soda is introduced into the water, the sulphate of lime is changed to carbonate of lime, which settles in a fluffy form, while the carbonate of soda becomes sulphate of soda, which remains dissolved in the water and has no harmful action upon the boiler.

If the water contains both sulphate of lime and carbonate of lime, caustic soda may be used to advantage. The first action that takes place is the precipitation of the carbonate of lime, with the formation of carbonate of soda, and the carbonate of soda acts upon the sulphate of lime, breaking it up as already explained. In case the carbonates and sulphates of magnesia are present in the feed-water, the same general methods are followed.

It must be distinctly borne in mind, however, that chemical purification does not destroy the impurities. It simply converts them into other forms which will not act injuriously on the boiler. Consequently, if the chemical action takes place after the water is fed to the boiler, the precipitated materials will collect on the sheets and tubes and must be washed out at regular intervals.

There is yet another class of impurities which may be found in boiler feed-water and which, when present, is the cause of serious trouble. The class referred to is corrosives, or those impurities which attack the metal parts of the boiler and eat them away. Such action is due to the presence of free acids in the feed-water, the common ones being sulphuric and tannic acids, though others may occur. For example, if water containing magnesium chloride is introduced into a boiler and heated, muriatic acid is liberated, and this free acid has a very rapid corrosive effect on the boiler. To counteract corrosion, alkalies should be added, which will neutralize the acids present.

ALCOHOL ILLUMINATION.

By DR. P. WITTELSHOFER, Berlin.

In all methods of illumination where the fuel is consumed merely in the presence of a draft of air, finely divided particles of carbon become separated and are not immediately oxidized. These being heated to incandescence produce the lighting quality of the flame. All the early methods of lighting depended upon the production of this incandescent or glowing flame, familiar examples being found in the candle, the kerosene lamp, and the ordinary gas jet.

An entirely new principle of illumination was introduced by the invention of the Welsbach incandescent gas light, usually known as the Welsbach lamp. In this a flame is supplied with a sufficient amount of air to produce complete combustion of the gases and there is, therefore, developed an intense degree of heat. Into the hottest zone, that is, in the outer portion of such a flame, is brought a finely divided refractory mineral substance, which becomes incandescent and transforms a part of the heat of the flame into a glowing white light. The burner used for laboratory purposes under the name of the Bunsen burner has served as a basis for the design of the peculiar burner adapted for this light. Auer von Welsbach, a chemist of Vienna, discovered the incandescent qualities of the so-called rare earths (cerium, thorium, erbium, yttrium, and zircon) and made them applicable in the technical industries. He studied the chemical peculiarities of these substances as well as the manner in which they could be used, and from these studies he devised the so-called mantle, a delicate web-like sleeve which surrounds the hot portion of the flame.

The great progress made possible by the introduction of the incandescent gas light depends upon the fact that since with a relatively small amount of fuel an intense light can be produced, the cost for the same amount of light is much less than formerly. Also with the invention of the Welsbach light it became possible to make use of those fuels which, when burning, do not give out much light, but produce a considerable amount of heat. Hence it was practicable to use alcohol as an illuminant, something impossible before, owing to the fact that it burns with a pale blue lusterless flame. The first alcohol incandescent lamps were devised in 1895, and attracted much attention by their brilliancy as compared with a similar gas light.

Through the efforts of inventors and manufacturers, several types of alcohol lamp have been put on the market, which because of their uniformity of operation and the excellence of their light give assurance that they will be able to compete satisfactorily with other lighting systems.

The chief difference between the alcohol incandescent lamp and those other systems which use liquid fuels, e.g., petroleum, or which use a gaseous product directly as illuminating gas, lies in the fact that in all the lamps using alcohol it must first be transformed into a gaseous condition. The vaporizing apparatus forms, therefore, an important part of the lamp.

In the construction of these lamps three types can be distinguished. The first class embraces lamps in which there is a small auxiliary flame of alcohol constantly burning, which heats and vaporizes alcohol drawn up through a tube leading from the basin of the lamp by the capillary action of a wick. After being vaporized, the alcohol passes through a small pressure-regulating valve into the peculiar burner, which is practically the same as used on the illuminating gas incandescent lamps.

In the second class there is a small auxiliary flame as in the other case, but it is controlled by suitable means, so that it may be turned down after the lamp is in operation. The alcohol to be consumed in the main burner is drawn up by a wick as in the former case, and passes through a heating portion where it is

vaporized. The necessary heat in starting is provided by the auxiliary flame; after the main burner is in operation, the heat from this aids in the vaporization. In this case considerable vaporization occurs in the wick itself.

In the preceding systems the general arrangement is such that the fuel basin is placed beneath the burner, the fuel for the burner being elevated and conveyed to the vaporizer by the capillary action of the wick.

Those of the third class are applicable only as hanging lamps, and are used for the illumination of large halls and out-of-door locations. In this type both the fuel basin and the vaporizer are above the flame, so that the liquid to be vaporized is not conveyed to the vaporizer by capillarity but by hydrostatic pressure. With this form of lamp, since the flame is beneath the vaporizer, the former furnishes the necessary heat, and automatically provides itself with the necessary amount of vapor after the operation is once started. This last type of lamp has recently been highly developed, so that it may now produce as much light as the most powerful gas light and about as much as the average electric arc lamp.

It is possible to manufacture powerful lighting apparatus of this character which operates reliably and with a low fuel consumption up to 250 candle-power and over. For lighthouse purposes such lamps have been constructed of over 1,000 candle-power, these however having the fuel supplied under artificial pressure.

In the type of lamp previously described it is often found an inconvenience to wait the one to one and one-half minutes during which the vaporizer is being heated and during which time but feeble light is produced. Inventors have therefore sought to devise a lamp similar in operation to the kerosene lamp, which gives a light as soon as the match is applied. The principle of this lamp rests chiefly in directing air currents at the upper edge of the wick in such a way that the flame will take the form most suitable for the use of a mantle, at the same time providing sufficient air both within and without the flame to promote proper combustion or give the flame the amount of oxygen necessary to produce the most intense heat. The difficulties in the manufacture of a lamp which shall be satisfactory in all these respects cannot be overestimated. It is gratifying, however, to observe how many inventors who have busied themselves with the problem have constructed lamps which have been satisfactory when carefully operated. It must not be forgotten, however, that these lamps have a higher fuel consumption than the former types.

In view of the competition which exists to-day between the different lighting systems, a decision as to which should be chosen for any given conditions ought to depend largely upon the cost of the light produced. This in turn depends upon the amount of fuel required to produce a given amount of light. The strength of a light is measured in light units. The unit in use in Germany to-day is the Hefner candle-power, which is somewhat less than the light produced by the standard paraffin candle. While the flame of a good kerosene table lamp produces about 24 Hefner candle-power and consumes hourly 75 grammes or 1.10 liter (0.176 pint) of kerosene, an alcohol lamp giving the same light uses hourly only 50 grammes (0.088 pint) alcohol, corresponding to 60 cubic centimeters (3.6 inches). Hence, on the basis of fuel used alcohol produces an equivalent lighting effect with 6 to 10 cubic centimeters less fuel per hour. If kerosene sells at 20 pf. (5 cents) per liter and alcohol at 25 pf. (6¼ cents) a light of 25 candle-power will cost 2 pf. (½ cent) per hour with petroleum and 1.5 pf. (0.375 cent) with alcohol. Alcohol lighting is therefore one-fourth cheaper than petroleum. A considerable advantage in the favor of alcohol lies in the fact that it is possible to produce an exceedingly strong light without increasing the consumption of fuel per light unit. It follows therefore that in the course of time alcohol lamps will be devised whose fuel consumption will be even less than in the example given. There are, of course, also high-powered kerosene lamps. These have, however, the great disadvantages arising from excessive fuel consumption, and consequently usually develop an undesirable amount of heat.

Alcohol lamps are found on the market in sizes from 20 to 70 Hefner candle-power, corresponding to the lighting requirements of both industrial and household purposes. These vary in their fuel requirements per 10 candle-power between 15 and 30 cubic centimeters per hour. Hence, at the usual price in small quantities of 25 pf. (6¼ cents) per liter (1.76 pint), the production of light per 10 candle-power would be between 0.37 (0.0925 cent) and 0.60 pf. (0.15 cent) per hour. In the case of very large lamps, as previously mentioned, the fuel consumption per 10 candle-power diminishes to 12 cubic centimeters (0.72 cubic inch) per hour, so that the cost is only 0.30 pf. (0.075 cent) per hour.

From the preceding it would seem that the alcohol lamp is destined to come into sharp competition with the kerosene lamp, but it is equally certain that it will take its place among other lighting systems. With respect to cost it is exceeded in economy by the incandescent gas light alone, it being cheaper than the electric incandescent lamp. Under many circumstances it is, however, preferable to the gas light, since it can be made in portable form, independent of fixed location, and can be used in any place desired without special adjustment. Transportability is the chief reason why petroleum lamps are still used in many places where the use of gas would be much cheaper. The need of a lamp which can be carried about is felt principally in small households, hence in spite of the cheapness of

gas, kerosene lamps maintain the supremacy for such uses. Take as an example the city of Berlin, where in the year 1900, out of 470,057 dwellings, only 76,479, or about one-sixth, used illuminating gas, there being 393,578 households in which the kerosene lamp was used entirely. As contrasted with the kerosene lamp, the alcohol lamp presents the possibility of increasing and cheapening the production of light, while at the same time creating less heat and emitting no disagreeable odor. Alcohol and kerosene, because of the difference in their chemical composition, differ materially in heating value. One kilogramme (2.2 pounds) of the former of 90 per cent purity releases during the process of combustion 5,500 heat units (calories) while the same quantity of petroleum completely burned gives off 10,000. It is seen, therefore, that alcohol has a heating value about half that of petroleum. In the combustion of these fuels for lighting purposes, there is of course a certain portion of the heat energy which is converted into light. In the case of the alcohol incandescent lamp, a much larger amount of heat is so transformed than is the case with the kerosene lamp. But even in the best alcohol lamps the heat changed into light is a very small percentage—only about 1 per cent—consequently in computations it introduces but very small errors to assume that all the heat corresponding to the volume of the fuel is given to the air of the room in which the lamp is operating. Calculation shows that an ordinary alcohol lamp of 25 candle-power would give to the room 288 heat units per hour, while a kerosene lamp of equal lighting effect would give out 750 calories. A large alcohol lamp of 50 candle-power heats up the air by 576 calories per hour; the same powered kerosene lamp gives out 1,500. It is seen, therefore, that the alcohol lamp gives off about one-third of the heat given off by the kerosene lamp, and this is a very decided advantage for alcohol.

Not less important than the smaller amount of heat developed is the lessened air pollution attendant upon the use of the alcohol lamp. Both alcohol and kerosene contain carbon, and in the combustion of both, carbon dioxide and water vapor are formed. The baneful effects of carbonic acid gas in the air of closed rooms are well known, and all rules of hygiene demand that in order to have as pure an air supply as possible, the amount of carbonic acid gas be reduced to the lowest possible amount. The chemical composition of kerosene shows that it contains 85 per cent of carbon, while in absolute alcohol there is only 52.2 per cent, and in 90 per cent alcohol but 44.6 per cent. It follows therefore that by the combustion of 100 grammes of 90 per cent alcohol only 163 grammes of carbon dioxide result as compared with 312 grammes of this gas resulting from the combustion of the same amount of petroleum.

If we consider the decidedly smaller amount of alcohol required to produce a given light-power as compared with petroleum, we find a still further advantage for alcohol from the standpoint of ventilation. An incandescent alcohol lamp of 25 candle-power produces 86 grammes of carbon dioxide per hour as compared with 234 per hour produced by a kerosene lamp of the same lighting effect. It is seen, therefore, that alcohol lighting has one-third the air-polluting effect of petroleum. This is borne out by the observed fact that the air in a room lighted by alcohol is usually in much better condition than when lighted by kerosene. We must add to these advantages the fact that the alcohol lamp is much more easily cared for and kept in condition, since there is no wick to trim or chimney to clean. In even the best kerosene lamps there is always a certain amount of soot and smoke, and leaking from the oil basin with its consequent odor and uncleanness. These are absent in the case of the alcohol lamp. The general excellence of alcohol illumination is evidenced by the rapidity with which it is growing in favor, and in a few years its use will undoubtedly be widespread.

An unmistakable sign of progressive culture is the cry for "more light." In fulfillment of this wish, alcohol has entered not only into competition with kerosene, but with those haughty sisters gas and electricity. While the two latter, being capable of distribution from a central plant, are more strictly applicable for the lighting of large and medium-sized municipalities and industrial plants, alcohol illumination is particularly useful for small communities and isolated buildings and farmsteads, which desire to have a cheap and effective system of lighting. In railroad operations, in small cities and villages, and principally in agricultural districts, thousands of alcohol lamps are in constant use. To these must also be added the increasing number which are in use in private households in both the cities and the country.—Specially translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

There is one marked difference between machines and the men who operate them which should be noted. Machines, no matter how well they may be cared for, depreciate from five to ten per cent per year, owing to the advent of other and improved machines, while men, if they are properly cared for, may appreciate in value several hundred per cent in the same time. Yet as a general rule machines and tools are nurtured, fostered, and preserved long after their period of usefulness has expired, while the permanency of service of the men of the organization who operate them receives comparatively no consideration whatever. It cannot be expected that the men of an organization will show any spontaneous enthusiasm for interest in or loyalty to a management that openly displays so little interest in their welfare.