

# TESTS OF ALCOHOL LAMPS AND STOVES.

## WITH COMPARISONS OF MEASUREMENTS, OPERATIONS, POWER, AND FUEL CONSUMPTION.

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THAT alcohol has extensively replaced kerosene and other fuels for domestic lighting and heating in the continental countries of Europe is well understood, but knowledge of the forms and use of apparatus especially designed for alcohol, and of the merits and cost

ation to bring them into popular use. Attention was then turned to alcohol, which proved a more satisfactory fuel so far as requirements of the incandescent mantle are concerned, and we find, therefore, on the German and French markets to-day a large number

at Washington, D. C., use being made of the excellent laboratory equipment of that institution.

The candle-power was measured by a Bunsen photometer, the standard being an incandescent electric light of 17.2 candle-power at 110 volts. To maintain the required voltage a rheostat was placed in the lamp circuit and adjusted as necessary until the potential was correct, as shown by a voltmeter. To determine the fuel consumption the lamp was filled with alcohol, lighted and placed upon a pair of balances reading to 0.1 gramme. The lamp remained upon the scales during the test and thus a continuous record was obtained by determining the loss of weight at frequent intervals of time, enabling the hourly fuel consumption of each lamp to be directly calculated. The stoves were tested by measuring the length of time required and the amount of fuel consumed in heating a weighed amount of water from room temperature to near the boiling point. Fuel consumption was measured by weighing, as with the lamps. With both lamps and stoves, determinations were made, when possible, of the operation at various needle-valve settings.

The fuel used was denatured alcohol known to the trade as "pyro." It was purchased at a local drug store and was marked "188 degrees proof, guaranteed by the United States Industrial Alcohol Company." The test of this alcohol by hydrometer showed a specific gravity of 0.817 at 18 deg. C., or 64.4 deg. F., which by reference to an alcohol specific gravity table shows that the alcohol was approximately 94 per cent pure or 188 deg. proof as guaranteed. Alcohol of this strength has a weight of 6.83 pounds per gallon at 60 deg. F., and this value was used in converting weight to volumes. A careful calorimeter test was made as to the calorific power of this alcohol, from which it was found that its heat of combustion was 6,695 calories (high value) or 12,051 B. T. U. per pound.

Four illuminating lamps were tested, each made by a different maker and of somewhat variant types. Fig. 1 shows a hanging lamp intended for store and outdoor use, rated at 70 horizontal candle-power and made by M. Cohn, Jr., Berlin. The lamp is quite simple in construction, consisting merely of a fuel reservoir, *R* (see Fig. 2), and containing a cotton wick, *C*, which feeds alcohol into the vaporizing chamber, *V*, contained within the chimney. The vapor issues from a nozzle, as shown in the cross section, and flows downward to the mantle shown at *M*, mixing with air, as in the usual Bunsen burner, the air entering around the nozzle at *A*. The flow is controlled by the valve, *W*, opened and shut by the use of

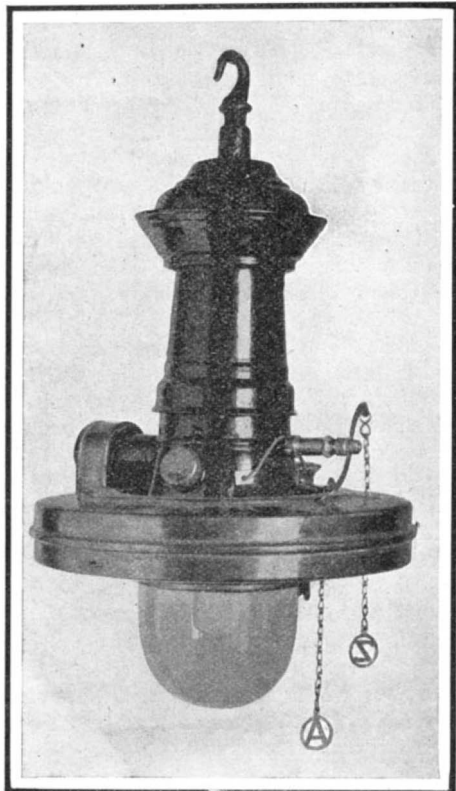


FIG. 1.—COHN HANGING ALCOHOL LAMP. GERMAN MANUFACTURE.

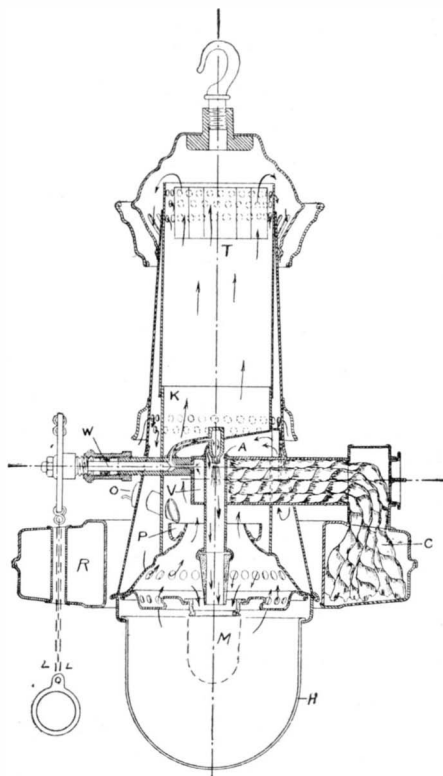


FIG. 2.—SECTION THROUGH COHN HANGING LAMP SHOWING INTERIOR CONSTRUCTION.

of alcohol as compared with other fuels, is still quite limited in the United States. Indeed, American inventors have given the subject of the design of suitable alcohol lighting and heating apparatus so little thought that, with the possible exception of small heaters such as have been used for chafing dishes and the like for years in this country, we must look almost entirely to the French and Germans for alcohol lamps and stoves.

The devising of apparatus which would give a brighter, safer, and more satisfactory light than the ordinary kerosene lamp in those households where gas and electricity are not available is a matter to which

of alcohol burners, most of which give an excellent light, with absolute safety from explosion, with no production of soot, and with but small consumption of alcohol.

Little is known with regard to the operation and fuel consumption of such apparatus in this country, and at the present price of alcohol many questions of economy must be solved if these lamps and heaters are to come into general use. In view of this fact and having secured the use of a quantity of such apparatus, the writers recently made a number of tests on four alcohol incandescent lamps of foreign manufacture for fuel consumption and candle-power, tests also being

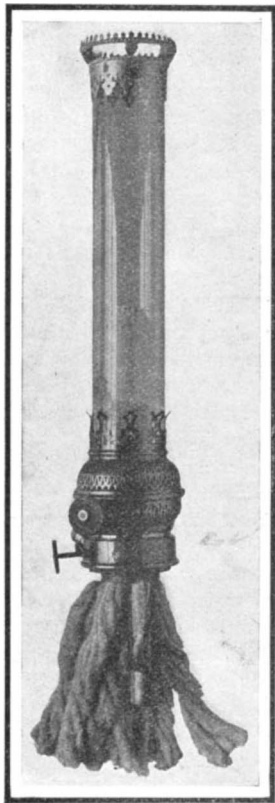


FIG. 3.—COHN TABLE ALCOHOL LAMP. GERMAN MANUFACTURE.

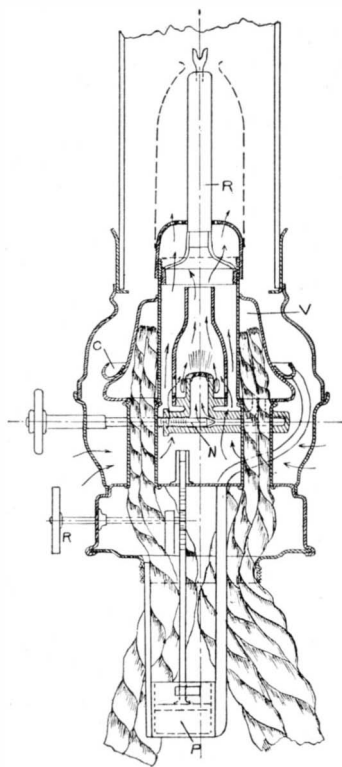


FIG. 4.—SECTION THROUGH COHN TABLE LAMP.

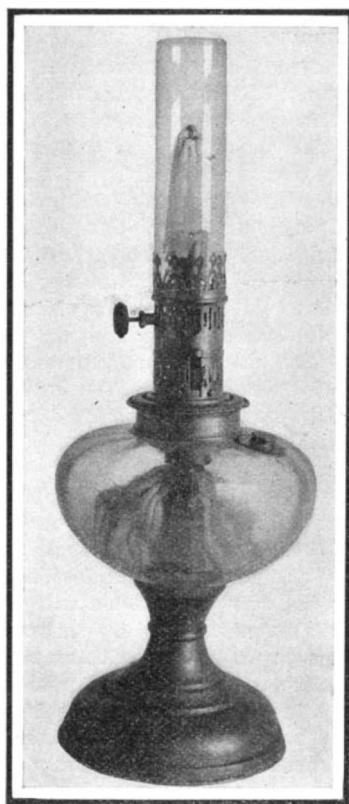


FIG. 5.—BEC NATIONAL FRENCH ALCOHOL LAMP.

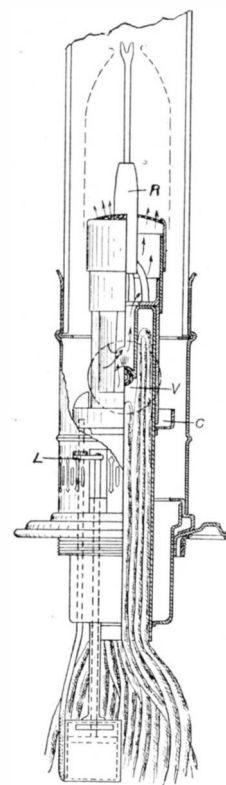


FIG. 6.—SECTION THROUGH BEC NATIONAL.

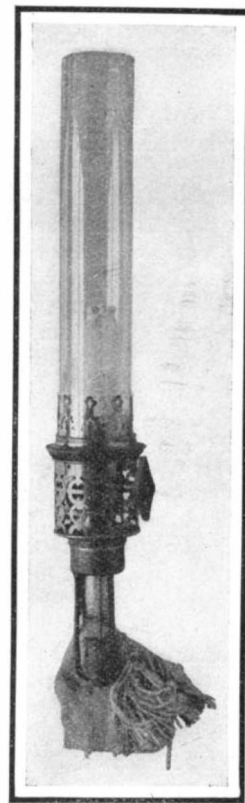


FIG. 7.—A SIMPLER BUT LESS SATISFACTORY FRENCH ALCOHOL LAMP.

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much attention has been given in Europe, but the difficulties to overcome have been such that development has been extremely slow. Kerosene incandescent burners were devised and put on the market more than ten years ago, but the lamps required too much care and technical knowledge for their successful oper-

made upon a representative kerosene lamp for purposes of comparison. In addition, the operation and fuel consumption of a number of small alcohol stoves were investigated, one of the stoves being made by a firm in this country. The tests were carried on in the physical laboratories of George Washington University

hanging chains, *L L*. The mantle is surrounded by a hemispherical glass cover, *H*, and the heated products of combustion rise through an inner portion of the chimney, *K*, heating the air supplied, which passes down on the outside of the hot portion of the exhaust gas tube, thus being considerably raised in tempera-

ture before combining with the vapor. The gases escape through the top of the chimney at *T*.

The starting of the lamp is a relatively simple operation. After filling the fuel basin, *R*, a small quantity of alcohol is poured through the opening, *O*, into a little cup, *P*, below the vaporizing chamber. This alcohol is then ignited and the opening, *O*, closed. After about a minute the needle valve is opened by pulling one of the chains. Another minute elapses before the mantle becomes heated to incandescence. The candle-power was measured both horizontally and vertically. The former averaged 30.5, the latter 36.2. No means are provided with this lamp for changing the needle-valve setting while in operation and the values given represent the average of one hour's operation at full needle-valve opening. The fuel consumption was 0.0229 gallon per hour, or, estimating upon horizontal candle-power, 0.75 gallon per 1,000 candle-power hours; or, in other words, 1 gallon of alcohol would be sufficient for 44 hours' operation.

Fig. 3 shows a burner adapted for use as a table lamp. The burner is quite ornate and with a tall glass chimney makes a decidedly pleasing appearance. The lamp is made by the same firm as above and is rated at 70 candle-power.

Fig. 4 shows the arrangement of the parts, it being seen that the lamp (as were all of those tested) is of the wick type, the wick conducting the alcohol to a vaporizing chamber from which the vapor issues into a Bunsen burner arrangement and burns at the top in a blue flame, heating the mantle to incandescence. The initial heating necessary to produce the vapor at starting is secured by burning a small quantity of alcohol in the cup, *C*, but during operation the heat conducted to the vaporizing chamber, *V*, down through the rod, *R*, which supports the mantle, is sufficient to carry on the necessary vaporization. A needle-valve, *N*, controls the exit of the vapor from the vaporizing chamber. In starting, a small quantity of alcohol is pumped up from the fuel basin by the pump, *P*, into the cup, *C*, the pump being operated by alternately turning back and forth a thumb nut, *R*. The alcohol in the cup is ignited and after a few seconds the needle valve, *N*, is opened a short distance, allowing the vapor to escape. It almost immediately ignites from the flame of the cup and the mantle soon becomes incandescent. The entire time of starting consumes about 45 seconds, counting from the instant that the pump is started to the time when the mantle begins to glow.

The range of possible settings of the needle valve is small, the maximum illumination of 24 candle-power, as determined, being secured with an opening of only one-eighth turn. An opening of one-half turn of the valve in this case produced undesirable blue flame above the mantle. The fuel consumption at the maximum candle-power stated above was 0.0191 gallon per hour, or 0.8 gallon per 1,000 candle-power hours.

a direct stroke by pushing down the spring-opposed lever, *L* (see Fig. 6, a partial section of the lamp). As shown by the diagram, a wick elevates the alcohol to a vaporizing chamber, *V*, from which it issues under control of a needle valve not clearly shown, and burns at the top of a burner similar to the usual Bunsen burner. The heating of the vaporizer is produced initially by the combustion of alcohol in the cup, *C*, and

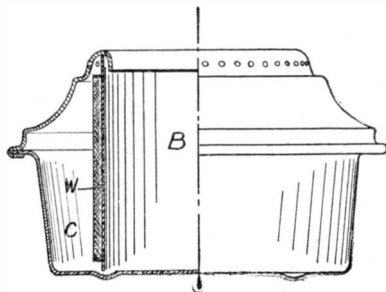


FIG. 9.—SECTION THROUGH TYPICAL SMALL ALCOHOL STOVE.

during operation by the heat conducted to the chamber by the rod, *R*. The operation at starting this lamp is substantially the same as in the previous cases, the time required being, however, somewhat longer, or about 80 seconds, although this varies with the experience of the operator. Since this lamp is provided with a needle valve the candle-power can be varied within

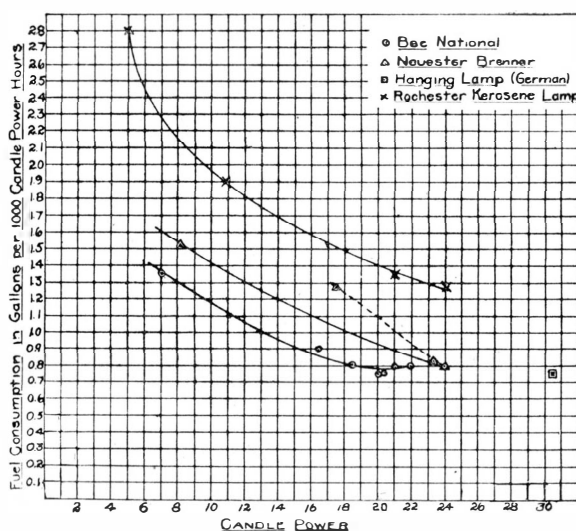


DIAGRAM I.—SHOWING THE RELATIVE FUEL CONSUMPTION OF VARIOUS ALCOHOL AND KEROSENE LAMPS.

narrow limits and in the tests here reported it was determined for eight different settings of the needle valve. These results have been plotted in Diagram 1. The maximum candle-power secured was with the

chamber. Greater openings of the needle valve than the most favorable increased the fuel consumption but not the candle-power by any appreciable amount. A slight hissing is noticeable, as with the ordinary Welsbach burner, and if sufficient excess of alcohol vapor is admitted the characteristic blue flame appears above the chimney. The lamp was tested for several hours and the fuel consumption at the maximum candle-power was 0.176 gallon per hour, or as in the other case, 0.80 gallon per 1,000 candle-power hours, or 1 gallon of alcohol will last 57 hours of continuous operation.

Fig. 7 shows a lamp which proved entirely unsuccessful in the test, it being impossible to secure more than a very feeble and unsatisfactory light. The cause seemed to lie in the unsuitable regulation of the air supply, causing the vapor to ignite and burn immediately upon issuing from the vaporizing chamber rather than at the top of the Bunsen burner. All attempts at adjustment of the air supply, for which more or less perfect means are provided, proved utterly fruitless, and the tests upon the lamp were therefore abandoned. One serious defect was found to exist in the fuel pumping and regulating devices, which in this burner are combined, both being functioned by one thumbscrew, shown in the figure.

The kerosene burner tested for the purpose of comparing candle-power and fuel consumption with the alcohol lamps was a circular No. 3 Rochester burner provided with a new wick and apparently in good condition. Four tests were made with the light varying from 5 to 24 candle-power, the fuel consumption being determined for each setting. The fuel consumed at the maximum of 24 candle-power was 0.31 gallon per hour, or 1.29 gallons per 1,000 candle-power hours. A gallon of kerosene would last 32 hours at this rate of consumption. The maximum candle-power probably could not have been maintained continuously without danger of smoke being produced. From 21 to 23 candle-power probably would have been about the maximum desirable in the ordinary usage. With this height of flame a gallon of kerosene would last 35 hours. The kerosene used was purchased in the open market, but no tests were made as to its specific gravity or heating value.

A summary of the relative illuminating values of alcohol and kerosene, as shown by the results of these tests, is shown graphically in the diagram. The candle-power developed is taken as a horizontal co-ordinate and the fuel consumption in gallons per 1,000 candle-power hours is read off on the vertical scale, the points representing the results obtained from different lamps are distinguished by the use of different symbols, as shown on the diagram. It is seen that the consumption is lowest at the maximum candle-power in every case, and that turning down the lamps, thereby reducing the candle-power, did not diminish the amount of fuel consumed in the same ratio as the

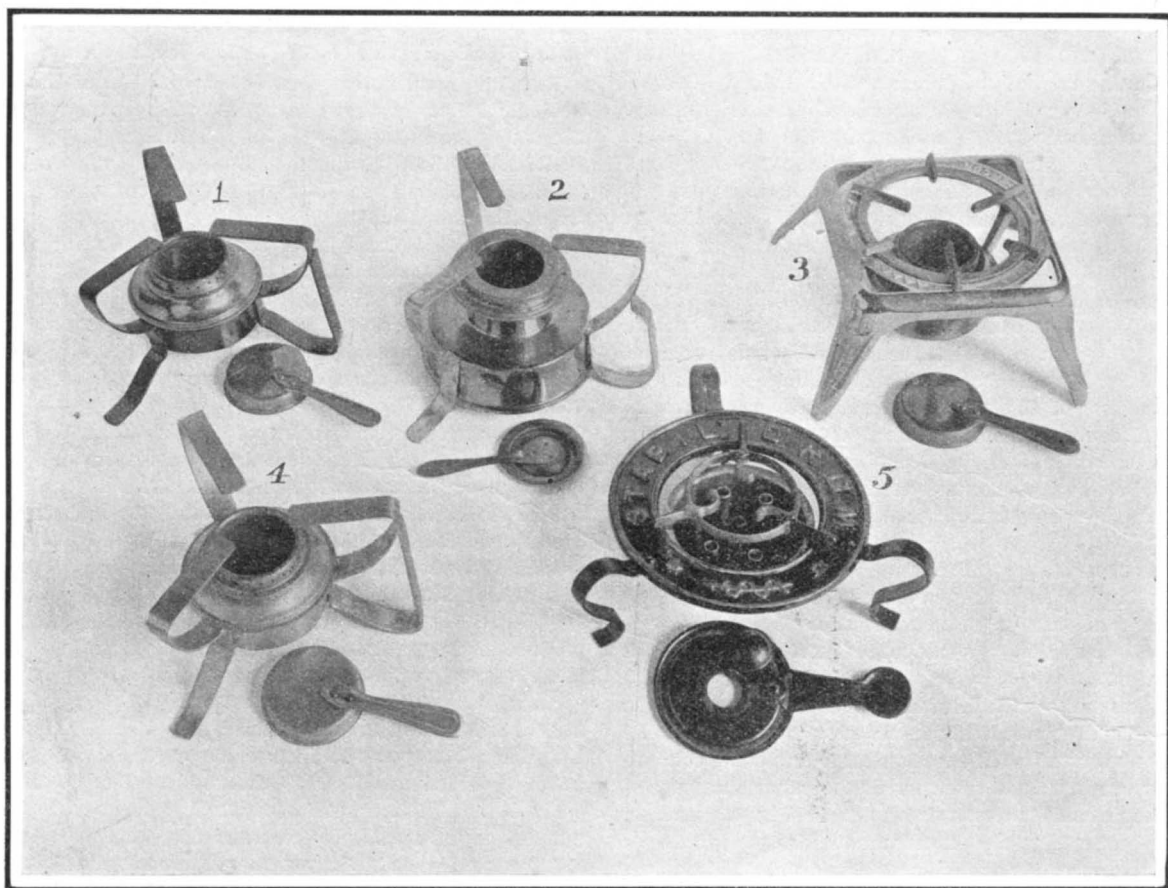


FIG. 8.—VARIOUS FORMS OF SMALL ALCOHOL STOVES OF FOREIGN MANUFACTURE.

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A gallon of alcohol would therefore suffice for 52 hours' operation.

Fig. 5 shows a smaller lamp, somewhat different in arrangement of details from that last described. It is called the *bee national*, being made in France by E. Boivin & Co. In this lamp the pump is operated by

needle valve open about three-fourths of a turn, its average at this setting being 22 candle-power. If the needle valve was closed below this value the light was reduced, and when the opening was about one-fourth turn the light became dim and finally flickered out, probably through insufficient heating of the vaporizing

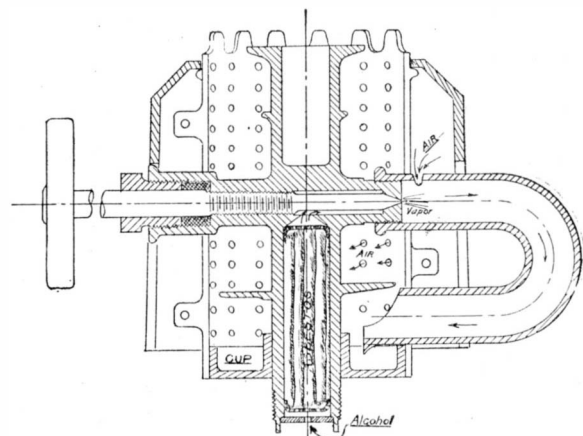


FIG. 10.—SECTION THROUGH BURNER OF "QUICK WORK" ALCOHOL STOVE.

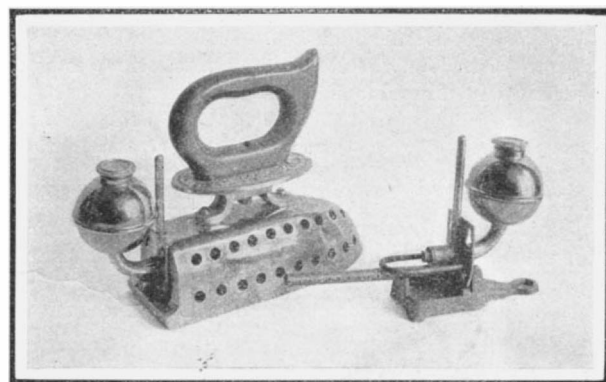


FIG. 11.—SAD IRON HEATED BY INTERNAL ALCOHOL BURNER, AND AN EXTRA BURNER.

light was decreased. For any lamp the different tests show that the relation between consumption and candle-power follows a fairly definite curve which is asymptotic to the axes in the case of the kerosene fuel. With alcohol fuel, however, there are indications that opening the needle valve beyond the most favorable

point, while increasing the fuel consumption, may finally decrease the amount of light obtained and the curve will make a loop and return upon itself, as is shown by dotted lines in the case of the Neuester Brenner lamp in the diagram, though this will depend upon the construction of the particular lamp with regard to the amount of heat conducted back to the vaporizing chamber.

It is seen that the curve for kerosene lies considerably above both of those for alcohol. Furthermore, the diagram shows that at best adjustment all the alcohol lamps used practically the same amount of fuel per 1,000 candle-power hours, namely, 0.8 gallon. On the other hand, the kerosene lamp required about 1.35 gallons per 1,000 candle-power hours at the most favorable point of operation, hence the kerosene consumption may be said to be about 1.7 times that of alcohol per candle-power hour on the basis of volumes. If kerosene sells at 15 cents per gallon, alcohol would have to sell at 25½ cents per gallon in order to furnish light at the same price. However, as compared with the kerosene lamp, the alcohol lamp has the advantage of being practically odorless in operation and of emitting an almost perfect white light, which is more pleasing in effect and agreeable in use than the yellow light of the kerosene burner. It has the disadvantage, however, of requiring much greater time in lighting, and the use of the mantle necessitates somewhat more careful handling, besides adding an extra element of expense. The mantles are, however, much less fragile than supposed; indeed, in the case of one of the lamps under consideration the lamp was carried by hand a considerable distance in the open air and the mantle was removed and replaced a number of times without apparent injury.

With regard to the mantles it may be said that so far as safety is concerned any mantle now used on ordinary gas burners may be equally well applied to use with alcohol. While it is perfectly possible that under certain conditions the alcohol lamp might explode as readily as the kerosene lamp, yet the peculiarities of alcohol are such that the flame resulting could be much more easily extinguished than that of kerosene under similar conditions.

The cost of lighting by incandescent electric lights at the usual rates charged in cities is about 60 cents per 1,000 candle-power hours, based upon a rate of 15 cents per kilowatt hour and upon a current consumption of 4 watts per candle-power. The ordinary Welsbach burner used for household purposes requires about 0.1 cubic foot of gas per candle-power hour, and the usual tip burner about 0.3 cubic foot per candle-power hour, which, with gas at \$1 per 1,000 cubic feet would represent an expense of 10 to 30 cents per 1,000 candle-power hours, respectively. Using the results given above, the number of candle-power hours which can be purchased for \$1 with different illuminants are as follows:

	Candle-power hours.
With kerosene at 15 cents per gallon...	4,900
With alcohol at 60 cents per gallon (retail) .....	2,080
With alcohol at 40 cents per gallon (wholesale) .....	3,120
With electricity at 15 cents per kilowatt hour .....	1,670
With gas at \$1 per 1,000 cubic feet (tip burner) .....	3,330
With gas at \$1 per 1,000 cubic feet (Welsbach burner).....	10,000

The foreign heating apparatus comprised a number of small stoves of the general type indicated in Fig. 8. While small, these stoves were found to produce a flame quite disproportionate to their size, it apparently being ample for the broiling of a steak or for the heating of a fair-sized kettle. The general arrangement of the parts of these lamps is shown by the diagram, Fig. 9, from which it is seen that there is a central basin, *B*, into which the alcohol is poured, which then enters the annular chamber, *C*, where it is absorbed by a wick, *W*. The wick being heated through the walls of the inner chamber the alcohol is vaporized and burns as it issues from numerous small holes seen at the top of the burner. The operation is decidedly simple, consisting merely in touching a match to the alcohol within the interior basin, which burns slowly for a few moments and then ignites the vapor as soon as it issues from the openings mentioned. With some of the lamps a small cover is provided to be placed over the interior basin, but this is omitted in the smaller sizes.

Heaters Nos. 1, 3, and 4, shown in Fig. 8, consumed 0.08 quart of alcohol while heating 1 quart of water from 20 to 98 deg. C. (68 to 208 deg. F.) in 40 minutes, the cost per quart of water heated being 1.2 cents and the cost of operation of the stove 1.8 cents per hour. Heater No. 2, which is somewhat larger than those last mentioned, consumed 0.043 quart in nine minutes while heating the same amount of water through the same range of temperature, the cost per

quart of water heated being 0.64 cent, or in continuous operation the expense would be at the rate of 4.26 cents per hour. Similar results for heater No. 5 are 1.68 cents per quart and 3.9 cents per hour, while for a small American-made heater of the type usually employed on chafing dishes similar figures are 0.52 cent and 1.25 cents respectively. These heaters are all, of course, of small capacity and adapted mainly to such household operations as may be carried on with a chafing dish. Only one stove of larger capacity was tested, this being manufactured in this country by a firm in Cleveland, Ohio, and known as the "Quick Work" stove. It differs from the small heaters in having a burner of the type in which vaporization is secured previous to combustion in a way similar to incandescent lamps. No wick is used, the fuel being forced into the vaporizing chamber under hydrostatic head of the fuel supply kept in the reservoir elevated about 2 feet above the burner. A cross-section of this is shown in Fig. 10. The operation of the stove is not unlike that of the usual alcohol incandescent burner. Preliminary heating is secured by opening the needle valve and allowing a small amount of alcohol to flow into the cup, after which the valve is closed and the contents of the cup ignited. After this has been consumed the needle-valve is again opened and the vapor which issues is readily ignited, after which vaporization continues automatically. This stove was first tested with the ordinary 94 per cent alcohol, one burner being used to heat water. Various needle-valve settings were used, ranging from one-half turn to one and one-half turns open. The position of this valve was, however, found to make little or no material difference in the operation of the stove, the consumption being practically the same at all settings, though the time required to heat a given volume of water varied. Thus, at needle-valve opening of one-half the time required to heat 1 quart of water 21 to 98 deg. C. (70 to 208 deg. F.) was 1,000 seconds and the fuel consumption 0.046 quart. With the needle valve at three-fourths opening, corresponding values were 810 seconds and 0.045 quart. At one turn open, 820 seconds and 0.048 quart, and at one and one-half turns open, 820 seconds and 0.049 quart. The reduced fuel consumption at the smaller opening is due undoubtedly to the fact that less heat is dissipated with the smaller size flame. The needle valve at three-fourths open would probably be found the most satisfactory setting in actual use. With this setting the cost of heating a quart of water is 0.67 cent, with alcohol at 60 cents per gallon, and cost of operation would be 2.97 cents per hour per burner.

At the request of the manufacturers of the stove, some tests were made upon the use of alcohol of various dilutions. Sufficient water was added to a quantity of alcohol to make its specific gravity 0.85 at 24 deg. C. (75 deg. F.), which gave it a strength of approximately 80 per cent. Tests were made with this mixture similar to the 94 per cent alcohol, from which it was found that the most favorable needle-valve opening was, as in the previous case, at three-fourths turn, at which the fuel consumption was 0.06 quart, this heating 1 quart of water from 22 deg. to 98 deg. C. (72 to 208 deg. F.) in 840 seconds. Greater openings of valve increased the fuel consumption and made no appreciable reduction in the time, while a less opening greatly increased the time and slightly increased the fuel required. If enough water is added to the 94 per cent alcohol at 60 cents to make it 80 per cent by volume, the cost of the latter would be 51 cents per gallon. As compared, therefore, with the operation with 94 per cent alcohol we find that the cost of heating 1 quart of water through the same range of temperature would be 0.765 cent, and at most favorable setting of the valve the cost of operation would be 3.27 cents per hour, a loss of 0.3 cent per hour, which shows a distinct disadvantage in dilution, as might be expected because of the heat which must be expended in vaporizing the water content of the alcohol.

Alcohol at 75 per cent strength, while it would operate in the burner more or less perfectly, showed about 10 per cent greater consumption for the same effect, and, of course, a proportionate increase in cost of operation.

These results with diluted alcohol, while negative in character, are interesting in showing that such alcohol may be operated with success so far as actual combustion is concerned, in a burner of the vaporizing type.

A household sad iron is shown in Fig. 11, and an extra burner for the same mounted upon stand or holder is seen by the side of the iron. This forms an extremely convenient and satisfactory article for household use and would probably be highly esteemed during the summer season. The operation consists in filling the small spherical fuel reservoir, after which a small amount of alcohol is also poured into the shallow receptacle of the stand, the burner being placed upon the stand as shown. A few moments after lighting the alcohol in the holder or stand, vapor issues from the numerous small holes in the horizontal pipe and is immediately ignited. The burner may now be placed

within the iron, which is soon heated to the temperature necessary for ironing. The time required from the moment of lighting to reach this temperature (about 300 deg.) is 8 minutes, and the alcohol is consumed at the rate of 0.129 quart per hour, making the expense of operation about 2 cents per hour, with alcohol at 60 cents.

#### EFFECT OF MOISTURE ON WOOD.

THE effect of water in softening organic tissue, as in wetting a piece of paper or a sponge, is well known, and so is the stiffening effect of drying. The same law applies to wood. By different methods of seasoning two pieces of the same stick may be given very different degrees of strength.

Wood in its green state contains moisture in the pores of the cells, like honey in a comb, and also in the substance of the cell walls. As seasoning begins, the moisture in the pores is first evaporated. This lessens the weight of the wood, but does not affect its strength. It is not until the moisture in the substance of the cell walls is drawn upon that the strength of the wood begins to increase. Scientifically, this point is known as the "fiber-saturation point." From this condition to that of absolute dryness the gain in the strength of wood is somewhat remarkable. In the case of spruce the strength is multiplied four times, indeed, spruce, in small sizes, thoroughly dried in an oven, is as strong, weight for weight, as steel. Even after the reabsorption of moisture, when the wood is again exposed to the air the strength of the sticks is still from 50 to 150 per cent greater than when it was green. When, in drying, the fiber-saturation point is passed, the strength of wood increases as drying progresses, in accordance with a definite law, and this law can be used to calculate from the strength of a stick at one degree of moisture what its strength will be at any other degree.

Manufacturers, engineers, and builders need to know not only the strength but the weakness of the materials they use, and for this reason they are quite as much interested in knowing how timbers are affected by moisture as they are in knowing how they are weakened by knots, checks, cross-grain, and other defects. It is obvious that where timbers are certain to be weakened by excessive moisture they will have to be used in larger sizes, for safety. So far, engineers of timber tests, while showing that small pieces gained greatly in strength, do not advise counting on the same results in the seasoning of large timbers, owing to the fact that the large timbers usually found in the market have defects which are sure to counterbalance the gain from seasoning.

The Forest Service has just issued a publication entitled "The Strength of Wood as Influenced by Moisture," in which are shown the strength of representative woods in all the degrees of moisture from the green state to absolute dryness, and the effects of re-soaking.

#### PRODUCTION OF MINERAL WATERS IN THE UNITED STATES IN 1906.

THE final returns just compiled by the United States Geological Survey show that the total production of mineral waters in the United States in 1906 was 48,518,395 gallons, valued at \$8,065,841, a gain of 1,974,034 gallons in output and \$1,574,590 in value over the figures for 1905.

In compiling this year's returns the Survey has endeavored to make its statistics represent only natural waters, sold still or carbonated, in bulk or in bottles, excluding water used for city supplies, water given away or used by guests at resorts, and water marketed in the form of ginger ale and other soft drinks.

Minnesota leads the roster of States in production but not in total value, the sales representing chiefly table waters marketed locally. Wisconsin is a close second to Minnesota in production and far exceeds all States in value of output, the famous wells of Waukesha giving it this prominent position. The production of this State in 1906 was 8,252,718 gallons, valued at \$2,422,694. New York ranks third in the list of producers, the water sold at Saratoga Springs and the large trade worked up by prominent table water springs giving the State its position. The output in 1906 was 6,481,074 gallons, valued at \$893,476. Massachusetts, which was fourth in rank, produced 3,857,955 gallons, valued at \$210,152, the product having been derived from many small springs that meet local demands for pure and pleasant drinking water.

Allowing for deductions made to confine the figures showing production to natural water sold as water, it appears that more mineral water was consumed in the United States last year than in any preceding year.

To ascertain whether the minute hand of a watch touches the glass, wipe the hand and put a little oil on it. Then the glass is closed and the hands turned. If the hand touches the glass in the slightest degree, visible circles will be formed.