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SIXTY-SEVENTH PAPER

(OF TRANSACTIONS)

OIL BURNERS AS USED ON THE RIVER VOLGA.

BY

Mr. G. B. FROOM

(MEMBER).

READ AT

THE INSTITUTE PREMISES, 58, ROMFORD ROAD, STRATFORD,

ON MONDAY, 22ND MARCH, 1897.

DISCUSSION CONTINUED

ON MONDAY, MARCH 12TH, 1897.

PREFACE.

58, ROMFORD ROAD,

STRATFORD, E.,

March 22nd, 1897.

A meeting of the Institute of Marine Engineers was held here this evening, when a Paper by Mr. G. B FROOM, on "Oil Burners for Liquid Fuel," was read.

Mr. T. F. AUKLAND (Companion) presided.

In the absence of Mr. Froom the Paper was read by Mr. Ruthven (Convener, Papers Committee).

JAS. ADAMSON,

Hon. Secretary.

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ADJOURNED DISCUSSION, ON MONDAY, 12TH APRIL, 1897.

The liquid fuel I have had most experience with, is the Russian "ostatki," which is simply the Russian word for "residue." It weighs about 54 lbs. to the cubic foot, and is the residue left in the retorts, after the lighter oils have been distilled out of the crude oil. These lighter oils being chiefly benzine and kerosene, and constituting about 40 per cent. of the crude oil, about 60 per cent. is thus left of the original amount as "residue."

I would draw the attention of any one thinking of contracting for a supply of "ostatki," to the fact that although "mazouta" and "ostatki" are generally supposed to be the same thing, and either name is used indiscriminately, even in Russia and Baku itself, yet there is a great difference.

In Baku, when they lose control over a fountain, thousands of tons of crude oil escape, and flowing all around, collect in the hollows and form shallow lakes, there, by the action of the extremely hot sun, the lighter oils are partly evaporated, the oil losing 10 to 15 per cent. of its weight in two or three days, but not so thoroughly as in the retorts, the remainder is then called "mazouta." This "mazouta," burnt in the same way as "ostatki," is said to be more wasteful in practice, although, through the presence of the greater number of thermal units contained in the lighter oils, you might expect a better result.

A fact not generally known about this oil is, that if you mix two equal quantities of different specific gravities, you do not get a liquid of a specific gravity answering to the arithmetical mean. Also if you mix two oils of different flashing points, the mixture will flash, not at the lower temperature, but at a slightly higher one.

To give some idea of the extent to which the use of liquid fuel has grown on the Caspian sea, into which the river Volga runs; in 1890, the year I left Baku, there were 53 tank steamers carrying oil to Astrakhan, at the mouth of the river, which made 725 trips altogether in that year, carrying over 1,150,000 tons of "ostatki" as cargo, and burning 300,000 tons as fuel. But as there is a very much larger number of other sea-going steamers there, both passenger and cargo, and all burning "ostatki," the quantity used as fuel is, of course, very much more.

On the river Volga, liquid fuel has nearly quite driven out both coal and wood. In the year 1886, the number of steamers using liquid fuel was 340, and in 1890 the number had risen to 688, burning about 600,000 tons a year.

About that time, from 1884 to 1889 (when I went to Baku), I was in the town of Nishni Novgorod, on the

Volga, and took great interest in the growth of the use of this fuel, supplying a large number of these boats with their burners. The type of burner which I found gave most satisfaction was Mr. Kauffmann's patent, he having had great experience with burners, being engineer in chief to the most important oil firm in Russia, Messrs. Nobel.

I have the pleasure of presenting one of this type of burner to the Institute, and I hope some members will be interested when they inspect it. Last year Mr. Kauffmann wrote me that he had, since 1889, sold 976 such burners for use in Russia.

Of course, beyond the quantities used on the Volga and Caspian, many Railway Companies in Russia use liquid fuel, also many mills, factories, &c., the total used being 2,500,000 tons in 1892.

In the discussion on Mr. H. C. Wilson's paper on "Liquid Fuel" last year, I see the Chairman mentioned the advantage of "no need for having ashes or cleaning fires." There being no need for trimmers, and the smaller space for stowage required, are also often mentioned, but another fact in the use of liquid fuel, perhaps not so well known, is that in multi-tubular boilers, no soot is formed in the tubes if the combustion is properly attended to—an obvious advantage; and again, through the absence of sulphur in liquid fuel, there is not that chemical action on the fire side of the plates, noticeable when using coal containing much sulphur. But the principal gain is through the complete combustion effected; in the case of "ostatki," 90 per cent. of the units of heat in the fuel being transmitted to the water —in comparison to the 60 per cent. in the case of coal, partly in consequence of there being no need for the admission of the great excess of air over that theoretically required, as is the case in coal fires.

Nearly all the burners used on the Volga and Caspian burn "ostatki," and although of various forms,

they all are on the principle of pulverizing the oil by a jet of steam. Compressed air has often been tried, but without success.

The shape of the opening in the burner for the escape of the steam and oil governs the shape of the flame produced. Thus, if the burner has a round orifice, like most British and American burners have, you get a long round flame, drawing to a point, in shape similar to a candle flame. If the opening is a horizontal slit, you get a flat sheet of flame.

A good burner should thoroughly pulverize the oil, so that every drop should be consumed before it has time to fall to the bottom of the furnace.

Some burners, mostly of British and American make, consist of two tubes, one inside the other, the outer one being, say, about one inch in diameter, with their ends so tapered or brought to a cone as to leave a narrow annular slit, through which the steam escapes on being admitted into the outer tube, thus blowing the oil, admitted through the inner tube, into the furnace in the form of spray. Such burners I do not think thoroughly pulverize the oil, as it comes in contact with the steam when in the form of a solid round stream, which is difficult to split up. Also the oil, by gravity, is inclined to fall over the lower edge of the annular space, and so the lower half of the outflowing steam does nearly all the work, and the upper half does very little of the pulverizing, and is therefore useless, if not detrimental to economical combustion.

There is another style of burner, very similar in outward appearance to the last, the only difference being that the inner tube is generally a little shorter than the outer one, and the steam flows through the inner tube, and the oil through the annular space. This is no better, as often, especially if the steam is admitted at too high a pressure, the oil is ckoked back by the rush of steam, and the flame goes out until the oil gathers

sufficient head to again force its way past the steam, when it reignites with a rush.

In both styles the flame is long, narrow, and round, liable to blister the back plate of the combustion chamber of a marine multitubular boiler, or burn the back stay nuts if so fitted, and are only suitable for boilers with long furnaces, like the Cornish and Lancashire type; even then the pulverization is seldom complete, and in many cases the combustion is imperfect owing to the shape of the flame, the air required only getting to the outside of it; this fault some inventors have tried to overcome by introducing a third tube in the centre to admit air, but this does not do away with the other objections.

These faults do not exist in the type at present used in Russia, the flame issuing from the burner in a thin sheet, which readily allows the admixture of the air.

The type of burner adopted in Russia is one like Kauffmann's, Nobel's, Lentz's latest, Alexandroff's, or Kalashnikoff's, all of which have exits for the oil and steam, in the shape of two long narrow slits, the oil above the steam.

If you look at the Kauffmann burner, the burner proper, you will see the word "par" cast on one arm, this is the Russian for "steam," and the burner should be so connected as to have this underneath. On the other arm is cast "neft" or naphtha, meaning the oil passage, which comes on top.

On taking out the two screws holding on the iron plate or shield in front, which partly protects the burner from damage by heat, the two arms can be unscrewed, and the whole burner taken to pieces, when it will be observed that the channels for the oil and steam only open to the furnace, so the flame does not come out all round the burner, as might be thought, but only through that part opposite the shield.

A small toggle is supplied which fits the holes drilled all round the burner, and with this you can regulate the width of opening of the slits, thus regulating both the oil and steam at their exit, as well as by the valves on their entry into the apparatus.

The other part, called the "sharnear," is bolted to the boiler front at the furnace side, and consists of a hollow plug, partitioned into two parts, with arms corresponding to the two arms in the burner proper, and joined to it by two lengths of gas piping, $\frac{3}{4}$ inch in diameter, and bent to the shape of one leg of the capital letter U.

The two side valves, on the "sharnear," regulate the steam and oil, the one connected to the lower arm being for steam. Which is which can be found by blowing down the two tapped holes on the top, one of which is for connecting the iron gas pipe leading from the service oil tank, the other for the steam pipe. The "sharnear" arrangement is very neat, and a great safeguard against accident.

It should always be a rule, on putting out a burner, that the oil must be turned off first, then the steam, and then the burner must always be swivelled round on the "sharnear," out of the furnace altogether. On starting the burner, should there be a damper in the funnel, open that first, then put a piece of lighted waste dipped in paraffin into the furnace, say a couple of feet in, swivel the burner into place and close all furnace doors, turn on the steam first just a little, then a little oil, and it will at once catch fire. It is as well for the operator to stand clear of the furnace door, as sometimes a little flame shoots back on lighting up.

The importance of opening the damper, turning steam on first and not oil, and of taking out the burner is this: suppose a man just shut off the oil and steam at the valves and closed his damper, possibly the oil valve may leak a little, and the drops of oil falling into

the hot furnace would turn to vapour, and on returning to light up again, the furnace would be full of an explosive mixture of oil vapour and air. By swivelling out the burner this is avoided, and any possible leakage of the valve is prevented by its being doubly shut off automatically by the cock in the "sharnear." In putting out the burner, if you shut the steam off first instead of the oil, you do not consume the last few drops of oil, which would have the same effect as the above leakage. So in lighting up, turning on the steam first with the funnel damper open, creates a draught and clears the furnace of any gas accumulated.

The cock between the two regulating valves should be kept closed. It opens a passage between the oil and steam pipes, whenever you wish to blow through the oil pipes to clean them.

Some years ago the Trans-Caucasian Railway Co. carried out some experiments, and among other conclusions come to was, that the best pressure of steam to use in the burner they tried was about 30 lbs. per square inch, when, at a distance of only four inches from the burner, the flame was seen to be of the beautiful pink colour of pulverized oil; decreasing or increasing the pressure made the results worse; in the first case the combustion became incomplete, in the second the steam did not thoroughly pulverize the oil. Changing the breadth of the opening of the exits also had great effect on the nature of the flame.

This pressure, in my opinion, is rather high, and I should say that burners of different make or size probably require different pressures to obtain the best results. With the Kauffmann burner I have generally started with a breadth of opening of about one-sixteenth of an inch, for both oil and steam, and then adjusted them by the toggle lever until by observation I have got their best position. As to the pressure, I have had good results with 10 lbs. and even less. Mr. Kauffmann, writing to me in 1894, recommends from 12 to 15 lbs.

Anyhow, a point to be noticed here, and one often ignored, is the absolute necessity of having a reducing valve on the steam pipe to the burners,—if that steam is taken from the main boiler,—the omission of this valve leading to a great waste of fuel.

The importance of having means to regulate the exits or breadth of opening, and also the pressure used, in order to regulate the length of the flame, is much dwelt upon by Mr. Gulisham-Caroff, the leading Russian author on Liquid Fuel, and to the study of whose works I am much indebted. In one of his books he agrees with Mr. Zenish, from which I have pleasure in quoting the following, freely translated by myself, from a paper read by the latter before the Russian Imperial Technical Society in 1878:—

"Thus it is clear that the boilers will sustain damage only at such parts where the plates receive the direct impact of the flame, such as the combustion chamber back plate and the boiler tube ends But they can only sustain damage if the burner is placed exactly parallel to the horizontal axis of the furnace; if the burner is placed not parallel, but inclined so that the flame does not strike the bridge, but first comes in contact with part of the furnace, that part is unduly strained, and therefore the position of the burner requires serious attention.

"Further, it is noticeable that the temperature of the flame is generally more concentrated at some particular point in its length. This point varies from one-third to two-thirds of the whole length of the flame from the burner, varying with the pressure of the pulverizing steam. Thus, if the pressure is lessened, the point moves away from the burner, and if increased moves nearer to the burner, when the combustion takes place entirely in the furnace, and the rest of the heating surface is heated by the products of the combustion alone. And thus," says Mr. Zenish, "by altering the conditions of pulverization in the oil burners, it is

possible to alter the length of the flame and change the position of the greatest temperature in regard to the heated surface."

By attention to these points, it is quite easy to arrange that the high temperature should be close to the front end of the furnace, when you have perfect combustion in the furnace itself, no flame reaching the combustion chamber nor tube ends, which are only heated by the hot products of the combustion, and therefore sustain no damage. This also leads to greater economy of fuel, as the whole length of the furnace benefits by the heat, instead of having the front end comparatively cool, as it would be if the point of highest temperature were near the bridge.

With a long narrow flame, like that given by the tubular burners first mentioned in this paper, the concentration of the heat in one point is much more marked than in such burners as the Kauffmann, where, owing to the flame being in the form of a broad sheet, the portion where the heat is concentrated is distributed over a very much larger surface, and so is less likely to do damage.

I have heard of a case in a marine boiler where, by inattention to the above, the nuts on the combustion chamber back-stays were so burnt that many fell off.

In Russia, in boilers intended for liquid fuel, the practice is not to put any nuts on these stays in the combustion chamber, they being simply screwed into the plate and rivetted over, when no damage ever takes place. So it is advisable in new boilers, specially meant for liquid fuel, to do without the nuts, as really it increases the safety and durability of the boilers. In the case of old boilers, already fitted with these nuts, it is better to build a wall of fire-bricks against the back plate, the thickness of the breadth of a brick, resting on the bottom of the combustion chamber and reaching to a height of about a foot above the level of the furnace crowns.

On the Caspian sea there are some old boats, like the s.s. *Lebedia*, thus fitted, and although the bricks used are not real fire-bricks, but of local manufacture, they hardly show any sign of damage from the flame.

Really the above is only a precaution necessary in case the burner gets into the hands of an attendant not familiar with its proper use, as explained above, or in case of neglect, which, of course, sometimes cannot be avoided.

The usual arrangement on the *Volga* is to have neither fire-bars nor bearers in the furnace; but simply a bridge made wholly of fire-bricks, no cast iron about it, and the front end of the furnace quite closed up, with the exception of a hole where the burner is introduced, about level with the point where, in an ordinary marine boiler, the pricker bar-rest hangs. Thus advantage is taken of the extra heating surface of the lower half of the furnace.

In some English experiments I see the fire-bars were left in, and a huge heat accumulator chamber of fire-bricks most ingeniously arranged; but this I do not think necessary. It complicates matters, is a bother to keep in repair, and, as it is easy to get complete combustion without its use, the only advantage I can see in it, is that, after the burner is put out and withdrawn, it would prevent the furnace cooling too quickly, but such a mass of brick, at a temperature of white incandescence, would probably place the engineer in charge, on stopping suddenly, in the same predicament as if, when burning coal, he had very heavy fires, thus the safety valves would soon lift and water be lost, which never happens with the ordinary style of burning oil. As to cold air impinging on the furnace plate, it is only necessary, to prevent this, by having a small sliding shutter fitted to close the hole where the burner is inserted, this hole being the only place where air can enter.

Mr. Kauffmann writes me that of late his firm have been using a new form of bridge in marine boilers,

which is an improvement on the above style. It consists of a lot of 4 or 5 inch diameter fire-lay pipes, about 18 inches long, and $\frac{3}{4}$ of an inch thick, simply piled on top of one another, forming a sort of grating. He remarks, "but remember this grating must be so arranged not to extinguish the burning gases too soon, and at the proper distance from the burner, otherwise you will make smoke."

The temperature of the oil in the service tank is also of some importance, it has been found by experiment that the best results are obtained when it is kept at about 95° Fahr.

This service tank ought always to be fitted with a gauge glass, so that the quantity of oil in it can be seen at a glance, without a light. Some accidents have occurred through engineers putting in a naked light to see how much was in.

This tank should also be fitted at the bottom with a cock and drain pipe, for draining off any water that separates from the oil and settles at the bottom, which it does more readily on being warmed. It is a curious thing that, however long the oil may have been standing, if you take a tumbler full, and let it stand a few days in a warm room, you will see some water accumulate at the bottom of the glass. This water, being in drops, seems through its spherical form to be pulverized with difficulty, and is the cause of the noise, sometimes like a succession of pistol shots, heard with the tubular form of burner, when the flame occasionally even goes out for a fraction of a second. This does not occur with burners like the Kauffmann.

Another point to notice is the necessity of passing the oil through wire meshes at the entrance to the oil feed pipe in the tank, so as to prevent the burner getting choked with dirt. This pipe should either project two inches up through the bottom of the tank, or be attached two or three inches above on the tank side, so that any water settling at the bottom will not get into the burner.

In the use of oil for smiths' hearths and various furnaces, it is better to use compressed air instead of steam, supplied by some form of blower. Indeed, you cannot use steam in a smith's hearth, because the iron will not weld if you do, not because there may be any difference in the temperature produced, but because if you play steam on red hot iron, it gets covered with oxide, a good example of this being seen in the Bower-Barff process of coating iron for its preservation.

As to the use of compressed air in steamers, if you use cold air the flame very often goes out, and if you warm it, the noise of combustion is very great, making it unsuitable for either passenger or torpedo boats.

An objection to the use of burners using steam in ocean going steamers, is the waste of water. In an ordinary boat, this waste in the best burners is only some $1\frac{1}{2}$ per cent. of the total water evaporated, or 5 per cent. in the worst class of burner, and is so small that, if desirable, it can be made up by an evaporator, especially if a reducing valve is used.

In large Atlantic liners, where there is a large number of boilers, I would suggest a small boiler being set aside specially to make steam for the burners of the others, and as the pressure would never exceed 20 lbs., the temperature of 284° Fahr. (53 lbs.), at which sulphate of lime is deposited, would never be reached, and the density could be kept down by frequent blowing down the boiler, so preventing formation of scale to any great extent.

It is important that no air at all should be admitted into the furnace, with the exception of what enters through the small hole through which the burner is put in ; this supplies quite sufficient air for the purpose of combustion, with the further advantage of keeping the burner quite cool.

A small steam pump is generally supplied to pump the oil into the service tank above the boilers from the

main supply, which may be kept in tanks in the spaces generally occupied by the coal bunkers, or engine-room ballast tank. The oil of course can be stored in places which could not be used for coal, thus saving much space in this way beyond the fact of the stowage allowance per ton being less than what is required for coal.

A question that might arise if the use of liquid fuel became greatly extended, is the following :—As we have seen, the supply of "ostatki" is dependent on the amount of kerosene or illuminating oil manufactured, therefore, it is easy to imagine in the future such a state that the demand for fuel might greatly exceed that supply, and although kerosene can be used as fuel, the price is generally prohibitive. However, we could always fall back on crude oil, either in the form of natural "mazouta," which I referred to in the beginning of this paper, or a better class of "artificial mazouta" could be prepared at very little expense.

As I mentioned before, the sun's rays evaporate 10 per cent. to 15 per cent. of the lighter oils in two or three days, and it would be a comparatively inexpensive process to erect large open boilers on the spot, in which the crude oil could be subjected to a somewhat greater heat for a few hours, when the result would be a first-class liquid fuel, as safe and as economical as "ostatki." In fact, I believe there many sources of oil known at present, in various parts of the world, which are not worked, as the oil does not produce a satisfactory illuminating oil when distilled, but if treated in this manner would produce an excellent fuel.

As to "ostatki" competing with coal in this country, I do not think it is likely, excepting in special cases, such as for torpedo boats, where I think the new style of water-tube boiler especially adaptable for it, also it would have an advantage over coal in raising steam for motor cars, being smokeless, so portable, and easily managed. Then in some processes for working metals, where a pure fuel is of importance, it might also be used.

Steamers are built in this country to use liquid fuel, lately one left the Tyne to trade in the Black Sea, built under the superintendence of Messrs. Flannery, Baggallay, and Johnson, of which firm I see two gentlemen are members of this Institute, and no doubt would be able to give us some interesting information as to results.

In regard to American crude oil, some of the previous arguments are applicable to it, and the fact that some 4 per cent. of the American crude oil is only left as residue after distillation must be kept in mind; at least this applies to the crude oil at present distilled in the United States. I saw, about a year ago, in an American paper, that there was some talk of asking the Government to lower the standard of quality demanded in illuminating oils, so that the large quantities of inferior crude oil, known, I believe, as Lima oil, could be refined. This Lima oil leaves a much larger quantity of residue.

It is rather in other parts of the world, where coal is much dearer than in this country, that I look for an extended use of this fuel. There are large supplies, I believe, in Galicia, Roumania, Canada, North and South Africa, Venezuela, Peru, Persia, Burmah, India, New Zealand, Japan and China, some of which perhaps not suitable for producing illuminating oils, yet could always be used as fuel, prepared in the manner suggested; at any rate supplying a cheap fuel on the spot in places where it is found, seems likely to make them centres of new industries if adopted.

With this paper I have the honour of submitting some photographs taken in Baku, which I hope will prove acceptable, in addition to the burner. The writing beneath them will sufficiently explain the subjects.

In the views of the oil-well derricks you will notice how remarkably close these derricks are to one another. Now this is a point of some interest, as it sometimes happens that a well may be sunk some 160 fathoms

deep without striking oil, whereas another one, only some twenty-yards away, may be spouting thousands of tons a day, although sunk only some thirty fathoms. This fact, to my mind, disproves the theory of the existence of lakes of oil under the surface in Baku.

On the other hand, I have noticed if a well strikes oil at some point at a depth of fifty fathoms, and that a second well, at a distance of say sixty yards from the first, strikes oil at a depth of 100 fathoms, that the probability is that a third well, sunk equi-distant from and in the same straight line as the first two, will strike the oil at a depth of about 75 fathoms. Showing that the oil runs in veins, any small divergence from this can be explained by those veins being naturally rather erratic in their course, like any other veins in mineral mines.

I believe Professor Mendaleieff, whose theory of the formation of oil is well known, inclines to this idea of veins.

The size of the wrought iron pipes used in starting a well vary according to the expected depth of the bore The usual first size is 15 in. diameter; never more than 18 in.; and as the depth increases, and the friction becomes too great to drive the large pipe, the boring is continued by smaller pipes, decreasing three inches in diameter at a time, the outer pipe keeping the upper part of the inner one free. When the pipe has come down to say six inches in diameter, the depth is generally so great, say 180 fathoms as a maximum, that it is useless to go on further with the bore, especially if no gas is escaping, or if the blue clay brought up by the boring tools does not smell very strongly of petroleum.

I must apologize for the many digressions I have made in this paper, and for it being so disconnected. I can only offer the excuse that my duties as engineer on board ship leave me but little leisure, and I have had to write a little bit at intervals when the opportunity offered.

DISCUSSION

ON

OIL BURNERS FOR LIQUID FUEL;

(PAPER BY MR. G. B. FROOM)

(MEMBER),

AT

58, ROMFORD ROAD, STRATFORD,

MONDAY, MARCH 22nd, 1897.

CHAIRMAN:

MR. T. F. AUKLAND *(Companion)*.

Mr. S. C. SAGE (Member of Council): About twenty years ago I conducted some experiments in London in burning a residue from a heavy tar oil. We sprayed the oil into the furnace by means of compressed air, and the burners were circular, two or three in each furnace.—I have one of those burners, but regret I forgot to bring it with me this evening. If this discussion is adjourned I will bring it on the next occasion.—We simply let the furnance bars be covered with clinker, and so long as the supply of oil was kept going the furnace was almost one continual mass of flame. I think there were three of these cylindrical burners, and they formed a flame very much the shape of themselves. We carried out a series of experiments in using this residue as fuel, but had a great deal of trouble with smoke. Black, heavy smoke came from the chimney, and we found that even at the low price at which we got the oil, it was not more economical than coal—not for the whole installation. We required to have a man continually watching to keep all the burners in operation, and see that they did not become choked. This boiler was working a workshop engine at the time, and steam was about 60 or 80 lbs. It was

very interesting to watch the experiment, and there are several boilers in London now running with this material, especially at those works which produce it. I am very much interested in the paper read to-night, and think that although it may not affect us individually in the practice of our profession, there is a great deal of importance attached to the subject, if not in this country, in other countries where this fuel is cheap and abundant as compared with coal, and it is a subject in which we, as engineers, should inform ourselves. Not very many of us have had the privilege of a practical acquaintance with the use of this oil fuel, but I am sure we are all much obliged to Mr. Froom for giving us the results of his experiences, which are highly interesting.

The CHAIRMAN: I have been told that one of the arguments used in favour of liquid fuel is that you avoid the smoke which is incidental in the use of coal.

Mr. SAGE: It appears from the paper that it is almost smokeless if properly manipulated, but the experiments that I conducted were with an entirely different kind of oil. It was a manufacturer's product, and it was perhaps due to our ignorance in managing it that it smoked very much. The smoke that I refer to was one of the objections in the experiments that we carried out more than twenty years ago. Sometimes the smoke was very dense, and we were afraid of the Inspector of Nuisances coming into the premises for an explanation. I believe that the method of burning oil as fuel has been much improved upon, and that the most approved methods are comparatively smokeless. I believe they attribute a great deal of that to the fact that the oil is sprayed with steam instead of with compressed air. I shall have very great pleasure in proposing a vote of thanks to our friend Mr. Froom for presenting this paper, and I think it should be the subject of discussion on a future evening. These burners on the table are very interesting, and I think we should have an opportunity of taking them to pieces and see how they act. It might be a great advantage

to us to know how they are made and work; and at the adjourned discussion I will bring my burner for the inspection of members.

Mr. F. W. SHOREY (Member of Council): It is much to be regretted that the author was not able to be present to-night, because the discussion would then have been much more interesting, as we could have asked questions and obtained further information on points that we were not clear about. The author speaks in the paper about closing the ash pits entirely, and also the spaces where the burners enter; but how is he going to bring about that perfect combustion without the admission of any air whatever? It seems strange to me that these should burn without any air.

Mr. SAGE: I do not think it is meant to be air-tight.

Mr. SHOREY: He also says that it would be an improvement if he had a shutter to close in all the air spaces; and again he says there was perfect combustion taking place. There are several little points I should have liked to ask the author about.

Mr. J. R. RUTHVEN (Member of Council): I should think the questions might be sent to him, and the answers received within a fortnight.

Mr. SHOREY: It would also be interesting to the members of the Institute to know the cost of this oil fuel compared with coal. I should think it is much cheaper than coal for certain vessels.

The CHAIRMAN: There cannot be any doubt about the saving in space for cargo carrying.

Mr. SHOREY: How about the question of insurance?

The CHAIRMAN: That is a question which must be entirely governed by experience. I am not aware that

the use of liquid fuel on board steamers has yet been brought before underwriters in relation to the question of insurance. Possibly, in the first instance, they would take the opinion of certain experts, and guided also by the results of such experiences as were available, they would arrange certain premiums. Those premiums would rise or fall as the losses were many or few. The duty of the underwriter is to arrange his premiums so as to make a profit. It does not matter to him how many losses there are so long as his premiums are on a proper basis.

Mr. SHOREY: But it would take some years to arrive at that. I should like to know how many accidents have occurred with these oil-burning ships as compared with those burning coal?

The CHAIRMAN: I do not know where these ships are insured, but I am perfectly amazed to hear the number of ships that are burning oil as fuel.

Mr. SAGE: I know of twelve or fifteen steamers being built in Belgium for burning this liquid fuel on the Volga; and, with the exception of wood, oil is the only fuel obtainable in certain parts of Russia. I should say they would have some local insurance society which would cover them.

The CHAIRMAN: If this discussion is continued a fortnight hence, I shall be very happy to make some inquiries and see what I can find out. Mr. Flannery has constructed many of these boats, and there is one mentioned in the paper that was constructed from designs by his firm. It would be very interesting and instructive if we could have some remarks from him on the next occasion, and perhaps he would send them in writing, if he is unable to attend.

Mr. SAGE: There was a boat built at the Wallsend slipway to go out to Batoum, and I believe that that is the one the author speaks of. She was constructed

for, and left here using, oil fuel. The boiler, I think, was an ordinary boiler, only it had no fire-bars.

Mr. RUTHVEN: We asked the author if he could be here to-night; he could not attend as he sails to the Continent out of Sunderland. I doubt if he would be able to come at any time in ordinary course.

Mr. SHOREY: Mr. Sage has proposed a vote of thanks to Mr. Froom, the author of this paper. Before seconding, I should like to say that in conveying our thanks to him for his paper, I think we might ask him whether he can possibly be present on the next occasion. With that remark I second the vote of thanks.

Mr. RUTHVEN: I think it would be a compliment to him, and that he would be pleased to know that his paper was attracting so much attention, and no doubt he would attend if he found it convenient.

Mr. BASIL H. JOY (Associate Member): Before the meeting concludes there are one or two remarks that I should like to offer upon the paper that has been read to-night. This subject of liquid fuel is one in which I have long been much interested, and I have often wondered why it is not more generally used; I suppose it is owing to the limited supply of the fuel obtainable in Britain. The question of the respective merits of steam or air for spraying the fuel has been raised, but I think it is pretty generally agreed that steam is the best, as its chemical components materially assist and intensify combustion. It is open to one objection in certain cases—an objection which the author makes very light of—and that is the amount of fresh water used. I was recently connected with a boat of about 300 I.H.P., fitted with a water-tube boiler, in which it was proposed to use liquid fuel, but as no evaporators were fitted, this was found to be too great an objection, more especially as a similar boat on her way out to Denmark was caught in a fog, and the use of her syren exhausted the fresh water so that she had to fill up with salt. This

is really not such a serious matter as has generally been thought, now that Mr. Yarrow has run his boilers with entirely salt feed for a considerable time, with no scumming; and no evil results seem to have followed. With regard to Mr. Sage's remarks that—in the burner he used—he was very much troubled with smoke, I can only suggest that the burner was unsuited to its purpose, as I remember some six or seven years ago inspecting the plant in a shop boiler in the Great Eastern Railway Company's Works, on Mr. Holden's system, and Mr. Holden then showed us how, by moving a ring on the nozzle of the injector, so as to make a greater air space, black smoke was immediately given off at the chimney which ceased when the air space was reduced. I recently enjoyed an afternoon's visit to the Works of the Liquid Fuel Company, at East Cowes, where Mr. House, the manager, very kindly explained the action of their oil burners. In that system the oil flows into what is called a generator, which is a casting containing a very tortuous passage through which the oil has to flow, and by the time it comes to the exit it is vaporised by the heat of the furnace. It then passes down a small pipe and round underneath the generator, stopping some three or four inches away. The end of the pipe is blocked up by a valve of carefully adjusted weight, which also forms the air cone. The pressure in the generator has to be sufficient to lift this valve; the vapour then flows out, is ignited, and forms a big mass of flame, filling the fire box. The generator is surrounded by fire brick, so as to form an igniter in case the flame is momentarily extinguished by any means. The burner has to be started by a small methylated spirit lamp. The author's remarks on fire bricks rather surprise me. He says that bricks of a local manufacture, not fire bricks, are used, and do not seem to suffer at all. Mr. Henwood has used the very best fire bricks he can get, and they fuse in a very short time.

Mr. SHOREY: With reference to the burner just described, I should like to ask a question: In the event

of a sudden stoppage of the engines and the generation of steam, does the jet go out?

Mr. JOY: The jet goes out, but the bricks are so heated that for quite a respectable time the heat is sufficient to ignite the vapour.

The CHAIRMAN: Mr. Henwood called upon me on Saturday with reference to this paper. He was going on to the Agricultural Hall, where there is an exhibition of brickmaking, but he told me he would like very much to have been here to-night.

Mr. SAGE: It seems to me that an intense heat, such as that which has been described, would not be very suitable for marine purposes, because it would be likely to concentrate the heat within a small compass. If such a refractory material as bricks become dissolved by the volume of flame in Mr. Henwood's process, I should say that that fact would make it very objectionable for use as a steam generator. The system which the author has described in the paper also develops a very powerful heat, because it takes the nuts off the combustion chamber bolts; but as the author says that ordinary locally made bricks were sufficient to protect the nuts in some cases, it may be more the impetus or the velocity of the heat that is so destructive.

Mr. SHOREY: Could you tell us, Mr. Joy, anything about the admission of air into the furnace you refer to? Is air admitted, and if so, how?

Mr. JOY: I am not personally interested in the furnace in any way. It was shown to me, and I have simply explained to you what I saw. The air there was admitted by a little fire door in front of the boiler, and any amount of air was going round; for the purposes of this oil furnace the Liquid Fuel Company used a peculiar form of water-tube boiler with small tubes; but I am now only speaking of 25 H.P. burners.

A MEMBER: What was the style of burner in the 300 I.H.P. boiler?

Mr. JOY: Liquid fuel was not tried in that case. It was only proposed. It was a steam lighter, and having regard to the experience in the other boat to which I referred, when the fog horn exhausted all the fresh water, they decided not to adopt liquid fuel. I think it was Mr. Holden's system that was suggested to be employed.

The proposed vote of thanks to the author of the paper was then put to the meeting and carried unanimously. It was further agreed that the discussion on the subject should be adjourned until Monday, April 12th, and that a communication should be addressed to Mr. Froom, asking if he could make it convenient to attend on that occasion.

Mr. SAGE proposed, and Mr. SHORBY seconded, a vote of thanks to the Chairman.

The CHAIRMAN, in responding, said he felt it a great honor that he, a non-expert, should be asked to preside over a body of experts like the members of this Institute. But he took great interest in these meetings, and if he could do anything to assist the Institute or its work in any way, he was always extremely pleased to do so.

ADJOURNED DISCUSSION

ON

OIL BURNERS AS USED ON THE RIVER VOLGA.

MONDAY, APRIL 12th, 1897.

CHAIRMAN:

MR. T. F. AUKLAND *(Companion)*.

The CHAIRMAN: We have met to-night to resume the discussion on the paper read at the last meeting on "Liquid Fuel"; but before calling upon anybody to re-open the discussion I will read a letter that has been sent to Mr. Adamson by our president, Mr. Fortescue Flannery, M.P. :—

"DEAR MR. ADAMSON,

"I was looking forward to attending the meeting of the institute to-night, but I find that an important matter in Parliament will absolutely prevent my getting away from the House. The subject of liquid fuel is one that is of great interest at the present time, and the fact that the writer of the paper is one of the chief engineers associated with me in my daily work makes me all the more interested in the subject now under discussion. If the discussion should stand over beyond to-night I shall look forward to taking some active part in it at the next meeting. Wishing the members a pleasant and instructive discussion to-night, believe me, yours very faithfully,

"(Signed) J. FORTESCUE FLANNERY."

Mr. F. W. SHOREY (Member of Council): Is the author of the paper present? You will remember that on the last occasion it was agreed that he should be asked to attend to-night, if possible.

Mr. J. R. RUTHVEN (Convener, Papers Committee): The following letter has been received from Mr. Froom:—

"Rotterdam, April 7th, 1897.

"J. R. RUTHVEN, Esq.

"DEAR SIR,

"I have just received the vote of thanks and extract of report on my paper, read on the 22nd ult., from the secretary, and have written him in acknowledgement. I regret to say I shall be unable to attend on the 12th inst., as I cannot leave my ship. Mr. Flannery is my superintendent, so if he presides on the 12th, I hope he will not come down on me too heavily, and that other members will also let me down easily. I have to thank you most heartily for reading the paper for me, and I am sure your kindness in doing so must have greatly aided in its successful reception. It would take almost another paper to answer all the points raised last meeting. One point I may touch upon is in answer to Mr. Joy's remarks about the firebricks in the *Lebedia*. I think in my paper I said that these bricks were only necessary as a precautionary measure against carelessness in the manipulation of the burner, and explained how it is quite possible so to adjust the flame that it should not impinge on the combustion chamber back plate at all, so that the nuts would not suffer, even if uncovered. If the bricks were subject to the direct impact of the flame, perhaps they might fuse, especially if in the vicinity of the hottest part. In fact, this is partly the cause of my objection to the firebrick arrangements in the furnaces I mentioned, and Mr. Henwood's experience is what is to be expected. Again thanking you, I remain, yours faithfully,

"(Signed) G. B. FROOM."

Mr. S. C. SAGE: We have here a gentleman who has a burner of another kind with which he is identified, and although it would not be discussing Mr. Froom's paper, it would be interesting if he would give us an explanation of the burner that we have before us,

shortly, and to the point, so that we may not entirely neglect the paper that has brought us together.

Mr. HERBERT C. WILSON (Member): I have brought for inspection by members a single burner for using liquid fuel, and have prepared a few notes on the subject of oil fuel for the discussion on Mr. Froom's paper, and with your permission I will now read them and then give a short explanation of the construction and working of this apparatus. Mr. Froom has stated that he has found the Kauffman burner has given most satisfaction, presumably when using Russian "Astatki." There are of course a greater number of other burners of this type, principally it would seem the inventions of Russians or Americans. Most of them work upon the principle of atomising the oil by means of a jet of steam, the principal difference being the various arrangements to produce either a round or flat flame. Many of these burners may have special qualifications to recommend them, such as the non-liability to become choked at the oil orifice, and the facility with which they may be opened up for cleaning and inspection while under way. Broadly speaking it may be assumed that the mechanical difficulties of procuring a steady, continuous, clean and safe flame from heavy oils has been overcome and the actual type of burner used is to a great extent a detail. No doubt a certain amount of experience is necessary with any of these types of burners to be able so to regulate the supplies and pressures of both oil and steam to produce the best results. The same indeed might be said with reference to ordinary coal firing. An experienced fireman, as is well known, will get more work out of a given quantity of coal with a minimum trouble to himself than the raw hand who sees nothing more than a hole in the front of the boiler to pitch coals into. Mr. Froom has touched upon the objection of taking the steam necessary to atomise the oil from the main boiler, but this objection under proper conditions may be very greatly overcome, as an evaporator for making up the feed is now common in almost every engine-room. The question as to whether a flat or round flame gives

the best result appears to turn upon the type of furnace used. It appears that Mr. Froom has been dealing with liquid fuel as used in a boiler originally constructed for the burning of coal, that is to say, with an ordinary cylindrical furnace and combustion chamber with return tubes, &c. It has been stated by many authorities, one indeed quite recently, that:

"Probably one of the greatest drawbacks to the use of oil as fuel, apart from cost and prejudice, has been the want of a boiler constructed to meet the altered requirements. Hitherto we have always tried to adapt a fuel to the boiler totally regardless of the fact, that without the fuel the boiler would be useless. The electrician adapts his motor to the current, and does not waste time trying to make the current subservient to the motor, and so it must be with boilers, they must be designed to suit the fuel. In most boilers so far used for oil firing we have carefully lined the surfaces with firebrick. Why? Simply to prevent the heat getting where it is wanted, namely, into the water itself. Could an arrangement more contrary to common sense be thought of?"

It must be seen that there is a considerable amount of truth in the foregoing paragraph. Mr. Froom has referred to trouble experienced in burning liquid fuel in an ordinary coal furnace, and in most arrangements up to the present, elaborate precautions have been taken to provide firebricks and baffles or protecting plates, and in fact a host of devices all more or less directed to force the fuel to adapt itself to the boiler, which certainly appears to be putting the cart before the horse. If, on the other hand, a boiler be constructed with a furnace specially adapted to comply with the necessary conditions, it may be assumed that the result in the way of steam making would be enormously increased and simplified. It is well known that a gaseous jet of a cylindrical form burns only around its periphery or outside edge, and that the centre of such a flame is made up of a conical mass of unburned molecules which

are, as it were, on their way towards getting to the outside edge and becoming burnt. If it is possible, then, to take advantage of this natural law, and construct the furnace of a circular form so that the periphery of the flame where the combustion actually takes place is in actual contact with such a furnace throughout its whole length, you would then have the maximum of efficiency and the minimum of space occupied. There is however, one most important point in this arrrangement and it is the method adopted for supplying the air necessary to support combustion in sufficient quantities and in the right place. Mr. Froom has referred to this peculiarity, and has stated that some inventors have tried to overcome the difficulty by introducing a third tube in the centre of this cone to admit air, but Mr. Froom adds that this does not do away with the objections. If, however, a furnace such as I have described, be divided into sections having air spaces between them, each one of these sections having its orifice of escape smaller than the mouth or entrance of the one next to it, the following effect will be produced :– The flame from the atomiser in entering the mouth of section No. 1 will draw in with it and around its periphery sufficient air to maintain combustion at its highest efficiency for a certain length of tube. The flame then reaches the annuler space formed by the difference in diameters of sections Nos. 1 and 2. Here, again, the velocity of the flame draws in with itself sufficient air to carry on combustion throughout section No. 2, and so on. It will be understood that the diameter and length of these sections depends upon the volume of flame to be dealt with. The effect is really to convert the furnace into a Bunsen burner. When the flame has reached the end of the furnace, and the molecules forming the cone in the centre have all been consumed, there remain certain volumes of highly-heated gases still ready to part with their heat to the boiler water through the ordinary medium of tubes, plates, &c. The great drawback to an arrangement such as described is the inability to convert the furnace to coal burning, and in a boiler of this

description a supply of the necessary liquid fuel is absolutely imperative. Mr. Froom has spoken at some length on the question of supply, and the crux of the whole question may be said to lie here. It is apparent that there are enormous quantities of astatki, or its equivalent, available in different parts of the world, but until the shipowner can be sure of obtaining the necessary supplies for his ship at the usual ports of call, it would be idle to expect the general adoption of liquid fuel for mercantile marine purposes. In so far as it affects the Royal Navy, many of the objections to its use in merchant ships do not exist. For special service vessels, such as torpedo-boats and small cruisers, the use of liquid fuel is too obvious to need insisting upon. The literature on this subject has grown, even during the last twelve months, very considerably, and the fact that one cannot take up a current number of one of our technical journals without finding articles, paragraphs, notices, and correspondence on the subject of liquid fuel points to its growing importance. The whole question may very properly be summed up in the question of supply, and until depots are established and regular supplies guaranteed, the use of liquid fuel in the merchant service must necessarily be confined to those seas and parts of the world where astatki is plentiful, cheap, and easily obtainable. Whether this question of supply is any nearer solution than it was twelve months ago it would be very interesting to know. Most of the Powers have adopted liquid fuel to a considerable extent in their navies with good results, and it is to be hoped that before long steps may be taken by our own Admiralty in this direction.

Mr. Wilson then explained the construction and operation of the Siegle burner, which, he said, might be described as a "gasifier," and it was necessary to heat up the metal forming a certain portion of the apparatus before the oil was turned into it. This metal having been raised to a certain temperature the oil in passing through it became vaporized, and the burner really became a self-acting gas producer. But unfortunately

the heavier oils produced a certain amount of coke, and if astatki were used with this burner, there would be a formation of coke at the hottest parts of the burner. This was the reason why on the Volga and elsewhere pulverizers were used instead of gasifiers, pulverizers being the class of burners referred to in the paper where the oil was pulverized by a jet of steam being blown into it. But if they could only obtain a mixture of oil that would suit the burner to be used, perfect combustion would be the result, and no bricks would be required.

Mr. Wilson also drew on the blackboard a sketch of a furnace for burning oil fuel, divided into three sections having air spaces between them, and he described in some detail the action and effect of the flame from the atomizer in the different sections.

Mr. F. W. SHOREY: I do not know if I am right in discussing the matter that has been brought before us by Mr. Wilson—whether it will be fair to the author of the paper—but I have not much to say with regard to the paper read on the last occasion, and I am very pleased to find that we have had another method of burning oil fuel brought before us to-night. Mr. Wilson referred to a difficulty arising through the formation of coke, but he said that with a certain combination of oil that difficulty might be overcome. I should like to ask if it is possible to get such a combination of oil. Again, should the boilers be specially adapted for this liquid fuel, because the existing boilers have not been constructed for burning oil, and if only specially adapted boilers can be used it would seem to involve an entire revolution in boiler construction. It may be possible that oil fuel will be used for torpedo boats, launches, and other vessels of a special class, but I do not think it will come into practical and general use in the mercantile marine. Mr. Wilson has sketched us a form of furnace, and he says that the gas not consumed in section No. 1 goes on into section No. 2, and so forth. I should be very glad if Mr. Wilson

would explain to us how he would construct a boiler with a furnace divided into three sections in the way described. The author of the paper dealt with one method of burning oil fuel, and Mr. Wilson has brought forward another method; but of the two I should give the preference to the one described by Mr. Froom, that is pulverizing and breaking up the oil by steam. Another point with regard to that furnace sketched by Mr. Wilson is—how does he get the pressure behind the jet to start the furnace? Is it necessary to get a donkey engine to work to start the fires? It seems to me that he must get steam from somewhere to start the operation.

Mr. S. C. SAGE: The subject of this discussion to-night is Mr. Froom's paper upon the burners such as are used on the *Volga*, but I think it is not out of place that we should also discuss and endeavour to account for results with burners with other systems. With reference to the remark as to special boilers for oil fuel, of course, in certain districts it would be advisable that boilers should be constructed for the purpose for which they are required, and I can very well understand Mr. Wilson's remark that the proper way to burn oil fuel is to burn it in a boiler specially constructed. But as regards the members of this institute who are engineers in the merchant service, I take it that it will be a long time yet before we shall be called upon to burn liquid fuel generally in merchant ships. No doubt. the establishment of depots is merely a question of supply and demand, and I doubt not there is plenty of liquid fuel in the world which only wants collecting, and it will be collected when there is sufficient demand, but so far as the present, and probably the next generation of sea-going engineers are concerned, I believe that liquid fuel will be consumed generally in boilers that are made to consume either solid or liquid fuel, until we have established all over the world depots and storage places for liquid fuel equal to what the consumption will come to. With reference to the Navy, I have here

a small extract that I took from one of the daily papers the other day, and which reads as follows:—

"An important committee of experts appointed by the Russian Government to decide as to the most suitable fuel for men-of-war cruisers and topedo boats have (says our St. Petersburg correspondent) after lengthened deliberations, in which several admirals, captains, and naval experts took part, decided as follows:—Firstly, that in consequence of the cost of liquid fuel as compared with coal, the use of the former in the Baltic fleet shall be left open for the present; secondly, that as an experiment, half the boilers on the ironclad *General Admiral Apraxim*, now building, shall be adapted for the consumption of liquid fuel, whilst the remaining boilers shall use the usual fuel; thirdly, as regards torpedo boats, this kind of craft shall burn liquid fuel. It has also been decided that large ocean-going vessels—cruisers and ironclads—shall for the present use coal, on account of the difficulty of establishing naptha tanks."

I think, gentlemen, that that is the principal difficulty—the question of the regular supply of such liquid fuel—and there is no doubt in my mind that for some time at least the boilers in which most of the liquid fuel will be consumed will be boilers that are adapted to consume either solid or liquid fuel.

Mr. LESLIE ROBINSON (Visitor): The remark that fell from the last speaker with regard to depots, deals, I think, with a very important question, because that is a great difficulty that has to be met in this matter. I was in Paris last week and a gentleman who is much interested in this subject asked me what the British Admiralty are going to do in the matter, I replied, rightly or wrongly, "I do not think that we shall adopt liquid fuel until we are forced to do so by the other Powers increasing their speed over ours." For merchant ships the requirements are not quite the same, but I think that this Institute is to be

congratulated on the fact that it has members who can put forward their views in such a clear and lucid way as Mr. Froom has done in the paper before us, and I should like to add my thanks to him for his contribution. The burners which he deals with are all of one class, which is not the only class, and they are all open to the serious objection that they use fresh water for atomising. That is a difficulty which the Admiralty have realized, but they are not holding back for that reason because they are now making experiments with liquid fuel in some of our smaller war vessels. They are fitting two Normand boilers for burning liquid fuel on Mr. Holden's system, and two similar boilers are being fitted for burning coal so that the results yielded by the two systems may be compared. There is also the question of price which is a very serious matter. We cannot think of adopting liquid fuel with the price at the present figure, and before liquid fuel can come into anything like general use the price must drop and depots must be established. I think we may take it broadly that the difficulty of burning oil as fuel is practically met. Which is the most advantageous way of burning it I will not say; but the great difficulties which stand in the way are, firstly, the question of cost, and secondly, the difficulty of obtaining fresh supplies, From the naval architect's point of view liquid fuel has great advantages, because it practically doubles the range of action of a man-of-war, and there is also the advantage that you can ship petroleum at sea more easily than you can coal. But even with those great advantages there are considerable disadvantages. The protection which coal affords is a matter of importance in the naval architect's design, and if by putting in liquid fuel you do away with those coal stores round the ship you also do away with a considerable element of safety against the smaller class of shells which might otherwise do damage; and that is a point in regard to which liquid fuel does not stand so well as coal. There is another matter in which liquid fuel has an advantage, and that is in forced draught. We all know that however much we

may applaud forced draught, it is a nuisance. We like it not although we have to put up with it. Now in using liquid fuel you get over that difficulty which is a great point. Another point in favour of liquid fuel is that you have no smoke, and in naval tactics that is a matter not to be lost sight of. But still we have to come down to the practical part of the question Take the American nation, the Americans have unlimited supplies of petroleum, and their engineers are as sharp as any to be found, but they have not adopted liquid fuel. The nations forming the Triple Alliance—Germany, Austria, and Italy—have accepted petroleum fuel for a small class of vessels, and directly those boats attain a great superiority over ours, we shall find Mr. Durston putting his best foot to the front. But I do not think we shall adopt liquid fuel until we are forced to do so by the increased speed obtained by the boats of other nations.

But after all the question comes to this: is the game worth the candle? It is a very difficult and very complex question and perhaps for powers like Russia and others which have their own supplies to fall back upon, and would not have to rely upon other countries to supply them in time of war, liquid fuel may be all very well, but I doubt very much whether in our lifetime we shall see it universally adopted in our own Navy. It is wise for Mr. Durston to try different systems, but I do not think that we have yet arrived at the time when we shall give up coal and take to liquid fuel.

Mr. E. N. HENWOOD (Visitor): This question of liquid fuel is a tremendous subject to go into, but as I have been asked to speak upon it I will just make a few remarks. I would first of all refer to that part of the author's paper where he speaks of the methods of pulverizing the oil, and where he simply confirms what I said a long time ago. He says that compressed air has often been tried for pulverizing the oil, but without success. It is rather sad that some years ago we found

that one of the shipowners of London, who was largely interested in oil vessels, was so preverse, in spite of all remonstrances, that he set up on board his ship an air compresser worked by steam, and the result was one of the most frightful fiascos ever known. Then further on in the paper the author says: "It is as well for the operator to stand clear of the furnace door, as sometimes a little flame shoots back on lighting up." My experience, after a good many years, in this, that there was never any trouble of the sort to require the operator to stand back, if the furnace was lighted in the ordinary and proper way, that the effects of any fragmentary explosion would go clean away up the tubes and that there was nothing to hurt you or even to singe your whiskers. Further down the paper the author states that "the temperature of the flame is generally more concentrated at some particular point in its length," and he explains how, by altering the length of the flame, you can avoid the intense heat causing damage to any part of the boiler. Well, that is all very nice, but my experience was this, that in a return tube boiler, by a proper arrangement of refractory material so that the combustion should be effective, no damage was sustained by the tube ends or the combustion chamber bolt heads. And in speaking about that part of the question, I would say that in my judgment it is essential to have a refractory material which can be heated up to and maintained in a state of incandescence, in order to effect the dissociation with the steam, because if, while using the oil, you are not at the same time dissociating the steam and using its hydrogen, there will be a very great waste of both fuel and energy. If on the other hand, you utilise the whole of the hydrogen that is derivable from the dissociation, then you will attain a result which will far more than compensate for any excess in the cost of the oil over the ordinary coal; in fact, it is well within the mark to say that over three times the result, in point of evaporation, may be obtained when oil fuel is thus properly used.

Mr. LESLIE ROBINSON: In practical working?

Mr. HENWOOD: Yes, in practical working. Now I have had one boiler running with two furnaces for 28 days and nights without stopping, yielding the highest efficiency and without causing any trouble whatever. A question has been raised as to whether the Government will ever take up the use of liquid fuel, but I consider that transcendant advantages would accrue to the fighting powers of a ship by having oil fuel carried in a double bottom, because we cannot take any credit for the increased resistance to shot by the padding of coal, inasmuch as when the ship comes into action her coal stores may be nearly empty, and therefore that which you say you rely upon for giving some little protection has been taken away. A question has also been raised as to the difficulty of maintaining the supply of oil fuel, but that is a difficulty to be as easily overcome as was the transformation of the old wooden ships into ironclads. Another great advantage that will arise from the use of oil fuel is the enormous saving of labour in the stoke-hole. Now there was one point referred to by one of the speakers as to which I should like to read a short extract from one of the technical papers:

"The experiments conducted at the New York Navy Yard in using liquid fuel in the third class torpedo boat of the *Maine* have been completed. The evaporative results were good, even at the highest rates of combustion, and it only remains to ascertain whether the stowage and carrying of this fuel can be so effected as to eliminate danger from the gas that may be given off, which is the one objection to the use of any fuel oil other than petroleum refuse. It is to be regretted that conditions other than those pertaining to the system of burning the fuel in these boats operated to prevent a trial of the boat in free route for any length of time. The department having authorised the fitting of this system in one of our tugs in order to demonstrate its practicability under ordinary conditions of service, preparations are being made to use fuel oil only in this boat, and it is hoped that the results will be such as to warrant its general use for tug and torpedo boats."

I do not see any reason myself why it should not be used in any vessel—a vessel crossing the Atlantic or any other place. Since I spoke here last year I have had the opportunity of trying this oil-burning apparatus in a furnace in which we were able, without any difficulty, to effect the crystalization of pure silica in five hours. To do that with coal required two strong furnaces burning for seventy hours. And beyond that there has been another test, and that was with the oxy-hydrogen blow pipe. A gentlemen thought that he could melt the special fire-brick, but the only effect that the blow pipe had on it was just to soften the surface, and that of a very small portion. I maintain, therefore, that the oil fuel system gives you the command of intense heat which cannot be obtained by any other system, and its value in blast furnaces and steel works will, I believe, be shortly demonstrated to the satisfaction of everybody concerned in those important manufactures.

Mr. BASIL JOY hereupon, by request, exhibited and briefly explained the oil burner used by the Liquid Fuel Co., to which he referred at the previous meeting.

Mr. LESLIE ROBINSON: I should like to ask Mr. Henwood if he can give us the actual figures upon which he basis his statement that oil fuel will give three times the evaporation with ordinary coal?

Mr. HENWOOD: I have not got them here, but will endeavour to supply them. I do not agree with the remark that has been made with reference to the present style of boilers being wholly unsuitable for use with liquid fuel. The marine return-tube boiler does very well, and I have very little objection to find with the water-tube boiler for this purpose. Certainly, a boiler that is fired internally is preferable for the use of oil fuel. In a 100 horse-power water-tube boiler recently, working at 160lbs. pressure under very adverse circumstances, at an electric lighting station ashore, the evaporation, when only about one-tenth part of the

power of the injector was allowed to be put in operation, was 15¼lbs. of water from and at 212° Fahr. per pound of oil.

Mr. LESLIE ROBINSON: That is a long way off three times the evaporation obtainable with ordinary coal. I am perfectly prepared to accept 15lbs. That is a result one can get in practice. The burner brought out by Mr. Siegle, of Paris, which has been described by Mr. Wilson, embodies a greatly improved application of the Bunsen burner principle. I quite admit that there are certain difficulties in connection with those furnaces, but I do not believe that they are difficulties which cannot be overcome. They are being worked at now, and I believe that before long the results will be before the public; and I believe that those results will amply justify the remarks that Mr. Wilson has made. Undoubtedly, from a scientific point of view that form of burner has great advantages, but from a practical point of view there are difficulties to be overcome, and it has yet to stand the test of a hard and continued trial.

Mr. SAGE: I do not suppose that many of us have had experience of burning oil as fuel at sea, but I think the consensus of opinion, except among those intimately concerned is, that there is not much chance, within the present generation, of oil fuel being generally used in the mercantile marine of any country, always excepting the Caspian Sea, as there are a great many difficulties to be overcome before the burning of liquid fuel at sea becomes an accomplished fact. In the first place it is somewhat explosive.

Mr. HENWOOD: No.

Mr. SAGE: It is inflammable, and it is liable to variations of bulk in different temperatures. In the second place it would, I should say, if carried in the position in which coals are now carried, have a very great influence upon the stability of the vessel. Another point is that it would add most materially to the weight

of the bunkers required and the cost of their construction. Speaking without the book, I should say they would weigh three or four times as heavy and cost at least ten times as much as the bunkers that are designed at the present day to carry coal; and as regards the question of stability, let us take a ship 18 or 20 feet deep in which, under ordinary circumstances, the bunkers would extend from the floors or tank top to the bridge deck beams. We will assume that the side pockets are full of liquid fuel. We know what a head of water of that height will require to make plating not only water-tight but oil-tight. We will take it that the vessel starts on her voyage with full bunkers, and that towards the end of the voyage her fuel is very low. In a heavy sea way what would be the effect of that small quantity of liquid fuel in the bunkers upon the vessel's stability and her general conduct at sea? I pity the poor fellows who might be in her. If the oil was carried in the double bottom as has been suggested.

Mr. HENWOOD: Hear, hear.

Mr. SAGE: It is evident you are not a sea-going man, or you would not say that. We will take it that a vessel is new and requires to have her double bottom tested—and it would have to be tested much more severely than is the case at the present day. Well, we will say that the double bottom has been tested and filled with oil. Owing to the consumption of fuel in the furnaces, some of the compartments become empty and have to be filled up with water for ballast purposes. I should like to know how much it would cost to prepare those ballast tanks for oil fuel again. I think it does not require talking about at all, it would be impossible to carry the liquid fuel in the double bottoms of ships when those double bottoms were also required to be used as ballast tanks. We have been advised by the author of the paper that the tanks for the supply of the furnace should be specially arranged so as to avoid any moisture which may be, and sometimes is, contained in the oil, being introduced into the burners. I

have been in a few ballast tanks in my time, and after they have been once or twice filled, I have seen some stuff there that would not burn very well in any burners. We must all come to the solid fact that it is the practice to build bunkers up the side of a ship, and if it is proposed to build those bunkers to carry liquid fuel, it does not require much special knowledge to know that the pressure would depend not upon the width but upon the height, and we can fancy what would be the effect of three or four feet of oil at the bottom of a 20 foot bunker coming across the Bay in a heavy beam sea. I deprecate any thought that we are not very much interested in the burning of oil fuel. It may come to a good many of our members to have to deal with this subject under certain exceptional circumstances; and the more we can learn the better it will be for all of us. But I think that the storage of this fuel ashore, as well as the carriage of it in ships, will have to be very carefully considered. Some gentleman dissented when I said before that it was dangerous, but some of these oils are explosive. There may be some that are not so dangerous as others, but some are explosive. We know that they are inflammable and liable to give off gas at temperatures to which they must be subject. At any rate I don't think we are likely to have oil fuel in use universally for a very long time to come.

Mr. HENWOOD: I do not suppose that any engineer would ever dream of carrying the oil in immense structures carried right up to the upper deck of any vessel. The comparatively small quantity of oil necessary to be carried in any vessel could easily be carried in certain parts of the double bottom, specially adapted therefor, and in such compartments arrangements would be made to prevent injury to the vessel in any way by the oil washing about when the tanks were only half full. Then with reference to the remark as to the oil being inflammable and giving off explosive vapours, I may say that the oil which it has been proposed to use as oil fuel does not give off any gas until it is heated to over 250 degrees Fahr. There is, in my judgment, every reason

why engineers should set themselves to face what ought to be a desire on their part to improve that most important part of their profession, the production of heat in the most economical and clean way. Under the present system it is anything but that, as everyone knows, and it is not in any way a system which can be upheld, because every engineer knows that out of every pound of coal put in a furnace a very large percentage is utterly wasted. If it was turned into its component parts, and only the inflammable portion of it consumed as fuel, a far better result would be attained.

Mr. H. C. WILSON: I do not want to read a supplementary paper, but Mr. Shorey asked me a question as to whether it was possible for a gasifier furnace to mix an oil that would be better to use than another one. I say distinctly, yes; it is only a matter of experiment, so that there is no difficulty about that. Mr. Shorey also asked me what sort of design of boiler I would have. My reply is that there is hardly a kind of liquid fuel furnace which lends itself more to adaptation for ocean going boilers than this one. There is not the slightest difficulty about that either. Mr. Shorey asked further how I was going to start the burner and if I required a donkey boiler for the purpose. There are two or three ways of getting over that. It is not a difficult matter to run up a little pressure by hand to start with, and in the small form of burner the necessary amount of heat is obtained by burning a small amount of oil in a small bowl. There is no present intention to recommend this burner for using astatki, but if you get a lighter oil, the American kerosene or any oil that does not contain a large proportion of carbon, this is a burner that you will get a good duty out of. Mr. Sage referred to the question of bunkers for oil fuel, but let me remind him that there are in practical working, as we are told in the paper, some 688 steamers burning astatki.

Mr. SAGE: Short voyages.

Mr. WILSON: Short voyages it is true, but they are all burning liquid fuel.

The CHAIRMAN: If there is to be no further discussion there is that letter from Mr. Flannery to be considered.

The HON. SECRETARY (Mr. James Adamson): Mr. Flannery had made all arrangements to come here to-night, but unfortunately he found it impossible to manage it. We were thinking of closing the session this night fortnight. We have a paper by Mr. Aisbitt on "Ship-building, Ancient and Modern," which will come up for reading this night fortnight, and it might be arranged that Mr. Flannery should introduce his remarks on this subject of liquid fuel the same night.

Mr. SAGE: Seeing that the meeting this night fortnight will probably be the concluding meeting of the session, and that we have a paper to be read that evening, I think we should at least allow a full evening for its discussion. I would suggest that Mr. Flannery might be asked if he will be good enough to contribute his remarks in writing.

After some conversation on the subject, it was agreed that the discussion on Mr. Froom's paper should now be considered closed; but that the Hon. Secretary should write to Mr Flannery, informing him of the meeting on April 26th, and stating that if he was unable to attend on that occasion the members would be pleased to hear any remarks on Mr. Froom's paper that he might be disposed to furnish in writing.

The CHAIRMAN asked the acceptance by the Institute of three pamphlets containing reports of papers read before the Society of Arts on the subject of liquid fuel, and then read the following letter which he had received from Mr. Milton, chief engineer and surveyor to Lloyd's Register:—

"2, WHITE LION, CORNHILL,

"*April 5th*, 1897.

"DEAR MR. AUKLAND,

"*Re* your letter of the 1st inst., I am sorry that I cannot give you the information you require. I

believe that most of the vessels in the Caspian burn liquid fuel, but very few classed steamers do so. The whole problem is one of cost of oil versus cost of coal. It is found that 1 ton of oil is required to do the work of 1·8 or 2 tons of coal, and it then comes to a question of £ s. d. Besides the cost of fuel the oil has less labour about it, but it requires special apparatus both of storage and for feeding the fires. Amongst the few classed vessels burning oil are the *Baku Standard*, belonging to Mr. A. Suart, and the *Ayrshire* and *Granville*, owned in Russia. A paper on the subject was recently read at the North-East Coast Institution. It was, I believe, mainly taken up in descriptions of the apparatus employed.

"Yours truly,

"(Signed) J. T. MILTON."

Mr. SAGE proposed a vote of thanks to the Chairman for presiding, and the motion having been seconded by Mr. Wilson, was carried unanimously.

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Mr. FORTESCUE FLANNERY, M.P. (President) in the course of a communication received after the discussion this evening, observed that he was particularly interested in the paper because its author, Mr. Froom, was one of the chief engineers associated with him; also because he had in his capacity as a member of the Petroleum Committee, become aware of the fact that much important evidence has been made public recently upon the subject of petroleum and its proper treatment. The great difficulty in the use of petroleum as liquid fuel, generally, at sea was the necessity for spraying or pulverizing it in the course of preparing it for combustion, and the fact that the spraying of petroleum was accomplished by a jet of steam, thus causing a great waste of fresh water from the boiler in which the steam used for pulverizing was raised. This consumption of fresh water had been to some extent met in the case of vessels in the Caspian Sea by evaporators; and in the case of a steamer recently

as a precaution in case the burners were not properly used. By regulating the burner as I explained, there is no direct impact of the flame on them, and without this impact I do not think they will fuse. Obviously, the *Lebedia* burners were properly attended to.

I must express my best thanks for the very kind manner in which my paper has been received, and only regret I was unable to attend the meetings personally.