for what the books call a "pneumatic trough"; which means a contrivance for handling gases, a simple but great invention. Put an inch or two of common water into the dish. Get a wide-mouthed jar, say a common fruit jar. Find a wide, flat cork, which will easily pass through the mouth of the jar, without touching the sides, and float the cork on the water in the wash dish. Now

find a little saucer-shaped dish to ride on the cork and to hold some easily combustible stuff, such as match ends, sulphur or phosphorus. The cork must lie flat and well balanced with its cargo of stuff to burn; and sometimes it will be more stable if the wider end of the cork is at the bottom. You will find

FIG. 1.

that you must get this point well fixed, as you have got to place the jar mouth downward over the cork and its cargo without disturbing the latter. Any saucer-shaped piece of tin or iron, as the round cover of a spice box, will do for the little dish; sometimes the saucers and plates of a doll's tea set serve first rate for such purposes, or the little dishes in a common box of water paints. You want to get the cork and its load well balanced, so you can slip the wide-mouthed bottle down over the cork. Then light the phosphorus or match ends, or what stands for your quick burner, and neatly put the bottle mouth downward into the water and over the burning cargo on the floating cork. As it burns, there will be an escape of several bubbles of air from the bottle, and you can explain this by the sudden heating of the air shut up in the bottle. But pretty soon the fire in the dish on the cork will burn more slowly, and finally it will go out. Meanwhile the cork, with its cargo, has risen up and into the jar, as the water absorbs and cools the air inside the jar.

Now note the air in the inside of the jar or bottle. It is thick with smoke and fumes; but these will be partly absorbed by the water in the bottle, for the water will rise part way up the side of the jar or bottle (Fig. 2). You want to perform this experi-

FIG. 2.

ment over and over again, so you will get rather expert in handling what will soon seem clear and simple to you. You will note that if you use nearly pure phosphorus from match ends, or with some sulphur from eight-day matches, or with some powdered sulphur or brimstone scattered on, you will get more absorption of the fumes remaining in the jar after

the burning. When you use wood or paper, coaxing it with a few drops of kerosene, you will not get as much absorption of the burnt fumes by the water. But in every case, with the burning of phosphorus you will get an absorption of the air in the bottle by the burning amounting to from one-fifth to one-third. The correct figure is about one-fifth; but you may drive off too much air at the start from the expansion from heating, before the real burning has gone very far; and this error in the experiment will show up as an apparent absorption of the original air greater than the real absorption and disappearance of the air in the bottle.

There are several sides to this experiment, and we will mention them here, so that you can be on the lookout for them:

First, the strong burning of the stuff in the little saucer, and the placing of the jar over this.

Second, as soon as the fire has gone out in the saucer and the water in the jar has finished absorbing the fumes from the burning, lift the jar quickly out of the water, first slipping a piece of cardboard over the mouth to keep the water that is in it from flowing out. Shake violently, using the cardboard cover, and set the jar right side up on the table. Note the amount of absorption of the original air in the jar.

Third, light a splinter of wood and thrust it quickly down into the air left in the upper part of the jar; the splinter is put out, as anybody should know it would be, because if the fire of phosphorus went out, wood or paper would not burn well in this same residual air. All the same, it is not a foolish thing to do, to test this same residual air with your splinter of wood. It sets you to thinking what it all means and you begin to note that there must be different kinds of gas as regards their ability to help burning. The gas oxygen that has gone off (it has gone into the water) helped the burning, and it amounted to only about one-fifth by volume of the whole air. The part of the air that is left will not help common burning, although it makes up some four-fifths by volume of the air; this remaining part is nearly all nitrogen. Just to set your mind at rest, you may like to know that there are three other things in the air in small quantities. These are some water vapor, some of your old friend carbonic-acid gas and a strange newcomer, called argon, the "lazy element," because it does not do anything but exist; that is, it does not make any definite compound with anything, but sometimes pretends to be like nitrogen as it is found in the air, about one part in a hundred by volume.

Fourth, put some litmus into the water at the bottom of the jar and note the action. Of course, you know enough by this time never to take one piece of litmus paper, nor one color, but two pieces; or, at least, one piece colored red at one end and blue at the other. You can take a bit of red litmus and let one-half touch a piece of soap to blue one-half. With both red and blue litmus you can catch both alkalies and acids. You will find that the water in the bottom of your jar turns the litmus red; that means that the burning has made something which went into the water and which has acid properties. If you used mostly phosphorus then the burning of the phosphorus has made one kind of phosphoric acid. If you used mostly sulphur in burning in the little dish on the cork, then the burning mostly made sulphurous acid, with some sulphuric acid. But in both cases, the burning with the oxygen of the air made things that are essentially acids. It was the great French chemist Lavoisier who found this out some hundred and forty or fifty years ago, about the time of the Revolutionary war; he showed that burning was an addition, and that the adding of the "burn-helping" gas (oxygen) in the air to the things burnt, as a rule, makes acids (or acid anhydrides, the acids minus water but willing to drink themselves to acids proper); and so Lavoisier called the gas that helps to do all this "the acid maker," which meaning is safely hidden behind the parts of the Greek makeup, "oxy-gen." You will find out later that this claim of oxygen to make all acids, is not quite exact, but that there are acids which have no oxygen in them: but

in every such case the acids have something which plays proxy for oxygen, so that in its broadest sense the name "oxygen," "acid maker," is not so bad for the "burn helper" in the air.

REPEAT THE EXPERIMENT OFTEN.

You must try this fundamental experiment of attacking the composition of the air over and over again and in every shape and method that your ingenuity can devise. Perhaps you can get some of the pure phosphorus to use, the kind that comes in yellow sticks and which must be kept under water to save it from burning up; or perhaps you can get a pinch of the so-called "red" phosphorus, a dark brownish-red powder, which is real phosphorus baked in a close vessel until it goes temporarily into this curious, sleepy form where it does not have to be kept under water to save it from burning; perhaps you can get some of this, to put in your little dish; but, whatever you do use, make it burn and make it take out all of the active oxygen from the air that it will, about one-fifth by volume at any rate. Usually you will get a larger apparent absorption, due to the aforesaid escape of some bubbles by heating.

You must keep your eye fixed on the several points: The good burning; the closing-in of the little saucer by the inverting of the jar; the absorption of part of the air in the jar and the testing of the remaining air; the testing of the water in the bottom of the jar. It all makes a part of the story of the composition of the air, but you will wonder how our friend limewater can help us out here. Well, that is an interesting

question; and, in this chapter, we can only begin to show how limewater may have a great deal to do with the problems of burning.

Your thoughts will run somewhat as follows: It is all right to test such things as sulphur and phosphorus and match ends; but common coal is the thing which makes the bulk of the fuel burnt, and we want to see what the air does to that, and how it does it.

The point which we are going to study is this: that coal burns first to carbon monoxide, CO, and this burns further to carbon dioxide, your friend carbonic acid gas, CO₂, or carbonic anhydride, the anhydride of true carbonic acid proper, H₂CO₃. Now the acids of phosphorus and sulphur and those strong-smelling things made from burning in the air, are readily absorbed by water; and they readily turn litmus red. But carbonic acid gas is only feebly absorbed by water; it has not much taste and it does not act strongly on litmus; and so we are up against the question of trying to prove that when coal, or carbon, burns in the air, it does make its own form of acid, or acid anhydride, just as sulphur and phosphorus make theirs. You can begin to see how we are going to do this with the help of limewater; for you have already sucked the gases from glowing coal through some limewater, and you are fairly familiar with the acid properties of the gas from burning coal. But that special point will wait for another lesson; we want to get this point clinched, of the approximate amount of active "burn helper," oxygen, in the air.

There are one or two questions which may come up to your mind at this time. One of them is this: What

would happen if the air were pure oxygen? That is an interesting question, and you will make some experiments later with pure oxygen to show what would happen. But there are two forms to that question. One form is, what would happen if the nitrogen were taken out from the air and only the oxygen were left? That is one thing, but it would be quite another affair if the nitrogen were taken out from the air, and if its place were taken by so much more oxygen; that would be a condition of frightful possibilities, as you will see when you come to make pure oxygen.

One more question that I want you to think over between now and the reading of the next lesson is this: Why do you have to *light* a fire? Why doesn't it light itself? There is the fuel, there is the air, which you cannot see, but which you can feel, and it is waiting to take hold of your coal. But why does it wait until you kindle it, with all sorts of coaxing, from the match, through the shavings or paper, through the kindling wood, to the hard fuel; why all this preparation for what seems all ready to take place of and by itself? This question is worth some attention, the right answer will open your eyes to some things which no one can see, but which we must all believe to be true; it is the story of the chemical units, noted by those initial letters, and the groups into which those chemical units unite, groups which make up all kinds of material things which you see and feel every day. You are getting nearer the top of one of the foothills of science, and one of these days you will see the main range, and you can see all this from the window of your boiler room.—Power.

A NEW METHOD OF HOUSEKEEPING.

THE FICK APARTMENT HOUSE OF COPENHAGEN.

WHEN the "home," as it now exists, is divested of the traditional glamor with which our fancy has clothed it, and regarded with a dispassionate and objectively seeing eye, its naked cheerlessness becomes appalling.

Yet housekeeping has been undergoing reform and improvement ever since the beginning of specialized industry. At first the family hearth was the center of all the industries which have since become specialized, and have been removed to factories. The removal of each class of work—soapmaking, brewing, baking, weaving, etc.—marked an advance in housekeeping. Now only four classes are left—laundry work (and this is fast going), housekeeping, cooking, and the care and training of children.

The inefficiency and unhygienic character of the usual methods of housekeeping are obvious. Much of the dust dislodged by the broom settles down again, after poisoning the air for hours. Carpets, curtains, and the upholstery and carved decorations of furniture are never free from dust.

No diligence in housekeeping can keep the house clean so long as it is heated with coal and lighted with gas or kerosene. The progress of applied science has given us electric light, steam heat, ventilating apparatus, and pneumatic dust collectors, but these blessings are enjoyed only by the rich and can not be introduced into the ordinary small home.

The defects of home cooking are apparent to every physician. Almost every other art has become highly specialized, but in the preparation of food we cling tentatively to amateur methods.

The same is true of the care of children, so that the mother is expected to be, as Charlotte Perkins Gilman says, an embryo combination of cook, nurse, laundress, chambermaid, waitress, governess, and housekeeper—Jack of all trades and master of none.

An attempt to reform this state of things has been made by Otto Fick, who established an apartment house of a novel type in Copenhagen in 1904. The apartments—twenty-five in number and containing from three to five rooms each—are rented unfurnished, so that each family can furnish its home in accordance with its own tastes and requirements. Each apartment has a kitchenette with a gas stove and a bathroom, supplied with hot water day and night. Electric light and central steam heating are included in the equipment, and each apartment is connected by telephone with the general kitchen, and also with the public telephone system. Meals are prepared in the general kitchen and sent up to each apartment by means of an electric dumb-waiter.

Privacy is as complete as in an apartment house of the usual type. The only commercial feature is the centralization and specialization of every task of housekeeping—cleaning, ventilation, lighting, heating, and preparation of food—so that the tenants are entirely relieved of the burdens of marketing, making fires, cooking, sewing, dishwashing, etc.

Luncheon is served in the apartments from ten to

twelve, and neatly packed luncheons are provided for school children and others who desire them. Dinner is served in the afternoon, according to Copenhagen custom, and tea until ten in the evening.

The menu is so extensive and varied that monotony can be easily avoided, and the general kitchen has a list of the preferences, and particularly of the aversions, of every family, in which it is gravely set down that one family is never to be served with mushrooms, a second with cabbage, a third with rice pudding, etc. Individual, as well as family, preferences are respected.

Dishes, plates, cups, etc., of the so-called "unbreakable" ware are furnished by the management, but each family may provide its own table ware and have it washed in the general kitchen, without, however, any guarantee against breakage. Laundry work, extra service and meals for occasional guests are furnished at low rates.

Cheapness, indeed, is the guiding principle, and cheapness combined with excellence is attainable only with the aid of centralized housekeeping. The kitchens and other service rooms in the basement are equipped with the most approved apparatus, and the food and other supplies are abundant and of the best quality.

The annual charges for rent, heat, light, baths, food, and service, including pneumatic "sweeping," window cleaning, and even shoe polishing, are about:

For 2 adults occupying a 3-room apartment..	\$420
For 2 adults occupying a 4-room apartment..	550
For 3 adults occupying a 4-room apartment..	735
For 4 adults occupying a 4-room apartment..	855
For 2 adults occupying a 5-room apartment..	655
For 3 adults occupying a 5-room apartment..	795
For 4 adults occupying a 5-room apartment..	930

Small additional charges are made for children and servants.

This first centralized apartment house has proved so successful that others are projected. Fick also purposes to erect a house with large general playrooms for school children and for small children. Nurses will also be provided so that mothers who have occupations away from home will be able to leave their little ones in safe keeping.

Another event of the Fick system is that it settles the servant question to the advantage of both employer and employed. Much of the work of the centralized household is performed by machines and the rest is skilled labor with definite hours of work. When housekeeping is thus raised to the rank of a specialized industry it will attract workers of a more intelligent class who now very justifiably refuse to work sixteen or eighteen hours a day.

There are other advantages, both economic and social. Under the present system a house is unattainable by an unmarried man or woman, yet the cost and burden of housekeeping act as preventives of marriage. The system is very elastic and allows of apartments of two rooms, or even one room, and of general dining rooms, reading rooms, etc.

Finally, the lifting of the burden of housework makes possible a reform in child culture. At present only the children of the wealthiest classes enjoy anything like proper care and training. All other children are sacrificed to the foolish tradition which regards the mother as the natural teacher and the home as the best school. Mother love is an instinct, and it implies no pedagogic ability, as daily experience proves. Education is a function of society, and it should be performed by persons of fitting character and ability, who have been prepared for the task by study, not by procreation. The fully developed co-operative house will have "crèches," playrooms, and open-air playgrounds and gymnasiums on the roof, presided over by skilled nurses and teachers.—Umschau.

SENSE OF SMELL IN FLIES.

By ALEX. HILL.

By far the most efficient fly destroyer with which I am acquainted is a dilute solution of formaldehyde. If two teaspoonfuls of formalin (40 per cent formaldehyde) be added to a soup-plate filled with water, flies go to it, one after the other, to drink, especially in the early afternoon. Some die in the water; many fall in the immediate neighborhood of the plate; others succumb on window sill or floor. As a result of leaving a single plateful of the solution on the kitchen table (I am writing in the south of France) hundreds of dead flies are each day swept up from the floor. Formalin water is free from the gruesome associations of fly-papers and other traps which hold their struggling victims. It may even be turned to ornamental uses. A wire cage placed in the center of the dish may be crowned with flowers, which flourish equally as well, with some slight but interesting changes in tint, in dilute formalin as in pure water. The solution neither attracts nor repels flies. Two similar dishes placed side by side, the one containing pure water and the other formalin, are visited, so far as one can judge, with equal frequency. It is somewhat strange that so small a dose proves fatal when taken into the fly's alimentary canal. I find that, to free a room from flies by vaporizing formalin, the air must be rendered quite irrespirable by a human being. The room needs to be amply ventilated before one ventures into it.

The interest which attaches to this observation, that flies will drink a solution of formaldehyde, lies in the proof which it affords that the mechanism of their sense of smell is similar to our own. No volatile body the density of which is not greater than that of air is a stimulant of our olfactory membrane. Formaldehyde, HCOH, has a density of 15 only. Playing in paradoxes, one might say that it undoubtedly has a malignant odor, but we cannot smell it. If the nose be placed close to a vessel containing a dilute solution of formalin a scent is recognizable, but this I take to be due (a chemist will correct me) to impurities present in the commercial product. Yet I find that when I sit