INSTITUTE OF MARINE ENGINEERS

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VOLUME XIV.

ONE HUNDRED AND EIGHTH PAPER
(OF TRANSACTIONS).

INDEPENDENT PUMPING ARRANGEMENTS IN CARGO STEAMERS.

BY

Mr. D. K. ROBERTS (Member).

READ AT

3 PARK PLACE, CARDIFF,

On WEDNESDAY, JANUARY 28th, 1903.

CHAIRMAN: MR. T. W. WAILES (VICE-PRESIDENT B.C.C.).

AND AT

58 ROMFORD ROAD, STRATFORD,

On MONDAY, FEBRUARY 23rd, 1903.

CHAIRMAN: MR. S. C. SAGE (MEMBER OF COUNCIL).

DISCUSSION CONTINUED AT

58 ROMFORD ROAD, STRATFORD,

On MONDAY, APRIL 6th, 1903.

PREFACE.

3 PARK PLACE,
CARDIFF,
January 28th, 1903.

A MEETING of the Bristol Channel Centre of the Institute of Marine Engineers was held here this evening, Mr. T. W. WAILES (Vice-President B. C. Centre) in the chair.

Mr. D. K. ROBERTS (Member) read a Paper on "Independent Pumping Arrangements in Cargo Steamers," and on which a discussion ensued.

GEO. SLOGGETT,
Hon. Local Secretary.

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IN designing the pumping arrangements of steamships, the requirements to be considered are reliability when working and economy in upkeep,

and this applies equally to boiler feeding pumps, air and circulating pumps, and the bilge and ballast pumps, each of these having its own work to perform, and that work being essentially different in each case.

In mail liners and passenger steamers the pumping arrangements are complicated by the necessity of providing a water supply and drainage system for the cabins, bathrooms, etc., also special arrangements for working hydraulic cargo gear where fitted, and in these vessels considerably more attention is devoted to the pumps than in the ordinary type of cargo steamer where the requirements are for the propelling machinery, water ballast, and hold drainage, and I propose to deal only with this latter type, the "tramp" steamer, where economy has to be practised, but where it is very often exercised in the wrong direction.

The ordinary pump arrangement which is fitted, and with which, no doubt, the members are familiar, is a group, consisting of air-pump, circulating, feed, and bilge pumps placed behind the main condenser and worked by levers from the main engine cross-head.

This arrangement, although apparently simple and economical on the score of first cost, has serious disadvantages, and, as on the efficient working of the pumps depends the economical working of the boilers and main engines, it becomes important to minimise as far as possible the liability to break down, with the consequent delay and expense of repairs.

On account of the high steam pressures now in use, the necessity of supplying pure water to the boilers, and the expense of obtaining this supply (whether by means of evaporators or carrying a stock on board), the boiler feed pump takes a very important place in the modern engine room, and if we consider that it runs continuously under conditions as severe as those of the main engines it will be clearly seen that we must give this subject more

consideration than is generally shown to it, both in design and treatment.

The chief requirements of a boiler feed pump are simplicity of arrangement, certainty of action, and economical working, while it is also desirable that all working parts should be easily accessible. These conditions, however, are not fulfilled in the ordinary arrangement driven from the main engines.

In feed pumps, when two rams are fitted, each pump is designed of a size sufficient to deliver the whole of the feed water to the boilers if required, there being in many cases a shut-off valve fitted to allow of independent action, but in practice both pumps are kept at work, with the result that each is only doing half its work or working intermittently, at one moment with a full load and the next running empty. The practical effect is, that the valves are rapidly worn out or broken, the gland packing is destroyed, leakage ensues, and any economy in first cost is lost through the necessity of supplying additional feed water (sometimes at a very low temperature), throwing extra work on the evaporator, with the consequent expenditure of fuel, or, in cases where no evaporator is fitted, introducing large quantities of salt water into the boilers.

The amount of gland packing consumed under these conditions is a considerable item in the economy of the engines.

A further disadvantage of this type of pump is the heavy shock on valves and pipes even while the engines are working steadily, and it is quite a common event in many ships for the feed pump valves or check valves to give out during a period of racing. The use of atmospheric valves on the pumps to cushion this shock results in considerable quantities of air being mixed with the feed water, and this leads to other evils, such as corrosion of boilers, etc.

On the other hand, a properly designed independent feed pump is capable of easy and accurate regulation so as to deal with the feed water in its

varying quantities, and to deliver it to the boilers steadily and quietly, without shock, thus avoiding the risk of breakage of check valves and feed pipes, which so often disables a vessel at critical times.

In fitting independent feed pumps, the crank and flywheel type, although good working pumps, are not so easily and accurately regulated as the direct acting type, and the latter is greatly to be preferred.

Direct acting pumps are of two classes, viz., the single pump, complete in itself, and the duplex pump, in which cylinders and pump body are duplicated.

They can be arranged to work either vertically or horizontally, to suit the circumstances of the case, the advantage of the vertical type being the small floor space occupied, while the horizontal type permits the pump to be placed in positions where the overhead space is restricted.

The duplex pump has the valve motion of one cylinder actuated from the piston rod of the other cylinder, and *vice versâ*, and while it acts well as a boiler feed pump is somewhat wasteful in the steam consumption, due to the comparatively short stroke and to the large amount of clearance. As each duplex pump has four ports in each cylinder (or eight in all), it will be readily seen that a large amount of steam is lost during each stroke, while the uncertainty in the length of stroke of this type of pump, due to various causes, also adds a proportionately larger amount to the clearance space to be filled by the steam. They can, however, be constructed with compound or triple expansion cylinders, with a corresponding economy in the use of the steam.

One disadvantage of the duplex type is that the two pumps are in reality only one pump, and if anything breaks or gives way on either side, the whole pump is disabled; therefore, as double the number of parts are involved and liable to break, it is evident that a good single pump of equal capacity is better than two pumps so constructed that one is entirely dependent on the other. The action, however, of the

duplex pump with its two plungers gives a constant flow of water without check at the end of each stroke, as in the case of single pumps, and this is in favour of the duplex.

In the single direct acting pump there is only one cylinder and one pump end, the cylinder valve action being actuated from the piston-rod by different methods according to the type of pump.

The slow speed direct acting type has been for some years adopted by the leading mail and passenger steamships as a standard feed pump, and they are constructed either single cylinder or tandem compound. In the single cylinder the steam consumption is greatly decreased by the arrangement of the steam valves, which permits the steam to work expansively, and not only makes this type specially economical but slows the piston down at the end of the stroke, so that the pump valves settle quietly and all shock on feed pipes is avoided. A further advantage of this type over the duplex of the same capacity is that the single cylinder, making only half the number of stops, has but one-half the waste for clearance, while the positive action of the pump and the expansion of steam in the cylinder decreases that tendency to vary the length of stroke to which direct acting pumps are liable.

The wear and tear on these pumps is remarkably small. In a steamer of 1,500 I.H.P. which came under my notice the pump has run nine months with the glands packed once and the pump valves adjusted by the ship's engineers, and during that time without a single stoppage of main engines for feed pump repairs.

If fitted in duplicate and used alternately one on the outward and one on homeward voyage, the minor adjustments can be made by the ship's engineers, and a few spare parts carried on board renders them independent of expensive repairs abroad.

This type is now manufactured by several well-know firms, and is made singly or in pairs, and can be controlled automatically by the quantity of feed water delivered by the air-pump into a float tank.

When fitted in duplicate they are so arranged that either or both can be used on one line of piping, and the objection formerly raised to independent feed pumps, viz., that they required a considerable amount of extra piping, is now done away with.

For many reasons boiler feed pumps should be run slowly and steadily; quick running pumps are wasteful and expensive, more especially when, as in the plunger type, driven from the main engines, they are run at a varying speed and to only a portion of their full capacity, and the fact that the independent direct acting type can be run steadily and economically with no shock to wear out or smash pipes and valves is a very strong recommendation in its favour.

Without going into minute detail a few figures will show the work required of the boiler feed pump, and perhaps show more clearly the advantages of the independent pump.

For a triple expansion engine working under ordinary conditions, 15 lb. of water are required approximately per I.H.P. per hour, and taking an engine of 1,000 I.H.P. as a standard, we require to handle 15,000 lb. of water per hour. As this engine will run on an average sixty revolutions per minute we have 4·16 lb. of water to deal with per revolution, equal to about half a gallon.

I have measured the feed pump plungers on an engine of 1,000 I.H.P., and find them $2\frac{3}{4}$ in. diameter with a stroke of 20 in. This gives a capacity of 119·6 cubic inches, or 4·3 lb., but as we have two pumps they are each only required to work at half their full capacity.

A slow speed direct acting pump, diameter of steam cylinder 8 in. and of pump 6 in., with a stroke of 12 in., or a duplex pump of 5 in. cylinders, 3 in. pump, and stroke of 5 in., will deliver this quantity of water per hour at twelve strokes per minute, the capacity of the pump being 2·2 gallons per stroke, or 1,584 gallons per hour.

It will be readily seen that the main engine driven pumps are working under conditions that tend

to excessive tear and wear, with constant risk of accident, while the slow speed of the independent pump reduces the wear to a minimum, and entirely removes the risk of serious damage.

The efficiency of a well made direct acting slow speed pump is remarkably good. In some recent trials at varying speeds the efficiency averaged 90 per cent., the speed of the pump varying from three double strokes to sixteen per minute, and equally good results have been obtained under ordinary working conditions with the pump running at its normal speed, and, if care is taken in the selection of a good design, first class workmanship and material, there is no doubt that the direct acting pump is at once the most efficient and economical for boiler feeding purposes.

In regard to the air pump we have, broadly speaking, a pump designed to maintain a constant vacuum while the engines are running at full power. The best results in this case are to be obtained by a pump of large diameter running at a comparatively slow, steady speed, and these conditions it is impossible to obtain economically in the main engine-driven pump, which partakes of all the variations of the speed of the shafting.

The amount of water to be dealt with per revolution is small, but if through accumulation in the condenser, through the ship taking a heavy list, or other causes, a large body of water is suddenly thrown into the pump, the consequences may be very serious, especially if the engines are racing, and most of the delays through air pump defects are due to broken valves from this cause. Serious strains are also liable to be set up when starting the engines, as all the condensed water accumulated during the process of warming up has to be quickly discharged by the air-pump during the first few revolutions.

This usually results in another serious loss, as all this fresh water is discharged through the hot well overflow into the bilges or overboard. The loss of this water has to be made up to the boiler again,

and if the loss is repeated by frequent stoppage and starting of engines, it becomes an expensive item.

It seems rather an anomaly that we should fill the boilers with fresh water, and fit expensive evaporators to maintain this supply, while on every occasion we start the engines several tons are thrown away in the bilges.

By fitting the air-pump independently of the main engine, this loss of feed water can be entirely avoided. A good vacuum can be obtained in the condenser before starting the main engines, and the speed of the pump so regulated as to maintain this vacuum whether the engines are running fast or slowly. This in itself is a great advantage in handling the engines while entering and leaving port.

The design of the independent air pump is usually two single acting pumps placed side by side and driven by a pair of cross compound steam cylinders, the high pressure cylinder on one side exhausting into the low pressure on the other side. The two pumps are connected by a beam and links attached to the crossheads, so that the effect of the two single acting pumps is similar to a double acting pump, with the advantage of using the steam expansively.

The disadvantages of the circulating pump when driven from the main engines are somewhat like the air pump, in that the engines have to be started before the pump comes into action, while any irregularity in speed throws a heavy shock on the pump, usually involving breakage of the valves.

A number of ships have been fitted with centrifugal circulating pumps to get over this difficulty, but as these have usually been driven by a single cylinder high pressure engine, having large clearances and exhausing direct into the condenser, the steam consumption has proved expensive, while the cost of upkeep on a fast running engine of this type is also high.

A direct acting pump using steam expansively is a more economical arrangement, and the cost of upkeep much less, as there is a smaller number of moving parts exposed to tear and wear.

A further economy can be effected in fitting an independent circulating pump of the direct acting type, since this pump can be arranged to do duty as a ballast pump.

The ballast pump as usually fitted does no work from the time of leaving port till it may be required to pump out water ballast at a loading port, and if a ballast voyage come between the discharge of one cargo and the loading of the next this period of idleness may run into months, with the possible exception that the pump may be used for a few hours to cool the condenser or turn the main engines in port.

We have thus as a return for the capital expended on this ballast pump only a few hours' work at long intervals, while the amount of deterioration that goes on in both steam and water ends, due to corrosion while standing idle, is great and expensive.

By fitting a connection between the independent circulating pump and the line of ballast tank piping, this pump can be utilised for the few hours necessary to discharge water ballast without interfering with its functions as a circulating pump.

The amount of bilge water in a modern steamer is usually very small. If the engine bearings are in good order no cooling water is required, and the source of most of the bilge water is usually the atmospheric valves on the circulating pump, and this quantity could be easily got rid of by a pump working a few hours per day.

The ordinary arrangement is to fit two ram pumps, each of a capacity equal to twice the amount required under ordinary circumstances, and it is not an uncommon experience to find these rams badly cut and scored through heating; while in some vessels it is the practice to disconnect one pump, slacken the packing gland, and let the pump run idle.

If the glands are kept packed tightly enough to make the pump efficient, the friction is very great, and altogether the expense of upkeep of these

pumps is a serious item out of all proportion to the amount of useful work done.

The functions of the bilge pumps can be economically performed by a general service donkey pump working a few hours per day, and this pump will drain the bilges much more effectively than the average bilge pump, and relieve the main engines of a considerable load.

The great objection usually put forward to the use of independent pumps is the amount of steam required and the cost of upkeep. But the amount of tear and wear on a slow running pump is obviously much less than on a pump driven at a much higher speed and without proper means of control, while the friction of main engine driven pumps absorbs considerably more horse-power than is required to do the useful work. Recent improvements in construction have very considerably reduced the steam consumption of independent pumps, and the exhaust steam, instead of being led direct into the condenser, can be utilized for feed heating, or evaporative purposes, instead of the steam usually taken direct from the boiler. It can also under certain conditions be used expansively in the low pressure cylinder of main engines. The initial cost will be found to be a very small percentage on first cost of the machinery, when the cost of the present system of fitting the pumps is deducted, while the greater freedom from risk of accident and delay is in itself worth a considerable amount. Shipowners are willing to spend large sums on improvements in loading and discharging cargo which may save a day or two in port where the saving is to them more apparent, but they do not always see the advantage of improving the propelling machinery to the same extent. The loss of a day in port entails no further risk to the ship beyond delay, while an apparently trifling accident to the machinery at sea at a critical time may mean the loss of the ship and cargo.

The arrangement of independent pumps which, in my opinion, would give the best results, is: A

twin air-pump placed behind the condenser in the position usually occupied by the present arrangement of pumps. A pair of direct acting boiler feed pumps controlled by an automatic float tank. A direct acting circulating pump fitted in the position usually occupied by the ballast donkey, and connected to the line of ballast tank piping, and a general service donkey pump, which may be connected to bilge pipes, ballast tank pipes and sea, and discharge on deck and overboard.

The floor space occupied would not be greatly in excess of the present arrangement. In the modern type of cargo steamer there is usually plenty of space in the engine-room, while in many cases it would allow the pipe connections, which are now crowded together in the vicinity of the pumps, to be arranged in a more accessible manner, and so avoid the necessity which now often occurs of having to remove several lengths of pipe in order to reach a leaky joint.

A very large proportion of the accidents which delay cargo steamers occur to the pumps, and as this, in my opinion, is very largely due to the system of fitting these pumps on the main engines, I have endeavoured on this occasion to place before you some of the advantages of fitting independent pumps, in the hope that a discussion of the subject may prove useful to us in leading to improvements which may diminish these accidents, prevent delay, and thereby increase the economy of the cargo steamer.

DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, JANUARY 28th, 1903.

CHAIRMAN:

MR. T. W. WAILES (VICE-PRESIDENT B. C. CENTRE).

MR. M. W. AISBITT (Vice-President) said in these days of triple and quadruple engines, and of a balanced engine, it was not necessary to have pumps direct from the main engine. For many years he had held the opinion that it was false economy to have air, bilge, or feed pumps fitted on the main engines; they ought to be driven independently of the revolutions of the main engines. The more slowly and regularly the feed water was supplied, the greater the efficiency.

Mr. W. DARLING said he should like to have heard the author give statistics showing the actual comparative horse power between the direct acting and the ordinary pump arrangement. He approved of the type of pumps described and shown on the screen by the author. Anyone who had experience, for instance, of centrifugal independent circulating pumps, especially in a light ship across the Atlantic, knew they had not to go far to find trouble. Only that morning he had had something to do with alterations in a steamer on account of pumps losing their injection water in a very slight roll. The ship was of considerable depth, carrying no less than 1,400 tons of water ballast when light.

Mr. T. A. REED said from an engineering point of view he quite agreed that the independent pump was the correct thing, but there were considerations to be weighed. Taking the average cargo boat, there was the first cost involved, and in getting out a steamer this was a thing that would increase the cost per ton D.W. and it was questionable if it would show a return for the outlay. The general question of independent pumps was wholly one of comparative cost, coal consumption, etc. What did it work out per I.H.P.? What was the return for the extra outlay?

Mr. W. GRAHAM said the author of the Paper had shown them that difference in first cost between the two systems of pumping arrangement was not very great. If that were the only difference he had no doubt the shipowner, necessary and avaricious though he was, would quickly go in for the independent pump, but he should like to emphasise the remarks of the two preceding speakers and ask Mr. Roberts for data to prove that in practice the independent pump was not more costly than the ordinary arrangement. At the same time, in endeavouring to get equally balanced cylinders they had to make due allowance for the engine which had to work the pumps. What should that allowance be? No one seemed to know. With independent pumps, however, they had no need to trouble about that problem. The three cylinders could be equally balanced and thus secure the maximum efficiency at the minimum cost. As against this, as he had observed, he did not think that separate pumps could work out as economically from the point of view of coal consumption and steam condensation — the something which had to go into the boiler to make up for that loss.

Mr. MASON said he had experience of both systems of pumps and he had come to the conclusion that the pumps off the main engine were more expensive to work than those working on the engine.

He did not agree with Mr. Roberts as regards the reciprocating pumps. Having had experience of them he was going back to the common or garden fly-wheel pumps. He thought they were more reliable and cost less for up-keep. With regard to Mr. Roberts' figures of the cost of supplying independent pumps, his information did not tally with the author's. For a set of engines indicating 1,500 h.p., the builders asked between £500 and £600 extra for the Weir pumps alone. He recalled two instances of pumps which practically ran on the vacuum. He had to alter the exhaust, and took the exhaust direct into the condenser from the circulating pump, but from Weir's feed pump he took it into the low pressure casing. There was a difference of 3 lb. per square inch when the cock was opened into the condenser and when opened into the casing.

Mr. W. SIMPSON expressed his preference for the pumps on the main engines. Mr. Roberts had stated that there was too much power for the feed-pump; well, this was easily remedied, either by taking out the ram or letting it run slack. He had had an ordinary compound running for eight years and he had only used one ram. The same thing applied to the bilge pumps. If they had all these extra-independently running pumps on a cargo boat it would mean an extra hand on board to look after them.

Mr. TOD said that with independent pumps less air was put into the boiler—a beneficial thing for the life of the boiler. In his opinion, broadly speaking, the sole duty of the main engine should be to drive the propeller.

After a few remarks from Mr. Cadogan and the Chairman,

Mr. ROBERTS, in reply, said while independent working pumps had been adopted for many years on passenger boats, where coal consumption was a comparatively minor matter, this was not the case with

cargo boats, so that it was difficult to procure statistics of fair comparison. He looked upon initial cost as part of capital invested, upon which dividends had to be paid, and the greater the general efficiency in working the boat the better the dividend. As to coal consumption, if the exhaust steam was properly utilised, the cost was not increased to any extent. If the quantity of steam which passed through the main engine remained the same after fitting independent pumps as before, they got more work on the propeller. If, on the other hand, they put the same work into the propeller, they saved a certain proportion of steam which they could devote to the pumps. Another thing, if they used the steam for their independent pumps, they could use it expansively, and this had been one difficulty which independent pumps had had to contend with. As a matter of fact, the expansion consisted largely of wire-drawing. The practical effect was that the pumps slowed down at the end of the stroke and settled everything very quietly, but it did not expand the steam to the fullest extent. In the case of a tandem compound pump they could expand the steam into the H.P. cylinder and exhaust into the L.P. cylinder; they thus utilised the exhaust, in which event there was decided economy. The actual difference by experiment between high pressure and compound pumps amounted to at least 30 per cent. in the cost of the steam. That was, more efficiency could be obtained out of the steam to the extent of 30 per cent. He was of opinion that a good deal of the corrosion of combustion chamber stays and plates was due to the air which was pumped in, owing to the high speed at which the feed pump was driven. As long as there was broken water—and there was bound to be with pumps driven from the main engine—a certain portion of air must get into the boiler, and, as had been pointed out, oxygen was a very active agent on steel plates. As to how he proposed to use the exhaust steam (replying to an interposing question of Mr. Reed), by the arrangement he had in his

mind, where the pumps were entirely independent, the exhaust pipes were led to a common exhaust connected with the feed-heater. The feed-heater was made of larger capacity so far as steam was concerned, because they were using steam at a lower temperature than the boiler steam. There was a series of switch-cocks, so that they could switch direct to the feed-heater, to the condenser, or to the atmosphere, to suit the circumstances of the case. If they made their surface large enough in their feed-heater they could not get back pressure. He quite believed that the same attention had not been paid to the development and improvement of the pump on board cargo ships that there ought to have been, and if the builders asked high prices it was the fault of their customers. Naturally the builders were not eager to discard their old patterns, but it was simply a question of supply and demand. Before the development of electricity it cost a small fortune to put a dynamo on board a ship, but at the present day the increased demand had resulted in the price being reduced to a reasonable figure. The same principle applied to the cost of pumps.

On the motion of the CHAIRMAN, seconded by Mr. DARLING, a cordial vote of thanks was passed to Mr. Roberts for his Paper.

A similar compliment was paid to the Chairman, on the proposition of Mr. GRAHAM, and the proceedings closed with the Chairman asking the Centre to accept an antique carved oak chair for the use of the President—a handsome offer that was enthusiastically taken advantage of.

PREFACE.

58 ROMFORD ROAD,
STRATFORD, E.

February 23rd, 1903.

A MEETING of the Institute of Marine Engineers was held here this evening, when a Paper by Mr. D. K. ROBERTS (Member), on "Independent Pumping Arrangements in Cargo Steamers," was read by the Honorary Secretary, in the absence of the author, and a discussion ensued. The various types of pumps referred to in the Paper were illustrated by lantern slides. The Paper was read at Cardiff by the author on Wednesday, January 28th, 1903. Mr. S. C. SAGE (Member of Council) occupied the chair this evening. The discussion was adjourned till Monday, April 6th, 1903.

JAS. ADAMSON,
Hon. Secretary.

DISCUSSION

ON

INDEPENDENT PUMPING ARRANGEMENTS IN CARGO STEAMERS,

AT

58 ROMFORD ROAD, STRATFORD,

ON

FEBRUARY 23rd, 1903.

CHAIRMAN:

MR. S. C. SAGE (MEMBER OF COUNCIL).

THE CHAIRMAN said that the subject should evolve a very useful discussion. It had engaged the attention of shipbuilders and engineers for many years, and he could remember thirty years ago seeing a good many sets of engines with independent pumps, and nothing on the engines but the shaft. He thought that was the proper arrangement. William Horne, who had charge of a large fleet of steamers, a very well-known man, and the inventor of the wooden ferrules for the surface condensers, and also the inventor of a complicated and peculiar expansion gear and valve, which, however, did not survive very long, was a very energetic man—like the present Mr. Holt—and was always devising something fresh in machinery. Some of his ideas were good, and some of the first attempts at surface condensing in this country were made by him. The Chairman stated he had personal knowledge of several of his ships fitted with independent engines for all the auxiliary pumps, the object being to work the pumps independently of the main engines. The author of the present Paper had spoken very pertinently of the

racing of pumps in a sea-way, with the accompanying shocks and blows to their parts, and some members present could speak of the great trouble and difficulty experienced in bad weather with pumps, especially in old ships with the bilge pumps. He would be glad to hear some of their members make a few remarks to open the discussion.

Mr. JAS. HOWIE (Member) said one could not but say they were in favour of what had been advocated in the Paper. He considered it would be better to sweep all auxiliaries from the main engines, and keep each one separate, doing its own work, which could then be gauged and adjusted. With independent pumps in use they would know better what the main engines were doing. With regard to first cost and upkeep, he did not think the upkeep would be a great expense to consider, but the first cost was a big matter to take into consideration, as the author had mentioned, and any additional heavy item of expenditure would probably not be accepted by the shipowner unless it could be proved that a monetary gain would accrue. In a passenger vessel where the price was not taken into consideration so much, and where the floor space was larger, the machinery could be distributed. He did not see why independent pumps should not be fitted in passenger ships, because the expense in those vessels, comparatively speaking, would not be so heavy, but he doubted whether separate machinery would be fitted in cargo boats. He quite agreed with the author in regard to the high-speed engine that the air pumps should be separate, also the circulating pumps. Bilge pumps had always been a trouble, and everyone would agree that a pump of some kind might be put to do all the work that the bilge pumps did. From what he had seen of them they did not require the packing and attention of main engine pumps, and they did the work much more efficiently. Taking the passenger ships and other more expensive vessels into consideration, he thought it would be the first step towards efficiency

and to the benefit of the engineers in charge. Also, it may be more economical in the long run. The machinery could be better attended to with comfort and efficiency by the engineers. But with the ordinary small cargo boat the shipowner takes into consideration the first cost; the difficulties of attending the working do not strongly appeal to him, and unless a good saving can be obtained he will stick to the pumps worked off the main engines.

Mr. W. LAWRIE (Member of Council) said that if they dealt with the subject in a general way they would probably be in agreement with the author—indeed, from an engineering point of view they could not very well contest what the author had said. He did not think there could be the slightest question as to the advisability of using for the boiler feed the independent pump, which was a much better pump in every way. It fed the boiler in a reasonable and proper manner. With the old ram pump attached to the engines, and the engines working at fifty to sixty revolutions, they worked with fair success, although they did lose a little water, which was often due to the careless way they were worked. It seemed to him that the independent pump would repay itself in a short time. Regarding independent air pumps, he thought that some members might be able to give some information on the subject. Personally he had not had the least experience with them. It was only when such changes were adopted that they began to find out the weak points, and that was the trouble very often with both shipowners and superintendent engineers. It was not only the question of first cost, but they knew perfectly well that with the first introduction of a separate pump there were a good many points which would not be foreseen, and which only experience would show. Consequently it was urged: "Let somebody else have the experience." If they were all shipowners he felt sure they would act in that way. So far as bilge pumps were concerned, they had all had

trouble with them. Still, it was an open question whether they would be much better off if they pumped with an ordinary independent pump from the bilges. Perhaps they would be in as bad a fix as ever. He agreed with the author that the independent engines were the correct thing, and it was only by close comparison that they could express an opinion as to which should be adopted. But, from the mere question of the convenience of everybody on board the ship, and for the better working of the engine, it seemed to him that the independent pumps were preferable. In the discussion at Cardiff a speaker referred to the centrifugal pump, and said that it required some alteration, but he had not told them what the trouble was. The question in his mind was more as to the air pump, and he hoped that some of the members had had experience and knowledge of the same, and could guide them a little in the matter.

Mr. G. SHEARER (Member), said he had had experience of all pumps separate from the main engines in the most modern ships, and he must speak highly of the air pump, which he considered was one of the finest adjuncts ever fitted for the marine engine. He was a strong advocate for all pumps being independent of the main engines. Only those who had had experience could quite realise the difference between the independent pumps and the pumps that were attached to the engine. With the independent pumps there was no trouble at all. The engines on his last steamer were over 15,000 horse-power, and at their highest speed the air pumps would never run over twenty-five strokes per minute. They were double pumps, something like those that had been illustrated on the screen, and were constructed by Messrs. Weir. Any man would find there was a wide difference between an air pump running at twenty-five strokes per minute and an air pump attached to the main engines when the vessel was in a heavy sea-way, racing and

driving and tearing everything to pieces. With regard to circulating pumps, the centrifugal pump had every advantage over the old circulating plunger pump. They had the advantage of running that circulating pump when warming up engines to get ready for sea, and they had also the advantage of it in cases of emergency, through the bilge injection, in the event of heavy leakage or the ship being flooded, as it could throw much more water than the old pumps. Speaking of bilge, or water-ballast pumps, there was a pump that he might mention, although he had had no practical experience of it. It was known as the drum pump, and was a cross between the centrifugal and the force pump. He believed the patentee was Mr. Johnson. He thought it would be a splendid pump for ballast work. It was a rotary pump, and, of course, there was always an objection to rotary pumps and engines. The fault with the drum pump was, so far as he could see, the wear on the sides or ends of the drum. They had never yet to his knowledge had anything to take up the slack or wear that took place between the two side covers and the drum. So long as that was tight they could keep the vacuum of the pump, but with the wear that went on in all cases the vacuum was lost to the pump to a certain extent, and there became a passage for steam into the rotary engine. He thought it was possible for it to be improved, either by packing or by allowing the sides to come together, and so to take up the wear. He supposed that most of them had had experience with separate feed-pumps. Weir's was certainly a splendid pump, and did good work with very little trouble. The Belleville was a good pump, and he had seen it do work that Weir's pumps would not, although Weir had improved his pump since. The Belleville was a much more simple and much cheaper pump.

Mr. W. LAWRIE asked whether there would be any reason against using independent air pumps on account of space occupied.

Mr. G. SHEARER said there was no more space occupied with the independent air pump than with the ordinary pump, and they could be placed anywhere. He would also keep the condenser separate from the main engine. He would have nothing on the main engine but the propelling power. He did not know the Line to which the Chairman had referred as having everything independent thirty years ago.

The CHAIRMAN said the Line he had referred to used to be called the Robinson Line, but it was really the Malcolmsons of Waterford. They built their own ships and they used to run round the coast and also to the Black Sea. Many of them were in the coasting trade.

Mr. G. SHEARER, continuing, said about the same date, thirty years ago, he saw two ships that had all their pumps independent. There was nothing on the shaft but the propelling engines. One was an American ship, the *New York*, and he did not remember the name of the other ; they ran between Sydney and San Francisco. The pumps were quite independent, and these were the first engines he saw with independent auxiliary gear. The combined air and circulating pumps, acting together on the same pump, had been used in many ships, but there was no advantage in this arrangement except possibly in first cost, and he preferred them to be separate. If there was any question that any of the members would like to ask regarding pumps he would be pleased to relate his experience in the matter.

The CHAIRMAN said he had known of several vessels fitted with the double-acting pump, one side air and one side circulating, and the sides of the condenser used to go out very frequently. With these pumps, as soon as the engine stopped they got the salt water through from one side to the other. He had been in favour of separate pumps for many years, and did not see that there could be any great objection on the point of economy in first cost. The

difficulty was to alter the type. Contractors had their typical patterns and did not care to alter them. He was of opinion that in all vessels that were subject to the racing of engines it was an important necessity that the pumps should not be attached to the engines, whereby they became subject to the fluctuation of speed. He thought it would not be taxing the mechanical ingenuity of designers to any extent to so arrange a set of pumps—air, feed, bilge, and circulating—that could be worked from an independent engine, and preferably into an independent condenser. Several years ago it was proposed to construct a salvage steamer fitted with twin screws, and to have a 20-in. centrifugal pump for salvage purposes, to be worked from the main boilers. It would have been a serious consideration as to the state of the boilers when the pump was used, as it would have taxed the boilers pretty severely to supply steam for the centrifugal engine when the other engine was at rest. According to the design suggested, but never carried out, the engine bed stood alone by itself, without the attachment of any details except the cranks, eccentrics, cylinders, and columns. The condenser also stood by itself, and there was to be a set of engines, compound, with the cranks at right angles, to work the air and circulating pumps from the piston rods of that engine, and the feed, bilge, and sanitary pumps from eccentrics on the crank shaft of the engine. Had that plan been adopted it would have proved to be not only a fairly economical engine to construct, but a highly economical engine to keep in working order. The pumps were designed to run at a moderate speed—from twenty-five to forty strokes per minute, according to the speed of the main engine. Of course, when the steamer had to go alongside a ship to pump her out, the auxiliaries would run just as if they were taking the steam from the main engine, instead of which she took the steam from the large centrifugal engine, and the condensed feed water went back into the boiler in the ordinary way. Referring to three steamers with which he

had been connected—the *Una*, *Aurora*, and *Paraguay* —these three vessels all had auxiliary pumps fitted, and although they were all jet condensers, the engineers were all unanimously in favour of them. There was no racing or thumping of the pumps and splitting of valves, but the main engines ran away as they liked and the auxiliaries ran gently. For twin-screw vessels he thought it would be far more advantageous to have for the double set of engines a good condenser and pump gear. One set would do for the two engines, and it would be economical. The risk of breakdown of the pumps themselves would be very small. For twin-screw ships one complete set of pumping and condensing apparatus would do for all purposes of navigation. He had had experience with several duplex pumps as feed, also acting as tank and ballast tank, pumps, and the amount of steam they consumed for the quantity of water they threw was abnormal ; also, they were not to be depended on for their strokes. His experience of the duplex pump was very unfavourable as compared with Weir's pump. With a compound engine connected with cranks at right angles with a rotary gear to drive the valves in the ordinary manner they had a simple engine that was understandable by them all, and he was sure it would be more economical, both as regarded first cost and in upkeep, as well as in steam consumption. He had a tracing of a design of pumps—air, circulating, feed, bilge, and sanitary—on the one shafting from a firm who made specialities of them in the north of England. The only alteration he had made was the addition of the feed and bilge pumps to the shaft. They warmed the main engine through, and the feed pump took the water away and saved the feed water that would be wasted unless provided with a tank for the large amount of water which went through the engines before working full speed. He had been in ships provided with feed tanks under the columns to take the drain from the engines, but before they got a revolution out of the engines, the tanks, which

were cumbrous things for the purpose, were overflowing from the drains. He thought the author was perfectly right in saying that much water was wasted, which, under a separate arrangement, was taken by the feed pumps back to the boiler again.

Mr. J. B. JOHNSTON (Member) said that no fresh water need be wasted; they could draw the water from the hot well when heating up the engines, and put it back into the boiler through the donkey pump. He would like to know the horse-power and the volume of steam required to drive the independent pump. Also, when the main engines were standing, where was the exhaust steam from the independent pumps going to? They could not put it into the main condenser, when the engine was not at work, as it would heat the main condenser. They knew where to find the valves in the ordinary feed or bilge pump, but some of the pumps that he had been with had a dozen different sorts, and it was like a clockmaker's job to find them, while the adjustment was so slight that the least variation would throw the pump out of gear. They must take into consideration the fact that they had a lot of radiation and condensing and no place to take their waste steam to. If they could get an arrangement to take away the exhaust steam it would be a first class system. He considered that the overhang of the levers would work the pump, the leverage was so great and the fulcrum fair. It was very seldom they saw in the racing of engines that anything carried away so far as the links were concerned. He had seen the spigot of the pump carry away, but found that to be due to a flaw in the metal. He believed in separate pumping engines if it could be proved that they were more economical both in regard to first and final cost than the usual style of working pumps.

Mr. G. W. NEWALL (Member) said that Mr. Johnston seemed to have an idea regarding the levers helping the pumps. He did not think that was possible. He thought the gist of the Paper

was a very good one, but he was of opinion that the author had not gone far enough from the point of the value of independent pumps to the shipowner. He considered that what should have been done would have been to make a comparison between useless strokes and revolutions on an average pump, working, perhaps, ten times the number of strokes it need do in order to accomplish certain work. If they could put the comparison into figures, so that the shipowner could see the amount of circumferential friction that took place in all the parts of the feed, air, bilge, and circulating pumps when fitted to the main engines, and show him that more value, with perhaps one-tenth of that friction, might be obtained, he might agree that first cost was not the thing that would frighten him. They wanted to point out to the shipowner that it was better to have a steady, easy-going pump, working at 20 to 30 strokes, instead of 65 to 100 per minute. The shipowner had not seen on paper what the author was trying to show.

Mr. W. McLaren (Member of Council) said that in his experience of the ships of the present day there was any amount of room in the engine room for the fitting of independent pumps, and he did not agree with the author when he spoke of there being so little room to spare. He did not think want of forethought attached to the shipowner so much as to the engine builder, who still stuck to his old style of pump while the specialist was going ahead. He was at one with the author regarding independent pumps, of which there were various makers on the market. There were one or two that the author had not mentioned, as, for instance, the Pulsometer Engineering Co's. Pulsometer, which was a quiet-working pump both for ballast and deck service. He had been shipmates with one, and he believed they were considered very serviceable pumps. He would like some information regarding the consumption of steam with independent pumps, as if they could get

that information it would be valuable to draw lines of comparison. Regarding the old wheel pump, the author did not seem to think that they were easily regulated. He did not care for them on board ship, on account of their knocking like steam hammers, so that they could be heard all over the ship. The direct-acting pump was much quieter; he believed they used much more steam than the wheel pump. The author had spoken of pumps fitted in duplicate, and used alternately, one on the outward and one on the homeward voyage. He would not care to run an outward voyage of any length on one pump and come home on the other, but would prefer to go in for shorter periods of service. The author also spoke of the revolutions of the ballast pump: he supposed he meant the strokes. Regarding the flooding of the bilges with the accumulation of condensed water at starting, he did not think that that was allowed at the present time, or that the engineer shut his eyes to it. He was of opinion that engineers were very careful of all the fresh water they could get; the general arrangement was to take it from the condenser direct. He would like the author to tell them at what temperature he was able to feed with the independent pump. He had been able to feed at a temperature of 210°; it was a question of the capacity of the pump to overcome the effects of the vapour.

Mr. P. SMITH (Member) said he agreed that the author might have gone a little further in the way of comparison of the various systems of auxiliary pumps. The trend of the Paper was to dispense with the whole of the pumps connected with the main engines and in that he was at one with the author. He agreed that they could be dispensed with, with the exception of the feed pump. There was considerable risk attached to the air pump connected with the main engine. Sometimes in starting the main engines he had known of several to smash up. The pump got charged with water, and even at sea he had known the same thing to take place, especially

when the ship was rolling heavily. Sometimes the pump had got no water, and at the next lurch of the ship got a full charge, which it was not easy to get rid of. With reference to the makers of pumps, Messrs. Weir and Messrs. Carruthers were looking to the future requirements, and were making preparation by building separate condensers and circulating pumps. So far as he could see the condenser and pumps were on the same bed-plate.

Mr. J. THOM (Member) said he did not see why the independent auxiliary pumps—circulating, bilge, and air—all connected together and driven by a compound or triple engine, should run any longer than those on the main engines, as the latter should be very much stronger to withstand the shocks they were subjected to. He certainly agreed it would be better from many points of view to have independent feed pumps, for feeding a boiler had to be done at as high a temperature as possible. There were many steamers now fitted with circulating centrifugal pumps, few indeed that were not. Some engineers found fault with them because they consumed a lot of steam, but he did not think they consumed more steam in comparison than some of the pumps that had been spoken of. They were on the same principle, only did not run so fast. He did not think there was much difference between high speed and slow speed so far as leakage was concerned; if anything, he would say that the slow speed leaked more than the high speed. Taking the average engine sent out at the present time to generate electric current, they could tell exactly what was being done; they could tell what the engine was doing to a nicety. Now, with their pumps and various other things on board ship, they were not able to tell what they were doing. He knew of an instance where separate pumps had been known to use 140 lb. of steam per I.H.P. per hour. That meant taking a great quantity of water out of the boiler to perform a small duty. These pumps would

not have taken so much steam had they been driven by the main engine. Regarding air pumps, he considered it was just as simple to arrange to drive them separately as any other pump. They were no freer from trouble and inconvenience when the pumps went wrong. He did not think the independent pumps were going to be any great benefit to engineers. He was certain that the pumps as now arranged took less power to drive than they would if driven separately. It would certainly cost more money to fit independent pumps in small steamers, and he would say that the pumps connected with the main engines were more satisfactory and less expensive. A frequent arrangement was to have two sets of pumps worked from the two engines, so that if one set went wrong the other set would be able to perform the duty. So far as the independent arrangement of pumps was concerned, what would be suitable for a small steamer would not be suitable for a large one.

Mr. W. LAWRIE asked what would be the difference in the loss of power of the independent pumps as compared with pumps worked from the main engine. The independent pumps could be made to do nothing but effective pumping, and he would like to know how much loss of power there was when the pumps were worked from the main engine.

Mr. THOM, in reply, said it would be necessary to have diagrams to show the difference referred to.

Mr. G. SHEARER said he considered there was very little loss with the independent pumps. The steam passing through those engines could be utilised for evaporators or the L.P. engine.

Mr. W. MCLAREN remarked that 20 per cent. of the breakdowns were due to the air pumps being connected to the main engines.

Mr. JAMES ADAMSON (Hon. Secretary) then read a communication on the subject from Mr. JOHN TOD (Member): "Being unable to attend the meeting at Cardiff in time to hear the paper on 'Independent Pumping Arrangements,' and considering it a most important subject, I venture to offer a few remarks. Mr. Roberts very truly says the requirements to be considered are reliability and economy in upkeep. I should like to see the coal economy with a comparative statement and the initial cost of both systems. I wish Mr. Roberts, or any other member of the Institute, could give us information on those points, as, for instance, the comparative cost of fitting all pumps independent of the main engine and of each other, also, all pumps coupled and driven independently, as I think from an engineering point of view it is generally admitted that it would be better if the main engine were used to drive the propeller only. It therefore becomes a question of cost with a tramp steamer to be able to run her year after year at a minimum of expenditure, and so enable her to compete with all comers and still be able to pay a good dividend. If any of our members have experience with all pumps driven independently, perhaps they will be good enough to give us the benefit of that experience. Many arguments might be raised for and against independent pumps. For instance, in favour, we have less varying strains set up in the propelling engine, and should anything go wrong with any one of the pumps they could be so arranged that it would be only necessary to stop that particular pump for repairs, and they could be run at a slower speed. Independent feed pumps I think almost a necessity with the high pressure now used, as by working them automatically the feed water would be delivered more regularly into the boiler; and by passing the feed through a heater it can be raised to a much higher temperature—due to the greater pressure in the heater—and less air would be forced into the boiler, which would tend to render the water non-

corrosive, and a better circulation would be maintained, and so in the long run economise in respect to delay and repairs. The only doubt in my mind is the initial cost, which would not be a large item when the demand became universal. Regarding the consumption, I feel sure that if a modern tramp steamer was fitted with three main boilers, each one available as a donkey boiler, and any two of them able to supply steam with ease at 200 lb. pressure, and carry, say, 160 lb. pressure on the H.P. piston, we would then never be troubled with the great variations in the pressure and temperature, but always be able to maintain 160 lb. on the H.P. piston watch after watch or throughout the whole voyage. One boiler could thus be open for cleaning and repairs at any time, while the donkey boiler as such might be dispensed with altogether, and I think, taking everything into consideration, we might work just as economically. However, if a tramp steamer was fitted with three main boilers, doing away with the donkey boiler, and only two used at a time, the main engines to drive the propeller only, the air and feed pumps to be convertible, and the circulating to be used as a ballast pump, etc., with careful design, we would seldom hear of a ship being stopped at sea through a breakdown of the main engines or pumps. We would also facilitate the discharge of cargo in harbour, and I think we should be able to pay as large a dividend if not larger."

Mr. W. E. FARENDEN proposed, and Mr. K. C. BALES seconded, that the further discussion of the paper be adjourned until April 6th. The proposition was carried unanimously.

Mr. JAMES ADAMSON remarked that by that date Mr. Roberts would be able to give them some further information, based on the questions that had been put by Mr. McLaren and others that evening.

Mr. J. R. RUTHVEN, in proposing that a hearty vote of thanks be accorded to Mr. Roberts for bringing such a valuable subject before the Institute, said if they made an effort to get some particulars of the cost of those different systems of pumping tabulated, they might be able to get a little nearer to a definite understanding and so make their discussion more valuable.

Mr. J. THOM seconded, and the vote of thanks was cordially agreed to.

A vote of thanks to the Chairman, proposed by Mr. J. B. JOHNSTON, seconded by Mr. WALKER, and carried unanimously, concluded the business of the meeting.

DISCUSSION CONTINUED

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, APRIL 6th, 1903.

CHAIRMAN:

Mr. WM. C. ROBERTS, R.N.R. (CHAIRMAN OF COUNCIL).

The CHAIRMAN: Before entering upon the further discussion of the subject for to-night, Mr. Adamson has a communication from the author of the Paper to lay before us, in reply to the discussion which took place at last meeting.

Mr. JAS. ADAMSON (Hon. Secretary): Mr. Roberts, the author of the Paper we are met to

continue the discussion of to-night, has been unable to attend, and has forwarded the following reply to the remarks made at the meeting when the Paper was read and in part discussed.

MR. D. K. ROBERTS in reply writes as follows :

"I have to thank the members of our Institute for the cordial manner in which they have received the Paper, and for the interesting discussion which it has evoked. I am pleased to see that in the general principle of independent pumps the members are practically agreed with me. As regards the question of first cost, this need not be so great as is apparently supposed by some, as we must deduct the cost of the original main engine driven pumps from our specification, and taking the ordinary type of engine for cargo steamers, this cost on a set of 1,000 I.H.P. may be taken at about £350 ; add to that the cost of the present ballast pump and feed donkey pump as now fitted, and a fair estimate gives £530 as the total cost of pumps. The cost of the installation proposed in my paper, as tendered by the pump makers (the figures are now in my possession), is £650, and allowing £100 for incidentals, the difference in first cost only amounts to £220, and this, in my opinion, might be reduced to less than £200. On the other hand, the engine builder who turns out a stock pattern asks a prohibitive price for any alteration on his standard specification, or the introduction of any speciality, and until the demand is greater I daresay this state of affairs will continue.

"As regards the I.H.P. absorbed by the pumps when driven from main engines, this depends greatly on the friction of the packing and the pressure applied to prevent leakage due to racing, etc., and it is evident that any extra pressure applied to the feed or bilge pump glands would act as a brake on the engine without increasing the useful work done, and this useful work can be done by about 30 I.H.P.

"The following figures are taken from a set of

independent pumps fitted to an engine indicating 1,100 I.H.P.:

	I.H.P.
Air pump (compound)	12
Circulating pump	5·4
Bilge pump	1·04
Feed duplex vertical	13·1
Total ...	31·54

which comes very near the theoretical amount required, while the advantage of having the pumps completely under control is worth a great deal. As regards the exhaust steam, this, in my opinion, is the crux of the whole matter. It has too long been the practice in fitting auxiliary pumps to allow them to exhaust direct into the condenser, and it will be clear to anyone who gives the subject the least consideration, that high pressure steam exhausted into the condenser, where we have to expend power in cooling it, lifting out of the condenser and pumping it back into the boiler, is waste of the most obvious kind.

"What I suggest is that this exhaust steam be utilised for feed heating, not by fitting an ordinary feed heater where the surfaces are too small to utilise the heat, but to fit a large heater where the feed water would practically condense the exhaust steam (although there is no necessity to maintain a vacuum in this heater), and heat the feed water to the highest practicable temperature. The pumps referred to in my Paper will pump feed water at a temperature of 210° easily, provided there is no necessity to *lift* the water, or, in other words, that it drains naturally to the pump.

"The question of coal economy depends, of course, on getting the greatest possible amount of heat from the steam, and I maintain that the independent pumps, by eliminating the enormous amount of friction, and avoiding the waste of useless work done by main engine driven pumps, tend towards the

economical working of engines and boilers. The difficulty of putting this clearly and comparatively lies in the fact that very few cargo steamers are fitted with independent pumps, but the results obtained in the large passenger steamers show that they have all the advantages of freedom from breakdown and efficiency in working.

"As regards the various types of pumps, I have only shown a few as examples. There are many on the market, but it is not always the cheapest pump that is the most economical. If the demand for good pumps increases, there is no doubt the makers will produce them at a reasonable rate.

"I should like to point out that not much alteration would be required on engine patterns in fitting independent pumps, as all that is required is to remove the lever bracket and the flanges on condenser to which the present pumps are attached, and the space can be utilised in such a way that no more room is occupied, or very little more, than with the present arrangement."

The CHAIRMAN: These are very pertinent remarks of the author in connection with the discussion. I am pleased to see Mr. Latta present, he will probably be able to give us a large amount of information on the subject.

Mr. J. G. LATTA (Member): I quite agree with the author that it is of great advantage with the present fast running engines and high boiler pressures to have all auxiliaries separate from the main engine. This arrangement is quite familiar to me, and is becoming much more general; it gives the main engines greater elasticity when only driving the propellers, and consequently much greater freedom from breakdown. A few years ago it was the general practice to drive all pumps from the main engines by means of levers, as described by the author, but at present few ships are built—and the number is

getting less—where independent feed and circulating pumps are not fitted. I can remember when only large mail steamers had these separate auxiliaries, but now the tramp of 2,000 I.H.P. and over has also adopted both separate feed and circulating pumps, and before long I feel certain the smallest ships will also come to see the wisdom of following the same practice. Regarding the type of pump, there can be no difference of opinion. As boiler feeds the direct-acting single pump of the "Weir" type has practically claimed this field as its own, and it is now the exception to fix duplex or crank shaft pumps for this purpose, but there must be another reason why the "Weir" pump is so much favoured, and no doubt this is because this pump has been designed and built on first-class lines and maintains its reputation by adhering to the highest standard of workmanship and material. The author raises the vexed question of steam consumption, and as there seems to be some difference of opinion regarding the consumption of a pump of this description, why, I do not know, I may say that every sea-going member can easily test it for himself by exhausting the steam used in driving the pump into the water to be pumped, and measuring the difference in temperature. Taking a job of 2,000 I.H.P., and 15 lb. of water per I.H.P., 180 lb. boiler pressure, and adding 5 lb. to the pump discharge, this gives:

$$\frac{30{,}000 \times 427}{60 \times 33{,}000} = 6{\cdot}47 \text{ H.P.}$$

Not a large amount, but still less if you exhaust the heat used into the feed heater to heat the feed water. To feed the boilers, allowing 65 lb. of steam per H.P., this gives 420·5 lb. per hour. The calculation then becomes:

Steam used in main engine	...	30,000 lb. per hour
Steam used in feed pump	...	420 ,, ,,
Total per hour	...	30,420 ,, ,,

Condenser temperature 120 deg.
Total heat supplied to feed pumps
per hour, 420 × 1,229 ... ... = 516,180 units
Heat used in work done,
6·47 × 42·75 × 60 = 16,590 ,,

Heat units available for feed heating 499,590 ,,
The temperature of the feed then becomes :

$$\frac{(30{,}000 \times 120) + 499{,}590}{30{,}420} = 134{\cdot}7 \text{ deg.}$$

In this case, by returning the heat not used to the feed water we only lose 16,590 B.T.U., which is absorbed in work done, the remainder of the heat going to raise the temperature of the feed water from 120 deg. to 134 deg. From these figures it will be seen that the feed pump as usually fitted on board ship is not the steam waster so many engineers assume. The author proposes to compound the feeds, but there is so little to save that even his 30 per cent. does not make it worth while, in my opinion. Of course we make a great many compound pumps, but chiefly for electric stations, where the economy is not nearly so great as on board ship. The next most important point is the cost, and Mr. Mason, of Cardiff, gives a figure for a 1,500 I.H.P. job to fit a "Weir" pump as between £500 and £600. I am sure Mr. Mason is mistaken in this estimate, as half the sum named would be more reasonable, or it may be he refers to a pair of Weir's pumps, with complete gun-metal water ends and a "Weir" heater. A builder might ask such a sum as Mr. Mason suggests, but the arrangement for a cargo steamer is extravagant, and seldom used. Regarding the separate air pumps advocated by the author, my firm have a great many of these working and at present on order, but we recognise that the expense is so great in fitting them to small jobs, and especially of the cargo boat class, that it is impossible to advise the use of them unless in special cases. As we think separate air pumps have

many advantages over the air pumps at present fitted, we have designed a new type of condenser with separate air and circulating pumps. In this arrangement the air and condensed water are dealt with by two separate pumps. That is, the air pump works as a dry pump dealing only with the air from the condenser, and a separate pump is fitted to deal with the condensed water. This pump is controlled by a float placed in the bottom of the condenser which regulates the speed. The separate air pump we place on top of the circulating pump cylinder, so that by starting the circulating pump the air pump is also started. This gives a great advantage in heating up the engines, especially for ships with frequent stops and starts, as the condenser is always kept clear of water and the vacuum is maintained during the time the main engines may be stopped. It also makes a much cheaper, lighter, and very efficient plant. At present we have a good many running and giving great satisfaction. I am sorry Mr. Shearer is not here to-night. At the last meeting on this subject he made a statement that I should like him to amplify. He said that in his experience the Belleville pump would do work that the Weir pump would not. I should like to know what that work was. I know of many Belleville pumps being fitted to feed Belleville boilers, but so far as I know many of these have been removed and the Weir pump substituted. I do not know of any Weir pump being removed and Belleville being fitted. I notice that the author makes a suggestion to fit direct-acting instead of the ordinary centrifugal pumps for condenser work with the idea of saving steam. My opinion is that you cannot get the direct-acting pump to do the work so well and so quietly, without any shocks on the tubes, as a centrifugal pump. The centrifugal pumps run very well without any air, whereas the direct-acting pump will not. That air will pass into the condenser and you will get banging, split tubes, and leaky condensers. The saving in steam consumption is so slight that I

would prefer the centrifugal to the direct-acting pump.

MR. J. THOM (Member) was much more in favour of fitting independent pumps than when he spoke at the previous meeting. Since that meeting he had considered the average style of pump on the market. When they made up their minds to have independent pumping machinery, by all means have it, but probably the cost would be about as much again as for pumps driven by the main engines. In passenger boats the pumping arrangements would be very different to those fitted in cargo boats. The man who built cargo boats picked out the cheapest method to a very great extent, and the price of the article finished and ready to do the work was a consideration never lost sight of. To introduce independent pumps without due consideration would be very wrong. He did not think there were many steamers—even cargo boats—that had not one or two independent pumps; these independent feed pumps were absolutely necessary to save corrosion with high pressures. In bygone days the pressures were much less, and independent feed pumps were not so necessary. With regard to circulating pumps, he considered the centrifugal style of pump would be very satisfactory, and he had no doubt it would be very beneficial in any class of steamer. He had heard it said that a direct-acting circulating pump gave a better vacuum than the centrifugal pump. He believed that a great many of H.M. ships did not have independent air pumps. Many were fitted with them, but many were not. Air pumps get very rough usage when on the main engines with an improperly constructed condenser, as when the vessel rolled heavily the pumps got the water at intervals and in gulps, which is the principal cause of breakdowns in air pumps. Such, however, could be cured, or at least lessened, as the water in the condenser might be directed to prevent an overcharge to any great extent, or the foot valves might be regulated so that only a certain amount of water could get through

into the pump. If due consideration were taken regarding the fitting of independent pumps it would, from the engineer's point of view, be a great gain in many ways. Most engineers took a great pride in their engine rooms, and they were always on the look-out for improvements, and he thought it very desirable that those in charge of large numbers of vessels and large numbers of men should consider the desirability of adopting such improvements as were discussed from time to time.

Mr. W. E. FARENDEN (Associate Member) remarked that the author had confined himself to advocating independent pumps for the ordinary cargo "tramp" steamer, but it was very doubtful whether they would be fitted, owing to the first cost, which was a big point to take into consideration in that class of vessel, where this question had to be so closely gone into. From the figures given them that evening it was shown that the first cost of fitting independent pumps would be fifty per cent. more than for pumps driven by the main engines. He quite agreed with the author in regard to the fitting of independent feed pumps. They should be of the direct acting type, of slow speed, fitted with automatic controlling gear. The slower and more regularly the feed water was supplied to the boiler the greater would be the efficiency. He was also quite in agreement with the many points put forward by the author against the air pumps being worked off the main engines. There was considerable risk in starting, in consequence of the pumps getting over-charged with water, and also at sea, in heavy weather, when the engines were racing, thus causing serious strains. He did not think, however, that it would come to fitting two single-acting air pumps in tramp steamers, unless a considerable saving could be shown over the air pump worked from the main engines. At the previous meeting on the subject, several members had spoken in favour of independent air pumps, working at about twenty-

five strokes per minute, which overcame the difficulties that the air pump worked from the main engines had to contend with. He would like to know, however, if the author, or any member, could give him the consumption required in pounds of steam per I.H.P. per hour for that class of pump, and also whether they were costly or otherwise in upkeep. He had heard that independent steam driven air pumps were rather uneconomical with small engines, and that they required from 30 to 40 lb. of steam per I.H.P. per hour with short stroke. Perhaps Mr. Latta would kindly inform them on that point. He was pleased to note the cost of independent pumps compared with pumps driven from the main engines, and understood the difference to be £220 against the independent pumps for a vessel with engines of about 1,000 horse-power.

Mr. W. McLAREN (Member of Council) was quite prepared to accept the opinion that independent pumps were the proper things to have on board any steamer, especially a cargo boat. He considered the engine-builder was the cause of the present system that prevented them getting the most efficient pumps.

Mr. S. C. SAGE (Member of Council) reiterated the opinions he had expressed at the previous meeting on the subject and as to the advisability and desirability of having all the pumps working separately. He quite agreed with Mr. McLaren as to the engine-maker being the principal stumbling-block in the way. The engine-makers objected to making alterations in their pattern, type, or style; otherwise he did not see any reason why an independent set of pumps for a cargo steamer should cost more than the usual arrangement. One of the builders of tramp steamer engines had within the last twelve years been making the condenser body of wrought steel instead of the cast type fitted on the bed-plate. He thought it would not be more expensive to simply erect the main engines and foundation

separate; the condenser, feed, bilge, air, and circulating pumps, which might also serve for the ballast tanks, could be worked by a separate compound engine at a slower rate of speed. He could not approve of the duplex pump for ordinary pumping purposes. He had never been at sea with centrifugal pumps as circulators, but he had been with plunger pumps of both horizontal and vertical type, and even with light ships and engines racing in a sea-way they did their duty very well. For the cargo steamer he did not think they would make any improvement in regard to first cost, up-keep, and general maintenance by substituting the centrifugal pump for the ordinary vertical double-acting pump of good design. Few cargo steamers were fitted with centrifugal pumps, and it was quite common for engines to have single-acting circulating pumps discharging the water through the condenser instead of, as formerly, sucking it through.

The CHAIRMAN asked whether any member had had any experience with the Edwards air pump.

Mr. JOHN MCLAREN (Member) said he had taken out two new cargo steamers fitted with the Edwards pump, and so far as his experience went they worked well. They only needed one new valve in six months. The cost of the up-keep was very little indeed, and there was no trouble to speak of. One of the advantages of the independent air pump was that it allowed them to keep the main engines free for working when entering and leaving dock.

Mr. LATTA regretted that he had not the figures with him relating to the consumption of steam required by the independent air pump, but he would be very pleased to supply them. He had records of several air pumps, and those pumps required a very small proportion of the total power developed, something like $\frac{1}{4}$ of 1 per cent. There was no doubt that independent air pumps cost more than the ordinary air pumps, but for certain types of vessels

the advantages were certainly very great. When entering or leaving dock it was very good to know that the condenser was always clear of water, and that they had a 26 in. vacuum. The engines were always easily started when the air pump was independent.

Mr. SAGE stated that he had got out a project some years ago for a separate condenser with compound engine complete with all the pumps attached. All the barrels were of brass, and the feed pump boxes were also of brass, and the contract price complete was less than £400. The combined power of the engines for the twin screws was to be 100 N.H.P. It was to work at a fixed rate according to the circumstances of the moment, and the maximum number of revolutions was to be forty per minute. He had mislaid the tender and tracing, but hoped to be able to bring them and show the design later on.

Mr. JAMES ADAMSON (Hon. Secretary) said he agreed in the main with the author in his advocacy of independent pumps. There were, however, several points in the author's Paper that he did not quite follow. With regard to the tons of fresh water referred to by the author as being lost every time the main engines were started, surely even the cargo steamers of to-day were so furnished with pumps that they could almost entirely overcome that, and save the fresh water from going to the bilges. He thought that nowadays most condensers were fitted with a connection to the donkey pump, so that the condenser could be drained whilst the engines were being heated up. With regard to the question of space occupied, many cargo steamers had a great deal more space to spare in the engine rooms than passenger vessels, and he did not think there would be any difficulty on that score. Of recent years the old type of condenser had been disappearing, and now they had a condenser that was separate from the main engines in a sense, inasmuch as it was built of steel or malleable iron and placed apart from the main

engines. That was a good step in the right direction. One or two steamers that he had recently seen had independent circulating and feed pumps, and also a few vessels with separate bilge pumps, but with the air pump attached to the main engines. He had knowledge of several air pumps of the Edwards type which had been working for some years, and had done their duty, giving very little trouble. He had advocated for many years and was strongly in favour of having a separate auxiliary condenser, so that the winches and other auxiliaries could exhaust into that condenser and so save all the water that would otherwise be lost when the vessel was in port. The old exhaust tank ought to be a thing of the past. He had seen several auxiliary condensers such as he had mentioned fitted in steamers twelve or thirteen years ago; these had cost very little indeed for repairs or renewals. In those vessels the whole of the auxiliaries—the winches or hydraulic engines, refrigerating and electric plant—exhausted into the auxiliary condenser, which was extremely valuable in port, or when entering or leaving port. He considered the auxiliary condenser was a good adjunct to both passenger and cargo steamers, and it paid for itself with interest, which was one of the main points brought forward by Mr. Roberts. With regard to the frequent breakdown of air pumps mentioned by the author, he did not know why an air pump should break down so frequently as one would infer from the Paper. He had not heard of many such accidents in his experience, and he knew of no reason why the air pumps should frequently break down in cargo steamers, and if there should be any reason it would be of interest to know it. Speaking of exhausts, he thought it was the practice for some of the auxiliaries to exhaust into the main engine receiver while under way, a plan for carrying off the exhaust which overcame the difficulty at sea referred to by Mr. Roberts, while the auxiliary condenser served the purpose in port.

The CHAIRMAN said they were much indebted to Mr. Latta for the information he had given them. It was a truism that there was nothing new under the sun. When he first went to sea, thirty-eight years ago, they had such things as independent pumps driven by independent engines. They had independent air, circulating, feed, and bilge pumps in the year 1865. That was a long time ago, and he could tell them that they found those independent pumps very useful, for they always had their condenser clear. Another advantage was that the main engines were ready to start as soon as they gave them steam, so they would see the idea of independent pumps was not new. There was not the slightest doubt that they were a great advantage, especially nowadays, when the pressures were so high and the pumps had much more work to do, and had to work at a much higher speed. He had no doubt Mr. Roberts' paper would be very valuable to the members.

Mr. J. B. JOHNSTON proposed, and Mr. W. MCLAREN seconded, a vote of thanks to the Chairman, and the proceedings closed.

Mr. D. K. ROBERTS in reply writes as follows:

"Referring to the adjourned discussion on 6th April, I note that Mr. Latta confirms my assertion that the independent feed pump is economical in steam and gives good results in practice.

"I hold no brief for the Weir pump, but can endorse his remarks as to design and workmanship. There are, however, other pumps on the market which are equally well designed and constructed, into the merits of which I do not propose to enter, but would leave the members to make their choice, judging by their own experiences.

"As regards the separate condenser with dry air pump, etc., I am aware of this arrangement, which has been in use for some time in land installations, and have a drawing of this which I might have

shown. The arrangement is good, efficient and economical, but the circulating pump can hardly be utilised on board ship as a ballast pump, and this is rather against it, in my opinion.

"As regards the use of direct-acting pumps for circulating, Mr. Latta assumes that the pump will be required to drive the water through the condenser, with risk of causing leakage. In my opinion, it is quite feasible to arrange the direct-acting pump to draw the water through the condenser and discharge overboard.

"The objection he offers to direct-acting independent pumps applies equally to reciprocating pumps driven from the main engines. As regards the Edwards air pump, this, in my experience, has worked very well when driven from the main engines, and can easily be adapted for independent driving; and I have no doubt an arrangement could be fitted to work one independent Edwards pump instead of the arrangement of two single-acting ordinary type.

"In reference to the loss of water when starting, very few of the engine builders who turn out a stock pattern fit a connection to the bottom of the condenser and a feed donkey pump. They do connect this pump to the hotwell, but it is obvious that when the air pump begins to lift the water quickly from the condenser, as in starting engines, the donkey pump is unable to clear it away, and the overflow means serious loss.

"It seems to be generally agreed by the members that independent pumps are desirable. The sum of the whole matter appears to be that we must utilise the heat of the exhaust steam, preferably for heating feed water, so as to obtain the greatest economy, otherwise any system of pumps which exhaust direct into the condenser will be wasteful and expensive.

"The details of the system ought to be modified to suit each case, and the exercise of a little care and consideration will give ample return for the slightly increased first cost."