used, and fed in and out as explained above. This class of work is said to be done remarkably cheap.

Another interesting example of the work of the machine is shown in Fig. 14. This represents a sphere with the screw thread cut on it, which screws into a hemisphere as shown. The whole of the work was done automatically, and though only a mechanical curiosity, well illustrates the capabilities of the machine. The process of turning up the sphere, preliminary to screw cutting, is shown in Fig. 10. Where revolving cutters are used the machine can turn out an immense variety of work. Thus in Fig. 6 it is shown at work on a spiral reamer. In this case it will be noted that the worm and worm wheel at the end of the lathe have been interchanged, the latter being placed on the lathe spindle and the former being connected to the leading screw. In Fig. 7 the machine is engaged in cutting a worm wheel, the operation being entirely automatic, the wheel being fed round tooth by tooth, as each is completed by means of a ratchet and wheel below the bed as shown. In Figs. 8 and 9 more wheel cutting is shown, while Fig. 11 shows another mechanical curiosity turned out of the machine when using revolving

place to another suggested play rather than mechanical engineering of a high grade. It is utilized for placing the armor plate machinery and boilers on the new United States cruisers which are being built by that firm. It is a peculiarly shaped instrument. A large vertical mast projects upward from a conical steel framework, which rests on the floating pontoon. The conical framework is inclosed with wood, and inside the house thus formed are four engines of 40 horse power each, controlling the drums for the pulley cables and the machinery for turning the arms around and propelling the lifting pulleys toward the outer end of the main boom. The height of the cone is 65 feet. The mast is 51 feet high above the boom. It is of steel, and hollow, being 3 feet in diameter, and braced here and there inside with extra thicknesses of metal. It rests in a socket on ball bearings, consisting of 42 steel balls, each 4 inches in diameter, and absolutely true. Another set of balls is used at the cap of the cone for lateral pressure as the arms swing around. From three stay plates that hook themselves over the top of the mast strong guy cables stretch to the lifting arm to prevent it from breaking. The arm with which

run right in from the river. The derrick is operated by the engineer in the third story. By means of capstans on the pontoon it can tow itself about the shipyard. The pump, I may say, is fitted up with all the essentials for extinguishing fires, and it will, no doubt, prove a very effective auxiliary to the fire department of the yard. The water ballast tanks, three series of five each, are heavily ballasted with cement, of which material nearly 60 tons are used. Each of the twenty compartments which constitute the hull is entered from the deck through separate manholes or hatches. —Transport.

LIQUID FUEL FOR STEAM MAKING

By F. R. HUTTON, C.E., Ph.D.

THE combustibles which are at the service of the engineer for industrial purposes come to his hands in three forms. The solid fuels are coal and wood, lignite and peat, in their natural or derivative forms; the liquid fuels are petroleum in its crude state or as a product of refining or distillation; and the gaseous fuels are either natural or artificial fuel gas. The solid fuels are historically the first; the liquid and the gaseous have only come to the industrial importance which they now occupy during the last thirty years.

The combustion of a fuel being a union with oxygen, which is a gas, it is necessary that the fuel, whatever its form, be first reduced to such a fine state of division that it shall be possible for the union to take place rapidly. For the solid fuels there is necessary a certain consumption of energy in the form of heat in bringing about this fine division, either by a process analogous to distillation, by which gas is made, which subsequently unites with oxygen, or else by union with oxygen only on the surface of the solid particles of fuel. In the latter case, from the relative slowness of the combination, the temperature of the flaming furnace is kept at a lower point than where the form and fine state of division of the fuel permit this chemical union at a more rapid rate.

Confining attention to the subject of fuels in a liquid form, it may be stated that the first experiment in this country upon any considerable scale seems to have been made at the Morgan Iron Works, in New York City, in 1865, and is identified with the names of Colonels Foote and Julius W. Adams. The very high price of coal at that time, and the recent large discoveries of petroleum, gave special interest to this series of experiments, although the previous investigations by Professor R. A. Fisher, of New Haven, had shown that the question of the substitution of oil for coal as a fuel was largely if not solely an economic question affected by the relative cost of the two materials and their accessibility in any locality.

The English experiments of the same period bear date of 1864, under the system of Mr. C. J. Richardson. These were specially stimulated by the marine interests, with a view to the advantages offered by oil as a fuel on board ship for strategic and practical reasons, and secondly, by reason of the special problems facing engineers in the colonies, where coal was difficult to obtain for locomotive purposes, and where, in the dry season, it was of prime importance that no spark should be discharged from a locomotive stack to ignite a parched and inflammable vegetation.

In the development of the use of oil as fuel three great classes of furnaces have been put forward. That class in which the oil is introduced to the fire box in a liquid form embraces four types. The first is that in which the oil is delivered into pans in the fire area, where it is set fire to with the access of what air can be got to it—a method obviously imperfect, uneconomical and accompanied with great waste in the form of smoke. In the second form the oil is delivered into grooves upon a step grate so that it overflows from step to step, meeting the air supply between levels. This secures a much better union with the air and seems to work well, particularly in metallurgical practice. The third type may be called drop furnaces, where the oil drips from a number of pipes on to the combustion area, and is there ignited. The fourth type introduces the oil as a fluid up from below through a porous bed of lime or other similar material, at the top of which it meets the air for combustion, and burns as from a wick. This is one of the most satisfactory methods of using the oil as an undivided liquid, but it presents the difficulty that perfect combustion cannot be insured for any great length of time. The heavy constituents of the oil accumulate in the porous layers and gradually interfere with the flow.

The second great system for the combustion of oils involves the principle of finely dividing the oil by means of a jet of air or steam moving at high velocity and forcing the oil in spray form into the fire box. The burner in all systems of this class is practically an injector, and the steam or air carries the fluid with it usually in an annular jet, and its fine state of division brings it to a condition in which it can combine rapidly and completely with the air necessary for combustion. It will be seen that in this system a subsidiary apparatus must be depended on when the fire is first to be started. There must be a pressure of steam either in the boiler which is being fired or in some other boiler, in order that the steam jet can be started, or else the fire must be started with solid fuel, and the use of oil begun only when the necessary pressure has been accumulated.

Where air is used to bring in the oil, a pump is required to produce the necessary pressure, and for this reason the plan of using steam as the inducing medium is practically the only one which can be used in locomotive service whereby subsidiary apparatus must be reduced to its lowest terms. As to the relative advantages of air and steam, when they are equally available, steam would appear to have the advantage over air, in that it is at a higher temperature than air usually is when it enters the nozzle of the burner, and that it does not entrain with it inert matter, such as nitrogen, which has to be heated up by the flame, but does no useful service in the combustion. Moreover, if the temperature of the flame is high enough to dissociate the oxygen and hydrogen which formed the steam, while the heat absorbed in this dissociation is the same as that given out in the combustion of the hydrogen of the steam, the mechanical effect is to increase the proportion of the hydrogen in the flaming mass and thereby to increase the length of the flame, with a consequent gain in its radiating effect. While

FIG. 8.

FIG. 9.

FIG. 10.

FIG. 13.

FIG. 11.

FIG. 12.

FIG. 14.

PITTLER'S UNIVERSAL TOOL.

cutters. It is impossible for us in the limited space at our disposal to describe one tithe of the ingenious automatic fittings Herr von Pittler has provided for his machine, but those interested in automatic tools will find a treat in store for them if they pay a visit to 55 Farringdon Street, London, where about forty of the machines are now set up. The machines are built in all sizes up to the very heaviest by the Deutsche Werkzeug Maschinenfabrik, Chemnitz, Germany, and are also being manufactured in France and Belgium.

A LARGE FLOATING CRANE.

WHAT our modest American cousins claim to be the largest floating crane ever built is now in complete order and running successfully at Messrs. Cramps' shipbuilding yard, Philadelphia. Not long ago it lifted a 70 ton boiler off the dock, towed itself a distance of 150 feet, and lowered its load into the cruiser New York in less than twenty-five minutes. Only two men were required to operate the machine; and the ease with which the 70 ton boiler was lifted from one

the lifting is done is 65 feet long, and the other has a length of 50 feet. The arms are made of built-up steel of the toughest quality. The longer one is fitted with traveling machinery, so that it may deposit its burden at any required distance within its range away from the mast. The short arm is anchored to the foot of the cone by strong cables, and when a very heavy burden is lifted, two long steel arms are dropped from the outer end to the side of the pontoon below. The contrivance is certainly ingenious. The pontoon on which the derrick rests is of iron and fitted with a system of water compartments. It is 13 feet deep, 69 feet long, and 62 feet wide. When a boiler or any heavy weight is to be hoisted, the water is let in on the opposite side of the pontoon in order to keep the derrick on an even keel. As the burden travels toward the outward end of the lifting arm more water is admitted, and before any lowering begins the machine is carefully adjusted and made level. The derrick is fitted with pumping machinery so that when its burden is left in place the water is pumped out. In admitting the water no pump is used. It is allowed to

there is no gain in units of heat, there may be a gain in the efficiency of the flaming mass to transfer its heat to the water in the boiler. On the other hand, there is required for the combustion a certain weight of air, and its introduction with the oil in the jet secures an intimate mixture of this air with the oil favorable to its union with it in combustion, and the specific heat of air is 0.23, while that of steam is 0.48, so that more heat is required to bring the vapor of water up to the temperature of the products of combustion than is required to bring air to the same temperature.

The fact, however, that the steam system requires no air pump will be a preponderating argument in its favor in many places. For the heating of forges also, the steam would appear to be an inconvenient diluent of the flaming mass.

It would be impossible here to allude in detail to the various forms of burner which have been presented for the use of oil as fuel. There are several features, however, which a good burner must have in order to work satisfactorily. The great difficulty in any form which has its nozzle near enough to the flame to have combustion begin at the very orifice is that the oil will carbonize at the orifice and gradually stop it up, sometimes checking it altogether. The burner must be of such construction that these pasty or hardened accumulations may be easily removed without stopping the apparatus, or else the burner must be fitted in duplicate, so that the one can be used while the other is being cleaned.

The best known injector of this class is that brought out by Mr. Thomas Urquhart, locomotive superintendent of the Grazi-Tsaritzin railway in southeastern Russia. His arrangement is a steam system, and the nozzle for the injector for oil enters within, but does not pass through, a thimble inserted in the rear water leg of the locomotive boiler. The flame does not reach the nozzle of the injector, and the trouble from carbonization or cooking of the oil particles is largely eliminated. If this should occur, or if the annular oil channel should become clogged by any matters in the oil, the steam tube can be retracted by a screw motion operated from the foot-plate of the engine, and the steam jet, which is one of the most detergent elements known in the arts, will immediately blow the opening free and clear.

In any of the comminuting systems of this class care must be taken that the flaming particles of oil coming into the fire box at high velocity from the jet should not impinge upon a particular spot of the heating surface. In all the systems it is aimed to secure this end by interposing in the path of the jet a baffle plate of fire brick or similar material. In the Urquhart furnace the fire brick is built up at the front end of the fire box nearly to the height of the lower row of tubes, and an arch is sprung across from side to side of the fire box, very much in the position in which the usual arch is found in bituminous fire boxes, and it is in this blind, rampant archway that the intensity of the combustion takes place. This mass of fire brick becomes white hot, and serves not only to store and radiate heat, but also to ignite the jet when it is cut off for a stop of the train. An objection to all burners of this class is the noise which they make, but in many places this need not be more objectionable than the noises in many fire rooms from quenching the ashes by turning a hose jet upon them. It is comparatively easy to prevent annoyance from explosive ignitions of the oil, if the precaution is taken to put into the fire box a lighted wad of waste shavings, and after this to turn on first the steam, and then the oil to the burner. Where the fire chamber can be once filled with vapor of oil before the flame is applied, there may be enough carbon ready to combine instantly with oxygen when the flame is applied to cause an explosion, which is always startling and may be dangerous.

The third great system of furnaces for burning oil embraces those in which the oil is first made into gas and is burned in the fire box in true gaseous form. This principle was applied in oil firing in this country as early as 1867, when a furnace of this sort, devised by Colonel Foote, was tried in the United States gunboat Palos. A flat coil of pipe conveying the oil to a larger pipe occupying the place of the bridge wall was brought up to a high heat by the combustion of the oil delivered in burners underneath the coil and in front of the retort. Superheated steam similarly heated by the issuing flame from the burners brought the whole mixture up to a very high temperature, and the products burned as a gas. In this case, of course, the gas and steam streamed out of the burners at a high velocity.

The Archer fuel process is essentially similar in principle, forcing the oil by a pump through a circular coil of pipe, which is kept at a high temperature by an annular fire surrounding the central retort, which, in this system, is called the "thermogen." Steam, in a similar coil, is superheated, enters the thermogen with the gasified oil and passes with it through the necessary regulating valve to the furnace of the boiler under which it is to be used. Unlike the vapor system already mentioned, it enters the furnace at a comparatively low velocity, without the rush and roar characteristic of so many of the other systems, and it is claimed not only that this peculiarity results in the consumption of less oil for a given amount of evaporation, but also that there is avoided the difficulty present in some of the comminuting systems of the formation on the heating surface of an incrustation due to the constituents of the oil which are not thoroughly burned in the fire box, but are carried forward to be deposited upon the cooler metallic surfaces. The difficulties of the gas system would appear to be those attaching themselves to the use of a retort which either could become clogged from residual matter in the oil or which would deteriorate from the action of the flame and from expansion at high temperatures.

The advantages which can be urged in favor of the use of liquid fuel are many and important. First, the crude petroleum has a higher calorific power than most of the coals, weight for weight. Where a crude oil can be used from which certain of the burning compounds have not been removed by refining, it is possible to secure a calorific power of 21,000 heat units, while the calorific power of coal may be put at from 12,000 to 13,000 heat units. This means that one pound of oil is equivalent to 1.6 pounds of coal. It is often called 1 1/4. English experimenters, using a lower calo-

ric power of coal, have obtained results correspondingly more advantageous for oil. This consideration has a very important bearing in both locomotive and marine service. In the locomotive tender it is possible to diminish the amount of fuel which must be carried between terminals to keep up a given speed or hauling power. The dead load is diminished with consequent obvious gain. But more important still, if there can be burned over a given grate area a fuel of higher calorific power, it becomes possible to make more speed from a given boiler in a given time, which means that the cylinder capacity can be increased without transgressing the limits of volume of boiler surface of grate which the conditions of practice in respect to gauge and curvature impose upon the designer of such machinery. In marine practice, not only is the ship lightened or the possible length between fueling stations increased, but, by a parity of reasoning, a smaller bulk of boilers can be expected to do a given amount of work.

Outside this fundamental and far-reaching advantage of a high grade liquid fuel, there are many practical advantages which need only to be enumerated to convince any one of the great convenience which is permitted by the use of liquid fuel. These are:

1. Diminished waste of fuel from the loss of combustible with the ashes and gases. In locomotives there is a loss of fuel through the stack, rated usually at from 10 to 20 per cent., according to the intensity of the draught. This is saved in the use of liquid fuel, besides which there will be no sparks to be taken care of in the smoke box, if arrested, or to set fire to property, if blown out.

2. A reduction in the cost of the labor for handling the fuel, which is twofold. There is in most plants an expense for handling coal into bunkers, and a second handling from the bunkers into the fire box. The oil handling for both of these steps is mechanical, while with the solid fuels the second step is but rarely so. It is possible, therefore, for one man with oil fuel to take care of many more boilers than with solid fuel.

3. In cities it is a matter of convenience and economy not to provide for the disposal of ashes, which from the solid fuels amount to from 200 to 300 pounds or more to the ton, and, where the plant is large, have to be provided for by special contract outside of the usual facilities offered by the municipal government. There is no flue dust to clog fire tubes and diminish their efficiency; but this may sometimes be offset by a deposit of oil residuals in them.

4. Where no firing tools are required, less injury is done to the brickwork of the fire boxes, and grate bars do not deteriorate.

5. Repairs to the brickwork of the ash pit and the boiler room floors are diminished, as the tendency to crack when heated by hot cinders and quenched by water is absent.

6. Better regulation of the fire is possible, as the demand for steam may vary. This diminishes losses of heat from blowing off at the safety valve, which doubtless often amounts to a loss of 5 per cent. or over.

7. The opening of the furnace doors for firing and cleaning is made unnecessary, so that the boiler may be expected to suffer less from unequal expansion and contraction.

8. Where the engine room is also the boiler room, the absence of dust and ashes about the machinery is of manifest advantage.

9. The absence of sulphur is favorable to the life of the boiler plate, and this is especially an advantage where there is moisture in the solid fuel, which permits the formation of an active sulphurous acid, corrosive in its character.

10. The labor of the fireman is made much more agreeable, inasmuch as all the work of cleaning and the strain of standing in front of open furnace doors are done away with.

11. Aboard ship, on the locomotive, and in cities, it is easier to secure a combustion as nearly smokeless as a due regard for economy will permit. For war purposes smokelessness is a matter of considerable moment, inasmuch as a trailing banner of soft coal smoke will betray the presence of a steamer otherwise invisible below the horizon. In the locomotive there are no cinders to annoy the travelers or the train crews.

12. In the contracted fire rooms of vessels the temperature of the room can be kept lower, and in tropical latitudes the lot of the firemen will be very materially mitigated for this reason, as well as by diminishing the severity of their labor.

13. On shipboard liquid fuel can be stowed in places where solid fuel could not be put.

The disadvantages attached to the use of liquid fuel will differ according to the nature of the oil employed. In this country two forms of oil are presented for fuel use. One is the product of the oil wells in Pennsylvania and Ohio—the crude petroleum as it flows from their mouth, sometimes more specifically designated as Lima oil, from the town of that name. In certain cities the limitations imposed by health boards and fire departments preclude the use of this material, and their reasons constitute two objections to be urged against the great bulk of available crude petroleum. The first of these objections is its inflammability or high flashing point. This means that because of the presence in the oil of light components which distill off in the form of vapor spontaneously, or under agitation, or at very low heats, there will be given off a light hydrocarbon vapor which will form with air a mixture that will ignite explosively when an open flame is brought anywhere near it. This peculiarity has a very important bearing upon the use of crude oil on board ship, where it would be kept in confined spaces, or in the locomotive, where naked flames are likely to be found around the oil tank. The second great difficulty with crude oil is its offensive smell, which has a very important effect in limiting its use.

The other form of oil used for fuel is the product of the refining process after the elimination of the naphthas and the kerosene or burning oils from the crude material, which leaves behind about 60 per cent. of the original quantity, having a specific gravity averaging 40° Baume, and a flashing point above the boiling point of water. This obviously is a very much safer form of oil for fuel and is not objected to by fire and insurance corporations, provided only that certain conditions looking toward the safety of the premises in case of accident are complied with. The usual requirements are that the storage tanks should be of

iron with tight covers provided with ventilating pipes and overflows; that the tanks if possible should be underground, and the piping also; and that the main tank, of larger capacity than the distribution tank, from which the oil passes to the burners, should be, if above ground, surrounded with a dike or embankment, inclosing a space large enough to hold the entire contents of the tank.

Oil of this class, having no volatile material remaining, gives off little or no odor, but there has been sacrificed not a little of its calorific power and of its length of flame. It will contain 85 per cent. of fixed carbon and upward of 13 per cent. of hydrogen in the ordinary run of samples, the balance being oxygen and impurities, so that it will compare in composition with coal of the bituminous class so much used for steam purposes, and will have by no means so much higher a theoretical calorific advantage over the solid fuels.

The disadvantages common to both forms of oil fuel are, where the vapor system is followed, the noise made by the burner, and, in the gaseous system, the sacrifice of part of the fuel efficiency for the distillation of the gas, and in both the air vapor and the gaseous system the necessity for auxiliary and additional apparatus, with their first and running cost.

It should be kept in mind that the production of coal is much in excess of the present production of oil.

But the final and conclusive argument is the commercial one, as to the relative cost of an equal weight of calorific efficiency in solid and liquid fuels. This calculation may be made to seek the answer in either equivalent price per ton of coal or equivalent price per barrel for oil.

The product of multiplying the weight of oil per gallon in pounds by the number of gallons in a barrel is the number of pounds of oil in a barrel. If this product be multiplied by the ratio in heating effect of one pound of coal to the pound of oil whose calorific power is known, we have a product which can be handled in comparison with the weight of solid fuel in a ton. If we divide the number of pounds in a ton by the product first obtained, and multiply the result by the price of oil per barrel, we get a figure showing what coal must cost per ton in order to be of the same cheapness. On the other hand, if we divide the above product by 2,000 or 2,240 and multiply the result by the price of coal per ton, we obtain the equivalent price per barrel which oil must cost if it is to be no more expensive than solid fuel. The cost of coal in this second calculation must include the labor and expense of handling the coal and ashes, which will be dispensed with where oil is the fuel, and the price of oil per barrel in the first calculation must similarly be taken as delivered to the consumer and not at its price at the wells.

A calculation made in 1889 by Mr. H. F. J. Porter for the use of oil under the boilers of an extensive steam plant in New York City showed that at the prices then prevailing for fuel oil of the quality at that time obtaining, 67 barrels of oil were equal to a gross ton of coal, and that with the conditions of the plant in question it would be possible to pay \$5.17 per long ton of coal, or that the equivalent price of oil was three mills per pound. Readers of this magazine will have noticed that in the department of mechanics, for August, 1892, it was stated that oil at 2.4 cents would compete with coal at \$3.95 per ton, but where coal was \$3.10 per ton and oil at 2.25 cents per gallon, the coal was cheaper. Where the price of coal drops to the neighborhood of \$1 to \$1.50, oil even at 1.5 cents per gallon is much more costly. An interesting table of comparative values computed by the above method was presented in the lecture by Dr. Dudley above referred to, and will be found in volume xvi. of the *Journal of the Franklin Institute—Engineering Magazine*.

ASBESTINE.

THE loadings, by which we mean those substances employed for increasing the weight or density of paper, and imparting certain characteristics to it, are diverse in their properties. The greater number of them lay claim to special characteristics in themselves, and naturally enough, when used, exert a corresponding influence on the paper produced. Thus china clay, the most universally used loading in the paper industry in England, is characterized by its soft and soapy nature, and imparts these properties to the paper in a greater or less degree in accordance with the proportion used. Papers highly charged with it are soft and absorbent. Hence this loading has been found to be specially adapted for producing type-printed papers. The ink on such papers is rapidly absorbed and dries almost immediately, the importance of which, in these days of quick-running printing machines, cannot be overestimated. Were it otherwise, the printed page would be badly smeared. Another peculiarity of this loading, second to its soft and soapy nature, is its adhesive properties. Notwithstanding china clay is always in a very fine state of division, and is so thoroughly miscible with water that it subsides only after long standing, it adheres with ready tenacity to the fibers forming the sheet of paper. This is particularly observed after the sheet of paper has been dried; and is, no doubt, due to the fact that the clay does not readily lose its water of combination, the presence of which maintains its absorbing power. When papers highly charged with china clay are clamped or wetted with water for the printing machine, the clammy nature of the loading causes it to adhere firmly to the fibers, and there is little dust formed, to which the printer so strenuously objects because it stops up the type.

Indeed, the chief essential properties of a good loading consist in (1) its degree of fineness; (2) its flocculent nature when mixed with water; and (3) its power to adhere firmly to the fiber. It is obvious that these three properties are dependent, in a measure, upon one another.

Asbestine, of which we wish to speak more particularly in this article, has been but recently offered to paper makers as a loading material. As many of our readers are aware, it is a species of asbestos rock found in extensive deposits in Austria and in other parts of Europe. In Austria it occurs in large quantities of more or less purity in the Carpathian Mountains, and is mined along with the mineral asbestos, with which,