INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1909–1910

Vol. XXI.

PAPER OF TRANSACTIONS NO. CLXI.

Marine Engines and Superheated Steam

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Read Monday, November 15, 1909.

Chairman: Mr. J. T. MILTON (Chairman of Council).

Early last year the author was asked by a firm of shipowners to make a report to them upon the progress that had been made in connexion with the use of superheated steam on board ship, and what had been the actual results arrived at, especially in such cases where highly superheated steam had been in use. It is partly the results of this investigation which he now proposes to place before the Institution, together with some general information collected during the time that this subject has had special interest for him.

It is now over fifty years since a means was sought to prevent the losses due to condensation in the cylinders, as this loss constitutes an evil which is common to all types of engines using saturated steam, and so attention was thus turned to the advantages to be obtained by hotter and dryer steam than that given off at the boiler. Although the British marine engineer has lagged somewhat behind engineers on the Continent in the use of highly superheated steam, that is to say, steam having a temperature of 180° F. above that due to its pressure, it must not be forgotten that in the practical adoption of superheated steam he may still claim to be the pioneer in its application to marine engines. James Watt recognized the real nature of cylinder condensation, and tried to eliminate the trouble by the use of steam jackets, a method which has remained in use up to recent times, although it has long been known that the losses in question could be more effectually reduced, and, under certain circumstances, entirely avoided by the use of superheated steam. Since the year 1830, engineers have made various attempts to employ superheating, but the subject does not appear to have been scientifically treated until 1857, when Hirn took the matter up thoroughly, and investigated it by tests on actual engines. At that period, owing to the low range of temperature and range of expansion, it was found that the degree of superheat adopted by Hirn was not high enough to be of much commercial value, and was only instrumental in reducing condensation to a very slight extent. It has since been found that an average temperature of 550° F. must be maintained in the H.P. valve chest in order to ensure the superheated steam being free from intermixed wet or saturated portions, coal and water consumption being considerably increased whenever the temperature falls to any appreciable extent below that figure. This partly accounts for the failure in early times to realize the economy from superheated steam which is now common in every-day practice, it not being then practical to either obtain or use the temperature necessary for high economies. A practical apparatus, capable of producing a high degree of superheat, did not then exist, and what was even a greater drawback, the best lubricant of that day could not resist the temperature inseparable from the use of a high degree of superheat, and trouble was experienced with valves and packing. Consequently superheating was abandoned in favour of compounding, introduced about that time, which, accompanied by the employment of relatively high steam pressures, and reduced range of temperature, offered another, though a far less effective, method of reducing the amount of initial condensation in the cylinders.

But when, more recently, owing to the development of compounding from double to multiple expansion, the limit of efficiency with saturated steam appeared to be reached, engineers once more turned their attention to superheating.

Without going deeply into the question of the action of heat in the cylinders, as this has been fully treated by many able authorities, it may not be out of place briefly to refer to some of the physical properties of steam. Saturated steam of a given pressure has a certain known temperature. If heat be added to the steam while it is still in contact with water (for instance in the boiler), more water will be evaporated, and the quantity of steam will be thus increased, but the saturation temperature will remain the same as long as the pressure is constant. On the other hand, if heat be taken from it by cooling or by the performance of useful work during expansion, a part of the steam will be condensed.

As no boiler produces perfectly dry steam, a certain amount of water is carried to the engine when saturated steam is used, and a further quantity is produced by condensation in the cylinders and receivers. As water, it is useless as a working fluid, and the heat already expended upon it is a dead loss. A natural desire arises, therefore, to add enough heat in the initial stage to obviate this waste. Superheated steam can only be produced by heating saturated steam in separate apparatus away from the water in the boiler. If heat be added to the steam when it is no longer in contact with the water, i.e. in the superheater, its temperature will be raised above that due to its pressure, in other words it will be superheated, and heat can then be extracted from it without causing condensation; such steam may be cooled on its way from the boiler, or when in the cylinder by the same amount that it has been superheated, and condensation will not be reached so long as the temperature of the steam is sensibly higher than that of saturated steam at the same pressure, in which case it will remain a pure and simple gas, and act as such in the cylinders. In other words, if saturated steam from the boilers is passed through the tubes of a superheater, the water contained in the steam is evaporated out of it, with the following results:—

1. Rise of temperature.

2. Increase of volume if pressure is kept constant: or increase of pressure if volume is kept constant.

The chief advantage to be gained by the use of superheated steam lies in the fact that cylinder condensation is practically eliminated, and that owing to the low thermal conductivity of superheated steam it does not so readily drop in temperature when exposed to cooled surfaces. Highly superheated steam in comparison with saturated steam is a bad conductor of heat. This property, which, on the one hand, is of great value in reducing the loss from condensation in the cylinders, is, on the other hand, an obstacle to the free transmission of heat to the steam in the superheater, and calls for special consideration in the design of the latter. Superheaters may be divided broadly into two classes.

1. Those in which the steam is superheated by the gases generated in the boiler furnace.

2. Those forming a separate unit having their own furnace.

The general design of a superheater of the first class naturally depends upon the type of boiler to which it is to be applied. Broadly speaking, there are three positions in which the superheater may be placed. It may be in the combustion chamber, an ideal place but impracticable. It may be in the uptake, so as to absorb the heat that is left in the gases after passing through the generator, or it may be somewhere between these two extremes. As already pointed out, the first position may be discarded owing to the difficulty in obtaining materials which under pressure will withstand the prevailing temperature. The second position with an efficient boiler gives only a moderate degree of superheat, resulting in a relatively low economy. It would appear, therefore, that the superheater ought to be in such a position that it will come in contact with gases from the furnace having a temperature of not less than 1,000° F. If the superheater is applied to ordinary Scotch boilers, it ought to conform to the following conditions :—

1. It should not necessitate much alteration in boiler design.

2. It must be efficient under varying conditions of temperature.

3. It should be easy of removal should such become necessary.

4. It should be easily cleaned.

5. It should be easy to remove, renew, or repair any tube without blowing off the steam in the boiler, or shutting off the boiler for any serious length of time

6. It should be easy to locate any leak.

7. It should be placed where least liable to external corrosion.

8. The superheater tubes should be parallel with the flow of the furnace gases.

9. Only solid drawn steel tubes should be used.

Upon investigation it would appear that with superheaters fitted in the uptake the gain in economy in coal consumption amounts to about $7\frac{1}{2}$ per cent., and it is doubtful whether this small gain is sufficient to pay interest on first cost and maintenance charges, especially in the case of vessels on short voyages, or where the length of time at sea is small in proportion to the time spent in port. In the case of superheaters in contact with higher temperature flue gases, giving a superheat of about 250° F., it is found that the economy with triple expansion engines averages 15 per cent. It may therefore be said that a low degree of superheat (say 500° F. steam temperature at the engine with boiler pressure 200 lb. per in.), while effecting a drying in the steam and a certain economy in consumption, is, commercially speaking, hardly worth considering. Owing to the relatively much greater economy to be obtained from a high degree of superheat, say a steam temperature of 620° F. at the engine, giving as already stated an economy in coal consumption of 15 per cent., it would appear that a form of superheater giving this temperature is the one having the greatest commercial advantages.

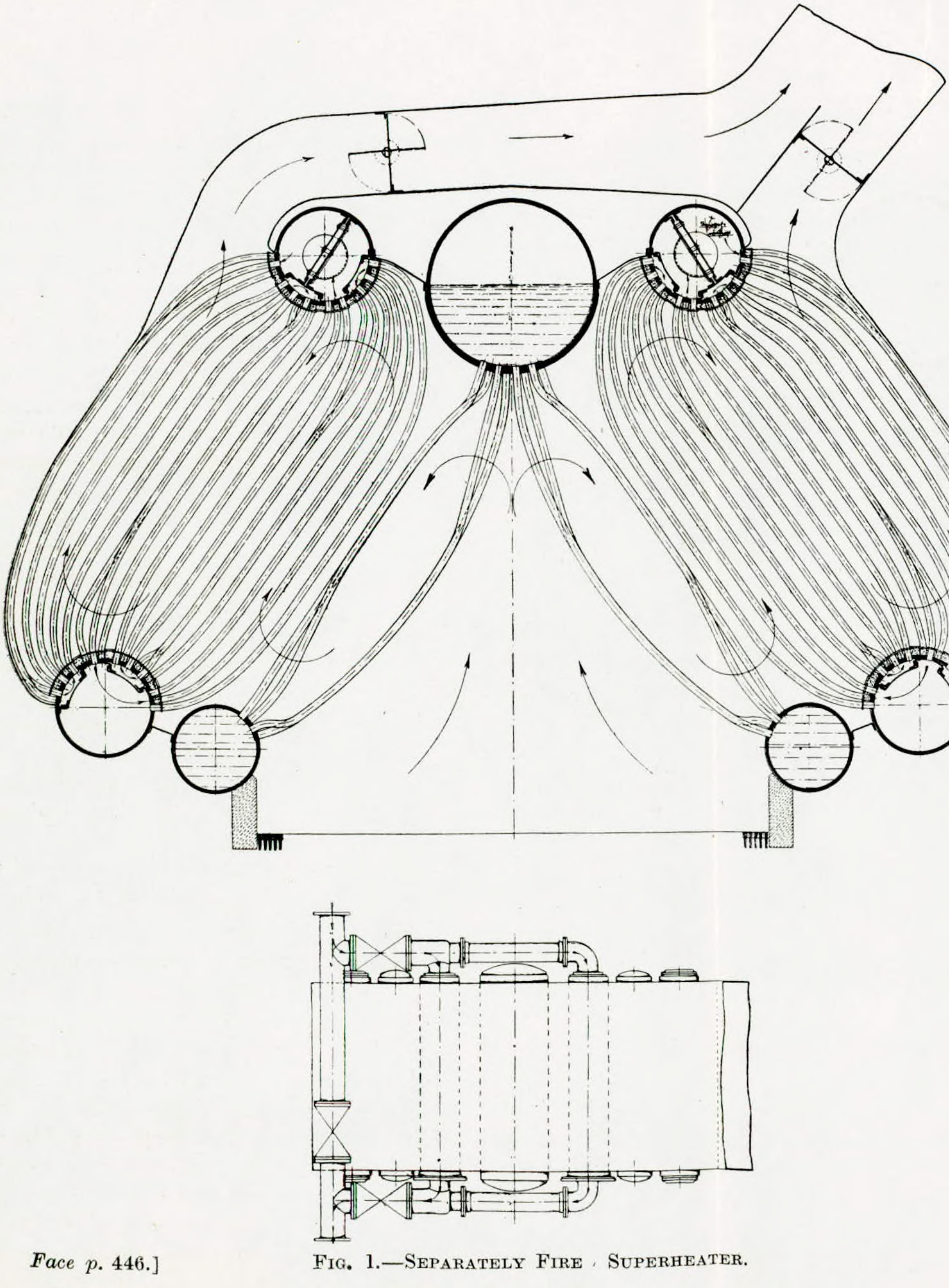
Although flame tube superheaters have been continuously in use on board ship since 1898 and 1899, the longest period that the author has had the personal opportunity of investigating has been on ships where the vessels have been using highly superheated steam for over two years, during which time no repairs have been necessary to the superheater nor have any repairs been required to the high pressure valves more than is generally the case where ordinary saturated steam is employed. With regard to the life of the superheater tubes exposed to high temperature, such as is experienced with superheaters of what may be termed the "flame type," it may be said that in the case of a vessel continually in service the average duration is about eight to ten years.

In locomotives where the coal burnt per square foot of grate is about three-and-half to four times more than in mercantile marine practice, where the draught is much greater, and the temperature of the gases meeting the superheater tubes is nearly double the temperature of what would be experienced in tubes of a marine boiler at the same distance from the fire box or combustion chamber, the superheater tubes last as long as the boiler tubes. Even supposing the superheater tube ends wear out in five years, the cost of repairing them is such a small matter as compared with the coal economy, that it makes a very small reduction in the nett saving. The life of the tubes in uptake superheaters may be said to depend on the original thickness of tubes used and the care taken of them to prevent outside corrosion.

On the question of fluctuation of steam temperature, it is found in practice that this is not so great as what at first sight seems likely, the steam generated and used being in proportion to the amount the fires are forced. The only time that the temperature rises above the normal, is when the engines are suddenly stopped. It is then found that the steam temperature in the superheater tubes rises about 50° F., but as the amount of steam at this increased temperature is only that contained in the superheater tubes, it is used up after the first few turns of the engines, and has not time to communicate its temperature to the valves and cylinder walls. In such cases where the auxiliary engines use superheated steam, this helps largely to keep down the temperature, which is easily reduced by slightly opening the fire doors after the ashpit dampers are closed. Where superheated steam is used, temperature and pressure are rightly considered of equal importance, and observation of the temperature gauges enables the engineer in the engine room to know exactly the prevailing conditions of any boiler, the state of its fires, etc.

The illustration, Fig. 1, shows a form of separately fired superheater suitable for large naval vessels. As will be seen by referring to the drawing, water tubes are placed in direct contact with the fire, forming steam generating tubes, and may be considered as part of the boiler installation. The first heat of the fire is taken on these tubes, and the gases are afterwards conveyed by a circuitous route over a series of superheater tubes through which the steam passes. By an alteration in the disposition of the superheater tubes on either side of the fire and a suitably designed arrangement of dampers, a superheater of this type can be made to produce a fixed temperature of steam under very varying conditions of working.

Experiments made on the effect of superheat and the consumption of steam in turbines has proved that with a superheat



Face p. 446.] Fig. 1.—Separately Fire , Superheater.

about 216° F. a reduction in consumption in steam as compared with saturated steam amounts to as much as 21 per cent. In considering the economy in coal consumption, allowance should be made for the amount of coal burnt in the superheater which by experiments has been shown to be about 11 per cent. with a superheater efficiency of 62 per cent., leaving a nett gain in economy of coal due to superheating of 9 per cent. For a 75 per cent. efficiency in the superheater, this figure may rise to 11–12 per cent. Reference need only be made to the good economy obtained by the use of superheated steam working in connexion with turbines on land power installations, to prove the necessity there exists for obtaining the same economy on board ship. This economy is of such a very pronounced nature that it must in time be recognized and adopted in general marine practice so long as it can be proved that it is not attended by increased possibilities of a breakdown. Turbines of the impulse type may be said to be more adaptable for high temperatures than those of the reaction type, due to the large blade clearances and to the small effect of expansion. As the friction of steam across the surface of the blades somewhat seriously affects the efficiency of the turbine, it is obvious that water in the steam will produce a similar result, so that the frictional resistance and wear set up by saturated steam will be considerably reduced by the use of superheated steam.

With regard to the design of machinery using superheated steam, the following conditions should be observed :—

1. Copper or brass should not be used for pipes or valves in contact with highly superheated steam.

2. Superheated steam pipes should have special arrangements for free expansion, bends in the pipes being generally preferred to straight lengths and stuffing boxes, owing to the fact that with high temperatures the material used in packing and stuffing boxes may deteriorate and prevent free movement of the pipes. Special attention should be given to the staying.

3. Cylinder castings should be designed with a view to withstand high ranges of temperature, and allowance made for free expansion in all directions.

4. A form of valve to the H.P. cylinder not requiring lubrication should be aimed at.

5. The packing in the H.P. rod should be metallic.

6. Only the very best hydro-carbon oils procurable should be used, the flash point of which should be not less than 700° F.

7. Efficient means should be provided to prevent oil passing into the boilers.

Although excellent results have been obtained with piston valves with solid rings, such as are usually manufactured by marine engine builders, a desire has been expressed for a form of valve which, while suited to the requirements of superheated steam, would yet not necessitate such accuracy in the fitting of the rings as that required in the case of the solid ring type. The valve as illustrated (Fig. 2) has therefore been designed with a split ring, and has been found to be very satisfactory. Experience has proved that narrow rings are not to be recommended for use with superheated steam, and that it is wise to make rings rather wider than is the usual practice with saturated steam. Wider rings, however, present another difficulty in so much that they are forced with great pressure against the liner, and excessive wear takes place. On the other hand, during compression, they are unable to withstand the excessive pressure on the outer surface, and are forced inwards, thus causing leakage. In the type of valve illustrated, the advantages of the wide rings are obtained, but they are so constructed as to overcome the aforesaid drawbacks. This result has been achieved by providing several steam-tight spaces on the inside of each ring which communicate with the steam port by means of radial holes about $\frac{3}{16}$ in. diameter arranged circumferentially round the ring. This ensures the pressure on both sides of the ring being equal, and the ring is only pressed against the liner by its own tension, which is sufficient to keep it steam-tight. In order to secure a good fit between the valve ends and the ring sides, and to avoid jamming the ring between the two, the valve end is made with a certain amount of elasticity, and is screwed up against the valve body in the centre only, leaving the outer edges to be pressed up by the steam. The steam pressure of the cover gives the ring sufficient freedom for expansion. During exhaust, however, the ring is held in position by the cover, till re-admission takes place. Excessive outward pressure of the ring against the liner, and consequently excessive friction, are thus prevented, although at some point of the stroke a perfect balance between the pressure on both sides of the ring may not occur instantly. The resistance to motion of this type of piston valve is very

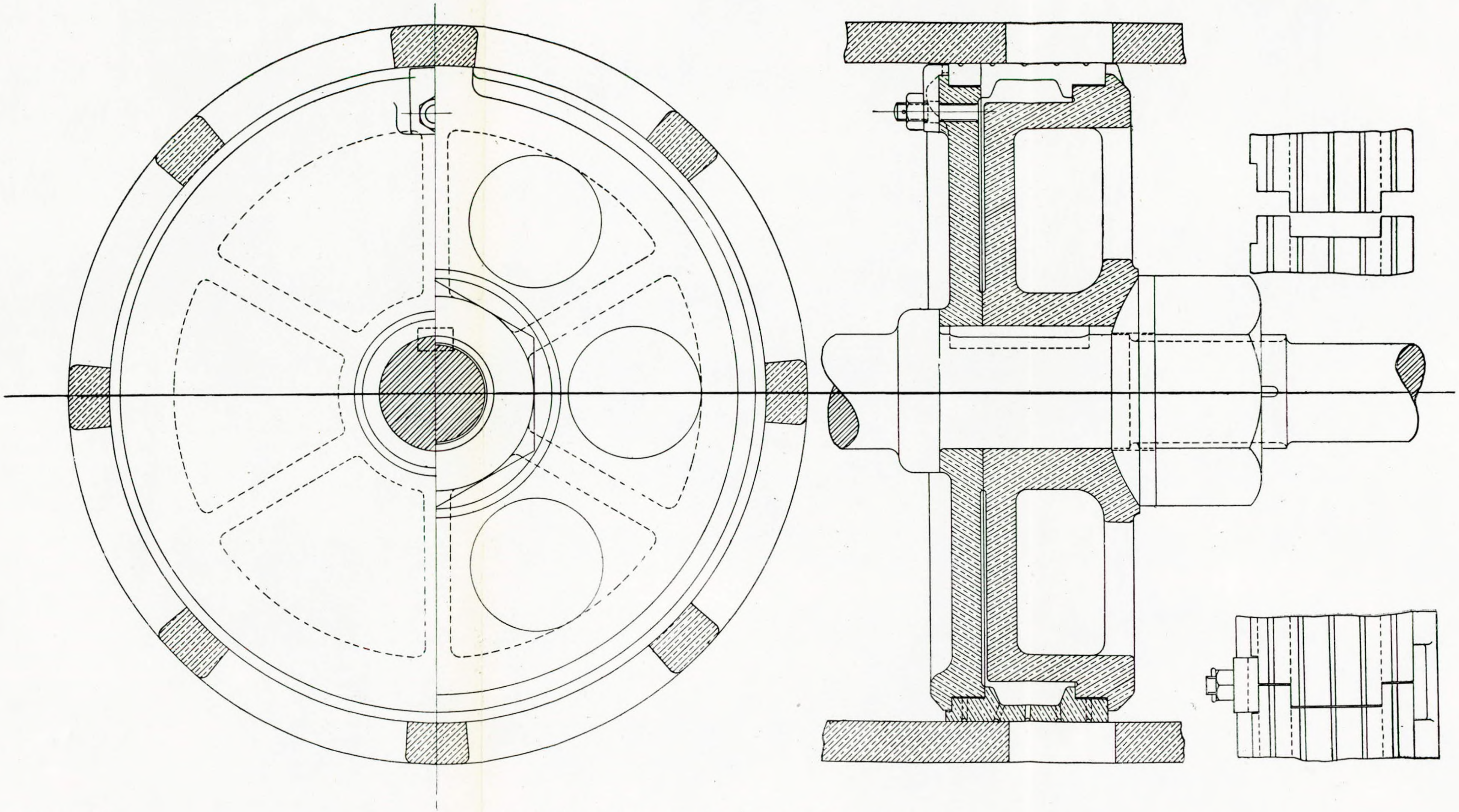


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FIG. 2.—PISTON VALVE WITH BALANCED SPLIT RING (PATENTED).

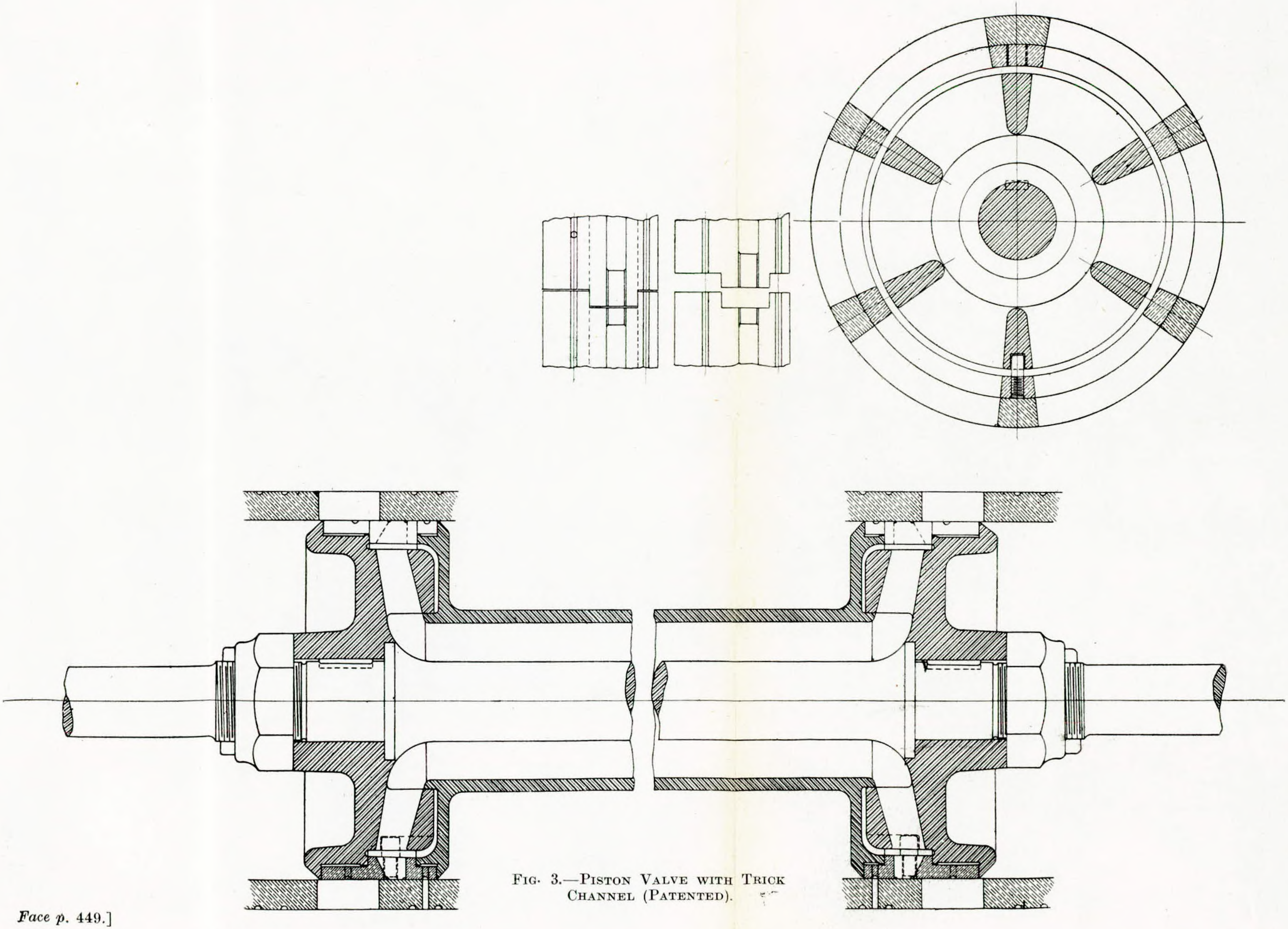

Fig. 3.—Piston Valve with Trick Channel (Patented).

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small, and the wear of the rings is almost infinitesimal. As compared with the solid ring type of valve, this modified type has the advantage of remaining absolutely steam-tight so long as there is any elasticity in the rings. The split or cut in the rings must always be placed opposite the broad bridge of the liner, so as to prevent leakage through the cut. The cut in the ring is protected on the outside by a cover, which is fixed respectively to the valve body and to the valve end or cover. The screws holding the split cover prevent the rings from turning. In cases where the split covers are cast on, special set screws must be provided for this purpose. A later form of this valve has been made with a trick channel, (Fig. 3) the object aimed at being the same as the trick channel in the slide valve type, i.e., to give double admission, and thus allow of a smaller valve being used for high piston speeds.

With regard to pistons, it has been found that the ordinary Ramsbottom rings, as generally used in marine practice, give the best results. It should not, however, be forgotten that with high superheat, wherever there is a sliding surface, lubrication is essential. In designing valves and pistons, therefore, it is necessary to reduce as much as possible the friction due to the weight of the moving parts. It is thus absolutely necessary that the body of the piston should not touch the sides of the cylinders, so that in the case of large high pressure cylinders (say over 24 in.) it is advisable to fit a tail rod, to ensure the piston being accurately guided throughout the whole length of its stroke.

Where trouble has been caused by piston rings breaking this may in nearly all cases be attributed to the decomposition of inferior oils, leaving a deposit on the cylinder walls and rings, which has prevented the rings having free movement. Slide valves on the I.P. cylinder have been known to give trouble where there has been much leakage of high temperature steam past the H.P. valve. However much care is taken in reducing by correct design the friction due to the pressure of the piston valve springs, it is absolutely necessary, with high temperature of steam, to provide for special means of lubrication. This can be easily effected in a variety of ways, and the difficulty which confronts the marine engineer is not the lubrication of the parts so much as the extraction of the oil necessary for this purpose. To prevent this oil passing through the feed water into the boilers it is necessary to have special arrangements for trapping it. Filters on the delivery side of the pumps have been found to be useless for this purpose, indeed it might be said they are of very little value whether oil is used in the cylinders or not, as in the author's experience it is an extremely difficult matter to design a filter on the pressure side of the pumps with sufficient area to prevent it being quickly clogged. It may therefore be taken as a *sine quâ non* that the filters be on the suction side of the pumps, and that special attention be given to see that they are kept in order. One of the simplest forms which this filter takes is an arrangement of cocoanut matting with coke layers between each pair of mats. The sizes of these filters vary according to the H.P., but in an ordinary tramp steamer of about 1,200 I.H.P., six mats would be employed, each about 24 in. by 15 in. These mats are laid one above another with 4 in. of coke between each pair of mats. After every three or four days' steaming, the mats are taken out, washed in hot soda water, used again, and the coke renewed. In some cases sponges are used instead of coke. Any small quantity of oil which passes these filters and gets into the boilers is easily dealt with by the use of soda or zinkara, which is much less deteriorating to an engine using highly superheated steam than is the case where saturated steam is employed. Should priming occur, the water carried over with the steam becomes evaporated in the superheater.

It is not easy to ascertain with any degree of accuracy the number of vessels now using superheated steam, but so far as we can learn there is now afloat about 350 vessels of all sizes, from river and lake steamers up to naval cruisers equipped with superheaters. Of these, Germany takes the first place in numbers, having fitted out about 274 vessels, 188 of which are for canals, lakes, rivers and coasting service, 81 sea-going steamers, and 5 vessels for the Imperial Navy. Britain has about 40 vessels using superheated steam, including 4 cruisers of H.M. Navy. America can be credited with 20, of which 8 are naval vessels; and France about 10, merchant ships. Taking the countries in order named, it should be said that the steamers ascribed to Germany include the vessels belonging to that country and those owned in Switzerland, Italy, Austria Hungary, Russia and Holland; most of these ships are fitted with the Schmidt type of superheater, and are worked on Dr. Schmidt's system of high superheat.

The first marine boilers fitted with this form of superheater were built in 1898 by Messrs. Sulzer Bros., of Winterthur, for vessels plying on the Swiss lakes. Owing to the very high cost of coal in this district, the advantage of superheating was a matter of great importance to the owners of these vessels. As a result of their success, other ships trading on the Italian lakes, the Rivers Oder, Danube, Volga, etc., were similarly equipped; the H.P. of these steamers ranges from 100 up to 1,000, the smaller river steamers from 130 to 800, and the Rhine steamers which are from 1,000 to 1,350 H.P.

Amongst the ocean-going vessels fitted are eleven ships belonging to the Oldenburg Portuguese Steamship Company, and nine vessels belonging to the Argo Steamship Company, these steamers having engines of 900–1,200 H.P. Other companies adopting Schmidt Superheaters may be mentioned: The Hansa Company, North German Lloyd, Compagnie Générale Transatlantique, and Compagnie des Chargeurs Réunis, Robt. Sloman, Junr., Hamburg.

The warships include the cruiser *Dresden*, *Mainz*, *Cöln*, *Kolberg*, of 26,000 average H.P. each, and the *Ulan*, a steam tender of 1,600 H.P.

258 ships are now equipped with superheaters working on the Schmidt system (including these ships now being fitted), having an aggregate H.P. of 250,000, the superheaters being in nearly every case applied to the standard Scotch or cylindrical type of boiler, either in the boiler tubes or uptakes, some few having directly fired superheaters, and other special designs. This system has been applied to vessels fitted with both compound and triple expansion engines. With compound paddle engines and superheated steam having a temperature of about 660° F. the fuel economy is about 30 per cent. as compared with the same type of engines using saturated steam, and about 15 per cent. as compared with triple expansion engines using saturated steam, that is to say, in the case of slow-running paddle engines ordinary compound engines using superheated steam is 15 per cent. more economical as compared with similar vessels having triple expansion engines using saturated steam.

The twenty steamers belonging to the two companies first named, with triple expansion engines and superheaters fitted in the boiler tubes, have in service realized an economy of 15–20 per cent., and in one or two cases where the vessels' boilers previous to fitting the superheaters had been forced, the economy realized has been more than this.

The steam pressure used in these ships is from 185–200 lb. per sq. in., and the average temperature of the superheated steam is 608–660° F. In several cases the original piston valves, such as those fitted in the engines when new, were retained, after superheaters were fitted, and appear to work very satisfactorily under the altered conditions. In the case of engines having H.P. slide valves, however, it was found that a steam tem-

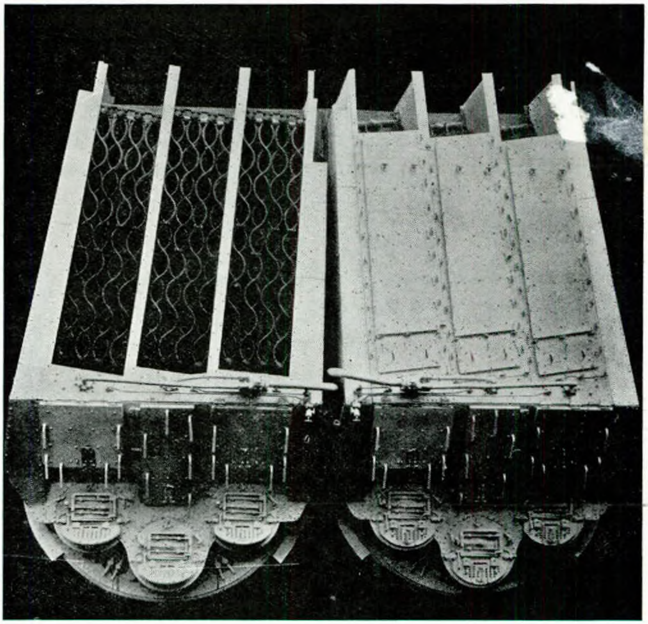

FIG. 4.

perature of 500° F. could not be exceeded owing to the difficulty in effectively lubricating the valve face. When slide valves are used, the oil is forced on to the face of the valve mechanically, and in the case of piston valves the oil is mechanically forced into and atomized in the centre of the main steam pipes and carried by the steam into the valve chest and cylinders.

After a number of successful trials on ships of the mercantile marine, the German Admiralty have made some experiments on rather a large scale in the use of the Separately Fired Superheater. The first ship fitted was that of the cruiser *Dresden*, with Parsons Turbines, and the writer understands that on trial very satisfactory results were obtained, and the ship is now in commission. Separate Fired Superheaters have also been fitted on the German Cruiser *Mainz* with Curtis Tur-

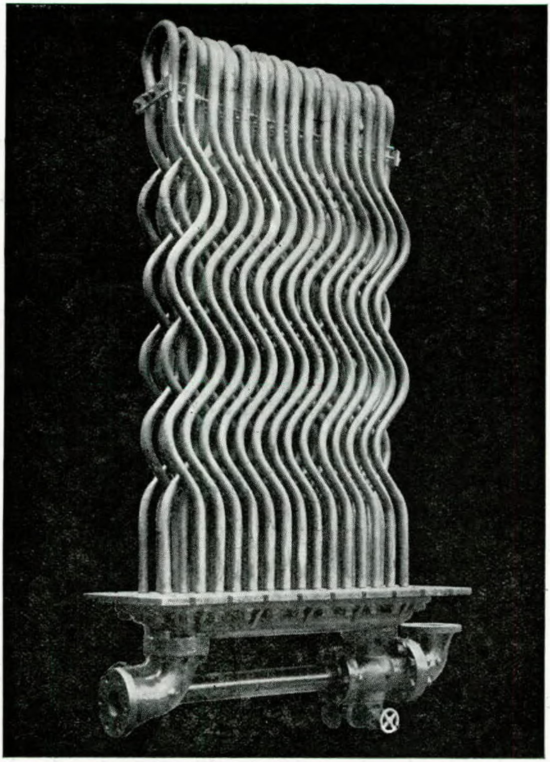

FIG. 5.

bines, but no official information has yet been given out with regard to the results obtained. It is stated, however, that the intention of the German authorities is to use superheated steam for further ships of the cruiser and battleship type.

In this country the first superheating installations in recent years were made by the Central Marine Engine Works at West Hartlepool, in the year 1891, but since that time this Company have fitted many other vessels with superheaters of the type illustrated in Figs. 4, 5. The first two vessels having superheaters of this type were completed about 1900, and have since been succeeded by other vessels having quadruple expansion five-crank engines. In these vessels the working pressure of the boilers is 255 lb. per square inch, and the steam superheated about 70° F. The waste gases in addition to heating the steam are utilized for heating the air entering the furnaces. As these vessels have engines of a very special design, it is difficult to say exactly what is the economy due to the superheater alone, but it is the opinion of the author that with a simple form of engines and by use of a higher superheat more economical results could have been obtained. Messrs. Thos. Wilson Sons & Co. in 1900 fitted the first of their vessels with a superheater from designs of their own, and although only a small economy has been obtained owing to the relatively low superheat, it has been sufficient to induce this firm to use superheated steam in fifteen vessels of their fleet.

The type of superheater is that of the usual uptake construction, utilizing the waste heat from the escaping gases. Here again the steam temperature obtainable ranges from 500° F. to 520° F., and it has been found that there is a distinct loss directly the temperature falls below 500° F. Owing to ineffective lubrication some slight difficulties were at first experienced with the piston rings and valves, but these have since been overcome, and so far as the author has been able to learn owners of these vessels are very satisfied with the results obtained. Amongst other shipowners in this country who have vessels fitted with superheaters in the uptake are the Great Eastern Railway Company, the Allan Line, and the Hall Line, but no data have been obtained regarding the performance of any of these vessels. The British Admiralty have made some use of superheated steam in recent years, but as the temperature employed was so low the results are not of sufficient interest to refer to in detail.

In France, the Compagnie Générale Transatlantique in 1906 fitted their vessel *La Rance* with Pielock superheaters, (Fig. 6) the engines having the Lentz Valve gear with Poppet valves. Comparative trials between this vessel and a sister ship *Garonne*, the latter having the same sized engines, but with slide valves and no superheaters, showed that the use of superheated steam resulted in a very large reduction in coal consumption. This company have since fitted three other ships with Pielock superheaters, and have recently decided to fit *La Garonne* with the Schmidt superheater. In America, one of the first vessels fitted with the uptake type of superheater was the

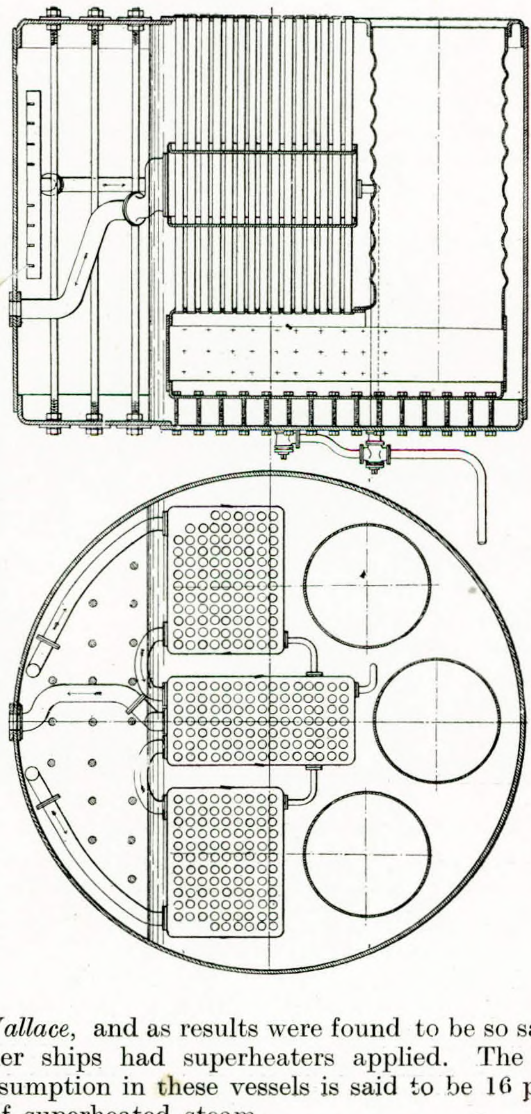

FIG. 6.—PIELOCK SUPERHEATER.

J. C. Wallace, and as results were found to be so satisfactory, two other ships had superheaters applied. The saving in coal consumption in these vessels is said to be 16 per cent. in favour of superheated steam.

The Foster type of superheater as illustrated in Fig. 7, was fitted in the s.s. *Brazos*, this vessel having quadruple expansion four-crank engines of 7,000 H.P. and eight single ended Scotch boilers. The ratio of superheater surface to heating surface of the boiler is as $4\frac{1}{2}$ to 1. The boilers work under Howden's system of forced draught. Although only a steam temperature of 460° is obtained the consumption of coal does not exceed $1\frac{1}{4}$ lb. per I.H.P. per hour. As the result of some trials carried out by the U.S. Navy Department on one of the lake steamers fitted with quadruple expansion engines, it was

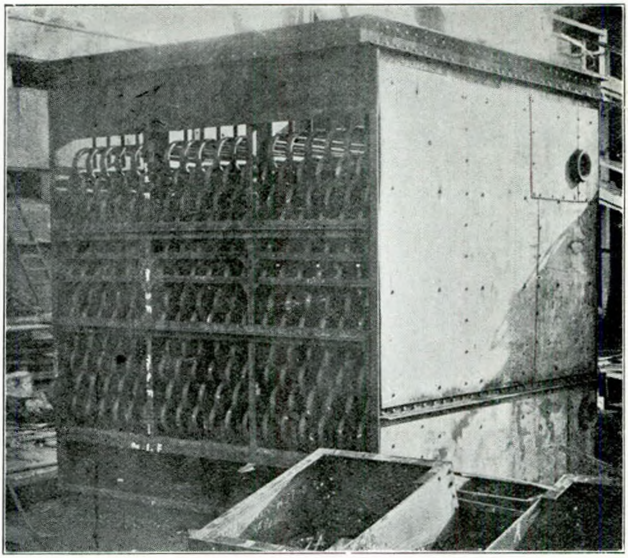

FIG. 7.

found that an economy of 14 per cent. to 15 per cent. in coal consumption was effected by superheating. Four of the eight boilers in the U.S.A. *Indiana* are fitted with superheaters, and owing to their success other warships have since been using superheated steam, but the results of their trials have not been published. There are probably several other vessels using superheated steam besides those mentioned, but those referred to afford very striking evidence of the practical success of superheating as applied to latter-day marine practice.

There is really only one practical obstacle against the general adoption of superheated steam of high temperature in reciprocating engines, and that is connected with the use of oil. As already stated, lubrication of the working parts presents no difficulties, and if proper lubrication is provided and special attention paid to design of stuffing boxes, valves, pistons, it may be said that no troubles whatever arise with reciprocating engines using steam having a temperature of 600°–620° F. To eliminate this oil from the feed water, and to prevent its passage to the boiler, is in the mind of the author the only difficulty which presents itself against the more general adoption of superheated steam. This difficulty has up to the present been overcome, in all the ships visited, by means of efficient filters, and no trouble has been reported owing to oil in the boilers. The economical production of highly superheated steam may now be said to present no difficulties, and its use enables the shipowner to make such a substantial reduction in the cost of propulsion that it becomes the duty of the marine engineer to avail himself of the great advantages which it offers in engines of suitable design. Many experiments are being carried out on these lines at present, and the results will probably lead to the general adoption of superheated steam in marine practice.

Mr. W. P. Durtnall: We must all highly appreciate the valuable and instructive paper we have just had the pleasure of listening to. It deals with a great question that should receive the attention of practical marine engineers, the reduction of fuel consumption. In my opinion there is no question but that the superheater will eventually come into general use. I do not know what effect would be obtained by adapting existing vessels, but in the more modern engines there is no doubt that great economies are, and can be effected by the use, in some degree, of superheated steam. Personally, as you are all aware, I am more closely connected with the rotary engine or turbine, and in connexion with the system I laid before you some time ago I referred to the fact that the use of superheated steam was one of the necessities and one of the most valuable factors in the running of high speed turbines. There we see the advantages obtained by the use of superheated steam which cannot be used with very large slow

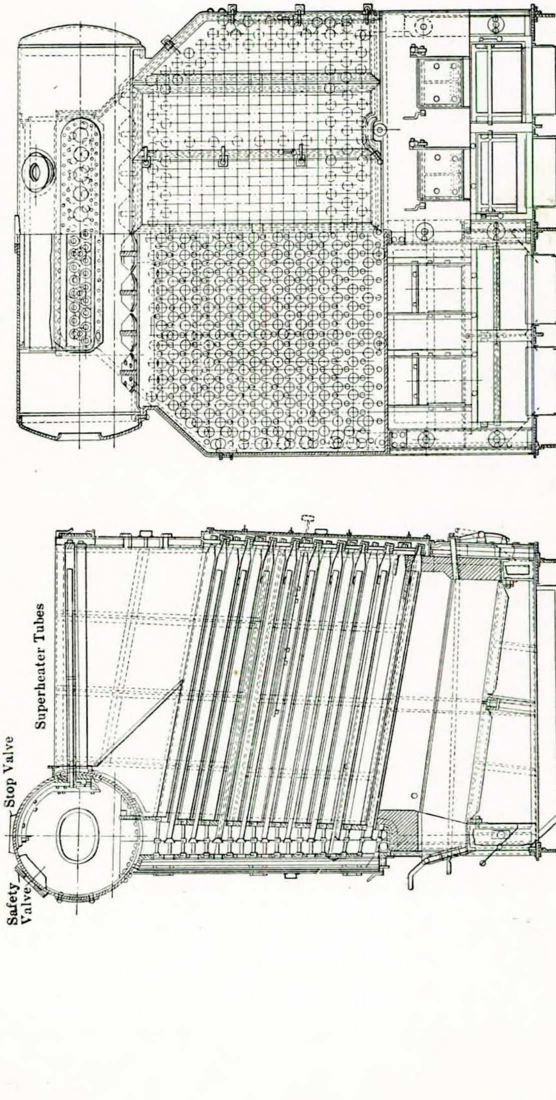

FIG. 8.—DÜRR SUPERHEATER.

speed direct-coupled steam turbines, the clearances being affected materially by its use. In running steam turbines at very high speeds superheated steam is quite as suitable for marine work as it is in everyday practice in the very large power stations in this country and all over the world. There is one question of a certain interest, especially in some conditions, sea-going conditions, which Mr. White refers to, in reference to the variation in steam supply when the superheater is under variable temperature as regards furnace gases. I have often gone into the matter, and my attention has often been drawn to it, and I should like to ask Mr. White if, in his opinion, it would be a practicable and satisfactory arrangement to have a separately fired superheater similar to the one shown in Fig. 1, with a damper regulation arrangement whereby the heat is sent in various directions through the superheater. That being so, I should like to ask whether it is not possible, or whether it has not been suggested, to have in use suction gas and have a gas-fired superheater. By such a method and by using electrically controlled pyrometers, the temperature of the heater could be automatically reduced when necessary. by lowering or raising the gas burners, etc. Mr. White has so ably gone into all the points, that this is the only point on which I thought it might be valuable to have more information. In the case of a new vessel which is to be fitted with saturated steam turbines at 1,370 revs., and it is estimated that afterwards, with a separately fired superheater, they will be able to bring the economy up by 10 to 15 per cent.

Mr. H. B. DEANE : Unfortunately I am only a " land-lubber," but I have had a good deal of experience with the superheater both with reciprocating engines and turbines. The engines I have had experience with were mostly of the Bellis type high speed reciprocating engines. We were never able to obtain a higher economy than 18 per cent., so I was rather astonished to see 30 per cent. quoted by Mr. White. Another point I might mention with regard to Mr. White's remarks as to the temperature going up to 660°. In the case of one engine we worked it at 600° for some time. That was supplied by a downtake superheater put into the combustion chamber of a Paxman-Economic type of boiler. As you all know, these are short boilers. There was a very high temperature in the combustion chamber and we may have, at times, exceeded the 600°, but that was the normal. We found we had to put in baffles in front of the superheater to keep the temperature down, as there was a certain amount of scoring. The oil we were using was otherwise good, as we continued using it at a lower temperature and found the scoring did not increase. In another case we used a Sulzer engine of 200 H.P. With that engine we had no trouble at all, and I put it down to a large extent to the fact that we were operating with Poppet valves. I am, therefore, interested to notice that Mr. White specially refers to the French vessel *La Rance*, which was fitted with Poppet valves. It will probably be the same type of valve, as it is used all over the Continent, and is rapidly superseding the Corliss type, even firms like Messrs. Musgrave, who held on to the Corliss valve, have now adopted the Poppet type for superheaters. Of course there are difficulties from the marine point of view in connexion with this, but I think they can be overcome. In reference to turbines, Mr. White mentions earlier in the paper that the impulse turbine is the right type for use with high superheat. That, I may say, has been my own personal experience, although I have handled a turbine of 3,000 kilowatts, or, roughly speaking, 4,500 H.P., which was of the re-action type as far as the low pressure system was concerned. It is common now, with high pressure turbines, to have impulse pressure as well as low pressure re-action; that seems to be the coming type of turbine.

Mr. H. Ruck-Keene: I am afraid I have not had experience enough with superheated steam to say much about this very interesting paper. We hear a good deal of what the Germans are doing in this respect; we are doing something in England, but without question in Germany they have gone a good deal farther than we have, not only for marine work, but I understand that on some railways nearly all the locomotives are fitted with superheated steam. It is apparent that with superheated steam a great deal of oil will have to be used for the lubrication of the cylinders, and the question arises, how will this oil be kept out of the boilers. There is no doubt that in boilers cleanliness is a very important thing, and the oil must be kept out by some means. Mr. White says "use filters." These have been tried, and they do keep out a certain amount of the oil, but do they keep it all out? Of course he says only the very best type of oil should be used.

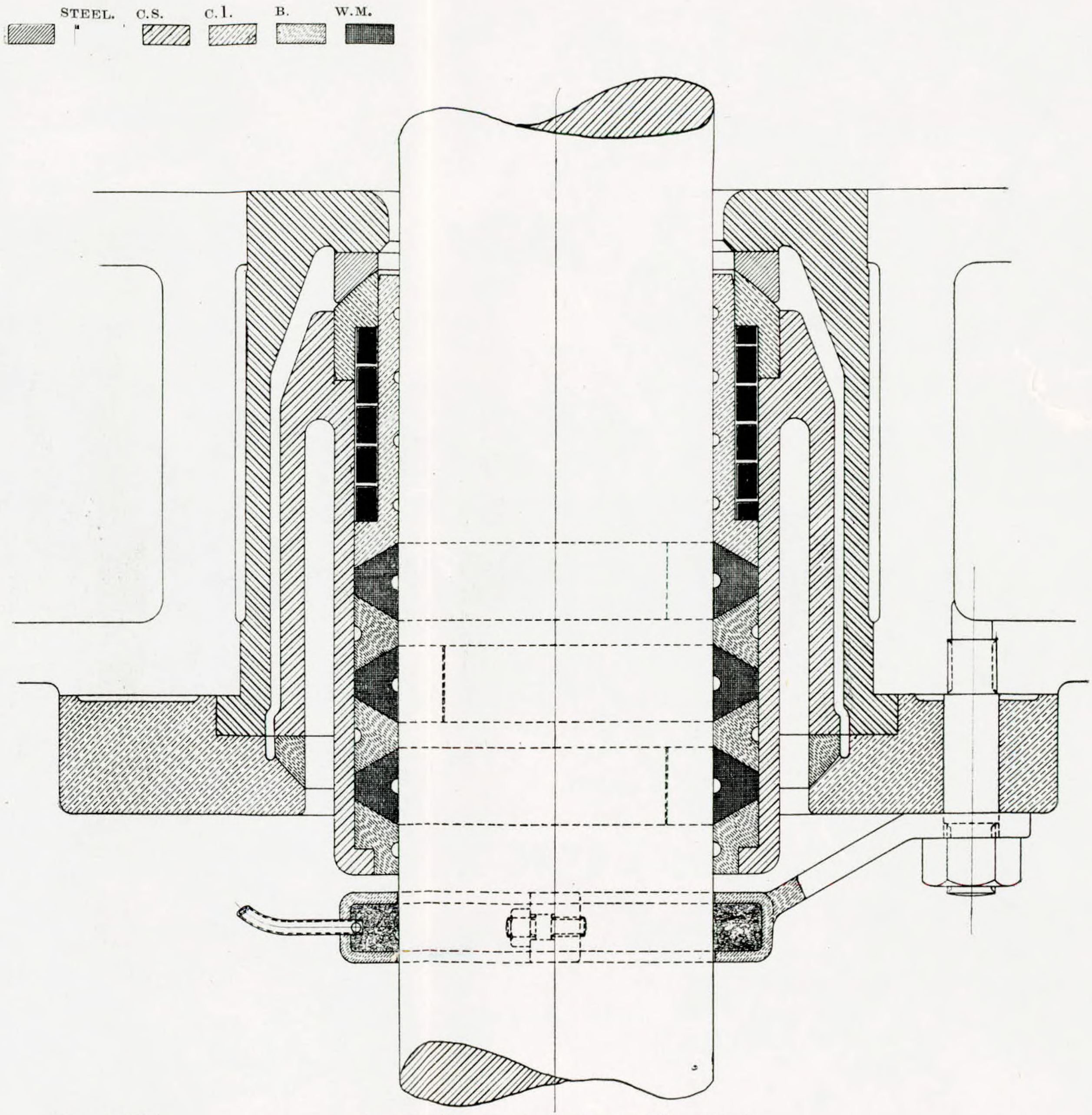

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Fig. 10.—Piston Rod Packing (Patented).

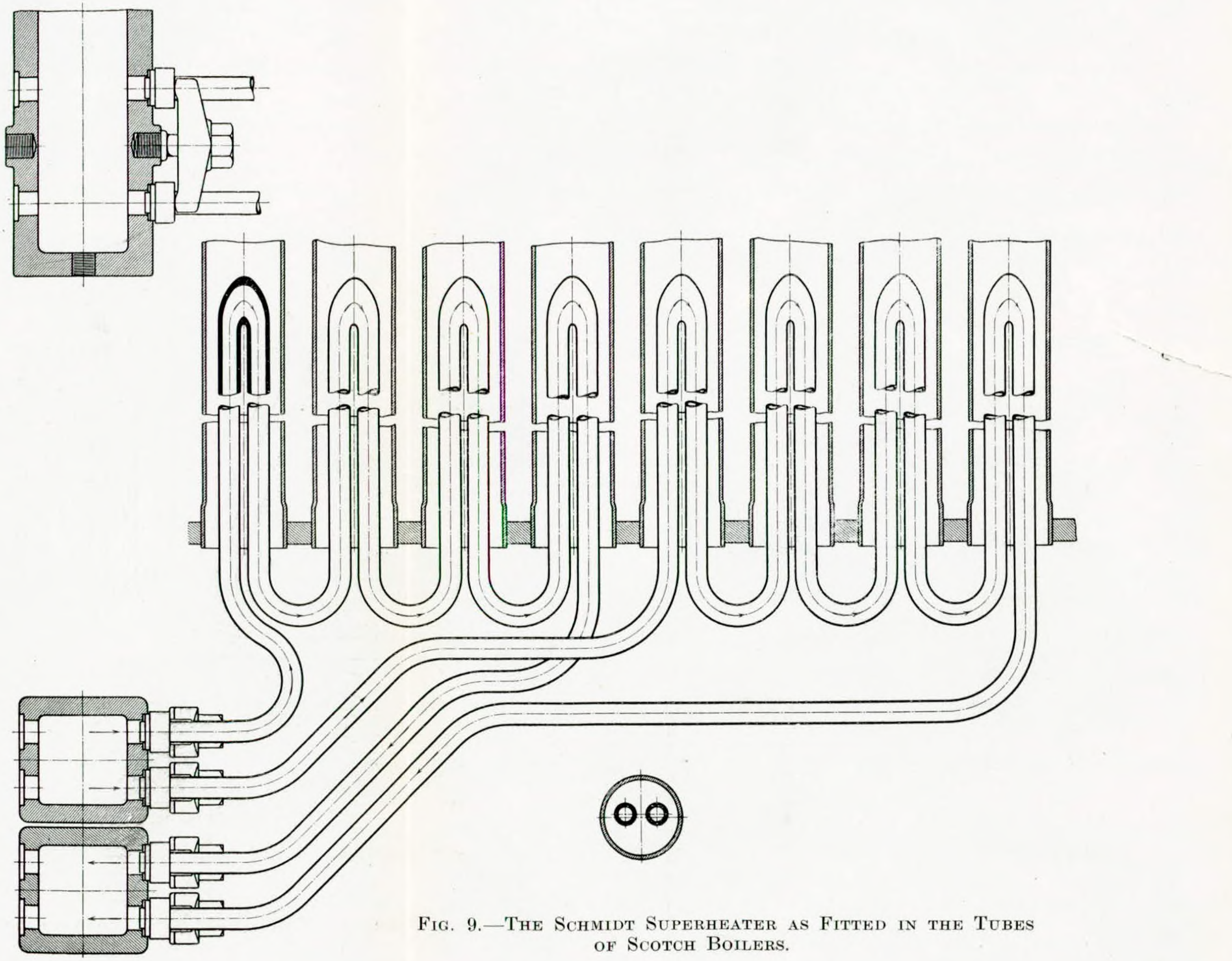

Fig. 9.—The Schmidt Superheater as Fitted in the Tubes of Scotch Boilers.

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Very true, but even then some oil will get in. This would require to be considered, to see that better arrangements are provided to prevent the oil getting into the boilers. Mr. White also says : " Where superheated steam is used temperature and pressure are rightly considered of equal importance, and observation of the temperature gauges enables the engineer in the engine-room to know exactly the prevailing conditions of any boiler, the state of its fires, etc." While it is absolutely necessary, with superheated steam, that the engineer should be able to take an observation with the temperature gauges, Mr. White does not explain how he would show in the engine-room on his gauges the temperature of the superheated steam in the superheaters. I know there are means of doing so, but I think an explanation on this point would be of advantage to us all. Another point I would like to raise is as to whether there would be any great difficulty in adding the superheaters he has described to existing marine boilers. Taking the ordinary Scotch boiler for instance, could the superheater be added without any great trouble ? He has told us that the superheater is very economical, and doubtless there is a certain amount to be gained from its use, but a few more figures on that point would also be of interest to us. I was interested in Mr. White's design of piston valve, but I would ask him whether, in a superheater of 550° to 620° when the steam has passed through the high pressure cylinder, there is any degree of superheat left in that steam when it gets into the I.P. receiver.

Mr. C. M. Ferguson : As a visitor I should like to be allowed to make a few remarks. The last speaker asked whether there was any superheated steam entering the I.P. receiver. I do not think so, because immediately the steam enters the high pressure cylinder practically the whole of the superheat is lost. With the ordinary saturated steam, condensation starts at the cut-off, but instead of that you get practically dry steam into the I.P. cylinder. The condensation on the cylinder walls brings down the superheat. Supposing steam is entering the I.P. cylinders at 60 to 80 lbs., you would have dry steam, at a temperature equivalent to that of dry steam without any water in it. I am afraid it would be difficult to get a superheater to suit the average marine type of boiler. Most of them are placed in the tubes or the uptake, and it would mean absorbing the heat from the forced draught heating tubes to get the superheat. I agree with the author that the superheaters in the uptake certainly absorb the heat from the forced draught tubes, but I think it would be a better plan to have the independently fired superheater illustrated in Fig. 1. The feature of the latter is that it takes up too much space in the modern boilers on steamers, and the fact that the superheater is independently fired means that it would necessitate extra attention, it would require more stoking and extra fuel would be needed to get the superheat. I think the uptake superheater a more ideal one and one that would require less attention than that illustrated in Fig. 1. Besides, there would be the excessive temperature and bent tubes to contend with, as I am sure the tubes in that position would give trouble. What has been said about Poppet valves is quite correct. I have had experience of them for five or six years, and found that the only valves that will stand a temperature of 600° are those by Sulzer. Sooner or later piston valves scored and leakages resulted, any benefit derived from the use of superheated steam being lost through those leakages. Messrs. Sulzer Bros. were the first to use Poppet valves in this country. As an example I might cite the Charing Cross Electricity Works. They are working up to 750° final temperatures with Schmidt and other types of superheaters. During the last two or three years I have had occasion to visit those works, and found that the Poppet valves were as good as when they were put in. The great difficulty experienced in fitting the superheater to existing installations is in connexion with the pipe work and the valves. In the case of existing steamers, it would be absolutely necessary to renew the steam pipes and valves, so that the cost would not only be that of the superheater, but also the whole of the connexions between the boiler and the engine. If the stop valves and other fittings between the engine and boiler are of the ordinary brass or phosphor bronze they will not stand any high temperature, and there will be continual leakage unless they are renewed. The question of oil elimination is very serious as far as marine engineers are concerned. Land practice is, of course, quite different. After the water leaves the boiler there is a big plant to eliminate the oil, so that the water goes back to the boiler quite pure. At the present time the filters used by the average marine engineer are so small that they do not thoroughly eliminate the oil. They are all right to start with, but after a while they become clogged up and allow a certain amount of oil to pass through ; that is the biggest difficulty marine engineers have with superheated steam, and until an effective means is used to thoroughly separate the oil before returning the feed water to the boilers, there will be constant trouble with superheaters. I do not agree with the author that the tubes will last eight to ten years. On Fig. 11 the tubes are so near the fire that the temperature at the point at which the gases reach those tubes cannot be less than 1,600° to 1,800°. No tube will stand that temperature for more than two to two and a half years. When there is no steam passing through they are punished worse than ever.

Mr. John McLaren : I think we are all indebted to Mr. White for reading this paper on superheated steam. It is not a new subject ; it has been before marine engineers for many years, but the difficulties in the way of it being adopted in marine use are so great that it has been shelved. Some of the speakers remarked about the lubrication ; that is the greatest enemy marine engineers have to contend with. I have had some experience on this subject, and I may say at once that in my opinion it is absolutely necessary for the superheater to be built along with the engine. The superheater should not be put on to existing engines ; the engine should be designed to use superheated steam. Mr. White mentioned the subject of valves. My experience of valves with superheated steam is that there is great difficulty with the lubrication. When we slowed down in coming into port or for any other purpose we used to get tremendous scoring in the valves and valve chamber, not alone in the high pressure, but also in the intermediate valve. Mr. Ruck-Keene asked whether superheating ceased after the steam left the high pressure cylinder, but we found the damage going on in the intermediate, the valve faces being badly torn. Another point mentioned by some of the speakers was the difficulty of preventing the oil coming through into the boilers. Many of the filters designed for marine purposes are very small, and in some cases put on the pressure side of the pump, where they are not effective and never will be. Until we have a very effective way of filtering the feed water on board ship I do not think we should entertain the idea of using superheated steam. I was much surprised at the figures Mr. White gives, and would like to ask if these are taken from actual jobs. He mentioned 30 per cent. saving in one case, and 18 per cent. in another, and I should like to know how these figures were obtained. In some trials we had there was a superheater in the uptake, and we had a difficulty in obaining even 5 per cent. All our trouble was in connexion with the valves, especially the high pressure valves and valve casing, the greatest difficulty being experienced in starting and stopping. I think these little difficulties have kept the superheater in the background for many years, and if means were taken of obviating these it would be a great advantage on board ship, especially when we are now making a step forward and adopting turbines. I should like to know the results on vessels where turbines are used.

Mr. W. E. Farenden: Some time ago I had the pleasure of going to visit a vessel of about 1,120 H.P. fitted with one of Schmidt's superheaters similar to that shown on Fig. 11. The superheater was fitted in the smokebox, It was a triple expansion engine of 200 lbs. working pressure, with two single-ended boilers and two furnaces in each. When the vessel was built she was not fitted with the superheater, and it was only fitted after she had been running for some time. In the first place all the main and branch copper steam pipes had to be done away with and replaced by steel pipes, and a different metal also had to be used for the valves. This job, I believe, gave very good results. The boiler tubes were cleaned from inside the smokebox door by a steam jet with a connexion fitted on the front of the boiler. The tubes could be quickly cleaned and nothing had to be disconnected to enable this to be done. I understood the fuel consumption per day before the apparatus was fitted was about 18 tons, and after the superheater was fitted the consumption was reduced to 15½ tons. The system worked very well, and gave no trouble. For a time I believe they had a difficulty with the high pressure piston valve, the rings giving very much trouble, but a new form of ring was fitted, after which no further trouble was experienced. As Mr. White himself mentions, I think the difficulty with the oil is the most important thing in connexion with the whole system. Most engineers endeavour to cut down the amount of oil used for lubrication as much as possible, and if this amount is increased to any large extent, in all probability much

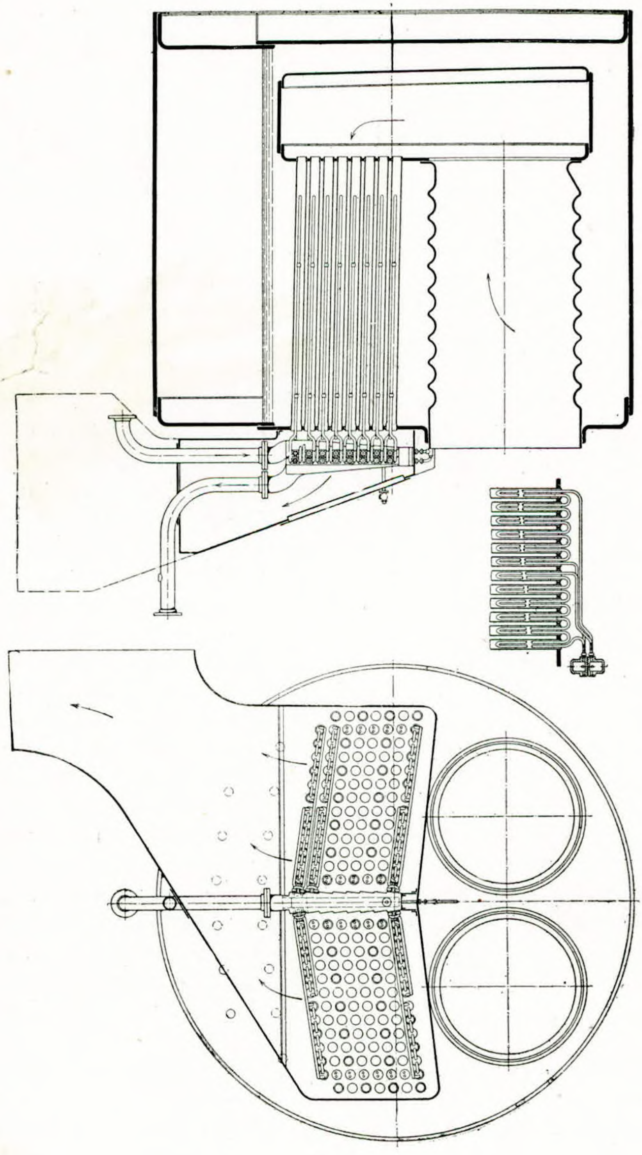

Fig. 11.—Schmidt Superheater as Applied to Two Furnace Boilers.

of it will get into the boilers. I would like to ask the author if he could give an idea of the consumption of oil necessary for a triple expansion job of 2,000 H.P. with superheated steam.

Mr. F. M. Timpson: Mr. White deserves the thanks of the Institute for the very interesting paper he has given us. He mentions that the Germans have gone very far ahead of us in relation to the use of the superheater for marine service, but I might point out that some of our companies tried superheated steam some years ago, and it was adopted by one of the best-known firms of the time. A friend of mine was in charge of a large vessel in which a superheater was fitted, and a great many of the troubles Mr. White speaks of were experienced. They had great difficulty with their piston rings. The oil question was another very difficult one. They tried most of the well-known brands of oil, and they all dried up and a good deal of rumbling was heard in the cylinders. As the oil has the same defect to-day, it occurred to me that some other substance might be used. Some of the land jobs use graphite for internal lubrication, with a very great advantage and decrease in the quantity of oil passed through. In Fig. 11 there would seem to be great difficulty in getting at the boiler tubes. Mr. Farenden mentioned using a steam jet, but some people would not have that as it damps the tube, which at times produces an accumulation difficult to move, Piston valves with holes through them have been used on many occasions, but I do not think it is the general marine practice to use Ramsbottom rings, in fact several important companies have entirely done away with Ramsbottom rings and have adopted other types, owing to abnormal wear with the former.

Mr. McLaren: With regard to this system of piston valve Mr. White suggests, I should like to ask him how long it is likely to last without receiving attention, also if it proves very effective. I remember many years ago a piston of this kind was fitted in a vessel and after two voyages it was removed altogether.

Chairman: One very important point has been raised by Mr. McLaren. If one wants to get the best out of the superheater, the whole job ought to be designed for the purpose. It is hardly fair to condemn the superheater because, in adapting

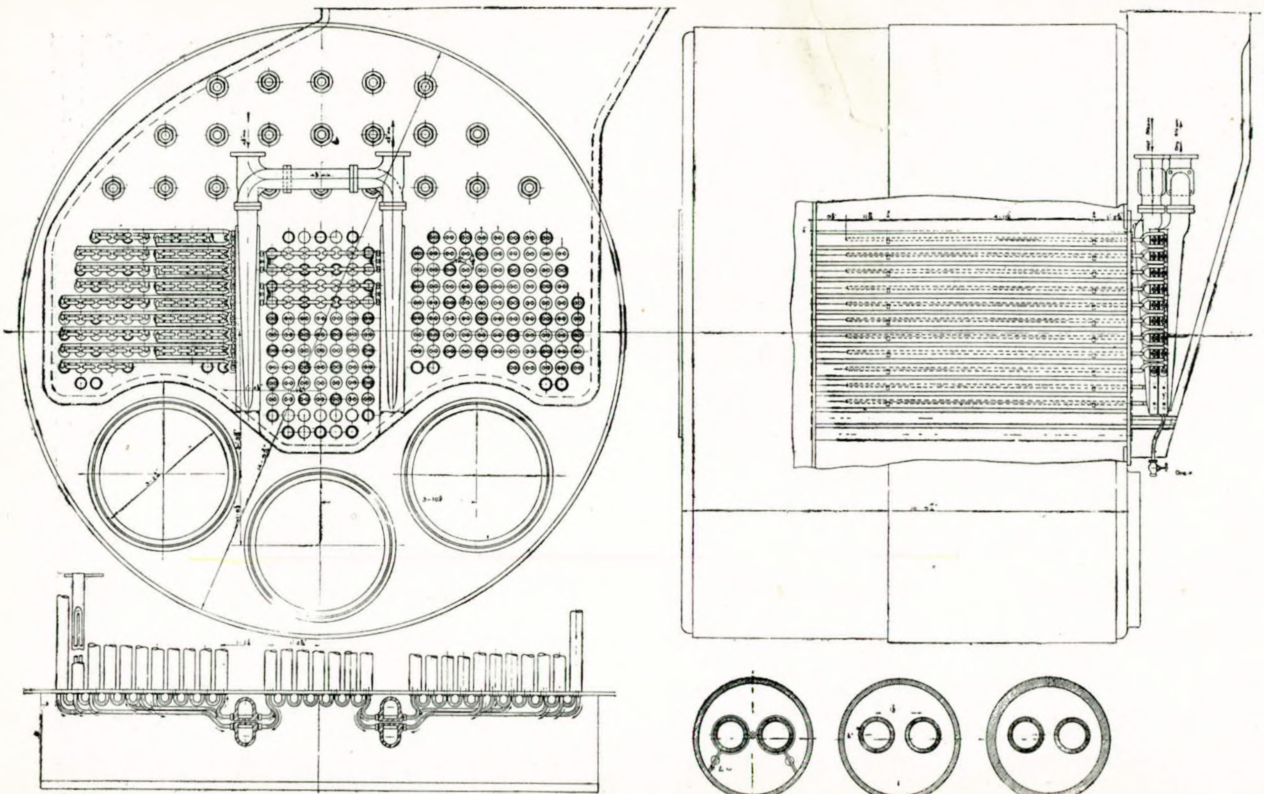

FIG 12.—THREE-FURNACE BOILER, NATURAL DRAFT, FITTED WITH SCHMIDT'S PATENT SMOKE TUBE SUPERHEATER.

a superheater to a design of boiler not originally intended to be used with it, the desired results are not fully obtained. Mr. White has given his view that it is essential to have piston valves to suit high pressure superheated steam, and if the high degree of superheat employed goes through to the intermediate cylinder, then you must also have special piston valves for the intermediate. If the engine is originally made to be used with the superheater it can be designed with these piston valves, and not only so but the superheater and boilers can be adapted to suit each other. The Schmidt system has been added to boilers which have been in use for some time, but this is not giving the Schmidt system a fair trial, and if the combined arrangement does not work well you must not blame the Schmidt. For instance, the ordinary marine boiler is made with fairly small tubes. If these are crowded with superheater tubes inside them it means that the forced draught will have to be considerably increased or there will be a difficulty with foul tubes. If the Schmidt system is adopted the boiler should be designed originally for the purpose and made with larger tubes than the ordinary tubes in marine boilers. With regard to the desirability of using superheated steam, I think both in theory and practice superheated steam must be more economical than saturated, especially with reciprocating engines. As Mr. White points out, the moment saturated steam begins to do work condensation commences, but a much greater part of the condensation is due to the cooling of the cylinder walls owing to the re-evaporation of the condensed steam during the exhaust stroke. When the steam condenses it deposits like dew on the surfaces, and the more work done during the stroke the more condensation there will be, but during the exhaust stroke, owing to the pressure being relieved, the deposited water on the hot cylinder is re-evaporated and the steam so formed goes through the cylinder without doing any work at all. But the re-evaporation takes heat out of the cylinder walls, and the next lot of entering steam is deposited as dew on the cylinder without doing any work. There is a very great deal of loss by this condensation, and it is with the view of preventing that loss that the compound engine is adopted. If superheated steam is used no steam will be deposited on the surface, re-evaporation cannot take place, and therefore there will not be this loss. In the case of the steam turbine, each individual blade is always under its own

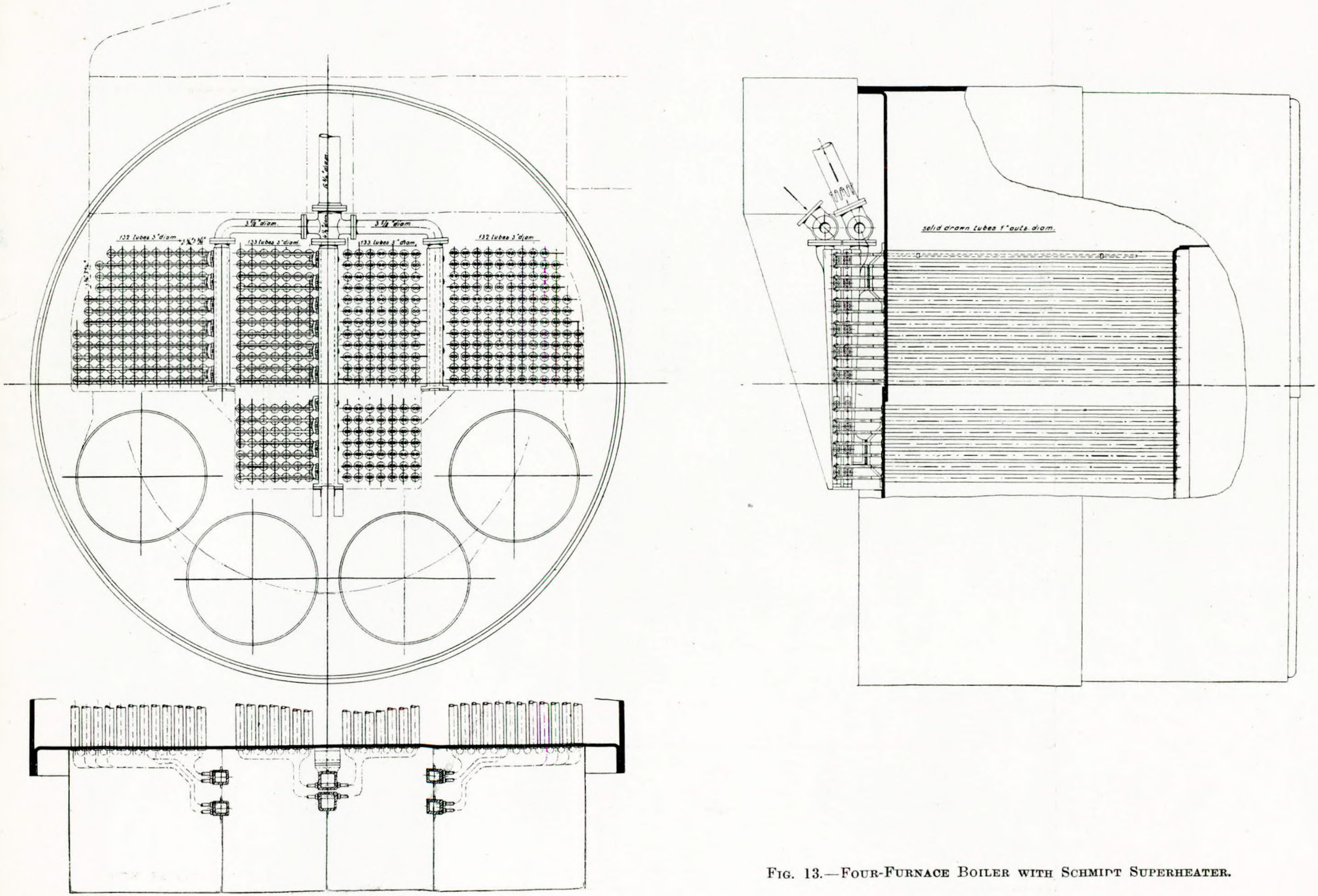

Fig. 13.—Four-Furnace Boiler with Schmidt Superheater.

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constant temperature, and the only condensation which takes place is that due to the conversion of heat into work. The loss by condensation in the turbine is no doubt largely due to the extra friction of the wet steam over that which would occur with dry superheated steam. In the turbine engine superheated steam would not give so much extra efficiency as in the reciprocating engine. On the other hand, in the turbine engine there would not be the difficulty with the oil ; being fed into the boiler I presume the only bearing which will draw oil into the steam is the low pressure end bearing, so I should think the oil difficulty will not be so great in the turbine. Of course several gentlemen have referred to the oil difficulty, and Mr. White in his paper very frankly said that it is *the* difficulty. Should no other gentleman like to take part in the discussion, I shall now invite Mr. White to reply to the points that have been raised.

Mr. White : I am afraid as time is so short that I shall not be able to answer the questions in the order in which they were asked, but as several of the members have put more or less the same questions in a different form, I will endeavour to answer them all.

Mr. Durtnall spoke about reducing the expense of fuel. Of course this is after all to the superintendent engineer and to the shipowner one of the most important things to be considered, and is of increased importance in view of the extra competition, that all British shipowners are meeting from foreign countries. Superheating was tried in the past by British marine engineers, and did not prove a success, so that the tendency has been ever since to leave it alone. Other countries coming freshly into the field of marine engineering, have perhaps seen more clearly the reason of the failure in the past of superheating, and knowing also that the conditions are different now, they have taken up the question unhampered by prejudice and have made superheating a success in a great number of instances. One of the most important developments of recent years, which has assisted in the success of superheating, has been the improved quality of the oils which can now be obtained. We have cylinder oils with a flash point of over 700° F. These oils will remain liquid with the steam and metal surfaces at a temperature of over 600° F. It is just as necessary to lubricate the working faces of piston valves as it is to

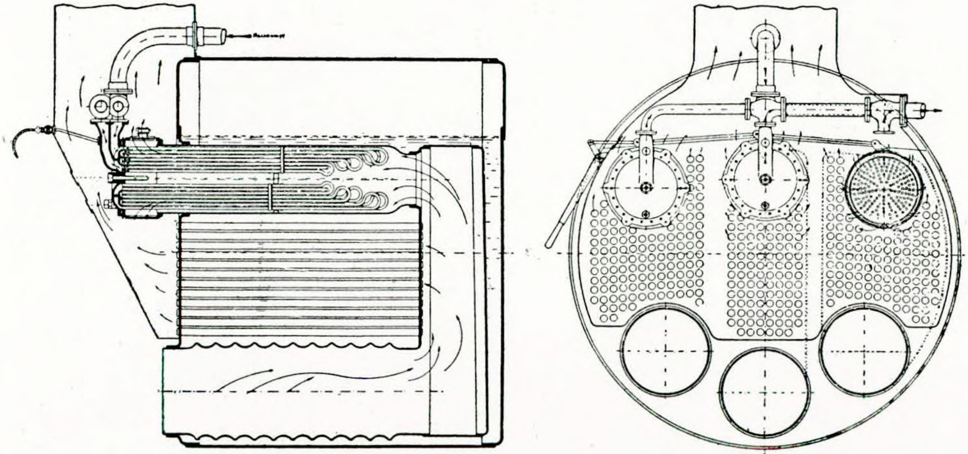

Fig. 14.—Early Form of Schmidt Superheater.

lubricate rods and shafting. For the purpose of lubrication we use wet steam, at the same time knowing that moisture in the steam to be in all other ways an evil. We refrain from using oil in the engines, not because it is an evil in the engines, but because it is injurious to the boilers. The ideal conditions, therefore, would appear to be dry stream, a moderate use of oil as a lubricant, and an efficient means of extracting oil from the feed water.

On the question of filters, the general practice has been to put a small filter on the pressure side of the pumps, and the type of filter of this description in general use is inadequate for the work it is called upon to do, and after one hour in service it is just as much choked up with oil, etc., as it is after a week's working. If you consider the amount of water which is passed through a filter in the course of one hour, it will be at once apparent that a very much larger surface is required than what is usually supplied in the type of filter which I refer to. When oil is recognized as a necessity to the engine, a suitable filter will be asked for, and as the demand increases, the design of filters will improve. I believe it has been shown that the use of oil in an engine having an early cut-off reduces the consumption 13 or 14 per cent., so that oil, whether with saturated or superheated steam, would appear to be necessary to the economical working of an engine.

On the question of the methods employed for recording the temperature, this is done by means of either an ether or mercurial thermometer. A container filled with mercury or ether is placed where the temperature is required to be measured, and by means of capillary tubings the temperature is conveyed to a gauge, which may be placed anywhere within view of the engineer. These thermometers act on the well-known principle that ether and mercury at certain temperatures give off a gas, which expands as the temperature increases. The gauge is marked to suit this expansion, and the temperature correctly recorded within a degree. The gauge may be in the boiler-room or on the engine-room platform, and the engineer keeps his eye on the temperature gauge, just as he does on the steam gauge, and from observations of these temperatures in question he can easily tell the conditions of firing, and the proportion of work that each boiler is doing. If the temperature of the steam rises higher than it is desirable, it can easily be checked by manipulating the fire and damper doors.

On the question of using suction gas in a separately fired superheater, this is, I am afraid, a matter I can hardly go into now, but whether suction gas is used or oil fuel is used in a separately fired superheater, it should be a very simple matter to make the supply of fuel directly in proportion to the temperature of the steam required. Mr. Deane questioned the 30 per cent. economy claimed for superheating, and said he had realized 18 per cent. I think he was very fortunate to get 18 per cent. on a fast running engine. Of course the 30 per cent. stated was for an engine with a slow piston speed, as in slow running engines the advantage of superheating is far greater than in fast running engines. The results from a vessel fitted with Lentz valve gear and Pielock superheater were described before the Institution of Naval Architects last year, and the economy given for that particular ship on trial has not quite been realized in actual running. I have some particulars of what she has done during the last eight months, also the performance of her sister ship with boilers similar to those on the last plate, but with ordinary piston valves. This vessel is now being fitted with superheaters, and after she has been in service, it will be interesting to note the comparisons between one vessel with Lentz valves before and after being fitted with the superheaters and the other with ordinary piston valves before and after being fitted with Schmidt superheaters. On the question of the life of the tubes, it has been stated that they will not stand more than two or three years. This statement can hardly be said to be correct because thousands of superheaters are in use in locomotives for eight or ten years, and the tubes have not shown much signs of wear, although exposed to a very much higher temperature than would be experienced in the ordinary mercantile service.

With regard to the application of the superheater to existing boilers of the ordinary marine type. A case was referred to by Mr. Farenden, who had visited a vessel which I believe was the ss. *Schwan*. This vessel comes to London every week, and can be easily visited at St. Katherine's Dock by any one interested in the matter. I wrote to the owners of this ship on the question of coal consumption, and they have replied as follows :—

"We very much regret that we are unable to give you exact figures concerning the saving in coal experienced during ten voyages of this year with the steamer *Schwan* after fitting with

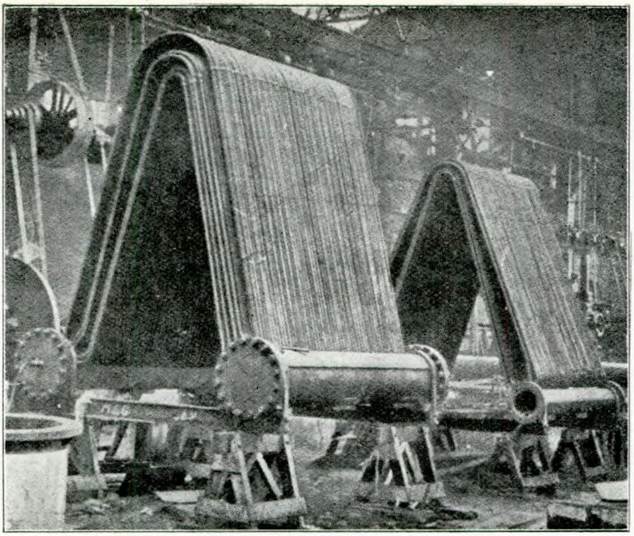

FIG. 15.—THE WATKINSON SUPERHEATER.

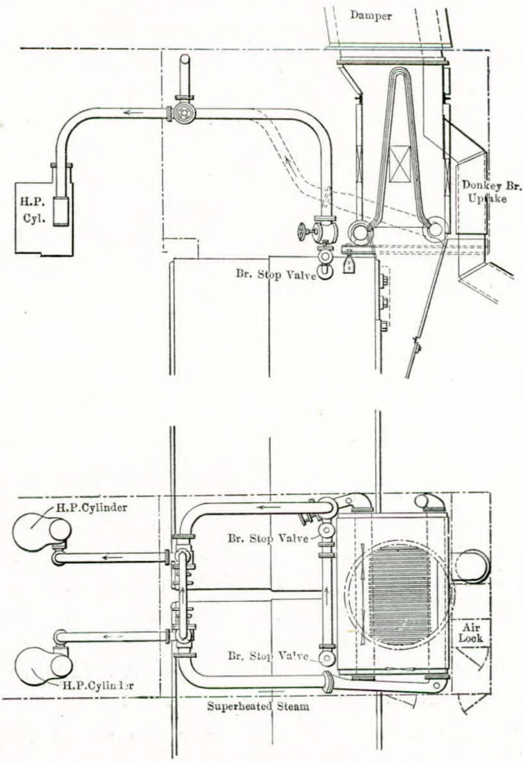

FIG. 16.—WATKINSON SUPERHEATER.

the superheater, as compared with the same number of voyages last year before the superheater was fitted, as requested by you in your letter of the 11th inst. During last year we only used English coal from the Hull district. Last spring we made experiments with English coal from another district, but since the superheaters have been installed, we have used chiefly German coal. According to our measurements and observations, we can state generally that a saving in coal of about $2\frac{1}{2}$ to $2\frac{3}{4}$ tons per twenty-four hours has been made, equivalent to a saving of about 13 per cent. As this steamer was equipped before the installation of the superheaters with a highly economical saturated engine and Howden's forced draught, the results completely correspond with our expectations. Assuming 140 to 150 steaming days per year, an economy in coal of about 350 to 415 tons would be effected, and taking the price of coal at 15.10 marks f.o.b. Bremen, a yearly economy of about 3,500 to 6,300 marks would be obtained (about £175 to £315 sterling). A further economy is obtained from the use of superheated steam for auxiliary purposes, and for working cargo in port. We can therefore state that the reduction in the cost of coal for the steamer *Schwan* owing to the use of superheated steam amounts to 6,000 marks per annum (£300 sterling)."

I believe the cost of the superheater was about £250. I also wrote on the question of oil to the Oldenburg Portuguese Steamship Company, which combination has about twelve ships running fitted with superheaters, and have received their reply as follows :—

"Confirming your favour of the 13th inst., we herewith beg to inform you that on the vessels of our company fitted with superheaters the consumption of oil for the lubrication of the valves and pistons is now, as before, about $1\frac{1}{4}$ pints per 24 hours. Besides this, we use about $1\frac{1}{4}$ pints per 24 hours for the piston rods and valve rods. Trials have shown that it is possible to do with a smaller oil consumption, as we have found that with a consumption of $1\frac{1}{4}$ pints per 24 hours, the pistons and valves give no trouble. Seeing, however, that with our present consumption, no trouble has been experienced with the boilers, we have no reason to limit the oil consumption to its utmost. If necessary we could limit the consumption to $1\frac{1}{4}$ pints for the pistons and valves, and $1\frac{1}{4}$ pints for the rods, per 24 hours, without running any risks in the engines, as at present our

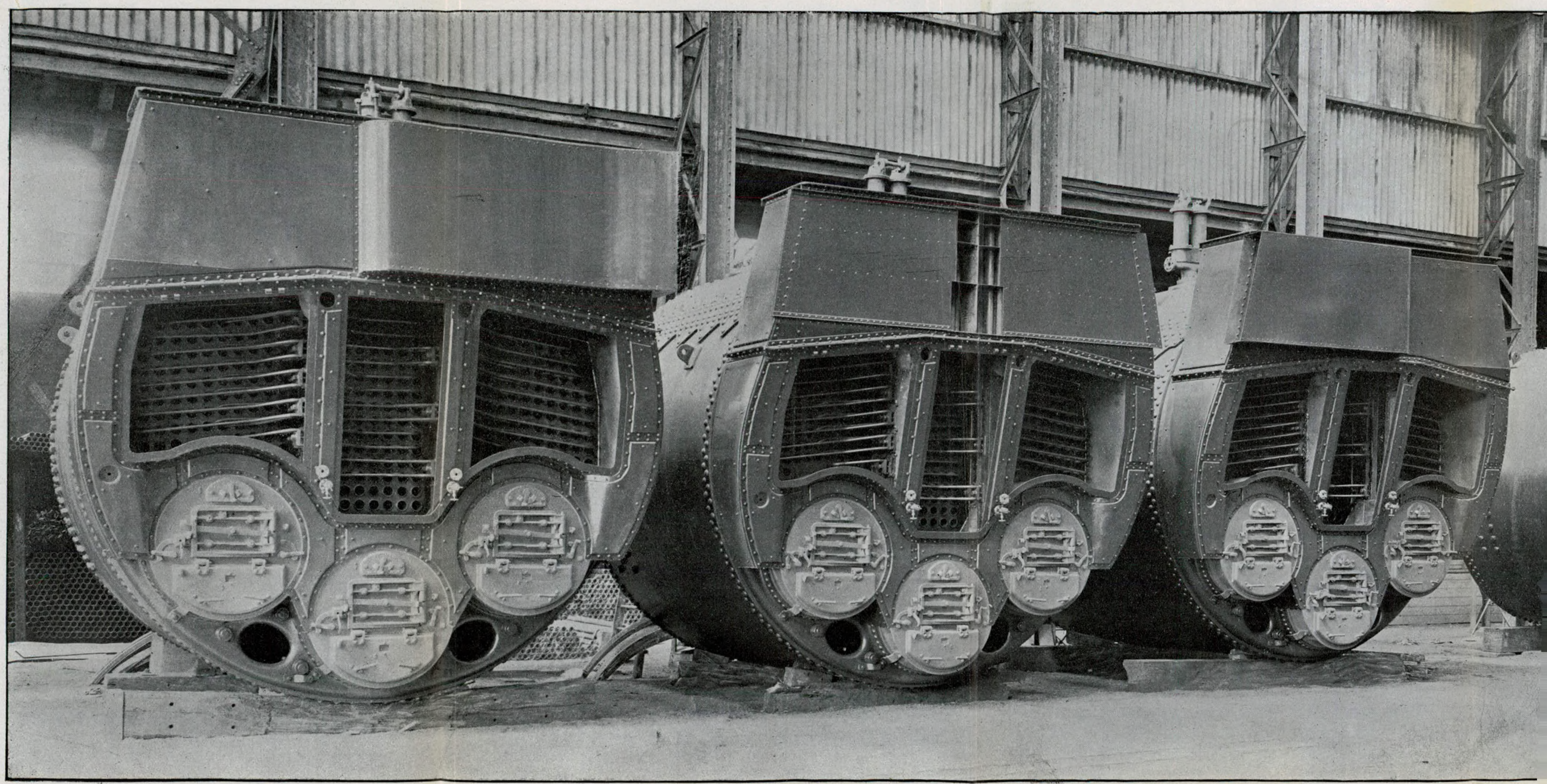

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FIG. 17.—BOILERS FOR S.S. "ERLANGEN," FITTED WITH SCHMIDT SUPERHEATERS.

cylinders are more than sufficiently well lubricated. But for reasons mentioned we consider it better not to further restrict the oil consumption, because of the intermediate valves, which are flat valves. With superheated steam, proper lubrication is necessary, but we are of opinion that the fear of danger resulting from the use of oil is in most cases exaggerated. We add soda to the feed water and clean the feed heater and filter casings frequently, changing the filter cloths every ten or twelve steaming days. Heat the feed water and you can scarcely trace any sign of oil in the boilers."

On the question of temperature in the I.P. valve casing, there is frequently found a superheat here of 40 to 50° F. where a superheat of 200° F. is used in the H.P. valve chest. Should the high pressure valve be leaking badly this will be at once observed by the rise of temperature in the I.P. valve chest, and if a flat valve is used in the I.P. extra oil will be required for lubrication if such leakage takes place. But as this leakage is easily and at once recognized the defect can be remedied. On the first ship fitted with superheaters in the uptake twelve or thirteen years ago, for Messrs. Wilsons & Co., Hull, the I.P. valve had to be renewed after the trial owing to the amount of wear that had taken place. That trouble has since been overcome, and this vessel's engines have been working very satisfactorily since. Since then Messrs. Wilsons have fitted about fourteen more ships with a similar type of superheater.

With regard to the question of the reduction in draught where the superheater tubes are placed in the boiler tubes, it has been found that with tubes of sufficiently large diameter say 3 in. or $3\frac{1}{4}$ in. tubes with natural draught, a reduction of the grate area can be made owing to the economy of superheating which keeps the ratio of grate area to area through tubes the same. The separately fired superheater shown in the illustration is a form which has been tried a good deal in Germany. The centre water drum is only for the purpose of supplying water to the tubes which take the first heat of the fire. Any steam formed in these tubes is taken into the main steam pipe and passes with the steam from the boilers through the superheating tubes.

A hearty vote of thanks was accorded to Mr. White on the proposal of Mr. E. W. Ross, seconded by Mr. W. E. Farenden, and to the Chairman on the proposal of Mr. Durtnall, seconded by Mr. J. R. M. Fitch.

Presentation of the Denny Gold Medal

IMMEDIATELY before the discussion took place on Mr. White's paper, the Denny Gold Medal for session 1908–1909 was presented to Mr. W. P. Durtnall for his paper on "The Generation and Electrical Transmission of Power for Main Marine Propulsion and Speed Regulation," read at the Franco-British Exhibition in July, 1908. In presenting the medal, Mr. J. T. MILTON, Chairman of Council, said :—Mr. Durtnall, you favoured the Institute last year with a very valuable paper, and some very useful discussions took place upon it. It was on a subject which has given a great deal of thought to marine engineers generally, and the Council of the Institute considered that your paper was the best paper of the session and that it was well worthy of the only award of the kind which the Institute, through the generosity of the late Dr. Peter Denny, is able to make to the authors of papers. The Council have therefore awarded to you the Denny Gold Medal for the year, and it is my pleasure this evening to hand it to you. The medal is a very handsome one; I am sure you will value it for its own sake, and I have no doubt it will be handed down to your family for generations as an heirloom. It is my pleasant duty on behalf of the Council to present you with this medal.

Mr. DURTNALL: Mr. Chairman and gentlemen, I thank you very much for the high honour you have bestowed upon me in recognition of my poor efforts in bringing before you the subject to which the Chairman has referred, and of which you showed your appreciation by the kind vote of thanks accorded to me at the time the paper was read. I value the medal the more highly because it comes from the Institute of Marine Engineers to a member of the electrical profession, a profession which will no doubt become more closely allied with marine engineering in the near future. I have great pleasure in informing you for the first time that the subject is now being taken up in a practical way. A cargo boat is being fitted with the system in about seven months' time, and I hope it will then be my pleasure to bring before you notes of the results of the trials. The Institute of Marine Engineers will be the first Institution to receive those results.

SESSION 1909–1910

PAPER OF TRANSACTIONS, NO. CXLII

The Engine-Room Telegraph and Communication between the Engine-Room and Bridge.

By MR. J. M. NEWALL (MEMBER).

Monday, December 6, 1909.

CHAIRMAN: MR. J. E. ELMSLIE (MEMBER OF COUNCIL).

CHAIRMAN: The paper to-night is on "The Engine-Room Telegraph and Communication between the Engine-Room and Bridge," by Mr. J. M. Newall (Member). Mr. Newall, unfortunately, is just recovering from a severe illness, and on his request Mr. J. H. Silley has kindly undertaken to read the paper on his behalf. I will now call upon Mr. Silley to read the paper.

It has long appeared to me that communication between the bridge and engine-room in the Mercantile Marine would be a most desirable thing, and after much planning and experimenting an instrument for recording the movements of the engines has been evolved, so that the orders given by the telegraph and carried out by the engineer are made clear by a visible signal at any part of the vessel of the direction in which the engines are working.

Since writing the paper describing what my experiments have led to my attention has been called to a paper by Mr.

Jas. Macartney read at Stratford on November 27, 1899, on the Engine-Room Telegraph, and I beg to offer an apology to him, as I find that a good many points of similarity exist between his arrangement of the telegraph and bell in the engine-room and that fitted as shown, but with this difference, that whereas he fitted his connexion to the reversing gear, mine is taken direct from the shaft itself. So that the shaft must move before any signal be given to the engineer, but the slightest movement answers my purpose.

On reading again his most instructive paper, and the discussion of it afterwards, I am confident that the points raised at that date hold good to-day.

A few extracts from the remarks of some of those who discussed Mr. Macartney's paper then only confirm me in what I wish to convey to the members of this Institution in showing this apparatus :—

Mr. J. T. Smith : Disputes occasionally arise as to whether the engines have really been moved in the direction indicated by the engine-room telegraph. The tell-tale arrangement suggested by the author of this paper would go far to settle disputes of that kind. At present there is nothing by which an engineer can prove that he has moved the engines as directed, and it often comes to be a question of evidence after an accident. . . . Mr. Shearer : Some engineers, I know, object to those tell-tales, and think the captain on the bridge knows too much of what is going on in the engine-room. But any such objections are, I think, a great mistake. The captain ought to know the movements of the engines. He is in command of the ship, and he is responsible for the movements of the ship, through the engines. . . . Mr. J. B. Johnston : This is a very good paper. But, with all due deference to the author, I really think we are admitting too much. If we admit that we require something in the engine-room to put us right, because when we ought to put the engines ahead we may put them astern, we admit liability. Mistakes have more often been made through the wrong order being telegraphed from the bridge. The engines have been ordered ahead, when, in point of fact, they were wanted to go astern. I have been called up on some occasions, and found that the man who was ringing the telegraph was so excited that he did not know what order he *had* signalled ; while we, in the engine-room, perhaps not knowing the danger, were perfectly cool, and were less liable to make a mistake. . . .

Mr. JAS. ADAMSON: This paper of Mr. Macartney's, from my reading of it, was written, I apprehend, not with a view to admitting errors in the engine-room, but rather to prevent engineers being brought before marine courts of enquiry, charged with offences which they had not, in fact, committed. I only gather that from the remark by the author about an engineer who was condemned by a marine board because he had no proof that the engines went astern when they were ordered astern from the bridge. I have learned that another special reason, which led to the timed movements being recorded, was exactly similar to that which led to the recording bell described in the paper—namely, a dispute as to the ahead or astern movements of the engines. In this case a floating stage was run into and damaged. The officer on the bridge maintained that the telegraph had been rung full speed astern, and the engineer on watch maintained the engines had been set to work according to the telegraph, which indicated ahead, and then astern; the contention by the officer on the bridge being that both rings were for astern, the second one being given because the first ring had no effect in checking the way of the ship. There were no witnesses to either side, and therefore no evidence, as by the time the chief engineer reached the engine-room the second ring had gone, and the engines were being altered."

Among the many instruments in use on a steamer none are of more importance in the safe working of a ship when using the engines than the telegraph. The Royal Navy officials recognize this important part of a vessel by using what one might term a "positive" gear, by having nothing in their telegraphs which is not mechanical. By this I mean that they insist on the hollow shaft bevel wheel type of telegraph gear, where each movement of the instrument on the bridge is conveyed to the engine-room by a series of shafts and bevel wheels operating a pointer on the dial in the engine-room.

They also insist that it is imperative for the safe working of the vessels of the Royal Navy that some indication of how the engines are working must be seen by the navigating officer, and to do this they employ another series of hollow shaft and bevel wheel gear which is led from the main line of shafting up to the bridge, where it revolves a pointer showing at a glance in which direction the engines are working and the revolutions they are working at. This is most essential in carrying out evolutions, and it gives the navigating officer just that control of the ship which it is desirable he should have.

A few remarks on the method adopted by the Navy in the present day, and as far as I can gather after exhaustive searches, the two largest vessels in the Mercantile Marine carry out the same practice, viz., the *Mauretania* and *Lusitania*.

The first type adopted in the Royal Navy was that where the revolution of a pulley on the bridge communicated to a similar pulley in the engine-room by means of wires led from the one place to the other, the place of the wire being taken by means of a linked chain running over a flanged wheel, where it had to go round corners or an angle, this of course being the well-known system adopted to-day in the Mercantile Marine. This system had a great many drawbacks and disadvantages, as if it was not very carefully watched and examined, the wires stretched and in consequence it was liable to give a false order when in operation. To obviate this, small stretching screws were fitted, and these required to be adjusted at very frequent periods.

There has been in use for some time past the "positive" gear used in the Navy, and it is the rule to fit this in nearly all warships.

This shafting is made of hollow steel tubing, and the motion is conveyed by means of accurately machine-cut bevel wheels. The transmitting instrument and the receiving indicator however have undergone but little change, being of the same type as the original instrument, one turn of the handle above corresponding to a similar movement of the indicating finger below. The complete circle being divided into a number of segments for the different orders.

Messrs Chadburn, Ltd., who have very kindly given me a great amount of information on this subject, say that they have fitted every class of vessel in the present Royal Navy.

The regulations now in force in the British Navy prescribe that the transmitting instruments are to be fitted with a wheel handle giving an order for each revolution, the upper part of the wheel moving in the same direction as the vessel should move, and the shafting to make at least half a revolution for each change of order. The pointer of the engine-room dial has to move in the same direction as the engine shaft for going ahead or astern, and separate gongs of different tone fitted for the ahead and astern movements of the telegraph.

For the reply there is a system of electric single stroke gongs, a push being fitted in the engine-room and a gong at each transmitting station.

In the instrument shown, the wheel handle makes one complete revolution for each change of order, the arrangement being as follows: The ordinary lever handle of the bridge transmitter is replaced by a hand wheel keyed on to a spindle which carries a bevel wheel; this bevel wheel gears into another containing double the number of teeth, which is in turn keyed to the vertical spindle which runs down the inside of the column, and which is connected by hollow steel shafting and bevel gearing to the engine-room indicator. It will be thus seen that one revolution of the hand wheel gives one-half a revolution to the connecting shafting. In addition to this train of gearing, the hand-wheel spindle actuates a geneva stop mechanism which moves a pointer from the centre of one order to the centre of the next. The pointer is moved sharply while the hand wheel travels through a small arc, whilst for the remainder of the revolution the pointer is locked in its mid position, and a stop is arranged which arrests the motion of the hand wheel when the pointer has reached its extreme order in either direction. A similar train of gearing actuates the pointer and bell movement of the engine-room dial, and it will thus be seen that all the backlash of bevel wheels and spring in the shafting is taken up during that portion of the revolution in which the pointer is not being moved. With the increased leverage of this new system it is possible to put the telegraph over from "full speed ahead" to "full speed astern" in three seconds.

Combined with the telegraph instruments described above as fitted to warships, is a speed indicator and direction telltale.

This instrument is connected to the shafting of the more modern warships, and is operated by means of hollow shafting and bevel wheel gear.

For fast running turbines the gear is arranged so that the direction tell-tale pointer revolves at about 100 revolutions per minute. The dial may be graduated to any number of revolutions.

As it is not necessary for this gear to run when the vessel has got clear away to sea, a clutch is provided at the side of Tachometer for putting the speed pointer out of gear and another clutch at the side of counter for putting the tell-tale pointer out of gear.

The counter is always in gear and may be arranged to give the "Ahead" revolutions only.

Some foreign Navies have recently adopted a system where the reply to the bridge from the engine-room is carried out by means of pressing a button in the engine-room and thus ringing a bell, one signifying stop, two ahead and three astern.

Messrs. Chadburn, however, have just introduced a new type which has overcome all the objections to the above system.

The arrangement which I understand has become the regulation fitting for the Japanese Navy, and is being adopted by the new vessels for the Italian Navy, is as follows.

In the engine-room and as near as possible to the starting position is fixed the transmitting instrument, which has a dial on which are the different orders corresponding to those on the bridge instrument, each order having a separate push with electric contact device; from these contacts electric wires are led to the bridge instrument.

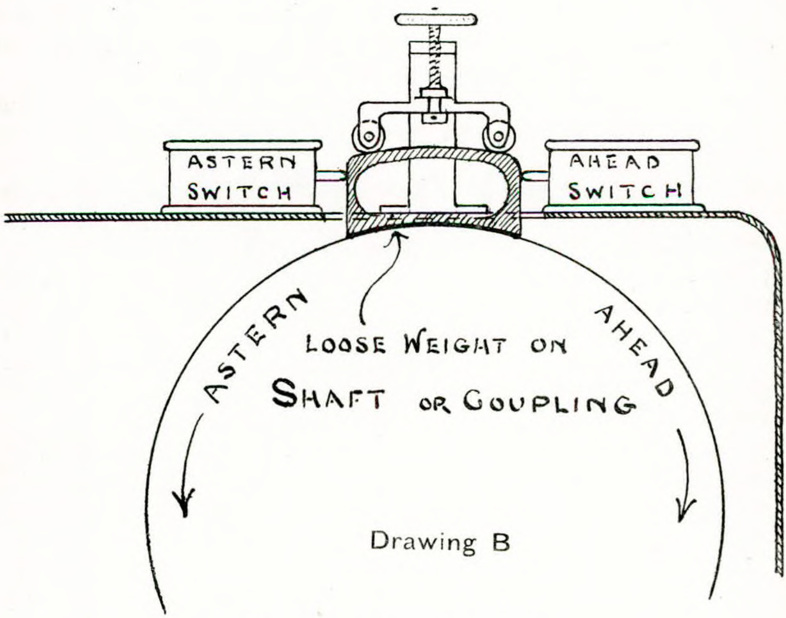
In this instrument are a number of electric magnets, one for each order on the dial, and in connexion with each there is a shutter device operating in connexion with a catch, which is controlled by a cam. This cam is fixed on the spindle of the instrument which carries the usual pointer and is operated by the wheel in the usual way.

Each order in the bridge instrument is marked on the dial, and in addition to this there is a transparent spot in the coloured glass and under this spot works the shutter referred to above.

On the order being signalled from the bridge to the engine-room, the assistant at the starting position presses the button of the transmitting instrument for the reply, and the shutter in the deck instrument corresponding to the order given is at once actuated and moves across the disc in the dial; at the same time a bell is rung, so that the answer given is both audible and visible. Suitable colours are used in daylight to enable the disc to be clearly seen, whilst at night the disc at the order given is obliterated by the shutter, the light in the instrument being sufficient to enable the operator to see which disc is in operation.

If, therefore, it is necessary on vessels in the Royal Navy to know how the orders given from the bridge are being carried out, how much more necessary it is that something of the kind should be used in the great Mercantile Navy.

The great objection to fitting an apparatus, such as that fitted in the Navy, to a vessel in the Mercantile Marine, is the cost, and my object in bringing the notice of this "Recordicator" before the Institute of Marine Engineers is because of its adaptability to our steamers, it being cheap to fit and just as efficient as any. Moreover, it will enable the owner, manager or superintending engineer to see at a glance how the engines



NEWALL'S "RECORDICATOR."

have been worked in going in and out of any port in the world, in going through a fog, or at any time.

The "Recordicator" is comprised of a number of different instruments for use on shipboard, each having a separate use, and each being so arranged that they can be fitted independent of the other.

First. To let the engineer working the engines know when he is putting them the wrong way.

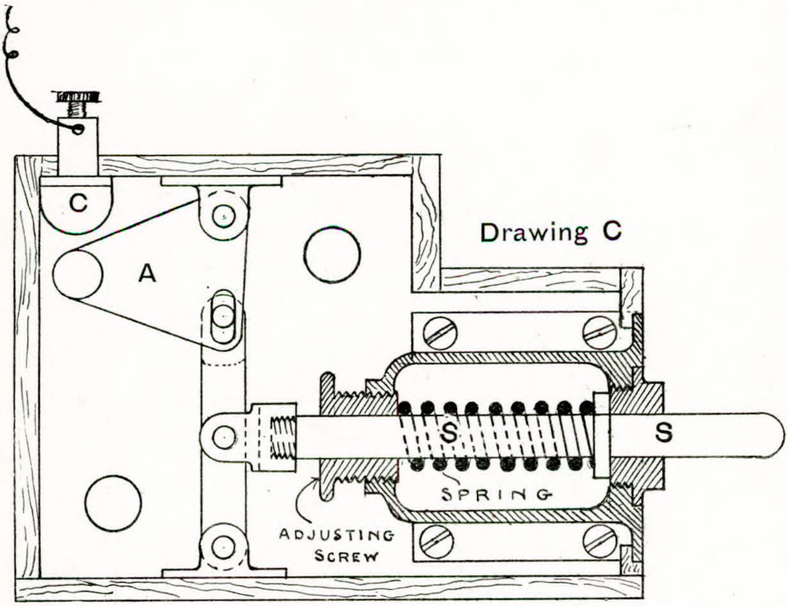
Second. To give a signal to the captain or navigating officer on the bridge, or any other part of the steamer, as to how his engines are working, and when they start and stop.

Third. To record every order given by the telegraph, and the movements of the engines in response to those orders.

The necessity of having some indication on the navigating bridge of a steamer as to how the propelling machinery is working, particularly in narrow waters, has been apparent for many years, and every responsible person connected with shipping knows that at present the navigating officer, be he captain or pilot, is very often placed in an awkward position by not being certain how the machinery is being operated by the engineer; and although, considering the number of steam vessels in our Mercantile Marine, the accidents are very few, still they do happen, and then the accident is usually very serious and costly.

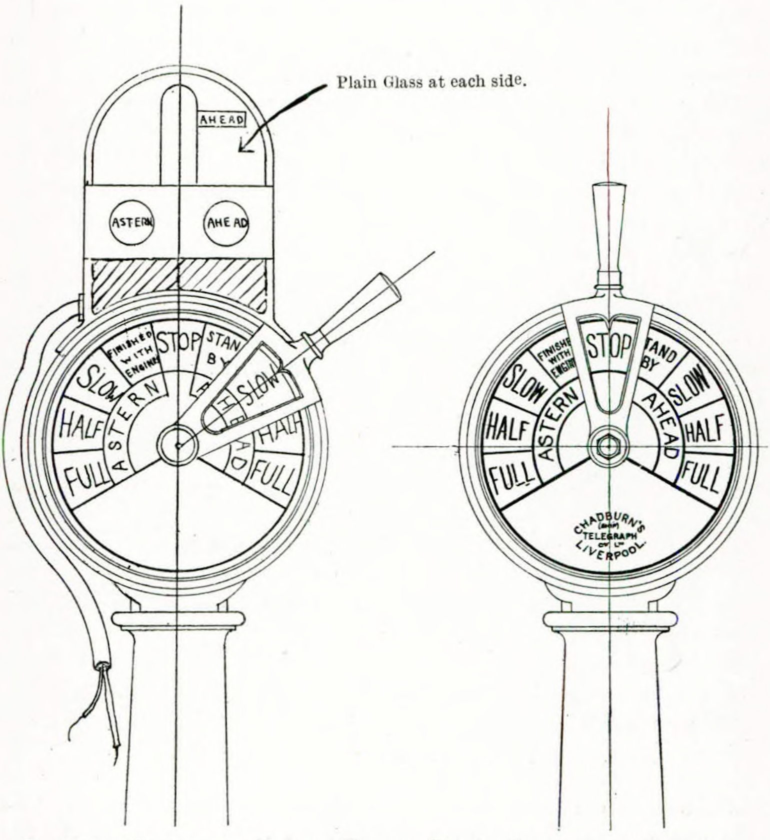
The first essential part of this invention is that appertaining to the indication of direction of the movement of the propeller shaft; and here it may be said at once that no part of this apparatus is attached to the reversing shaft, or links or valve motion in any way. The direction of rotation of the shaft in its movement is obtained by laying a weight upon the shaft or coupling, and letting the weight fall to either side as it is carried round by the movement of the shaft. The weight—made of cast iron, leather lined on the underside to give it sufficient friction—is placed in a central position on the shaft, when the shaft is at rest. The weight is loose upon the shaft, but is kept in its central position by means of an iron plate with a slot in it cut sufficiently large to allow the weight to move laterally about one inch each way from the centre position, but with only sufficient clearance sideways to allow the weight to move. At the forward and after side of the weight are wrought iron brackets carrying a pair of rollers attached to a moveable spindle for adjusting the friction required on the weight. This is not shown on the model, but is illustrated by drawing *B*. At each side of the weight, in a thwartship direction, are two spring boxes. The springs are fitted to the spindles in such a manner that on the weight moving over in either direction it comes in contact with the spindle, and depresses the spring. On the shaft ceasing to revolve the energy stored up in the depressed spring is used to push the weight back into its central position. At the end of each spindle, opposite to the weight, is a contact make and break switch, of very special construction, so made that the movement of the part which makes the contacts, or completes the circuit, moves at a very much greater rate than the spindle, to ensure the circuit being made at the first movement of the shaft.

If, therefore, by means of a weight placed upon a shaft free to move in either direction with the shaft, but in its movement putting switches into operation to which lights—or other



PLAN OF SWITCH USED ON SHAFT, NEWALL'S "RECORDICATOR."

visible or audible signals—be attached, it follows that if you have one coloured light (say white) for ahead, and a different colour (say red) for astern, it resolves itself simply into carrying the necessary wires, etc., to any part of the vessel to enable any person to see just when the shaft is moving or stopped, and in which direction it is moving also. The ahead and astern light wires, having to pass through the engine-room, a connexion is made from them to the engine-room telegraph and from the telegraph to a brass box with glass front, which is placed directly in front of the engineer whose duty it is to work the engines. The ahead wire is connected over the astern series of movements, and the astern wire over the ahead series of movements required from the bridge. Should the telegraph ring, say "Slow ahead," and the engines be put ahead the



SHOWING METHOD OF FIXING ENGINE REPLY SIGNAL TO TELEGRAPH INSTRUMENT.

current set up by the weight on the shaft moving over "Ahead" operating the switches, sends the current through the "Astern" movements of the telegraph, and thus no signal is made to the engineer; but should he, on getting the signal to go "Slow ahead," inadvertently put his engines "Slow astern," the current set up by the weight on the shaft going astern is directed through the ahead series of movements on the telegraph ; a connexion is closed to the brass box directly in front of the engineer, and the glass front instantly becomes illuminated with the legend " WRONG WAY," and a bell rings, which warns the engineer of his mistake and thus prevents all chance of accident, it being necessary only to start the shaft in a contrary direction to that ordered by the navigating officer for the engineer to see and hear that he is going the wrong way.

The Second Instrument is of very simple construction, and is very efficient. It consists of a brass standard, and is fixed on the navigating bridge of a steamship so that it can readily be seen from either side, or by the officer working the telegraph giving orders to the engine-room. The head of the instrument has four glass dials, two on the port side of it and two on the starboard side. The dials are marked "AHEAD" and "ASTERN." On the shaft revolving in the engine room and the weight being carried over sufficiently to make a contact with the switches, the current flows to the lamp on the instrument on the bridge, and on lighting, illuminates the dial, showing *at once* when, and in which direction, the engines are working. On the shaft ceasing to revolve, and the weight being forced back into its neutral position by means of the spring in the box, the light in the instrument on the bridge is put out, and the officer knows at once when the shaft or shafts come to rest. A similar instrument may be fitted with advantage on the after poop of large steamers, so that the officer stationed at that part of the vessel can tell at a glance what orders are being executed in the engine-room, and he can then, if there be danger, stop the engines before any damage is done. This instrument would be of very great service in the manœuvring of large vessels through narrow waterways, such as dock entrances, going alongside or coming to anchor in harbours full of shipping, and as the signals can readily be seen from the shore would materially assist the Marine Superintendents, Dock Masters and others in carrying out these manœuvres in letting them know how their orders are being carried out.

The Third Instrument in connexion with the apparatus is of very great value as a means of placing on record every order given by the navigating officer, and how it is carried out by the engineer. It is made up as follows : Upon the casing carrying the wires connecting the bridge telegraph to the engine-room is fitted a box. This box has the same number of terminals as there are orders on the telegraph—usually Stop, Slow, Half and Full Ahead, and Slow, Half and Full Astern. The telegraph wires run through this box, and upon one of them is connected a cross bridge piece ; on the bottom of the box is fitted one long terminal bar, and in front of this are a number of short terminal bars. The centre bar is fitted so that when the telegraph stands at " Stop " the cross-bridge-piece rests upon it and makes connexion with the long terminal bar. On either side of the short centre terminal are fitted an equal number of other terminal bars, corresponding to the distance moved by the cross-bridge-piece over the distance marked from " Stop " to " Slow Ahead," " Slow Ahead " to " Half Ahead," " Half Ahead " to " Full Ahead," and from " Stop " to " Slow Astern," " Slow Astern " to " Half Astern," " Half Astern " to " Full Astern," so that when the telegraph moves from one order to the other the cross-bridge-pieces rest only on the terminal bar corresponding to the order given to the engine-room. The long terminal bar is connected to the earth or return wire of a lamp in the ordinary lighting circuit. In the chart-room, or captain's room, is placed the recording instrument. It consists of a series of drums carrying a roll of paper. The paper is led from a feeding drum over a loose centre drum on to a large drum driven by clockwork. The clockwork drum revolves at the rate of a quarter of an inch per minute, but may be made to move at any rate, and moves the paper over the loose centre drum at that rate. Inside a brass box with glass front, under separate lock and key, are fitted a number of electro magnets, each magnet operating a pencil. The electro-magnets are connected by wires from the terminals in the box through which the telegraph wires pass, and are placed so that the pencils are all in the same straight line, one above the other. The pencils are held off the paper by means of springs whilst the electro-magnets are not energized. The clockwork being started, and the paper commencing to revolve, no mark is made on the paper until the telegraph stands at a definite order. Directly an order is given to the engine-room by the telegraph, and the cross-bridge-piece comes to rest on its terminal corresponding to the order, contact is made through the cross-bridge from the long terminal to the short terminal, thence to the magnet in the box which, becoming energized, moves its pencil on to the paper roll and marks a perfectly straight line on the paper until the order is changed, when another pencil comes into operation through the same means and marks its straight line until the telegraph is moved back to stop, when no mark whatever is made on the paper. The uppermost pencil and the lowermost pencil are connected with similar magnets direct to the signal instrument on the bridge coming from the engines direct, and these pencils in their turn mark the paper in a straight line only as soon as the shafting commences to revolve, and as long as it revolves. The top pencil marking the ahead movements of the shaft and the bottom pencil the astern movements. The paper roll is marked with lines running the whole of its length, the "Ahead" orders being marked in the spaces above the centre-line, and the "Astern" orders being marked below it. Thus, should the order be given for, say "Slow Ahead," the pencil commences to mark the paper at once, and only on the engines moving does its recording pencil mark, so that should the engines be put astern, a mark would be made above the centre line by the telegraph, and below the centre line by the engines, thus showing exactly what was ordered and what was given. A device can be fitted whereby every minute can be marked on the roll in numerals, so that the time can be recorded also, but it is not considered absolutely essential. The paper rolls run for fifteen hours, which covers the time of most manœuvres, but the roll can be changed in a few minutes, so that a continuous record, say going through a fog, could be kept. It becomes apparent that, when the Admiralty Court have laid down so many rules for the guidance of ships at sea and for the prevention of accidents, such an apparatus as described in the foregoing should be of the very greatest service, for with it, the managers and others of our great shipping lines may see what their vessels were doing at all times. It will give the captains and navigating officers greater confidence in what their ship is doing in going through a manœuvre, and it will prevent the engineer in narrow waters from putting his engines the wrong way. And as the insurance premiums are very rightly reduced as a vessel keeps clear of accidents, so it should, where fitted, reduce the present premiums, and incidentally help the shipowner to keep his vessels running when otherwise he would lay them up. Its value as a true mechanical record in a case before the Admiralty Court would be manifest.

The telephone is coming into regular use on board ship for the giving of orders both to the engine-room and forecastle and after deck, and in very long vessels they are a great boon, as so much can be said, with time saved in the carrying out of instructions. They have this advantage also, that no matter what the weather may be the order given by phone is always distinctly heard. The many fittings now used on board ship, undreamt of a few years ago, may give some of our members an opportunity in the future for a subject of a paper.

This paper might very well include, not only the means of communication on board ship, such as telegraphs, telephones, etc., but also that very essential instrument by means of which the communication is made between "ships that pass in the night," and signal stations ashore—I refer to the Morse lamp.

Mr. Silley: I am afraid I may have some difficulty in now describing this instrument as well as Mr. Newall himself would. I can only say that I saw it in Liverpool and had the working of it explained to me on one ship, where they spoke highly of it. I shall do my best to answer any questions that may be put.

Mr. Silley then gave a demonstration with a large model of the Recordicator, explaining the working of the various parts.

Chairman: The subject is now open for discussion, and Mr. Silley will be pleased to answer any question he can, and the report will afterwards be sent on to Mr. Newall that he may reply to the whole discussion.

The Hon. Secretary. The following is from Mr. Wm. McLaren (Member):—

"Mr. Newall's paper on "The Engine-Room Telegraph and Communication between the Engine-Room and Bridge" deserves a good discussion for the thought, labour and time he must have spent in preparing it. As the sea-going engineer must know, it is always a debatable subject as to who was right and who was wrong. The cool head can always detect the excitable operator at either end of the bridge and engine-room communication devices on board ship, and it is the excitable man who usually makes a mistake in giving or executing an order. At the bridge end the thought is "What a time he takes to move her!" at the engine-room end: "Does he think we can go sideways, taking about six months wear out of the engines ?" with words possibly that never appear in print. The most trying time the writer ever experienced with the working of engine-room telegraphs was at submarine cable repairing work in shallow waters, also a trip lasting forty-eight hours in December, 1889, from Gravesend to Wapping in a fog and the ship holed in addition. Perhaps the Port of London Authority may now be improving the waterway and successfully controlling the bargee. My opinion is that with the Royal Navy Positive gear for any device used to start or stop ships' engines by signal, owing to the liability of electric contacts to fail in the connections when most needed, I would advise a careful selection of the device, as, even with the most careful supervision over such devices, and the contacts made damp, insect and dust proof, yet somehow and sometimes they go off. But I do not wish this to be understood that I consider no recording device should be used. So long as it works, it will record the operations it is set for. In his paper the author says, " with the increased leverage of this new system it is possible to put the telegraph over from 'full speed ahead' to 'full speed astern' in three seconds." I consider that three seconds is slow, one second should be the proper time as the action should be momentary. I must express my thanks to, and congratulate Mr. Newall on his Recordicator and the effort he has made to solve the problem of indicating the orders and their fulfilment."

Mr. F. M. Timpson : I think this is a very clever invention and one which must have taken a good deal of thinking out. We are indebted to Mr. Newall for bringing such an elaborate model and description before us. The only thing I can see that would be liable to contention is the recording arrangement, which appears to be under control of the ship. I should think such an arrangement should be entirely out of the control of the people in the ship, and let there be a continuous record for the whole voyage.

Mr. Silley : I do not see why that should not be arranged.

Mr. Timpson : There is such a thing as the possibility of the records being altered.

Mr. Silley : The only way in which variation could be made would be by anything going wrong with the pencil.

Mr. Timpson : I have seen electrical devices which never seem to come into use without the contacts going wrong ; however we have more recently advanced considerably in our styles of contacts and covers. The whole device is very clever, especially the dial showing the operator when he is going the wrong way. I presume that is carried right through the ship, so that the man on the look-out or astern knows at once also.

Mr. Silley : The instrument could be fitted up astern, if necessary, or wherever it is desired.

Mr. Timpson : The " wrong way " dial would only be required on the deck and in the engine-room, but the other dials might be in different parts of the ship. I do not see that much criticism can be given on the instrument because the whole machine seems to be exceedingly well thought out and covers most of the weak points in the present system. I do not know whether Mr. Newall proposes to have chains and wires as shown in the model ; there may be a little stretching in them. We have seen telegraph wires requiring a great deal of adjusting, and if these are finely adjusted there may be trouble on that score.

Mr. L. R. G. Hare : It seems to me that the contacts would require to be very well protected, especially in the engine-room, where there is a great deal of moisture and oil about. I should like to know whether there will be any indicator on the shaft, and if so on what part of the shaft he proposes to fit it.

Mr. Jas. Adamson : I think it is intended to be put on the tunnel shaft, abaft the thrust.

Mr. Hare : It would have to be in some place where it would be properly protected.

Mr. G. W. Newall : It is on the first coupling, as a matter of fact.

Mr. Hare : My first thought, when reading the paper, was that the " Astern," " Ahead " and " Wrong Way " apparatus would be an advantage without the recording part, and if the latter is going to lead to complications it could very well be left out.

Mr. W. E. Farenden : It seems to me to be a very useful apparatus. There are occasionally differences of opinion between the deck officers and the engineers ; the system before us to-night clearly shows when the engines are going the wrong way and should settle all matters of dispute. I should like to know what ships this system has been fitted in and the approximate cost of supplying and fitting it. Perhaps Mr. Silley might have some idea. I understand there would be a recorder in the engine-room and another on the bridge—they would not be required anywhere else—I see also that it would clearly record whether the engines were put ahead or astern, but does the instrument record the half speeds also, say, "Slow Ahead," "Slow Astern," etc.?

Mr. HARE : There are pointers for each on the recorder, the pencil presses on the paper.

Mr. SILLEY : It would indicate whether slow or full speed on the paper only. For instance, if the engines are moved from "full" astern to "half" astern another pen comes into operation. What I have always looked upon as a weakness in other systems is that very often when you want to go ahead you have to run the links across and move the engine the least thing astern. If the recorder is attached to the link gear the danger signal would be given on the bridge, whereas this system has the advantage that you do not get any danger signal until the engine has actually commenced to move. Immediately it moves you run your links across to the opposite direction and would not be a tenth part of the time. In other types the officers on the bridge would be much alarmed, under conditions where the engine did not move at all, and would be under the impression that it was going astern instead of ahead.

Mr. TIMPSON : Half a turn would not disturb it. Sometimes you require to take a half turn and bring the engines back again.

Mr. SILLEY : The other systems in use are attached to the valve gear all the time you are running over the links.

Mr. TIMPSON : It is certainly better on the shaft than on the link motion.

Mr. HARE : Of course you would still get the false record on the bridge even with this system.

Mr. SILLEY : It takes a time to move the engine ; it *seems* minutes while one is waiting before getting it over in the opposite direction, and it would certainly be rather alarming to any one on the bridge, although the engine has not moved at all.

Mr. HARE : How does Mr. Newall propose to get the indication ?

Mr. SILLEY : It is through the heavy weight laying on the shaft which drops down directly the shaft begins to turn. That is the most important part of the apparatus and should not be tampered with.

Mr. CRUICKSHANK : How would it be possible to tell if one of the pencils got broken ?

Mr. SILLEY : It would be quite easy to see whether or not it pressed against the paper. In answer to Mr. Farenden's question, I understand one of the Allan line boats is being fitted up with the apparatus, and the cost of fitting up the whole arrangement was, I think, about £70.

The members then examined the Recordicator model in detail, Mr. Silley explaining the working and answering the questions raised.

Mr. ADAMSON : Before proposing a hearty vote of thanks to Mr. Newall for his kindness in writing this paper and in sending this model for us to see, I would say that I do not think I am altogether satisfied with the explanation given by Mr. Silley in connection with the " half turn " given before starting the engine, and I was on the point of rising to the subject when Mr. Silley anticipated me. I am inclined to think there would be some trouble in the event of, say, an engine with a good deal of moist steam about the casings and perhaps lying for three or four minutes before getting an order to go either ahead or astern, involving one or two half turns either ahead or astern before executing the order. All these half turns would go on to the paper and, if brought before a court of law, and especially before a judge who did not thoroughly understand the technical points, it might go hard with the engineer. I should also like to emphasize the remark referred to by Mr. Hare that there are so many contacts between the recorder pen in the chart-room and the engine-room that one of them getting out of order even momentarily would give a false record, and if that contact held off for a short time there is no means, as far as I can see, of that knowledge being conveyed either to the bridge or to the engine-room. We have known of electrical contacts which momentarily went off ; in fact, a case came under my notice not long ago where both contacts were broken, first the stern and then the forecastle, and about half an hour afterwards the contacts came all right again. Probably this was due to the vibration of the ship bringing them together again, the initial cause being moisture, but in the event of such a case happening with this Recordicator I am afraid there would be a good deal of trouble on account of the break in the contacts. These are two points which occurred to me as points that ought to be emphasized, especially the former, as we know that if an engine does not go ahead or astern immediately, the time appears long to the man watching. Mr. Silley referred to that fact, and there is no doubt this system has a great advantage over those we have hitherto seen, where the gear was connected to the recorder, whereas to this one the shaft is connected. That, of course, will minimize the time limit between the actual movement—the wrong movement—and the right movement. I have been in correspondence with Mr. Newall for some time on this subject, and he was not aware, as he mentions, when he wrote the paper originally, that we had already had a paper by Mr. Macartney on the subject. Of course he gives credit to Mr. Macartney for the work he did a good many years ago in this matter, and this is an extension of that work, and a very elaborate extension of it. No matter what our views may be as to the little details we all give him great credit for his ingenuity in the construction of his model as well as for the paper he has been good enough to give us to-night. I have much pleasure in proposing a hearty vote of thanks to Mr. Newall.

The motion was seconded by Mr. E. W. Ross, and carried with acclamation.

MR. NEWALL'S REPLY TO DISCUSSION.

Before replying to the points raised at the discussion of my paper, I wish to place on record my indebtedness to Mr. J. H. Silley for his kindness in reading the paper and his explanation of the model. Also my thanks are due to Mr. Adamson for calling my attention to various incidents which have guided me somewhat in its preparation.

If I may be permitted I should like to answer the questions raised in a general manner, as the discussion really hinged upon the reliability of the electrical contacts. In the model the loose weight is shown resting upon the shaft or coupling, and free to fall to either side as the shaft moves either "Ahead" or "Astern." The system adopted actually is that as shown in drawing B, where the weight is kept down on the shaft by means of the adjustable screw with rollers. This is done to enable the operator to adjust the weight so that the friction on the shaft of the weight may be such that the springs in box in drawing C may just overcome it, when the shaft comes to rest. This arrangement is fitted to the *Devonian* of the Leyland line, where it has worked successfully for five or six voyages. It was this vessel that Mr. Silley saw fitted, and is the only one so far. The system of contacts as compared with the model are also different, those fitted on the *Devonian* being the usual Switch system, the electrical connexion being made by the angle piece A in drawing C sliding in between two contact pieces C, when the weight is operating the spindle and spring S. By this method no dirt or other deterrent can gather on to the contact points to affect its efficiency. The "wrong way" box is fitted directly in front of the engineer working the engines, and it is not necessary to fit it in any other part of the ship. The question of altering the records of the movements of the telegraph and engines had been raised in Liverpool before the model went to London, and I am pleased that Mr. Timpson asked the question at the discussion. It is proposed to have only one Recorder in the ship, and that to be stationed in the chart-room, the key of the pencil-marking box to be kept by the captain. It will have been noticed that no vertical lines have been printed on the paper to show the minutes. The paper moves at the rate of a quarter of an inch per minute. In the event of an accident to a vessel which was recording the orders given, say, during a fog in the Channel, I assert that it would be impossible to alter the chart of those orders, with any degree of accuracy, as on running into a fog the instrument would be started and the time noted. The marks on the chart being simply horizontal lines, giving no time, where, on the accident taking place, would the offender commence to falsify the chart ? It would be necessary to remove the chart, measure up the minutes and then so disfigure the reading that I am afraid the action would place the delinquent in a very invidious position should a court of law have to settle the case. The Recordicator, taken as a whole, comprises the weight and switches in tunnel, the wrong-way box in the engine-room, the signal boxes on the bridge and aft the recording instrument. Each of these parts may be fitted separately ; each has its part to play, and each is independent of the other. In conclusion I thank the gentlemen who so kindly contributed to the discussion, and for the kind manner in which the paper was received, and I trust that this subject may not be allowed to drop until the perfection of some such device is an accomplished fact.

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SESSION 1909-1910

VOL. XXI.

PAPER OF TRANSACTIONS NO. CLXIII.

EXPERIENCES WITH BOILER SCALE

By MR. WM. HENDERSON (MEMBER).

Read Monday, November 1st, 1909.

CHAIRMAN: MR. F. M. TIMPSON (MEMBER).

ADJOURNED DISCUSSION

Monday, November 29th, 1909.

CHAIRMAN: MR. J. G. HAWTHORN (HON. MINUTE SECRETARY).

LECTURE

NOTES ON BOILER COVERING

By MR. ARTHUR P. STROHMENGER, F.C.S.

On Monday, November 22nd, 1909.

CHAIRMAN: MR. J. LANG, R.N.R. (MEMBER OF COUNCIL).

DISCUSSION ON PAPER BY MR. H. RUCK-KEENE (MEMBER)

ON

THE TREATMENT OF MARINE BOILERS ON LONG VOYAGES

Monday, January 10th, 1910.

CHAIRMAN: MR. J. E. ELMSLIE (MEMBER OF COUNCIL).

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