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# OIL FUEL ON SHIPBOARD

BY

Mr. GRAYDON HUME (Member),

READ ON

*Monday, February 4th*, 1907.

Chairman, Mr. W. LAWRIE.

ADJOURNED DISCUSSION

*Monday, February 18th*, 1907.

Chairman, Mr. W. C. ROBERTS, R.N.R.

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# Oil Fuel on Shipboard


BY MR. GRAYDON HUME (*Member*),



READ

*Monday, February* 4, 1907.

CHAIRMAN: MR. W. LAWRIE.

*Discussion continued Monday, Feb.* 18*th.*


IN presenting this paper it is my hope to treat the practical side rather than enter into a discussion as to the commercial feature. For the purpose of more comprehensively placing the subject before you, I have had some blue prints and magic lantern slides made of actual installations now working with satisfactory results. Fortified with these and other data, I will now endeavour briefly, and I hope clearly, to pourtray a mercantile installation.

To my mind oil is an ideal fuel; it is pumped into the bunkers in much the same way as fresh water is taken on board, thus doing away with all dirt and dust so aggravating to all on board. Automatic appliances feed the oil to the furnaces, where it produces an even fire, burns with very little smoke, increases the output of the boiler, leaves no dirt or ashes behind, thus placing our oldest auxiliaries, the Irishman's Chariot and the Ash hoists (Armstrong or otherwise), on the retired list. It is easily controlled, light, and apply a torch to the burner, open a valve, and the fires are lighted; close the valve, and the fires are extinguished, leaving no burning embers to be consumed without producing energy. In the beginning there were no sparks, in the end no ashes.

Thoroughly satisfied that as a heat-producing agent oil fuel is firmly established, we will now discuss its relative value as a heat producer, and the economy that may reasonably be expected by its application and adoption. We will endeavour to compare the three most common substances employed in producing heat, namely, coal, wood and petroleum oil.

Coal is fired in a widely different manner by various users, and the results obtained vary so materially that no correct data can be formulated and established for estimating the number of barrels of oil requisite to equal a ton of coal.

It is necessary before such comparison can be made on this basis to have the specific and exact results that a probable user of fuel is obtaining with coal. As the average coal user does not know the exact results he is securing from his coal, so that he may express it in pounds of water evaporated to pounds of coal consumed, we must assume an average condition.

For example, suppose coal cost 12*s*. 6*d*. per ton of 2,000 lb. and the theoretical number of B.T.U. to be 13,000 to the pound and 55 per cent. of these H.U. are transmitted to the water ; assuming that fuel oil has a theoretical heat value of 17,310 B.T.U., and knowing that 77 per cent. of this theoretical value can be transmitted to the water where the highest type of apparatus is employed, there will be available 13,300 heat units in each pound ; dividing 13,300, the effective number of heat units in a pound of oil, into 14,300,000, the heat units that may be utilized in a ton of coal would give in round numbers 1,070 lb. ; therefore assuming the above conditions to be actual ones, one pound of oil in steam producing power would be practically equivalent to two pounds of coal. Thus Texas oil weighs about 7·65 lb. to the gallon, making 140 gallons or 3·34 barrels of oil equivalent to a ton of coal on the above assumption, and at 3*s*. 9*d*. per barrel would equal, in price, coal at 12*s*. 6*d*. per ton.

The American Society of Mechanical Engineers has established the following relative proportions between coal, wood and petroleum oil in conducting boiler tests :—

1 lb. wood equals ·4 lb. coal.
$2\frac{1}{2}$ lb. wood equals 1 lb. coal.

Other authorities estimate $2\frac{1}{4}$ lb. of dry wood equals 1 lb. of good coal. The ordinary wood used in firing boilers contains about 25 per cent. of water, therefore only ·3 to ·4 lb. of combustible material is represented in each pound of wood. The total heat of combustion in wood is 10,974 B.T.U., and 75 per cent. of this figure is 8,230 units, and represents but 56·5 per cent. of the available heat units in that of average coal ; 279 of these units are required to vaporize 1·4 lb. of water that each pound of wood contains, therefore the net available heat is only 7,951 units per pound of wood burned holding 25 per cent. of moisture. This figure may be used for a close approximation in comparing a certain amount of wood with coal of a known value. Suppose the calculated amount of heat in a pound of coal be 13,035 B.T.U., and an actual test showed an evaporation of 7 lb. of water per pound of coal, then 13,035 : 7,951 : : 7 : 4·28 ; that is, one may expect to evaporate about 4·28 lb. of water per lb. of wood in the same boiler.

Summarizing the above results, eliminating the odd figures and assuming an average weight of oil and not the actual weight of the product, we deduce the following :—

One cord of hickory or hard maple weighs 4,500 lb., equals 2,000 lb. coal, equals 1,000 lb. of oil.

One cord of white oak weighs 3,850 lb., equals 1,711 lb. coal, equals 850 lb. of oil, equal to 122 gallons, equals 3·9 lb.

One cord of beech, red or black oak weighs 3,250 lb., equal to 1,445 lb. coal, equals 720 lb. oil.

One cord of poplar, chestnut, or elm, weighs 2,350 lb., equals 1,044 lb. of coal, equals 525 lb. oil.

One cord of average pine weighs 2,000 lb., equals 890 lb. coal, equals 445 lb. oil.

These tabulated results are based on good quality of coal and wood, and on the assumption that the fuel oil appliances are of such a nature, character and design as will produce an evaporation of not less than 100 lb. of water from and at 212° F. to the gallon of oil burned.

For a number of years the use of oil fuel was pretty well confined to the Caspian Sea and the rivers in its neighbourhood; the oil being plentiful was used extravagantly, and fresh water being plentiful, steam was plentiful for pulverizing purposes without any risk of salting up the inside of the boilers, which of itself is an important factor.

Of recent years oil has been discovered in various parts of the world, and its use has become more general for marine purposes. Engineers were not slow to recognize that in order to produce satisfactory results the system of controlling and handling it between the storage tanks and the furnaces was a most important factor; all grades may contain dirt, bits of waste floating and foreign matter which are liable to disturb the adjustments of the installation, whose duty it is to deliver the oil to the furnaces regularly, and as nearly automatically as possible.

The successful application of oil to boilers is a strictly engineering feature, and should in no instance be delegated to any one who is not familiar with the subject in its various details. Oil is a subtle fuel, a good servant, but a bad master; any one desirous of obtaining the best results must neglect none of the details which go to make up a first-class plant. The differences existing between the highest and lowest form of oil firing constitute the various degrees of efficiency that may be reasonably expected by the adoption and application of oil fuel and the installation of a plant for handling same. This being admitted as true, I will now try and answer this question by making three selections from the several thousand designs of burners on file or otherwise in the patent offices of Great Britain, United States, and the Continent, many of them unwieldy castings, and, like street medicine vendors' productions, if only applied, perfection would be attained.

(First).—Using air as an atomizing agent.

(Second).—Using steam as an atomizing agent.

(Third).—Centrifugal action as an atomizing agent.

In the first case the following are requisite:—

Storage or settling tanks. A pumping system with strainers or mud boxes, also a large air vessel on discharge side of pump capable of keeping the pressure constant. A meter for measuring the quantity of oil used. Air blowers. Heaters. Burners. Gasoline engine and auxiliary blower.

I will now try and describe these.

*Settling Tanks.*—There are two of these placed in some convenient position either on built seatings, on stringers, or in 'tween decks, each large enough to hold 12–15 hours' supply; the main object of these tanks being to separate the oil from any water which it may hold in suspension. In the bottom of these tanks are wash plates or rolling divisions, which prevent the water from again mixing with the oil through the pitching or rolling of the vessel. Above these divisions is a steam coil for heating the oil to say 100° F. to 130° F. In case by accident they should be allowed to overflow, there is an overflow pipe fitted which allows the oil to run back to bunkers. On each there is a gauge glass fitted similarly to what is fitted on an ordinary tank to show the height of oil, and noting the amount of water, or the consumption checked at the end of each watch. Each tank is fitted with a suction and drain pipe, the former about 8 in. from the bottom, and the latter at the bottom to drain off any water which may have found its way into the bunkers. There is also a manhole fitted for cleaning purposes.

You will appreciate the necessity of these tanks when I tell you that a few drops of water getting into the burner may extinguish the flame, necessitating the introduction of a lighted torch when there may occur an explosion of the gases in the furnace causing back firing.

The *Pumping System* is generally conveniently situated in or near the stokehold, its functions being to convey the oil from the bunkers to the burners, and should consist of duplex pumps of suitable design and size to handle the oil with ease. No system should be acceptable which does not employ three pumps connected for alternate use. Oil is not so easy to deal with as water ; oil leaks do not take up themselves, therefore this battery requires careful design, and mounted on a drip-pan or save-all for cleanliness and accessibility. As with coal, all sorts of extraneous matter finds its way into the bunkers, then it becomes the duty of this circulating system to provide means of filtering and removing these accumulations without disturbing the continual performance of the pumps, therefore strainers or mud boxes are fitted in duplicate on the suction side of the pump, having a by-pass allowing the one to be cleaned while the other is at work. It is not unusual to find a filter fitted on the discharge side of the pump to prevent any particles of old packing, etc., finding its way to the burner.

It being desirable that a uniform pressure should be maintained on the burner, the pump discharges into the bottom of a large air vessel (fitted with a gauge glass and safety valve; from the latter a pipe is led back to the suction) which keeps the pressure steady; from the side of this air vessel some distance from the bottom a pipe is led to the oil meter, thence to the heater and burner. It is essential that all piping be iron, not copper, also that exceeding care be used in making all joints, as if the stokehold plates were to get covered, the vessel's safety might be endangered.

Certain fuel oils are of great viscosity, which increases as the temperature falls; it is therefore necessary there should be means of heating oil in the bunkers, so that it may more readily flow to the pumps. The usual manner of accomplishing this is by placing coils of a few turns of steam pipe near the suction pipe mouth.

*Air Blowers.*—These generally take the form of Roots' Blowers, so well known to you all, and fitted with duplicate steam engines, only one of which is in service at a time, and draws free air from the stokehold or heater as may be desired, and discharges into an air cushion tank which maintains the desired pressure steadily, then led through a pipe to front of boilers, where a branch pipe is led to each burner, on which is fitted a stop valve to control supply.

*Heaters.*—These are about 10 in. in diameter, having a one in. copper pipe coil inside, 8 in. diameter and 6 ft. long; oil enters heater at one end and discharges at the other; either live or exhaust steam can be used.

*Burners.*—These consist of a jacketed pipe, the oil flowing through the pipe and the air flowing through the jacket surrounding the pipe, at the outer end of which are two valves, the one to control the oil supply, and the other the air supply.

*Furnaces.*—This is a feature in connexion with an installation which on many occasions does not get the consideration to which it is justly due. The result of combustion being heat, its intensity is here varied by the various conditions, namely, how, when, where, and the rate at which, air is admitted into the combustion chamber. The condition of air when admitted controls the efficiency of its mixture with the oil, and consequently its complete combustion. Frequently complete com bustion is impaired on account of the method of its introduction, to a very high percentage. The operator may try to increase the rate of combustion without raising the temperature of the gases, thus resulting in smoke, unless there is admitted a sufficient quantity of oil to raise the air to the same temperature as the combustion chamber before any heat is given off, thus wasting fuel. The difficulty is, therefore, to strike the happy medium, so that no excess heat will be carried up the chimney. In the early stages of combustion the gases distil at a low temperature, rising rapidly, enter the tubes and pass up the chimney unconsumed. There are various arrangements of brickwork, but all agree that an extended front is necessary, and that the throat of the furnace be lined, also the bottom, so that the hot bricks will consume any leakage; also that back and sides of combustion chamber be lined up as high as the lower row of tubes, the idea being to obviate the danger of localizing the heat and damaging the boiler. Retarders (one revolution per ft.) fitted in tubes will prove beneficial, by reason of the fact that such devices not only prevent the heated products of combustion from passing too freely through the tubes, but likewise cause a uniform distribution of these gases in their passage through the tubes to the root of the funnel.

In thus causing a more uniform and effective heating of the tubes, the liability of the end of the tubes to be burned is undoubtedly diminished. With oil as a fuel but little soot forms on the heating surfaces. Where retarders are not used in large tubes in an oil fuel installation, it is reasonable to presume that a certain portion of the gases of combustion reach the funnel without coming into contact with any of the boiler surfaces. Where coal, however, is used as a fuel in a Marine boiler, the resulting coating of the tubes by soot generally reduces their sectional area to a degree sufficient to materially impede flow of the gases of combustion, and therefore under such conditions the gases reach the base of the funnel at a comparatively low temperature. Where oil is properly burned it can be regarded as a fact that the velocity of the flow of the gases is greater than when coal is used, and, therefore, retarders should be used in the case of Marine type boilers; as an aid to the proper regulation of the supply of oil and air to the burners, mirrors are sometimes so arranged that the man in charge of the fires can observe the colour of the gases leaving top of funnel.

*Gasoline Engine.*—For purposes of raising steam in such an installation as the foregoing, there is frequently fitted a small auxiliary blower driven by an oil or gasoline engine, sufficient to work, say, two burners in each boiler till there is sufficient steam to work the larger blowers.

It is not infrequent to find a combination of steam with this type of installation where the D. boiler is fitted for burning coal and oil, steam only being used on D. boiler when burning oil. The accompanying drawing explains such an installation.

I have heard the suggestion made of fitting a compressed air tank large enough to contain enough air to raise steam.

The following particulars and summary of the voyage of a steamer will interest you. The vessel was originally fitted with the Howden system of forced draft, and made several trips under coal fuel before the oil plant was installed. You will observe there is recorded a fan pressure of $\frac{1}{2}$ in. It is well known to engineers that the humidity of the atmosphere is a determining factor as regards evaporative efficiency. This can be ascribed to two conditions :—

*First*, to the displacement of a certain amount of oxygen in a given volume of air by the moisture of the atmosphere.

*Secondly*, to the decreased rapidity of diffusion of the combustible gases with the oxygen due to the presence of the inert moisture. Hence in this case the forced draft fan was used at times with beneficial results. It is therefore reasonable to infer that when operating a boiler at a given capacity, the efficiency varies inversely with the humidity.

Steamer, 350 ft. × 47 ft. × 27 ft. 6 in.

Machinery, 25 in. × 42 in. × 68 in. × 45 in. stroke × 180 lbs. pressure.

Number of boilers, 2. Number of furnaces, 8. Average diameter of furnaces 3 ft. 8 in. Number of tubes, 556 each boiler. Length, 7 ft. Diameter of tubes, 2 in. inside. Total heating surface, 5,740.

Summary of passage.

Total steaming time, 16 days, 0 hours, 1 minute.

Steam pressure boiler average, 158 lb. H.P. Cyl., 155 lb. M.P.Cyl, 43 lb. L.P.Cyl, 8 lb. Vacuum, 26 in.

Revolutions, 77·8 per minute ; total, 1,792,570.

Distance by ship, 3,237 knots. By screw, 4,226. Slip 27 per cent.

Speed average by ship 8·43 knots.

Horse Power, Main Engines, 2,000. Auxiliaries (estimated), 240; total, 2,240.

Consumption, 2,970 barrels of 42 gallons, weight per barrel, 7·48 lb.

Barrels per hour, 7·74. Miles per barrel, 1·09. 1 H.P. per hour, 1·08 lb.

Air pressure at Fan ½ in., at positive blower, 1 lb.

Funnel temperature 540° F.

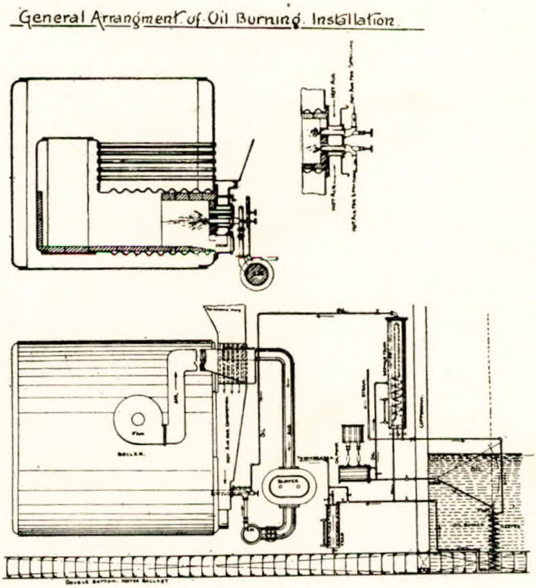


FIG. 1.

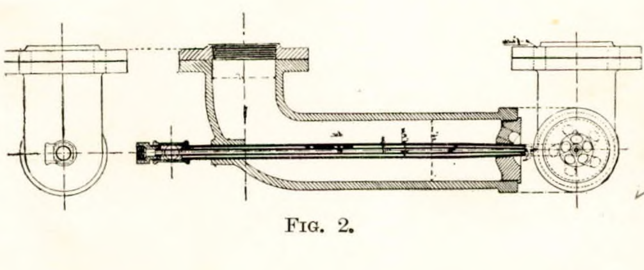

FIG. 2.

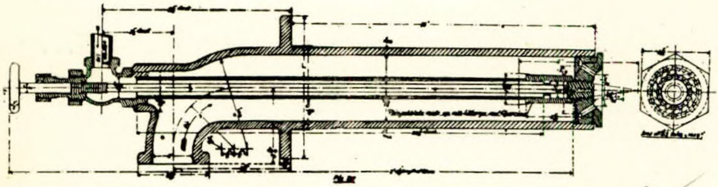

FIG. 3.

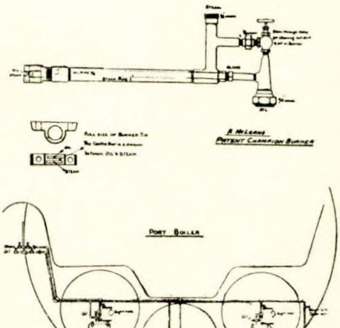
STEAM
OIL
FULL SIZE OF BURNER TIP
BETWEEN OIL & STEAM
PATENT CHAMPION BURNER
PORT BOILER

FIG. 4.

The following letter from a friend of the author who has been accustomed to deal with oil fuel for the past eight years, will be interesting and instructive.

"Great care should be taken to have tanks thoroughly clean before putting oil in. No waste should ever be used for wiping out fuel tanks, for it is bound to give trouble sooner or later, and usually happens in heavy weather when ship is rolling heavily.

"Anything which will stop the regularity of the flow of oil in the system will cause smoking, and any attention given towards having a clean supply of fuel will be amply repaid.

"The fact should be borne in mind that any little smoking soon clogs the tubes and runs up the consumption, which never lowers again until tubes are swept. The soot is heavy and sticky, and cannot be blown out thoroughly with steam blowers but must be swept, for which purpose I have found spring scrapers to answer best. It will also pay to see that cargo lines are drains before loading fuel. A little water in oil will make burners work badly, caking up the spray plugs and nozzles so that they shoot the oil out side ways. This is worse with the air system than with steam, and the only remedy is to pull each burner out and clean it.

"The presence of water can be very readily told by the frying sound with air system, but with steam there is such a roar that the water is not noticed until the burners commence to puff out.

"The fuel loading line should have a strainer with ¼ in. holes in it somewhere, for the refiners are not above having foreign matter in the lines and tanks. If these precautions are taken such a thing as cleaning a burner at sea should never occur. All fuel oil plants should be provided with heater, but with oil used on West Coast this is an absolute necessity with an air plant; and while I never used it with steam, still I do not think it would make a very nice working plant without a heater.

"With natural draft systems the burners should point so as to converge at about 3 ft. from burner end, and if draft is admitted from below, should be pointed down at a slight angle, as the entering draft drives the flame up against the crown of furnace. By far the better way is to allow some of the air to come in from the four quarters of the furnace; this keeps the flame so supplied that it will burn without smoking on a minimum amount of oxygen. No more air should be allowed to enter than will just complete combustion. The way to get at this is on some calm day choke down draft until burners will just make steam without smoking. Under natural draft this will generally be a pressure in furnace of 2 in. water less than atmosphere. This will be the least amount of air that the plant will run with, and when there is any wind the draft openings can be closed somewhat. This is a very simple matter on paper but where the firemen are depended on to do the regulating it becomes another question. Left to themselves or even watched for that matter, they will open the draft to the limit, for it gives them a wider margin to work on and they can set the burners once for all, and I have yet to see the fireman who was interested in the fuel bill. However, a great deal can be done in the way of improvement in consumption without making it troublesome to get steam without smoking.

"Now with forced draft the matter becomes quite easy, for the fan can be regulated once or twice a watch, and after it has been determined what the difference between the fireroom and ash pan is required to be and since the furnaces all are regulated with one fan, it is only a question of looking at the water gauge once in a while. With one steamer burning coal it was necessary to carry 2½ in. air pressure at fan. With oil the fan barely turns over in a calm, and where there is any wind the fan is stopped and some of ash pan drafts partly closed, ½ in. negative in ash pan, all retarding of draft should be done at furnace front, and as soon as gases are lit they should be allowed a free path of escape. Theoretically, closing the damper in funnel would have the same effect as closing ash pans, but the plant will not work nearly so well in practice.

"Another thing which has to be called to many engineers' attention is that the atomizing agent is not intended as a jet to increase the draft.

"Time and again I have seen them, as soon as the steam started down, jump for the compressor and speed it up.

"If the compressor runs too slow it will cause smoking through the oil not being atomized properly. If it runs too fast it will jet the fire through the furnace and into the back connexion, and to hold the steam it will be necessary to open up a little more oil. Of course it is much less trouble to keep steam with a surplus of atomizing agent, for it will handle more oil than needed, and for that reason one never sees a compressor running too slow.

"In practice it is necessary to allow a little margin both in draft and atomizing air, but if both of these be limited as far as practicable then you have the best fire obtainable.

"Anything that causes smoking should be remedied at once, for it is not the little extra oil that is being burnt at the time—and the smallest quantity more than the burner can handle will do it—but the extra amount needed to penetrate the soot thus formed.

"Smoke or no smoke, the tubes should be swept every two months at least. With some boilers trouble is experienced with back end of tubes leaking, although ferrules will stop this as a rule and have to be used where the boilers are forced hard; still they retard the draft and are more or less troublesome in this respect, and in small tubes the oil soot soon chokes them. In many cases, where trouble of this kind has occurred, cleaning tube sheets and tubes just at sheet has put an end to the difficulty. It is very necessary to keep these parts absolutely clean, and scale that would not be noticed burning coal, will give no end of trouble with oil. I have no doubt that this is on accountof the brick work, for on lowering the bricks the tube trouble ceases, but then the stay nuts suffer. The oil pressure on burners should be kept as low as practicable, which is generally about 15 to 25 lb. pressure according to the density of the oil.

"By carrying the pressure low the burner valves can be run almost wide open and anything that will pass the strainers will go through them, whereas if the pressure be kept higher and burner valves have to be kept shut pretty well off, and any little drift that comes along clogs, it is a continual performance going from one to the other. Almost all beginners believe in a high pressure, and it is hard to make some men, who have not burned oil before, believe that the lower pressure is better.

"I have found it much easier to break in new men and educate them to believe that smoking is a crime, and that they are there to save oil, than to take a man who has been improperly trained and thinks he knows all about it, and cannot see the reason for being so particular. If the oil is to be burned properly and economically one has to keep a sharp look-out on everything, and old steamship firemen, and even some engineers, do not take kindly to it.

"Some men learn it quickly, and some never learn, just like firing coal. It is not the one who does the most work who accomplishes most, but he who can see the heat in the fire (which should be of an orange-red colour) and do the right thing at the right time.

"Another system which proves quite handy is a small bell or whistle led from the bridge, to be blown when smoke is seen. This is especially good at night, for the men below learn that too many calls brings the Chief out to chat with them."

The general characteristics of the installation and burner are shown in the accompanying plans.

We now come to steam as an atomizing agent. In this case, large evaporators have to be installed to make good the water lost; varying from 5 to 15 per cent. of total evaporation according to class of installation; instead of air blowers there is a steam pipe led from the auxiliary steam-piping system down and along front of boilers with a branch led to each burner having a valve to control supply at each burner. The general characteristics of the installation and burners are shown on accompanying sketches.

The following particulars and summary may be interesting:

STEAMER.

Principal Dimensions of Machinery.

Number of boilers, two, all tubes fitted with retarders.

Diameter, 11 ft. 6 in. Length, 11 ft.

Length between tube plates, 7 ft. 4 in. Tubes inside diameter, 3¼ in.

3 corrugated furnaces in each; large diameter, 4 ft. 4 in. Small, 4 ft.

Heating surface of one boiler made up as follows:—

Tubes, 2,291. Furnaces, 176. Com. Chambers, 257.

Tube plates, 101. Working pressure, 180 lb.

Total heating surface, 2 boilers, 5,650 sq. ft.

This vessel was converted for burning oil fuel early in January 1905, the same engine-room staff has been in vessel since 1904, and the following table extends over the same period.

## Comparisons of Fuel.

| Name. | Time Steaming. | Average I.H.P. | Average Revolutions per min. | Average Boiler Pressure in lbs. | Vacuum. | Consumption per day. | Consumption per I.H.P. per hour in lbs. | Average Speed per hour. | Mean Average Draft. | Displacement in Tons. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | D. H. | | | | Ins. | Tons. | | Knots. | Ft. In. | | |
| England. Durham Coal | 14 19 | 1,654 | 63 | 165 | 22 | 31 | 1·7 | 11·1 | 17 1½ | 6,150 | — |
| Port Said. Welsh Coal | 13 10 | 1,680 | 63·5 | 165 | 23 | 31·7 | 1·7 | 10·6 | 21 7½ | 7,900 | — |
| Colombo. Indian Coal | 5 8 | 1,528 | 62 | 165 | 23 | 32·5 | 1·9 | 10 | 23 2 | 8,480 | — |
| Calcutta. Indian Coal | 19 18 | 1,652 | 63·3 | 175 | 23 | 35 | 1·98 | 10·24 | 18 8 | 6,750 | |
| Port Said. Welsh Coal | 13 9 | 1,658 | 63·4 | 175 | 23 | 30 | 1·6 | 10·6 | 23 9 | 8,750 | — |
| Moji. Japan Coal | 24 0 | 1,674 | 63 | 175 | 24 | 32·7 | 1·8 | 9·9 | 17 8 | 6,350 | — |
| San Frisco. Oil. | 28 2 | 1,515 | 62·3 | 180 | 23 | 24 | 1·48 | 8·9 | 22 10 | 8,380 | A |
| San Frisco. Oil. | 25 18 | 1,550 | 63·6 | 180 | 23 | 23 | 1·4 | 9·6 | 22 11 | 8,425 | B |
| San Frisco. Oil. | 24 14 | 1,700 | 66·3 | 180 | 23 | 21 | 1·35 | 10·7 | 23 1 | 8,490 | C |
| San Frisco Oil. | 27 8 | 1,663 | 64·5 | 180 | 23 | 22 | 1·26 | 8·9 | 23 1 | 8,490 | D |
| Hong Kong Oil. | 18 10 | 1,743 | 68·1 | 180 | 23 | 24 | 1·28 | 10·5 | 14 10 | 5,250 | D |

A. Type of burners Lassee.
B. Type of burners used Champion.

C. Type of burners used McLean's.

D. Type of burners used McLean's after 18 months' experience.

A, on this voyage none of the Engine-Room Staff had any previous experience with oil fuel.

B, the second voyage compared with the first shows considerable saving due to improvements and increased experience on the part of engine-room staff.

C, it will be observed, comparing these data with the first two voyages, shows that considerable increase in efficiency has been secured, thus showing that even on a first voyage oil fuel installation can be operated with a fair degree of success with an intelligent though inexperienced crew.

The following extract is taken from a letter of the Chief Engineer :—

> "There are a lot of little details which go to make oil burning successful, the least alteration of a burner tip will show a big difference in your fire. Then you can have too little or too much air in your furnace, and according to conditions of weather you have to alter conditions below to suit the pressure of oil, varying from 3 to 15 lb."

Messrs. Wallsend Slipway Co., Ltd., Wallsend-on-Tyne, have been most successful in fitting Steam Atomizing Installations, having now fitted nearly eighty ships, and the Managing Director, A. Lang, Esq., has kindly supplied me with sundry drawings and other data, the type of burner used being the Rusden & Ecles Patent, of which they have the sole right. The accompanying sketches will show the characteristics of installation and burner.

By courtesy I have been privileged to peruse log abstracts of sundry steamers, and calculating with this system the consumption of oil works out 1·32 lb. per I.H.P. per hour.

We now come to the third system, that of mechanical spray. Doubtless you are all acquainted with the form of nozzles used for lawn sprinkling ; in these little devices we have a somewhat similar problem. In the case of oil, as the fluid is more viscous than water it would seem that great pressure should be applied to the fluid in order to effect a corresponding breaking up of the oil into particles. From the accompanying sketches it will be seen that the fluid passing through the orifice under the action of heavy pressure, has imparted to it a rotary motion caused by the introduction of spiral blades which should be sufficiently near to the orifice so that the rotation of the oil

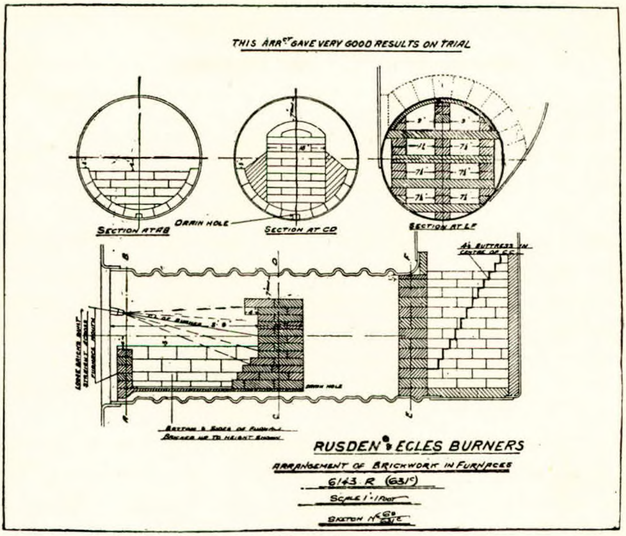
THIS ARR GAVE VERY GOOD RESULTS ON TRIAL
SECTION AT AB
DRAIN HOLE
SECTION AT CD
SECTION AT EF
RUSDEN & ECLES BURNERS
ARRANGEMENT OF BRICKWORK IN FURNACES
6143 R (631c)

FIG. 5.

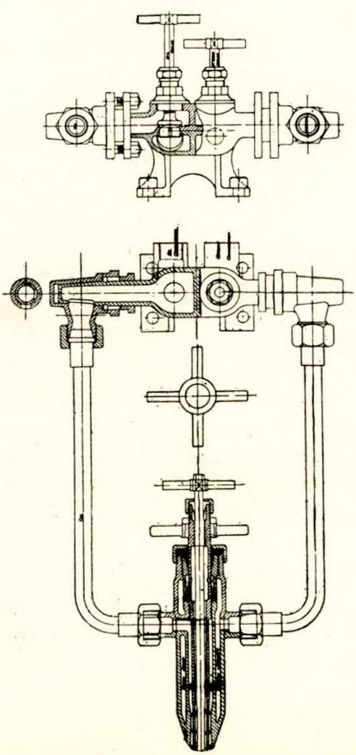

FIG. 6.

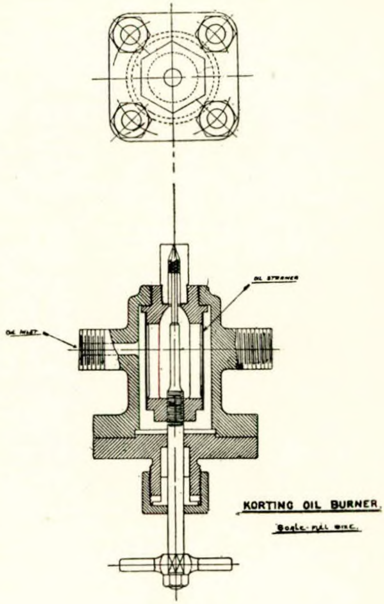


FIG. 7.

will not be reduced through the action of skin friction in the passage between the blades and tip of the orifice.

This type of burner is the invention of the Korting Brothers, and known as the Korting Burner, and Messrs. The Wallsend Slipway & Engineering Company, Ltd., have also adopted this system, and of which they are the sole proprietors. The following are results of tests made with the Korting Burner using oil fuel sprayed by mechanical means which appear to have been conducted with great accuracy, and are worthy of careful analysis.

### Comparison of Oil Burning Trials with the Rusden & Ecles and Korting Patent Burners and Coal Burning Trials on Marine Type Boiler.

*Particulars of Boiler with which trials were carried out.*

| | |
|---|---|
| Mean diameter . . . . . . . . . | 12 ft. 6 in. |
| Mean length . . . . . . . . . . | 11 ft. |
| Number of furnaces . . . . . . . | 2 |

| | |
|---|---|
| Inside diameter of furnaces . . . | 3 ft. 7 in. |
| Number of tubes . . . . . . . . | 262 |
| External diameter of tubes . . . | $2\frac{1}{2}$ in. |
| Total heating surface . . . . . . | 1,695 square feet |
| Grate area under coal . . . . . . | 40 |
| Working pressure . . . . . . . | 120 lb. per square inch |

All tubes fitted with retarders.

| | Coal Trial. | Oil Burning Trials. Rusden and Ecles Burners, Natural Draught. | Oil Burning Trials. Korting Burners, Natural Draught. | Oil Burning Trials. Korting Burners, closed Stokehold, Air pressure $1\frac{1}{8}$ in. |
|---|---|---|---|---|
| Duration of trial . . | 6 hours | 3 hours | 3 hours | 4 hours |
| Class of fuel . . . | Best Mickley Picked | Borneo Crude Oil | Texas Oil | Texas Oil |
| Average steam pressure | 113 lb. | 115 lb. | 115 lb. | 105 lb. |
| Average temperature of feed water . . | 55° F. | 70° F. | 50° F. | 107° F. |
| Pressure of oil at burners . . . . . | — | — | 60 lb. | 140 lb. |
| Temperature of oil at burners . . . . | — | 54° F. | 212° F. | 107° F. |
| Quantity of water evaporated per hour . | 7,558 lb. | 7,690 lb. | 6,850 lb. | 14,951 lb. |
| Quanity oil burned per hour . . . . . | — | 620 lb. | 559·6 lb. | 1,222 lb. |
| Quantity coal per hour | 974·3 lb. | — | — | — |
| Water evaporated per lb. of oil (actual) . | — | 12·4 lb. | 12·23 lb. | 12·23 lb. |
| Water evaporated per lb. of coal. . . . | 7·76 lb. | — | — | — |
| Water evaporated per lb. of oil from and at 212° F. . . . | — | 14·75 lb. | 14·9 lb. | 14.06 lb. |
| Water evaporated per lb. of coal from and at 212° F. . . . | 9·31 lbs. | — | — | — |
| Total quantity ash . | 283 lb. | — | — | — |

The above firm issues the following standing orders for the guidance of captains and engineers.

## Oil Fuel Burning.

*Standing Order.*

The following rules are to be strictly observed :—

Each engineer must acquaint himself thoroughly with the plans on board the vessel and with the actual run of the pipes, including :—

(*a*) Bilge wells or channels in way of the oil fuel tanks, and the special suctions to same from oil fuel pumps.

(*b*) Oil fuel suctions from settling tanks.

(*c*) Fuel pump discharges.

(1) To settling tanks and gravitation tanks.

(2) Overboard.

(*d*) List of tanks and spaces in use for oil fuel.

(*e*) Filling pipes from deck to oil fuel spaces.

(*f*) Heating coils in settling tanks.

(*g*) Oil supply pipes from gravitation tank to burners.

## Instructions for Working Oil Fuel.

(1) Each engineer coming on watch, to examine each well and space for leakage, and report any such leakage immediately to the chief engineer.

(2) The engineer going off watch is to leave the pump to settling tanks and gravitation tank in order, for the engineer coming on duty.

(3) The engineer when going on watch is to see that the settling tank not in use is full of oil or in process of being filled ready for service. For filling the settling tanks they must be filled to overflowing, so that any movement of the vessel does not interfere with the settling of the oil.

Steam is then to be turned on to the heating coils and the temperature of the oil raised to not less than 180 degrees and not more than 200 degrees, and the oil is to be kept between these temperatures for six hours (the object of heating the oil is to settle any water that may be contained in same more quickly), but it is of the greatest importance that the temperature should be raised to not less than 180 degrees and not more than 200 degrees as stated above.

The steam is then to be shut off and the oil allowed to settle to within four or five hours of the time when it will be required to use the tank.

The water which may settle is then to be drained off. The oil is then to be heated again for two hours to bring down any more water which may yet be in the oil.

This water to be drained off immediately before the oil in the tank is to be used for supplying the gravitation tank.

In vessels which are fitted with two small tanks only, great care must be exercised in keeping the alternative tank full, and drained of water.

(4) When about to raise steam on the boilers, care is to be taken that the oil to be used for this purpose has been, if possible, in the settling tanks for at least eight hours, and that the oil has been heated as described, and all water that may have settled drawn off.

(5) When starting burners, steam should be injected into furnace before oil is turned on, and on no account is a light to be applied till steam is turned on.

This must be strictly attended to, or otherwise a dangerous explosive gas might form which would have disastrous effects if a light were applied to it.

(6) All strainers and mudboxes on oil system to be examined at least once a day.

(7) Chief engineer to report to captain any leakage from oil fuel tanks.

(8) If salt water has to be put into the boilers to make up, these should be frequently tested by salinometer, and if extra density arises, the boilers must be examined at first opportunity and extra scale removed.

The CHAIRMAN : Some ten or twelve years ago we had two very good papers on the question of oil fuel, but the experience of that time was mostly confined to some of the Russian rivers. Mr. Hume has now brought us a shade nearer home, and his paper is a very welcome addition to the two which were previously read. The amount of detail placed before us in the present paper is great, and shows how thoroughly Mr. Hume has gone into the subject. He is now prepared to answer any questions or criticisms that may be introduced.

Mr. FRANK COOPER, R.N.R. : In the first page of the paper the author refers to the very subject one desires to ask about, namely, the cost of running boilers with oil fuel compared with coal. Of course we know that coal differs in price at different places. So, presumably, does oil. Still, a comparison may be made to show which is cheaper on an average basis. In the table, where comparisons of coal and oil burned on the same ship are stated, are we to understand that the pound per hour applies to a pound of oil as compared with a pound of coal ? (Mr. Hume : Just the same.) In several parts of the paper Mr. Hume refers to "pressure of oil." Presumably that is due to the pumps forcing the oil through the burner at so many pounds per square inch. (Mr. Hume : Yes.) In one of the diagrams there is apparently a perforated spray. Does the oil come through a single nozzle or through perforations ?

Mr. HUME explained that it was a single orifice that the oil came through. The oil was atomized by the air striking it as it came through. The air sprayed the oil in various directions. (Mr. Hume illustrated the system of spraying the oil by a further reference to the diagram.) Continuing, he said the altering of the diameter of those holes sometimes had a great effect upon saving oil.

Mr. J. McLAREN : Is there any chance of the oil dropping to the bottom of the furnace ?

Mr. HUME : Yes ; the hot bricks would burn it.

Mr. J. McLAREN : Does the air strike just in front of the orifice ?

Mr. HUME : It crosses the orifice at an angle of 60 degrees. The oil comes out and the air carries it. It is divided up into little globules.

Mr. W. E. FARENDEN : How many burners are there in each furnace ?

Mr. HUME : There are two in each furnace.

Mr. RAIMEY : What is the shape of the flame ?

Mr. HUME : It spreads out like a lot of feathers, twisting and turning every way when burning.

The CHAIRMAN : Is there any part where the flame is most intense in the length of the furnace? Does it go up to the tubes? Does it increase?

Mr. Hume: The flame increases as it leaves the burner.

Mr. Frank Cooper: What is the pressure of air and oil?

Mr. Hume: The air pressure is a little under a pound. The oil is anything from 15 to 25 lb. With steam atomizing you have a little more. The pressure of the oil depends on how much you open your valve. If you open it wide you do not require so much pressure.

The Chairman: If you are using steam you will require to have a reducing valve.

Mr. Hume: With steam, about 100 lb. is the usual pressure. That seems to be a pressure which suits very well for atomizing.

Mr. E. W. Ross: What is the oil like? Is it dense or fluid?

Mr. Hume: Some of it is very thick. Some of it is like treacle, and will not pump unless it is heated to about 200°. No American oil is quite so thick as the Asiatic or Black Sea oils. There is a line of steamers from Constantza to Antwerp, and they burn oil when coming to Antwerp and coal when going back. They take the fire bars out and change over.

Mr. Frank Cooper: I notice you seem to make a great point of getting rid of the water out of the oil before it reaches the burner. Then you go ahead and use steam to atomize the oil. What is the great danger of water being in the oil before it gets to the burners if it is to be mixed with water when it gets there?

Mr. Hume: When at the burners the oil does not mix with water. It mixes with dry steam, that is to say a gas; water passing through the burner clogs it, and also wastes the oil.

Mr. Frank Cooper: I notice in the table that this steamer gradually increased her pressure. She started away with 165 lb. and she gradually worked up to 180 lb. I do not know whether she had new boilers or a new certificate, but usually it is the other way about. Usually we get reduced from 180 lb. to 165 lb. Was she allowed to carry more pressure, or was it that they could carry more pressure with oil than with coal ?

Mr. HUME : The boiler pressure was always 180.

Mr. COOPER : Then evidently they were not able to get the same steady pressure with the coal. It seems to me that we are very much indebted to Mr. Hume for this paper, but I do not think oil fuel will be a very fine thing for engineers. It seems to be more dangerous than coal.

Mr. W. E. FARENDEN : Could the author give us the reduction in weight of stowing oil as compared with coal ? What saving is there with oil as compared with coal ? What is recommended as the best method of burning oil ? I understand there are some boats now being built and fitted with steam spray in preference to air. Looking at the figures in the table, I see that the consumption per I.H.P. per hour of oil is 1·32 lbs. That is very good, but with a well-designed quadruple expansion engine we can get as good if not better results from coal. Does Mr. Hume know a burner called the Wolff ? It is a spray burner. I believe it is one that is coming in very much ; and perhaps he can tell us how this Wolff spray stands in the mercantile world. I also understand that most of H.M. cruisers for this year are to be fitted with oil burners. Of course, they are also fitted for coal burning, so that any time when required they can fire with coal.

Mr. JOHN McLAREN : I consider that we are very much indebted to Mr. Hume for this able paper. We have motor cars and engines driven by oil. Now we come to steamships, and I think the matter wants some consideration. I would like to know something in regard to the wear and tear of the oil-tanks on board a ship. Mr. Hume has referred to leaks. There seems to be a lot of leaks when carrying oil. A coal bunker will stand a deal of rough use. Mr. Hume has also spoken of a line of steamers which burn oil one way and coal when returning. What do they do with the oil tanks on those steamers ? Are they used for ballast, or are they kept empty ? It is all space. How does it work out putting fuel on board ? It occurs to me that putting oil on board must be far more expensive than taking coal. But against that the labour of working the oil on board ship must be cheaper than burning coal.

Mr. W. McLaren: Our thanks are due to Mr. Hume for bringing so practical a paper before the Institute. He has referred to the price of oil as 3*s.* 6*d.* per barrel. But from what I have heard in the city it turns out at about 5*s.* 6*d.* per barrel, which makes it rather expensive. Of course, against that there is a promise of 16 lb. of water evaporated per pound of oil. I would like to be able to make a comparison between oil and coal on a pound per pound basis, as one is somewhat confused when told that 10,080 lb. of oil is equal to a ton of coal at 12*s.* 6*d.*, which is not much value for a ton of coal. There would certainly be a saving of space in the cubic capacity. The oil works out at 22 cubic feet, and the coal at 40 cubic feet. If we take the figures 10,080 as against 2,000, another saving appears in regard to weight carried. Mr. Hume is quite right that we ought to progress, and it may be that oil is bound to come, providing we are not going to lose our prestige by losing the value of our coal fields. Apart from that—and since I have heard this paper read, added to what I have read elsewhere—I would not care to go on board a ship and take charge of oil fuel without some experience of it. The only experience I have had with oil fuel has been in land work. We have been told of the benefits we are to get as compared with coal, but the way the insurance offices have treated the case does not encourage its adoption. If the oil were reduced in price, it might be greatly adopted on shore. From some tests made in the testing-room of the Institute, oil came out well against the best Welsh coal.

Mr. Britton: It has been stated that the heat in the stokeholds of steamers burning oil is in some cases terrific, and that it requires men inured to heat to work in those stokeholds. I would like to know what type of burner is being used in the new cruisers. The Admiralty has been carrying out extensive experiments at Haslar with oil fuel.

Mr. T. R. Stuart: Generally one can tell some of the oil-burning cruisers by the smoke they make. Under such conditions perhaps Mr. Hume can tell us something of the condition of the tubes in the smoke box. We know what sort of a non-conductor burnt oil is. I should like to know the drop-off in efficiency of a ship like a cruiser; as to a great extent, I believe that is why the Admiralty has not adopted it, at least for very high powers. The steamer referred to by Mr. Hume shows, in the results tabulated, peculiarities in the differences of speeds and displacements with practically the same horse-power, thus rendering the tables of very little use. Thus, when using Welsh coal at 7,900 tons displacement, 10·6 knots with 1,680 horse-power is obtained. In another case, with 8,490 tons displacement, about 500 tons more, the speed is increased by ·1 knot with only an increase of 20 horse-power. In another instance, with the same displacement, the speed is 1·8 less knots with a decrease of about 40 horse-power. From experience of ships of that class I should say that if the speed were increased from 9 to 10 knots, at least ¼ more horse-power would be required.

Mr. A. H. Mather: The paper is one of the most practical that has been read before the Institute, and is of all the more value from the fact that it is compiled from the results of actual experience in the handling of the apparatus described. There are a great many points in the paper well worthy of consideration, and a good deal of the information contained will, I venture to think, be new to many. I have never had any actual experience at sea with oil fuel, although I have had to do with various experiments ashore and the design of oil fuel burners, and I had no idea that there was such an elaborate arrangement of tanks necessary for getting any water out of the oil as is described in the paper. I take it that most or all of the ships fitted for oil fuel have the duplicated tanks holding from twelve to fifteen hours' supply. This means tanks of a very considerable size. Then for heating the oil in those tanks a steam coil is provided, which no doubt means additional work in the way of keeping joints tight. This heating arrangement must take a considerable amount of steam. I would like, if Mr. Hume could give us, some idea as to the amount of steam required for this purpose. A year or two ago I was doing some work in one of the dockyards while experiments were being carried out on board a destroyer lying close by us, and when the wind happened to set our way we were nearly choked by the volumes of thick black smoke. Later on I made a trip on board one of the battleships fitted for oil fuel, and during part of the run the ship could have been seen from one end of the Channel to the other by the cloud of smoke. This, however, was improved upon as the experiments proceeded and the proper adjustments were made. I had an opportunity of going through the stokeholds while the trials were being made, and it was quite impossible to hear any one speaking on account of the noise made by the burners. I would like to ask Mr. Hume if it is possible to burn oil fuel without making such a noise ? Faulty combustion might have something to do with it, but I should like to know if that noise is general with all oil fuel installations. I have also found the noise very considerable when using oil fuel on some land boilers of the Babcock type, but not so bad as was the case on board the battleship.

Mr. A. Robertson : What is the average temperature in the combustion chamber ?

Mr. Hume then replied : Mr. Farenden has spoken of the storage of the oil. It is carried in tanks built in the ship. The best method of burning the oil is, I think, the air method. Altogether that seems to give the best results. The average consumption on the ten voyages of the steamer mentioned in the paper is 1·15. The Wolff burner mentioned by Mr. Farenden is the burner used in the Roumanian boats running to the Continent. The Admiralty tests and the Naval experiments are confidential. It is not for the general good that everybody should know the results arrived at. Mr. J. McLaren has asked about leaks and the maintenance of bunkers. The bunkers are built specially strong of plates about half an inch thick and tied with gussets to stand the full head of oil. The same bunkers are used for coal as for oil. After carrying coal they are cleaned out, scraped and filled with oil, and then go right away on the voyage. After carrying oil they are pumped out, washed and steamed out, and then filled up with coal. The oil is put on board in the same way. The barge comes alongside and pumps it into the steamer. The labour, when using oil, is certainly cheaper. In some ships the reduction in the firing and trimming staff has amounted to 75 per cent., and such a reduction means a big saving in wages and food. In regard to the commercial aspect of the case, I would recommend any person who contemplates abandoning the use of coal to consider the relative merits of both fuels before doing so. Mention has been made by Mr. Britton of the heat in the stokeholds. In two or three short trips that I have made from London to Dover the heat did not seem to be more than would be found in an ordinary stokehold. I might say that the heat is about the same as would be experienced in the ordinary stokehold. I do not know what type of burner they are using in the Navy, but I have cut the following remarks from the *Shipping Gazette* of January 26 :—"Although all the destroyers in the Navy Estimates for the current financial year are to do their steam trials on oil fuel exclusively, provision will still be made on them for the burning of coal. This is not because there is any unreliability about liquid fuel. On the contrary, oil has been a proved success not only in conjunction with coal, but alone ; the *Gadfly*, first of the turbine coastal destroyers to be tried, showing an oil consumption of 1·5 lb. per equivalent I.H.P. on trial and exceeding her designed speed by a knot and a half. In a time of war, however, we should be forced to fall back on our native supply of coal, and the furnaces have to be fitted for this purpose. It is not difficult to make the furnaces adaptable to both liquid and solid fuel." In regard to a glutinous deposit forming on the tubes, I would say that only occurs in the case of smoke deposit. It is very hard to penetrate, and naturally the consumption increases until the tubes are again swept. As to the varying conditions of speed of the ship mentioned in the table, that was because of the varying kinds of weather experienced. The data I have given are all actual data, and the conditions were entirely dependent on the weather. I might say that soot only forms through an over supply of oil getting in. One gentleman asked how the tanks were supplied. Those tanks are filled by means of an oil-pump from the bunker. In many cases there is no water in the oil at all. The amount of steam that is used for heating and settling varies according to the amount of water in the oil. Perhaps it would not be used once in a voyage, but, on the other hand, it might have to be used every day. It depends on the oil. In regard to noise, I must say again that the Admiralty experiments are confidential, and not for discussion.

Mr. MATHER: Do you find the same noise with a good working burner?

Mr. HUME: No. Steam makes a little more noise than air. With the air system, once you are under way, you can hear yourselves talking. There is more of a hissing sound with the steam. I regret that I cannot say what the average temperature of the combustion chamber will be. The gases go up the funnel at about a little over 500°, which, I consider, is fairly low.

The CHAIRMAN: It is quite impossible to complete the discussion of such a paper in one night. Is it the wish of the meeting to have a further discussion, and if so, when?

Mr. FRANK COOPER: I beg to propose that this discussion be adjourned until some convenient Monday. The subject has not been anything like threshed out yet.

The CHAIRMAN: There is an open date on February 18, and another on March 18.

Mr. W. E. FARENDEN seconded the proposition of Mr. Cooper, and suggested that the adjourned discussion take place on February 18.

The proposition was agreed to.

The CHAIRMAN then moved that a vote of thanks be accorded Mr. Hume for his interesting paper. He had gone to a very great deal of trouble and had given them a paper which had been described as practical. He thought that was about the best description they could give it.

Mr. E. W. ROSS seconded the motion.

Mr. J. MCLAREN proposed, and Mr. A. H. Mather seconded, a vote of thanks to the chairman.

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Communicated by Mr. W. J. A. LEUZEY.

The paragraph *re* weight of Fuel Oil, "Texas oil weighs about 7·65 lb. to the gallon, making 140 gallons or 3·34 barrels of oil equivalent to a ton of coal on the above assumption," appears to be misleading, as the specific gravity of Texas fuel oil at 60 degrees Fahr. equals about ·950, or about 238 to 240 gallons per ton of 2,240 lb., being actual facts. To which the author replies as follows: The calorific value of Texas oil fuel is about 19,237 B.T.U. as now imported, the paragraphs referred to, i.e. 6 and 7, being taken as "supposed data" to show the working of a comparison. Neither is the price of coal in Texas 12/6 per ton of 2,000 lb. as stated also simply as a figure for comparison.

## ADJOURNED DISCUSSION.

*Monday, February* 18.

CHAIRMAN: MR. W. C. ROBERTS, R.N.R.

THE CHAIRMAN, in opening the meeting, said he was sorry he did not hear the paper read. The author would be very pleased to answer any questions that members might put to him in regard to the subject.

Mr. W. LAWRIE: When Mr. Hume read his paper a fortnight ago the members who took part in the discussion congratulated him on its practical excellency, and as one reads into it that view is confirmed. We are given a considerable amount of information which, before the paper was printed, I think was confined to only a few engineers, and after it is put into print and passes into our TRANSACTIONS, I think it will be the means of diffusing an amount of knowledge on the subject not readily obtained by the sea-going engineer, more used to coal fuel. To a member like myself whose knowledge of oil fuel is limited the paper is more than interesting. Mr. Hume says:—

"To my mind oil is an ideal fuel; it is pumped into the bunkers in much the same way as fresh water is taken on board, thus doing away with all dirt and dust so aggravating to all on board. Automatic appliances feed the oil to the furnaces, where it produces an even fire, burns with very little smoke, increases the output of the boiler, leaves no dirt or ashes behind."

That last sentence but one rather impresses me. There is a sort of ring of the first verse of the first chapter of Genesis. With all these qualifications for oil burning, which I take it are beyond doubt, it is hard for most of us to discuss them. The statements recall the presidential address of Sir Marcus Samuel, delivered in this room a little over twelve months ago, when he told us that his firm were letting run to waste a considerable amount of crude petroleum—I think in Borneo—for which they could not find a market. Seeing the success that has attended the oil fuel, and the economy, it is astonishing that such should happen. I do not know whether it is so yet or whether they have found a market for the oil, but one would have thought, after reading Mr. Hume's paper and seeing the good results from the use of oil on board ship, that the oil which was run to waste might have been used for fuel.

Engineers whom I have heard speaking of oil burning, considered that it is very fierce on the boiler, and that there is something in the statement appears from some of the slides shown on the screen, where you see the front part of the furnaces built up with brick, also the throats of the furnaces and the combustion chambers lined up with brick as high as the first row of tubes. Do the parts of the plates that are exposed, —the furnace between the bricked-up front and the throat, not suffer ? It seems to me that the intensity of the flame must more or less affect the plate, and I fancy it will be fiercer on the boiler than the ordinary coal fuel. In the descriptive letter which Mr. Hume gives in his paper, it is stated that the tube ends give trouble if any scale gets on the boiler. You cannot remedy this very readily by getting inside to remove scale when at sea. If there are any nuts on the tubes, I should not fancy that they would stand very well, nor the other stay-nuts exposed to the flame in the top of the combustion chamber at the back. The number of good points that are to be gained by using oil fuel more than compensates possibly for any difficulties experienced. But Mr. Hume will, no doubt, be able to tell us whether they have any troubles, although the letter does not say anything about any ; but in that letter we have a very good guide as to what is ordinarily done on board oil-burning ships. One thing that did surprise me somewhat was to find that the Wallsend Slipway and Engineering Company have turned out no fewer than eighty oil-burning steamers. Are they employed in any particular trade, or are they ordinary cargo boats ? With regard to settling tanks, I understand you pump the oil in and then allow the water to separate into the lower part of the tank, where there are wash-plates and other devices to keep the water apart from the oil. That seems to me almost a crude way of separating it. I think it might be possible for our chemical friends to come to our assistance here, so that the water might be removed in some more scientific fashion, so that the light giving out owing to the water getting into the oil might be entirely prevented. We know, as Mr. Hume says, that oil is a good servant, but a bad master, and confessedly it needs some one to attend to it who has a knowledge of the subject ; that is to say, the ordinary fireman is scarcely to be trusted with it. In vessels where they have an engineer on watch in the stokehold as well as one in the engine-room, it would be quite within the power of the engineer in the stokehold to deal with the pumping system, and it must increase the work of the engine-room staff. What rearrangement of the crew is necessary ? Do we have an engineer or two extra, or a few less firemen ? There can be no doubt of the extra work devolving on the engineers, and if the main engines under his charge required special attention, I am afraid the oil pumping would require some one else to devote attention to it. When it is necessary to deal with the burner, can it be easily withdrawn from the furnace should any stoppage require to be cleared or overhaul necessary ? The paper is very interesting to me, and I must say that I have very little fault to find with it. I hope that some of the other members have had some experience with oil fuel, and that they will be able to deal with the matter a little more fully than I can.

Mr. Peter Smith : I regret I was not present when the paper was read ; especially to have missed the views of the oil burners, and other details thrown on the screen. In criticising a paper, I usually try to disagree with the author, in order to provoke discussion. In this case, however, I don't know sufficient of the subject, having had no experience of oil fuel, so I am not going to give myself away, nor yet mislead the members. I consider, however, that Mr. Hume has given us a very able and instructive paper, which even without discussion, will prove a very valuable addition to the transactions of the Institute.

Mr. W. E. Farenden: I believe it has been found from actual results that one pound of oil is equal to about 1·75 pounds of coal, which is not such a high figure as that given by Mr. Hume in his paper. Owing to the heating power of oil pound for pound being greater than that of coal, a much smaller quantity of air is required to burn oil than coal. From oil there is no residue: from the latter there is the accumulation of ashes, mixed with particles of burnt coal and cinders. In the letter which is printed in the body of the paper it is stated that "great care should be taken to have tanks thoroughly clean before putting oil in. No waste should ever be used for wiping out fuel tanks, for it is bound to give trouble sooner or later, and usually happens in heavy weather when ship is rolling heavily." Will Mr. Hume say what method is usually adopted in cleaning out the tanks before putting in the oil, as I understand it is most necessary to have a supply of clean fuel? I understand in some steamers they use coal in the bunkers, and also after using coal those bunkers are cleaned out and oil put into them. What method is usually adopted for the thorough cleaning out of those bunkers? Mr. Hume refers to the trouble experienced in some of the boilers, and goes on to say that in "some boilers trouble is experienced owing to the back end of tubes leaking, although ferrules will stop this as a rule and have to be used where the boilers are forced hard; still they retard the draft and are more or less troublesome in this respect, and in small tubes the oil soot soon chokes them." Again he says: "It is very necessary to keep these parts absolutely clean, and scale that would not be noticed burning coal will give no end of trouble with oil. I have no doubt that this is on account of the brickwork, for on lowering the bricks the tube trouble ceases, but then the stay-nuts suffer." Can Mr. Hume give us any idea as to the cost of repairs to boilers using oil, compared with boilers using coal, as I think the upkeep of these parts of the boilers—that is to say, the combustion chambers, tubes, furnaces, and stays, must be more when burning oil than when using coal? Mr. Hume does not mention the flash point of the oil; would he state—what it requires to be? Will he also tell us whether residuum is being used to any extent? It is the refuse oil or tar left after benzine has been given off. It is known in Russia and Roumania as massuth, and is used as fuel on the state railways in Roumania, the crude oil being excluded on account of its low flash point, which is 73 degrees Fahr.

Mr. Frank Cooper (R.N.R.) : When this paper was being read I was inclined to attach a good deal of importance to the extra duties placed on engineers by the use of oil fuel. But I had only heard half of the paper read. Since reading the paper right through, I find that Mr. Hume has made a clear case in favour of oil as against coal. He makes out that it is as cheap as coal, as efficient, takes up less space, and entails less labour, besides the great advantage of doing away with coaling days, which anybody who has gone to the East will be very glad to get rid of at almost any sacrifice. The reason, I suppose, why oil has not been adopted quicker than it has been is, in the first place, our national conservatism. We do not like to change from what has been. In the second place, you cannot get oil fuel at every port, not at the present day at any rate. With regard to the flash point of the oils that they use for furnaces, I believe Sir Marcus Samuel told us that some of the oil they used had such a high flash point that they could put a red-hot poker into a bucket of it and it would not do any harm. I believe that is what Sir Marcus Samuel said in this room in regard to some of the refuse they burn from the Borneo oils. Mr. Hume states the three methods of atomizing oil. The first is by using air ; the second, by employing steam ; and the third by centrifugal action. I take it that the third method is only another way of using air as an atomizing agent. It is nothing more than centrifugal motion of the fan, and is simply another method of atomizing the oil. Mr. Hume does not pretend to go into the commercial aspect of the case, and that is the reason he does not give us any prices of oil, or perhaps it may be that the oil varies in different places considerably, as is the case with coal. I should like to add my meed of praise to this paper.

Mr. Jas. Anderson : I was unfortunate in not being able to hear this paper read, but there are one or two points which occurred to me since reading it. There is a comparison between coal and oil. Now the cost of the coal and the cost of the oil come out the same. The next question of burning oil is that of capital expenditure versus wages. When you instal oil it decreases the number of men in the stokehold. On the other hand, as has been pointed out, one would almost require an engineer in charge of the stokehold instead of a fireman. I think it has been found necessary in the Navy to put a competent man in charge of the stokehold. The question is whether the cost of the auxiliaries, plus the extra work in oil tanks, etc., will not counterbalance the saving in wages due to the decrease of firemen. This is a commercial nation, and if it is to be suitable for tramp steamers, that is a point that will most certainly crop up—whether the saving in wages will not be counterbalanced by the increased expenditure. Mention is made of dirt getting into the oil. I was once on a trial trip where a ship was hung-up owing to dirt getting into the oil filters. It is a most necessary thing that there should be a complete double installation of filters, so that one set can be overhauled while the other set is in use. Then we come to the pumping system. Mr. Hume says it should consist of a duplex pump. Now in nearly all steamers the duplex pump for boiler-feeding purposes has been displaced by the simplex type of pump. I think it will be found to be almost necessary to do the same in this case. The duplex pump, it is claimed, gives a more even flow, but if one puts on an air vessel of sufficient capacity, the fluctuation of pressure is so slight that I think the duplex will be displaced, in this instance also, by a simplex pump. Mr. Hume also says: "It is essential that all piping be iron, not copper." What is the reason for this? I cannot see it from the paper.

Mr. F. M. Timpson: Probably conservatism on the part of this country is partly the cause why oil fuel has not been more adopted; the price is another reason. The *Caledonia* was at one time running successfully on the Clyde with oil fuel for a season, but the price went up and they had to drop it. Mention has been made of the excessive smoke given off. Two yachts were fitted for burning oil fuel, but the smoke was so bad that it was dispensed with. The oil fuel installation was removed and coal substituted. As Mr. Anderson remarked, it is a costly installation with so many tanks and details, and it has to be considered from the commercial point of view, compared with coal.

Mr. Stuart: In the event of building a steamer to use oil fuel, what type of burner would Mr. Hume put in, and how would he burn the oil? Would he kindly give a definite opinion on that point? Is there any other line of steamers, except those carrying oil, that use oil as fuel? A line of steamers has been mentioned using coal and oil alternately on the voyage. If it paid them to fit fire-bars and carry firemen for burning coal, it does not seem clear why they should use oil; and if the reason was the difficulty of getting it, there does not seem much chance for outside steamers getting it. They would certainly get the oil cheaper if they were in the trade.

Mr. Peter Smith: I do not think there is any question about the success of oil fuel. It has been pretty well proved that oil can be used successfully. The Great Eastern Railway has a large number of locomotives fitted for burning oil fuel. A very senior driver on that railway, who takes charge of the Royal trains going to Cambridge and Newmarket, spoke to me very highly of it, and said it was far superior to coal in manipulation. They can get the pressure up to blowing-off point, and by checking or shutting off the oil fuel prevent the safety valves being lifted and consequent loss of fresh water.

They never wasted a drop of water. But, as Mr. Timpson has pointed out, it is a question of cost. Directly oil fuel comes into use largely, up goes the price; as, for instance, in motor cars and the price of petrol. Really I do not think oil fuel will ever become a commercial product, because of the item of price. Coal is now going up, it is true, much as oil would, but there are more sources of supply. If oil were taken up to any large extent for marine purposes, the price would become prohibitive.

Mr. Lawrie: Steam is used as an atomizing agent; from 5 to 15 per cent. of the total evaporation of the boiler is used for maintaining that atomization. Perhaps Mr. Hume could explain why there is such a wide difference in the systems from 5 to 15 per cent. In large installations it would be a tremendous lot of water.

Mr. Hume: Mr Lawrie has asked a question as to the action of the flame on the boiler plates. I think oil fuel is better for the boiler, because they do not have to open the furnace doors as when they are working coal fires. When the doors are opened the cold air rushes in, and a fair estimate of variation would be some 100 degrees. Such rapid extremes of treatment must result in injury to the furnaces. With the oil-fuel system the furnace doors do not require to be opened throughout the voyage. There is constant heat, and the full efficiency of the boiler is in that way secured. With regard to the nuts on stay-tubes, they are protected up with brick-work to keep them from being burnt. We found they were very much burnt in any case, even with coal fires. They would be much more severely burnt with oil. That is why they are bricked up. When renewable ferrules to protect these are put on, the ferrules are burnt away in time, but they keep the heat from getting at the sore point round the neck. As to the ships fitted up at Wallsend, a question was asked regarding the trades they were engaged in. A number of those boats belong to the Shell Line that carry the oil. A number are also trading in the Caspian Sea and the rivers in Russia. I think there are some general cargo ships burning oil. The Red Star steamer *Kensington* has been so fitted, but owing to the price of oil and the restrictions imposed by the dock companies in regard to loading facilities they had to abandon the use of oil on that steamer. In London it is necessary to go to Thameshaven to load oil, and that loses a lot of time. In regard to settling tanks : those are fitted with one object, namely to get rid of the water. When oil bunkers are taken on board they are not expected to take water, but water occasionally gets in through a leaky rivet-hole. The tanks are necessary to permit the water to settle. The only system is by heating the oil and letting the water drop to the bottom of the settling tanks, it being of a greater gravity than the oil. The pumping arrangement is generally attended to by an engineer, or a fireman, if he is properly trained. The pumps and all auxiliary machinery should be in the engine-room and under the control of the engineer. In many cases that is not so. It is put in a recess of the oil bunkers which is frequently forward of the boilers. I do not think the use of oil entails any extra work. The pump can work away steadily, and has a safety valve on the pressure pipe, and goes back on the continual discharge to the continual suction. The next point is in regard to the burners and the cleaning of them when they are choked up. Burners should be designed so as to permit of rapid and easy examination, overhauling and renewal of special parts by inexperienced men. Just ordinary firemen should be able to take out a burner and renew it. It should be so designed that they could do that without any great trouble.

Mr. Lawrie : I had in my mind some ships that I had been in, and I know it was as much as one could do to get into the stokehold to look at the gauge glass. If you had some grain cargo getting into the mud-boxes necessitating the close attention of the engineers, at such a time there is a lot to do in the engine-room without extras.

Mr. Hume : A man has to go into the stokehold now and again, and perhaps clean his mud-box in the stokehold.

Mr. P. Smith : May I ask if the tanks in these steamers are specially built, or do they form part of the vessel, the same as a water tank.

Mr. Hume : Just as a water-ballast tank. They are structurally built to carry liquid in bulk. They are strongly bulkheaded and tested with a full head of water to the height of the ship. They have to be about eight feet above the upper deck to stand classification requirements, and the bulkheads have to stand that. In reference to Mr. Farenden's question, it has been found that slightly over a cubic foot of free air per pint of water evaporates at 212°. A reference has been made to the cleaning of the tanks. The filling pipe to the tank is drawn out, the valves opened, and the tank wiped up dry before any oil is put in. It is scraped down, and any coal is all scraped out as nearly as possible. Then it is dried up and the oil put in. There should be no water left in the tank at all. We have not found that the up-keep has been any more, if so much, when burning oil as when burning coal. If anything it is less up to the present on the steamers with which I have to do. The flash point required by the classification societies is nothing less than 150°. That is the minimum, and is, I think, a very safe one. The greater amount of the oil used is Residuum, and Mazoot is one name for that. It is a very thick black oil, which has to be heated in the bunker before the pump will draw it. Mazoot is another name for fuel oil. It is a Russian name for it. I am sorry I have not been able to get the result of the Wolff spray burner to which Mr. Farenden referred. I will try and find out about it and let you know. Mr. Frank Cooper has asked about the extra duties that had to be done. It is no use fitting up for oil-burning unless the work is done in a first-class manner. The dangers attending oil are worthy of a first-class installation. If that be supplied the extra duties devolving on the engineers are not worth speaking of. The centrifugal action of spraying oil is that it gets a twist round on the burner. It separates itself through that centrifugal motion, but it requires air to burn. On the last page you will see the results obtained by the Wallsend Slipway Company where it was burned with the natural draught and with the closed stokehold. Without air oil will not burn. Mr. Smith, I think, has answered the point in regard to commercial prices. It depends whether there are depôts and the supply and demand more than anything else, I would say. Mr. Anderson has asked some questions in regard to coal *versus* oil. I think that is brought out pretty well in the comparison made on the first page of my paper. In that comparison there is wood, coal and oil. I think that explains itself so far as I can do. Further on in the paper there is a table showing the results from a steamer. That gives the consumption per h.p. at 1·08 pounds; that is, with an air system. At another place it shows 1·26 and 1·28. I have compared that with commercial coal got at various parts of the world. Compared with Indian coal it gives a saving of 35 per cent. With Welsh coal obtained at Port Said there is a 20 per cent. saving. I think that shows very favourably for oil. The next question was in regard to first cost. I think that is a matter more for principals to go into than for me. I am pleased to see that Mr. Anderson thought that duplicate filters were necessary. They are very necessary. The least little oil getting into a burner clogs the whole thing up. It is necessary to open the burner and waste more oil. With smoking a tarry substance is deposited on the tubes. It is neither solid nor liquid, and is a bad conductor of heat. The type of pump does not matter very much whether it is a duplex or a simplex. Mr. Anderson has referred to the use of iron piping. The whole of the installation should be of iron, because oil attacks copper, and in a short time it becomes perforated with little holes and leaks accordingly. It does not come out in the form of a leak, but as a vapour, and if a light were brought near it you might get your hair singed in going past. Iron pipes are to be recommended on that account. Mr. Timpson has spoken of smoke on some yachts. I am inclined to attribute that to bad installation.

Mr. Timpson: It was a good number of years ago, so perhaps it was. There is a good number of launches using oil fuel in this country.

Mr. Hume: Referring to Mr. Stuart's question as to which type I would recommend, I think the results given in the paper answer that. That is about as much information as I have on the subject. You see the results obtained from the three different systems, and I know of no other system than these. I know a great many kinds of different burners other than those I have shown, but I do not know any different system of burning other than those I have given. The line of steamers I have referred to as burning oil one way and coal the other are the Roumanian railway boats running from Constantza to Antwerp and Rotterdam. They carry cargo both ways, and change over from oil to coal at Antwerp or Rotterdam. I think a fair estimate for such a change-over should be nothing under twenty-four to thirty hours in the ordinary course of things. In an exceptional trial, where everybody has his little bit to do, a man comes at once and jumps to it. These boats do not carry oil; they carry general cargo. They only take bunkers to bring them to Antwerp, and then they load up coal on the Continent to take them back again. Mr. Lawrie, I think, asked a question about the brick-work at the front and throat and in the combustion chamber.

Mr. Lawrie: I have said that that showed that there was a very considerable action on the plates, beyond what there would be when using coal. I think the plates exposed most will suffer.

Mr. Hume: The part exposed to the heat?

Mr. Lawrie: Yes.

Mr. Hume: The evaporation is so great there. The throat of the furnace is the only part which requires brick-work. The reason for the bricking up of the front of the furnace is to keep the air heated as it enters the furnace, so that it will not go in just cold raw air.

The evaporation must be very good with oil fuel when you get a temperature of 540° Fahr. leaving the boiler tubes.

Mr. Hume: There have been some instances where the brick-work has so baffled the flame from the back that it has often come back and fused the burners altogether. There was not enough room for combustion.

Mr. Lawrie: Is there any of this brick-work in the centre of the furnaces on board ship nowadays?

Mr. Hume: Yes. The Shell boats carry these brick-walls in the centre of the furnace. The general system to be recommended is to have the furnace as clear of obstructions as possible.

Mr. Peter Smith: I would like to ask Mr. Hume if there are any extraordinary precautions necessary in oil-carrying steamers before men can be sent down to clean out the tanks. I know there are man-hole doors on the top, but do you require to have any opening in the bottom as well, before you can safely send men in to clean out the tanks? Or, is it all done by ventilation from the top by wind-sail or something of that sort.

Mr. Hume: The tanks are washed down with the hose. The gas is pretty strong. The men go as far as they can. The washings are then pumped out. A steam-pipe is led into the tanks as a permanent fixture. It is generally kept a little bit open at the top. The pipe is continued to the bottom. It is there either for fire extinction or for cleaning purposes. The steam cools the gases. It is not necessary to have an opening at the bottom as well as at the top. The fan can draw a lot of air providing the tank is dry, and providing it gets no water. It takes the vapour out, and it is discharged rather high from the ventilator on deck.

Mr. Anderson: Is it necessary to have iron suction pipes from the tank to the pump as well as iron discharge pipes? Have all the pipes in connection with the oil to be of iron?

Mr. Hume: Preferably. It is because of the chemical action which takes place on the copper, and wears it very thin. It becomes porous and spongy, and vapour is the first thing which works out.

Mr. Anderson: When you are drawing you are under the pressure of the atmosphere, and you would be inclined to think the vapour would be drawn into the pump.

Mr. Hume: Then the pump won't draw.

Mr. Anderson: The pressure of the atmosphere must be greater than the pressure in the pump. The vapour coming from the oil will take the easiest way, which is the pump. The pressure of the atmosphere is forcing the vapour into the pump.

Mr. Hume: There is no vapour if the pump is drawing oil. The chemical attacks copper and wears it away.

Mr. Anderson: So it is necessary to have your pipes of iron?

Mr. Hume: Not necessary, but iron lasts longer.

Mr. Robertson: Not long ago a ship left the Clyde for a seventy days' run to San Francisco. Looking at the table in Mr. Hume's paper I see that the longest steaming time is 28 days 2 hours. What is the maximum amount of scale for safety on a voyage of that description? The greater heat from oil is more susceptible to act by burning the plates and stay ends than is the case with coal as fuel.

Mr. Hume: The less scale you get in the boiler the better. What the minimum amount would be before the furnaces came down I should not like to say.

The Chairman: Is there any peculiarity in regard to an oil-burning boiler as compared with a coal-burning boiler—that is to say in the proportions of the combustion chamber and tubes? Are they smaller than what would be used for forced draught in a coal-burning boiler?

Mr. Hume: Most of the ships running at present are vessels that have been converted, more or less, from their original design for coal burning. Some of them were originally fitted with Howden's system of forced draught. But with retarders in and tubes about 7 feet long very good results were obtained. In one ship the tubes were 3 inches inside, and in another they were $2\frac{3}{4}$ inches inside. Those ships were originally designed for burning coal, but very good results were obtained when burning oil. If you are designing a ship for a trade where you are going to burn oil continually, $2\frac{1}{2}$

inches would be a suitable size of tube, with retarders, and nothing less than 7 feet 3 inches in the length of the tube.

The CHAIRMAN : The combustion chamber would be of the same proportions ?

Mr. HUME : It is very difficult to enlarge the combustion chamber owing to the restrictions put on us when designing. The larger the space you can get for combustion the better the result will be.

The CHAIRMAN : We are very much indebted to Mr. Hume for bringing so interesting a paper before us. There is not the slightest doubt that if oil were a little cheaper and there were depôts all over the world and a sufficient quantity of oil at reasonable prices—there is not the slightest doubt that it is superior to coal. I have seen oil burnt on a trial trip of the *Clam*, one of the Shell Line boats, but I do not think the results were altogether favourable on that occasion. Further, I do not think any commercial firm of shipowners make use of oil at all, so far as I know. It is simply confined to the Anglo-American Company and others dealing with oil, carried as cargo.

Mr. HUME : There are over 300 ships using oil on the Pacific coast.

The CHAIRMAN : Oil is much cleaner and gives less trouble than coal, so far as I have seen it used. The subject of Mr. Hume's paper deserves to be carefully considered. As Mr. Hume gains more experience of it, or hears of more experience with those vessels trading from 'Frisco to China and Japan, I am quite sure he will be pleased to give us any further information that he might obtain. I have much pleasure in thanking Mr. Hume for his paper and for the kindly way in which he has answered the questions put to him.

Mr. BERTRAM proposed that a hearty vote of thanks be accorded Mr. Hume.

Mr. LAWRIE, in seconding the proposition, said : When you come to read the paper carefully you find that most of the ideas that occur to a man are really made clear in the paper. As a rule we are under the impression that the best paper is the one that creates the greatest amount of discussion. I must say that Mr. Hume's paper is the exception that proves the rule. Mr. Hume's paper has not created very much discussion, because it is so complete in itself that it does not give us a chance to fire much at him.

The proposition was carried unanimously.

Mr. HUME thanked them for the kind way they had treated him in the discussion and in the reading of the paper, and he hoped he had not wearied them by it. He had had to cut the paper down considerably, but perhaps on a future occasion he might have a little more information to impart.

A vote of thanks to the chairman terminated the proceedings.