THE AERATED FUEL COMPANY'S SYSTEM OF
BURNING OIL BY COMPRESSED AIR.

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JOS. M. WILSON, President, in the chair.

MR. COLLINS: The advantages of oil as fuel seem to have occurred to those engaged in handling the article, in this country, very soon after its discovery in Western Pennsylvania, as there are accounts of its use, in a crude way, under boilers more than twenty-five years ago. The number of plans devised for burning this liquid fuel, and the number of patents issued for them, are very large; but it is only within the last seven or eight years that a method has been devised for burning oil in a way to meet all the requirements of the different kinds of fire required in various lines of mechanical work. What are these requirements? We shall not attempt to describe each kind of fire in detail, but generally the requirements of a perfect oil fire are:

(1) That it shall be capable of giving the varying degrees of heat required in each line of work, and be subject at all times to the instant control of the workman.

(2) That it shall produce complete combustion, leaving no smoke or smell.

(3) That it shall be entirely free from sulphur or other impurities.

(4) That it shall be capable of being made a more or less oxidizing flame.

(5) That it shall be as safe as, if not safer than, a coal or wood fire.

(6) Last, though not least, that it shall be at least as cheap, in cost of fuel, as coal or wood.

The experiments which have been made to obtain these results may be divided into three general classes: In one

a retort or system of retorts is employed to convert the oil into gas before it is burned. This plan demands, in nearly every instance, the use of more or less complicated apparatus, or necessitates a special arrangement of the fire box, which unfits it for service in the event of the stoppage of the gas generating device.

Another class uses steam, or steam and air, to atomize the oil. The objection to every steam-jet burner is that it cannot be successfully used in all kinds of work, as it is difficult to get the highest degrees of heat when steam is mixed with the oil, and the heat from a steam-jet burner cannot be perfectly regulated nor made subject to instant control.

The third class relies upon air alone to atomize the oil. This is done in two ways: One is by spraying the oil, which is allowed to run out on the tines of a fork in the burner, by means of air under six or eight ounces pressure from a fan blower.

The chief objections to this system are:

(1) That it is of necessity a gravity system; that is, that the oil must be at some point a little higher than at the point of combustion, in order to enable it to flow to the burner, as six or eight ounces pressure from a fan blower is not sufficient to lift the oil to the burner, as is done where air under ten or fifteen pounds pressure is applied to it.

(2) That it requires more power to run a fan blower, to spray a given amount of oil, than it does to run an air compressor to spray the same amount.

(3) That a fan-blast burner, as has been shown by repeated independent tests, consumes nearly one-third more oil for a given amount of work than the compressed air burners.

The other air-spraying system is to subject the oil to sufficient pressure, to lift it from the storage tank, placed below the point of combustion, to the tip of the burners, where it is met by the air under the same pressure and driven into the fire, through an orifice, varying from one-thirty-second of an inch to five-eighths of an inch in diameter, in a fine spray. It is this compressed air system,

FIG- I.

devised and patented about seven or eight years ago, and since then gradually perfected by James H. Bullard, of Springfield, Mass., and now owned by the Aërated Fuel Company, that we propose to describe more fully in this paper.

The diagram (*Fig. 1*), here shown, represents a small plant arranged according to this system. *G G* is an air compressor, which may be called the heart or life of the system. The compressor may be run either by a belt from shafting or better by steam direct from the boiler, as shown in the diagram. *Fig. 2* shows a duplex steam-actuated air compressor. The air, compressed usually to about fifteen pounds to the square inch, passes into the air receiver shown on top of the compressor. This equalizes the pressure and eliminates the pulsations of the air compressor. The governor on the air compressor allows no more steam to be taken than is needed for the number of burners in use at the pressure required. From the receiver the air passes through the main air pipe *K*, down to the tank containing the oil, which is always placed below the level of any of the fires. As this tank is made air tight, the pressure of the air on the surface of the oil forces it through the main oil pipe *J* to the only outlet which it can find, namely, at the tip of each burner *A*, on the small oil pipes extending upward from the main pipe *J* to each burner. It will be noted that the main air pipe *K*, besides being connected with the oil tank, extends by small branches to the top of each burner *A*, and meets the oil which is conveyed through a small pipe in the interior of the burner to a point very near its tip. Exterior and interior views of the burner are shown in *Figs. 3* and *4*. The air in the burner surrounds the small oil pipe so that when it meets the oil at the tip of the burner it strikes the oil on all sides and mingles with it, thus forcing the oil from the tip of the burner in a fine spray. This spray, looking like a jet of water, extends four or five inches from the tip of the burner, which is always placed about one inch from an orifice in the furnace through which the spray of oil and air is driven. At the distance of four or five inches from the tip of the burner the oil, when lighted, bursts into a flame,

which may be varied all the way from a yellow, and if desired, a smoky flame to a clear white flame as bright as an electric light, by governing the proportion of oil and air by means of the cock at the butt of the burner. Its length, also, may be varied from fifteen to sixty inches, or more. The pressure under which the oil is forced into the fire varies all the way from one-half pound to about twenty pounds to the square inch, according as the kind of fire required for the work varies from a gentle heat through different degrees of red heat up to an intense white heat. In this way the Aërated Fuel Company's system meets the first requirement which we have stated, namely, that the fire shall be capable of giving the varying degrees of heat required in each line of work.

Before passing on to notice the other points, we may add, as a further description, that where the system is used on a large scale, it is usually desirable to employ an automatic oil pump and tank (shown in *Fig. 5*, as built specially for this system by the Hall Steam Pump Company), although this is not necessary. From the main storage tank in the ground the oil is raised in small quantity by this steam or belt-actuated oil pump, which is automatically controlled by a float valve in the small tank under the pump. When the oil reaches a certain level in this tank, the pump stops until enough oil has been used by the burners to lower the oil in the tank sufficiently to start the pump again. In practice, the oil pump, in large plants, works continuously, though slowly.

We have already indicated, in general, that the fire is at all times subject to the instant control of the workman by turning the cock at the butt of the burner. This is used where a slight variation only is required. When it is desired to alter the proportion of the air and oil to a greater degree, this is done by partly closing either the air valve in the pipe above the burner or the oil valve in the pipe below. The air pipe is spoken of as being above the burner, but the burner may equally well be placed with its air and oil connections horizontally, and the air pipe be carried down and placed under the floor, as the oil pipe should always be.

In this case the burner is situated at the centre of an inverted Π .

Our second point, that an oil burner should produce complete combustion leaving neither smoke nor smell, is secured in the Aërated Fuel Company's system, by supplying at the tip of each burner exactly the proportion of oil and air requisite to give perfect combustion. Some free air is also taken in at the opening in the wall of the furnace through which the oil spray enters the box. This opening

FIG. 3.

FIG. 4.

varies from one to four inches in diameter. Where the system is used for generating steam, or similar work, requiring a large amount of free air, this is admitted through the ash-pit doors, or better from the rear of the fire box through a special flue under the floor, so that the air passing through this flue becomes heated before it enters the fire box.

A great deal of thought has been expended by the managers of the Aërated Fuel Company, to meet the fifth requirement, namely, to make their system not only as safe

as a coal or wood fire, but even safer, and they feel that they have accomplished this, both from the testimony of the insurance companies and of users of their system, and also from the fact that the system is so arranged that if the air pressure stops at any time from the breaking of a steam or air pipe, the fires are instantly extinguished, and the oil in the pipes runs back to the storage tank. Where an automatic oil pump and tank is used, the oil pump stops as soon

FIG. 5.

as the air pressure stops, because the oil, ceasing to be forced into the fires, rises in the tank under the pump and shuts off the steam from this pump so that only ten or twenty gallons is above ground at any time, and this is stored in the iron tank under the oil pump. The only possible way in which fire can occur with this system, is by some workman carelessly turning on his oil and air and omitting to light the

fire, thus causing a fine vapor of oil to gather in the fire box. If enough of this is allowed to accumulate before it is lighted, an explosion is pretty sure to follow. But all the fires can be instantly extinguished by the engineer, or by any one else, shutting off the steam from the air compressor, and each fire may be shut off by its separate oil and air cocks without affecting any other fire.

A special feature of this company's system is that fires can be obtained at various levels, even extending to different floors of the building, on the same plant, and a different amount of air pressure and a different amount of heat can be maintained at each forge or furnace. In some places furnaces on the same line of piping are using two pounds of air pressure per square inch, and others beside them are using fifteen pounds.

While our first five points are of interest to users of oil as a fuel, a system which should supply them all and yet not comply with our sixth point, namely, to be at least no more expensive than coal is, would not be acceptable to the majority of manufacturers. It should be noted in the first place—and this point is one which it is difficult for many persons to realize—that the amount of oil required to equal a ton of coal varies very greatly in different lines of work. In small forgings, and the melting of lead or other soft metals, the amount of oil needed to equal a ton of coal can be reduced by careful handling to about forty gallons, while where a high degree of heat is required, or where the oil is to be burned in a large fire box, as when used for generating steam, the amount of oil needed to equal a ton of coal rises to 80, 100, 150 and in some cases to 175 gallons. It is difficult to get accurate figures, as most manufacturers either do not know, or will not tell, how much oil they use in their work ; but from an abundance of reliable data in the company's possession, from users of the system, the great economy of the system is demonstrated beyond peradventure.

It would naturally be supposed that in order to consume completely varying amounts of oil it would be necessary to increase the number of burners largely according to the

demands of the work, but with the Aërated Fuel Company's system the regulation is so perfect that the amount of oil which can be thrown through the same burner varies through a range of from 1 to 400, perfect combustion being obtainable with whatever amount of oil is used. Of course, a different sized tip is used for various lines of work where the amount of oil needed varies greatly, but otherwise the only object in multiplying burners is to distribute the heat properly through a large forge or furnace.

It is claimed, by the advocates of the various processes for burning oil with steam, that the component gases obtained by superheating and decomposing the steam give additional heat. It is no doubt true that heat is obtained by burning these gases. But the advocates of mixing steam with oil for fuel purposes seem to forget that to decompose the steam, which they throw in with the oil, requires a certain portion of the carbon contained in the oil which is the chief heat-giving factor; so that the extra heat obtained from burning the steam gases is at the expense of part of the heat contained in the oil. In other words, this process amounts to what is called "taking money out of one pocket and putting it into the other." Beside this objection, steam-jet burners require to be fed by gravity and hence are not perfectly safe. A careful test made with one of the best and most largely used of these burners, by the Farr Alpaca Company, of Holyoke, Mass., shows that it takes nearly six per cent. of all the steam made by the boilers to spray the oil to generate this steam, whereas the amount of steam required to run an air compressor for spraying oil by the Aërated Fuel Company's system for this purpose was found to be less than two per cent. of the total amount produced by the boilers. Moreover, the steam so used in spraying oil is consumed, whereas the steam used to run the air compressor may be used to heat the feed-water or be condensed and used again in the boilers. It should be borne in mind also, that where a steam-jet burner is used for generating steam, the fire varies, for the reason that when the supply of steam is ample and its force on the oil strong, the atomizing is more perfectly done and consequently a greater

amount of steam is generated, but when the steam supply is low, a low fire is obtained. In other words, a steam-jet burner works in exactly the reverse way to what is desired, giving most heat when least needed, and least heat when most needed.

To illustrate the amount of heat which can be obtained, at a recent test in burning terra-cotta at the New York Architectural Terra-Cotta Works, the Aërated Fuel Company's burners, on a circular kiln about eighteen feet in diameter, were lighted at the same time on Tuesday morning as the coal in a smaller kiln, the fire in each case being started at a low degree of heat and gradually increased in intensity to the end of the test. The kiln burned by the Aërated Fuel Company's system was finished Saturday afternoon, or in about 95 hours, while the one burned with coal was not finished until Sunday afternoon, or in about 120 hours. The actual degree of heat obtained here was not taken, but on the fourth day before the highest heat was reached, an iron rod about one inch in diameter thrust into one of the peep holes was melted to the point where the iron ran from the end of it in just two minutes by the watch. A similar test in Springfield, Mass., showed that a three-inch square iron was heated to a dripping heat in twenty minutes when the forge was hot, or in thirty minutes beginning with a cold forge, using not over three-fifths of a gallon of oil. At the Westman Gas Company's regenerative gas furnace, Hackettstown, N. J., two three-sixteenths-inch tip burners gave a heat of 3,200° by a pyrometer test.

In connection with the foregoing, it may be interesting to quote the analysis of lima oil, which is the kind usually used for fuel, made by Prof. Chas. Mayr, of Springfield.

"By ultimate organic analysis, the oil was found to consist of

	<i>Per Cent.</i>
Hydrogen,	17'10
Carbon,	80'20
Oxygen impurities,	2'70
	<hr/>
	100'00

"The specific gravity of the oil at 75° is .831.

"One cubic foot weighs 51 pounds, 14 ounces.

"One gallon weighs 6½ pounds, very nearly.

"Its theoretical heating capacity per pound is 18450.2 (pounds of water × degrees F.) heat units."

The same authority says:

"A weight of 7.3 pounds per gallon would correspond closely to many of the grades of petroleum; also, 20,000 heat units per pound is not an uncommon value for the theoretical number of heat units contained in a pound of the fuel.

"In order to derive approximate formula representing the cost of petroleum and coal, let us make the following assumptions:

42 Gallons oil,	1 barrel.
1 Gallon oil weighs	7.3 pounds.
1 Pound coal contains	12,000 heat units.
1 Pound oil contains	20,000 heat units.
Per cent. of heat in coal transferable to water, . . .	70 per cent.
Per cent. of heat in oil transferable to water, . . .	80 per cent."

In summing up, it may be said that there are about 200 plants using with this system in this country and in several countries of Europe, and that it is doing about fifty different varieties of work. By fifty varieties we mean that the kind of fire varies to this extent; but speaking generally, it is used for all kinds of iron and steel forging, tempering, welding, annealing, etc.; for making tin-plate; in glass works, for glory holes, lears and ovens; for generating steam; for burning lime, cement, terra-cotta, sewer pipe and brick; for heating chemicals and asphalt; for japanning; for oxidizing lead; for heating retorts in gas works; for drying sand, salt, etc.; for singeing cloth; for shrinking ordnance. From the fact that the system is used in so great a variety of work, there seems to be practically no kind of fire for which it cannot be used, the only question being one of economy as compared with coal; for, as before indicated, while the economy is very great in some lines of work, in other lines there is little or no economy. The line to which the Aërated Fuel Company is at present particularly turning

attention is, for generating steam on steamships and particularly on government torpedo boats. The system is already used on steamships in California, where coal is relatively very expensive, with excellent results; and from the fact that the oil can be stored at the lowest possible point in the ship and forced from that point to the fires, and the fact that the pressure maintained on the oil keeps up a steady flow even when the ship is tossing in the waves, and from the fact that it uses less steam for spraying the oil than any other system, it seems particularly adapted for use on steamships where it is necessary to economize room and steam-power to the greatest extent. If the price of crude oil can be maintained at its present figure, or better if it can be reduced slightly, there is every reason to suppose that before many years the use of oil on steamships, especially those requiring great speed, and hence great steam generating power, will soon become not unfrequent. It is well known that a well-managed oil fire will get from one-third to one-half more horse-power from a boiler than can be obtained with coal unless a constant force draft is maintained on the coal.

Lack of time has prevented speaking of the improved quality and increased quantity of work produced by the fires of the Aërated Fuel Company's system, but testimony on both these points is ample; so that the system seems destined to be still more widely used in the future, as its merits become more generally understood.