INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1903-1904.

President—SIR JOHN GUNN.
Local President (B. C. Centre)—LORD TREDEGAR.

Volume XV.

ONE HUNDRED AND TWELFTH PAPER
(OF TRANSACTIONS).

AUXILIARY PUMPING MACHINERY ON BOARD SHIP,

WITH SUGGESTIONS FOR ITS IMPROVEMENT.

BY

STEPHEN HARDING TERRY (MEMBER).

READ AT
58 ROMFORD ROAD, STRATFORD,
ON
MONDAY, SEPTEMBER 14th, 1903.

DISCUSSION CONTINUED
MONDAY, OCTOBER 26th, 1903.

READ AT
3 PARK PLACE, CARDIFF,
ON
WEDNESDAY, NOVEMBER 25th, 1903.

PREFACE.

58 Romford Road,

Stratford.

September 14th, 1903.

The opening meeting of the Autumn Session of the Institute of Marine Engineers was held here this evening, when a Paper by Mr. S. H. Terry (Member), on "Auxiliary Pumping Machinery and Suggested Improvements," was read and discussed. In the unavoidable absence of the author, the Paper was read by the Hon. Secretary. The chair was occupied by Mr. W. C. Roberts (Chairman of Council). It was announced that, although Mr. Terry was unable to attend this evening, he hoped to be present when the subject was further discussed.

JAS. ADAMSON,

Hon. Secretary.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1903-1904.

President—SIR JOHN GUNN.

Local President (B. C. Centre)—LORD TREDEGAR.

VOLUME XV.

ONE HUNDRED AND TWELFTH PAPER OF TRANSACTIONS.

AUXILIARY PUMPING MACHINERY ON BOARD SHIP,

WITH SUGGESTIONS FOR ITS IMPROVEMENT.

BY

STEPHEN HARDING TERRY (MEMBER).

READ AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, SEPTEMBER 14th, 1903.

DISCUSSION CONTINUED

MONDAY, OCTOBER 26th, 1903.

READ AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, NOVEMBER 25th, 1903.

THE author of a recent communication on this subject (Mr. Roberts) has given us a very valuable paper dealing with the efficient arrangements of auxiliary pumping machinery. It is now many years ago (May 19, 1880) when in a contribution in the pages of the *Engineer* on this subject I first committed myself to print, my text being the foundering of the Union Line ss. *American* (see Appendix).

In that letter (the substance of which is here submitted to the meeting) the folly of entrusting the safety of a ship of some 2,000 odd tons to hand pumps is sufficiently set forth. A further correspondence, some portion of which is herewith included, took place in the pages of the *Engineer* on June 4 and July 2, whilst the *Engineer* thought the matter sufficiently important to base a leader on this correspondence on June 25, 1880, page 461. Again, on the occasion of the loss of the *Teuton*, on November 4, 1881, *Engineering* published the first of a series of letters of mine, whilst on page 135 of volume 33 of *Engineering*, for February 10, 1882, a leader based on my letters was published. And in the *Newcastle Chronicle* for November 5, 1881, a leader written by Mr. Clark Russell, based on the figures I put before him, entitled "How and Why Steamships Founder," was also published.

At and about the period alluded to it was quite unusual to find any independent steam pumping arrangements beyond ballast tank pumps even in the largest mail steamers. It seemed to me at that time an absolute and criminal absurdity that a vessel of several thousand tons register and several thousand horse-power should be allowed to founder by the admission of a few hundred tons of water per hour, when the provision of efficient pumping machinery, requiring no more than 10 horse-power, would keep her afloat for an indefinite period. In several wrecks, *Clan Macduff*, *Bristol City*, etc., which took place about twenty years ago, accompanied by great loss of life, it was usually a stock phrase that the crew and passengers worked at the hand pumps until they dropped exhausted.*

* And even to-day, since this paper was written, viz., in the present month of October, 1903, we read that in the collision between H.M.S. *Hannibal* and H.M.S. *Prince George*, the latter vessel was kept afloat by the crew of both vessels working the hand pumps of the *Prince George*.

It fell to my lot to criticise these arrangements for removing bilge water as commensurate with the watering of greenhouses or the washing of decks, but as wholly inadequate for the efficient removal of such portion of the Atlantic or Pacific Oceans as had, through faulty construction, defective design, or careless seamanship, been permitted to stray within the vessel.

At the time of which I speak the "centrifugal pump" was but little known on board ship. Throughout the length and breadth of the United Kingdom there were but two or three firms that made these pumps: Messrs. Gwynne & Co., of Essex Street Works, of London; and Messrs. John & Henry Gwynne, of Hammersmith, and one or two others. I well remember in those days, when I was engineering inspector at the Local Government Board, being called on by Mr. John Gwynne, in order to ask my permission for the reprinting of my letter on the foundering of the *American* in his catalogue. Feeling sure that in this way the arguments I set forth for the adoption of potent pumping machinery would reach a larger public, I assented.

At that time I took great trouble to put these facts before the principal shipbuilders and owners of this country, and before the technical advisers of Lloyd's Registry of Shipping. In this matter I received considerable assistance from a man who was the great friend of all "who go down to the sea in ships," and who became a dear and valued friend of mine, the late Benjamin Martell, for many years Chief Surveyor of Lloyd's and Member of the Council of the Institution of Naval Architects. I also received much help and encouragement from the late Mr. Reid, assistant to Mr. Martell, and Mr. Cornish, who was then assistant and has now succeeded to Mr. Martell's position at Lloyd's. Although I do not claim that my suggestions thus put forward led up to the present condition of things, I have at least the satisfaction of knowing that I suggested the general adoption of centrifugal pumping machinery, and that its general adoption in all large, and even in small, vessels is now universal; and that whereas at that time centrifugal pumping machinery was only made by two or three firms, there are now at least a dozen engaged in its manufacture.

In a paper* which I wrote for Mr. Samson Barnett, which was published by him in his Catalogue of the Submarine Exhibition held at the Agricultural Hall in 1882—which was followed by another exhibition, entitled the Metal Trades Exhibition, in 1883, both of these exhibitions being epoch-making in improvement of auxiliary machinery, steam steering gear, and improved appliances on board ship—I dealt with the all-important subject of the proper number of bulkheads and their construction and stiffening, as also with the proper provision of suitable centrifugal pumps provided with efficient suction and discharge pipes, and it is on this latter point that I have something to say now.

It is satisfactory to realise that any British-built, well-equipped vessel of over 1,000 tons, and many of much smaller size, are now almost certain to be fitted with centrifugal pumps; but I regret to have to state a fact that is well known to most of us, that either from motives of false economy, from ignorance, or from a supposed or real lack of space, the suction and discharge pipes and valves of these pumps are often too small in diameter, too lengthy, too complicated, and have frequently far too many abrupt turns, angles, bends, and unions for the efficient passing of so weighty a liquid as water at high velocities.

Long ago I pointed out that to be really efficient in the event of the flooding of the engine-room, or compartment in which the centrifugal pump was situated, it would be necessary that the pump should be placed sufficiently high to enable it

* Entitled "The Foundering of Steamships and how to prevent it; or, Design and Equipment *versus* Insurance."

to continue working when the main engines were already drowned out. This, of course, would require the provision of an efficient foot valve, to enable the centrifugal pump to hold its water when standing; and it is, of course, also of great importance that the donkey boiler be so placed that the fire should remain alight after the main boilers are drowned out.

Only in a very few ships are these points attended to, yet they are of vital importance if the full advantage of the presence of a centrifugal pump capable of removing 1,000 tons of water an hour is to be secured.

From a navigation point of view, and to avoid swamping boats when the emergency pumps are running, I have always felt that something less crude than the mere hole by which the condensing water and discharge from the emergency pumps are emitted should be provided. We must prevent all less carefully handled shore boats, or even the ship's own boats when alongside, during the slow moving of the engines, or during the running of the circulating pumps preparatory to starting the main engines, from the risk of being nearly swamped by the discharge of cooling or bilge water at this opening or openings. I am convinced that the proper practice would be to deliver such water overboard at or below the water line through a syphon. This arrangement has been done for years with closets; surely it is about time it was done with condensing water.

I am sure I am appealing to the feelings of all present when I say that the reduction of noise and vibration in an engine-room is of utmost importance, not only for the comfort, nerve-power and endurance of those whose duties keep them there, but for the general success and good character of the ship from a passenger's point of view; and I have often felt that the talent and skill displayed by the designers, supported by the ceaseless care of those in charge of the main engines to render them free from offensive vibration and knocking, is rendered futile by the abominable noise made by some small undersized centrifugal pumping engine running beyond its proper speed, because for purposes of economy (?) its disc is too small to give the proper peripheral velocity without excessive speed. I once took the late Mr. Frank Marshall into the tunnel of an Atlantic greyhound to see a certain type of single-acting engine running. He complained that as it was not running I was wasting his time. We stood by it and turned on a light, and found it, by pocket speedometer, to be running 450 revolutions without a sound or vibration. It is here that the advantages of the single-acting engine comes in. This engine, originally made by one or two firms only, and non-compound and wasteful of steam, is now made as economical as any other type, while engines of this construction made by a number of firms run with absolute silence.

I should have been glad to have made this paper much more full of detail and less retrospective, but it has been written against time; and I trust that, when read at the meeting, it will produce an instructive discussion, at which I have every hope and intention of being present.

I regret that through absence from the neighbourhood of London I am unable to read it myself. I have no doubt, however, that it will be well put before you by the Hon. Secretary, who kindly offered to read it in my absence.

I have made some suggestions as to suction and delivery pipes, and the necessity for avoiding unnecessary resistance to the flow of water; I will now say a few words on the steam connections—a matter of the greatest importance to all auxiliary engines. In the April number of *Fielden's Magazine* for 1901 an illustrated article of mine, entitled "Steam Pipes Ashore and Afloat," was published; and in this article I showed some of the dangers which arise from badly designed steam-pipe connections to auxiliary engines. To ourselves the necessity for providing dry steam is apparent, but to the draughtsman this matter is of secondary importance, as it sometimes seems to be also to the consulting engineer or naval architect.

Having taken steam from the highest part of the boiler, the next thing to do is to take your pipe up to summit level at once, and let there be a fall which never becomes a rise between that point and the pumps; due consideration must be given also to the provision of this in such a way that even with a considerable list there shall be no ponding up of the water of condensation.

Some designers seem to think that steam and water can advantageously fight their way in opposite directions in the same steam pipe; they cannot. Wherever possible, let the last two or three feet of steam pipe be vertical; coming downwards, let this pipe be continued straight down past the stop valve, which may lead off horizontally to the engine steam chest.

If water be present in the pipe either as drops, as a stream, or as slugs, it will nearly all shoot past and away beyond the horizontal opening leading to the engine, into the prolonged vertical pipe, which, if somewhat enlarged and fitted with a valve or cock, will serve to drain away the water from the steam most efficiently, and so one source of noise and breakdown will be eliminated.

There are, of course, a number of water separators, some costly, some cheap, some efficient, and some not worth the space they occupy or the weight they displace. The great point to remember in designing a separator is that water, being heavy, acquires momentum, and tends to shoot past openings through which steam, being light, flows easily. Many water separators are constructed in ignorance of this principle.

Another point to remember in regard to auxiliary steam pipes is not to make them too large. A small pipe well lagged and protected at the flanges will give much more satisfactory steam supply at the end of 100 ft. length than a badly drained unlagged pipe of twice the area; and in the case of the smaller pipe, the steam velocity will keep the water moving and will not allow the accumulation of those dangerous slugs which burst cylinder covers, break piston rings, and generally damage engines, besides being responsible, when coming in moderate quantities insufficient to cause breakdown, for a lot of unnecessary noise in engine-rooms. At the discussion I hope to have more to say on this point, and also on the arrangement of special pumping machinery combined with ventilation, as fitted throughout the fleet of the Shell Transport Company, of which the Lord Mayor of London is chairman, the arrangements having been schemed out by Sir Fortescue Flannery, M.P., and myself, and patented in our joint names in 1893, although we had fitted this arrangement experimentally at a prior date, the first vessel so fitted being the ss. *Murex*. The result effected by the system being that, whereas the insurance on oil boats was once as high as 14 per cent., it is now below 2 per cent., and explosions or fires in vessels fitted with the system are unknown; besides which, the freedom from obnoxious or explosive vapours and from moisture enables cargoes of special quality, such as rice, coffee, tea, tobacco, and spices, to be carried in the same holds which a few hours earlier held oil.

A description of this system formed the subject of a paper written by me in the joint names of Sir Fortescue Flannery and myself, and read by me before the Southampton meeting of the Institution of Naval Architects at their summer session in 1894, with Lord Brassey in the chair, on which occasion the late Sir Edward Harland, the late Mr. Martell, and Sir John Isaac Thornycroft all spoke on the merits of the system.

An illustrated article on this system appeared in *Cassier's Magazine* for November, 1899, and I also read a paper on this subject before the Shipmasters' Society in the Hall of the Chamber of Commeree, on January 20th, 1898.

DISCUSSION

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, SEPTEMBER 14th, 1903.

CHAIRMAN:

MR. W. C. ROBERTS (CHAIRMAN OF COUNCIL).

THE CHAIRMAN, in inviting discussion on the subject, called on Mr. Shearer to open.

Mr. GEORGE SHEARER (Member) said: I quite agree with the author in respect to his pumping arrangements, and also with his remarks regarding steam pipes. I think that for many years all, or at any rate most, ships were badly supplied with auxiliary pumping gear for use in case of stranding or accident or heavy leakage. The best principle that I have seen is that carried out in the modern cruisers and battleships. On those vessels a main is fitted running right from forward to aft. In the larger class of ships these mains run to something like 18 to 20 in. in diameter. That diameter is, of course, above the size required for the ordinary merchant steamer, although in the larger cargo and mail steamers I do not think it would be much out of place even to have a main of that size. The valve connections to the main drain, which runs fore and aft, are taken up to the main deck. There is an ordinary valve for each compartment. Consequently, if any of the compartments become flooded where it is not possible to get below, anyone has free access to it from the deck. Most of the big steamers employ centrifugal pumps for circulating nowadays, and those pumps can be connected to the main drain the same as the ordinary bilge ejector. There are very few bends or corners of any description in the plan that I have had to do with; it is certainly a straight run from the fore part to the engine-room, and also from the after part to the engine-room, and any bends in the pipe would be to take the line of the centrifugal pumps which, as you all know, are always more or less to port or starboard. With regard to the steam and exhaust pipes, we all know that the best method of draining the pipes is to have a direct fall from the engine to the boiler or tank. There are many main steam pipes that are simply water traps, as I know from experience. They are a disgrace to any designer of an engine. If the author's idea of pipes were carried out there is not the slightest doubt that we should have less liability to accidents because of water hammering and general explosion of pipes.

Mr. R. BRUCE (Member) said he did not know that he had anything to say of a controversial nature. He was more particularly anxious to hear Mr. Terry's remarks upon the ventilation side of the subject. That was of more interest to him than the pumping machinery. At the same time he thought they could all agree as to the desirability of having convenient steam pipe connections and also simple water connections. Between the time that the author had first referred to and the present day most of them knew that the size of centrifugal pumps, and the facilities for pumping generally, had been very much improved, so that now there was not the inconvenience and noise that there used to be. Nowadays machines were all very much more perfect in their construction and design, and the makers of high speed engines were able to fit engines of the type they were speaking of on board ship that were very quiet in their working. Superintending engineers would not have anything that made a noise, and he thought they would agree that, as a general rule, the improvement in machinery of that type had been very marked. These engines were now, he thought, generally satisfactory. The author had referred to the single-acting type of engine. Well, the single-acting engine had its advantages ; it also had its disadvantages. An engine of that type was generally more extravagant in the use of steam, and it had to be bigger, because it was only effective on one side of the piston. For dynamo driving they were very much employed, but for centrifugal pumping and similar work on board ship he thought the engineers who had charge generally preferred the double-acting engine. In his younger days he remembered that it was a very common thing to have fitted on board ship what was called a "water lifter," which was connected to the holds and bilges, and as the steamer came into port the boilers were blown down through these lifters and the bilge water cleaned out. They did not use any extensive pumping machinery at that time. Nowadays in big ships the division into compartments was a measure of safety. When a ship was well divided into watertight compartments they could depend more or less on moderate pumping appliances. When they heard the details more fully explained in the light of Mr. Terry's experience and arrangement they would probably be able to say more on the subject, and no doubt members would be more ready to give their experience. The difficulties felt at sea they were all more or less acquainted with, and they were most interesting topics to discuss.

Mr. W. McLAREN (Vice-President) said he was under the impression that the paper which they had heard that evening was with a view to a continued discussion on the paper read during the previous session by Mr. Roberts, on "Independent Pumping Arrangements on Cargo Steamers," and that being so, he would like to ask at what temperature the independent pumps would put the water into the boiler. With regard to the author's remarks concerning centrifugal pumps, he was of opinion that the centrifugal pump, as separate from the condenser, was a very valuable pump. His experience had been with the high speed type. In the early days to which the author had referred, engine-rooms were somewhat crowded and there was a scarcity of room, but at the present day—taking cargo boats—he thought there was ample room for these pumps to be fitted. It might just be a question of weight in regard to cargo carrying. He would like to mention again the pulsometer. He had had some experience with it at sea, and he had found it very efficient and very quiet. He was not, however, prepared to say how it compared in the matter of steam consumption with the centrifugal pump, driven either by a double- or a single-acting engine. Referring again to independent pumps, he was prepared to admit that the single-acting pump was the pump to have. He had had some trouble with the duplex pump; when one part of the pump gave out the other part was also out of action. Mr. McLaren then referred to a circulating centrifugal pump he once had difficulty with when in the Thames. They had been lying in the river at a wharf, and when leaving had touched a bank which had formed outside the ship. In that instance they found that they frequently lost their water when sand came, but only for a short time. Otherwise the pump worked without difficulty. A 5″ belt-driven centrifugal pump of which he had charge going about 1,600 revolutions per minute, was able to lift the water from seventeen feet below the centre of the pump and discharge it about fifty feet above. That, he thought, showed that the centrifugal pump was very efficient.

Mr. D. HULME (Member of Council) said that on one occasion he had charge of a pump that had been built and fitted on board a steamer, and a technical journal was asked to send down a representative to see it and write an article thereon, or quote it in the paper. One of the pressman's remarks was that it was not a donkey pump. When asked why he made that remark he replied, "Well, the chief engineer cannot hear that pump working when he is in his berth." The centrifugal pump was a very useful pump, and properly connected would discharge a lot of water from a ship. Obstructions such as small matter in the bilges would not interfere with its workings; sand and stones would also be discharged with ease and freedom. There was no choking of the valves. He might add that where a centrifugal pump was fitted to a ship he had found it a very useful thing to have a double set of suction valves. In the event of one getting choked the other valve would act and keep the flow of water going. They had worked very successfully in ships in which he had been. Also, they were not very expensive to make. So far as steam pipes were concerned he thought they would find that all the valves that were put on the auxiliary engines had a drain-cock fitted at the lowest part for draining out the water. He would very much like to hear what the author of the paper had to say as to the ventilation of ships. That was a most important matter, and he hoped to be present when Mr. Terry was with them to resume the discussion.

Mr. A. H. MATHER (Member of Council) said they knew that with centrifugal pumps there was a difficulty in getting a high efficiency on both the suction and the discharge sides. In many cases that was due to the character of the pump. Pumps such as those fitted in warships were of the highest class that could be got. Those warship pumps were constructed with brass or gun-metal cases, and as compared with some of the centrifugal pumps that were fitted into merchant steamers, with cast-iron cases, the difference was very great, as might be imagined. With cast iron a lot of corrosion took place, and the parts of the casing which should be a close working fit to guide the water to the outlet were often broken away, resulting in a great drop in the efficiency. With regard to the single-acting air pump, the general idea was that this pump was far and away the best pump for producing a vacuum. He did not quite see where the advantage came in over the double-acting pump. Lately, he had seen one or two independent single-acting air pumps that were driven by a single cylinder engine; it was the most awkward machine that anybody ever designed. He had known an hour to be spent in trying to get such a pump started, and when at last fairly away, instead of doing its work at 70 to 80 revolutions per minute as intended, it would not run at anything less than 200, due to the great difference in the load on the up and down strokes. A double-acting pump driven by the same engine would be a far better machine, it would take an equal load upward and downward, and in such a case he did not see that the single-acting type possessed any advantage whatever over the double-acting.

The Edwards air pump was a single-acting pump, and it was one of the most efficient air pumps we had, but its efficiency was not due to its being single-acting. The question as to the arrangement of steam pipes was one well worth considering, but it would be an awkward matter to arrange that all main supply pipes should go in a vertical direction. In a good many cases, with a well designed pipe arrangement, branch pipes were taken from the top side of a horizontal pipe, and the bad effect of catching water was thus lost. The best arrangement, if possible, would be to have all branches taken off in a horizontal direction from a vertical main.

Mr. JAS. ADAMSON (Hon. Secretary) said that Mr. McLaren had questioned if it were intended to continue, under the heading of this paper, the former discussion initiated by Mr. Roberts in his paper of last session. Such was the intention. Mr. Terry had proposed to reopen the discussion, and letters had been exchanged on the subject during the past few months, with the result that Mr. Terry had reconsidered some of his former contributions and notes on pumps and connections, and had prepared the paper now read, but which, unfortunately, had not arrived in time to be printed beforehand. However, as the discussion would probably be adjourned it could then be in the hands of members, and with the presence of Mr. Terry the subject could be discussed to better advantage, when also other members who had expressed a wish for further discussion might be able to attend and take part.

An American was reported to have remarked that they did not manufacture heirlooms in America. He was inclined to agree with the statement if pumps were included, as the cheap pump introduced to our market a few years ago was certainly not an heirloom. Several of our own makers followed suit by cutting down the scantlings of their own designs to meet the competition, with the result that pumps were put on the market which were ripe for the scrap heap in a few voyages. Such a course of policy was, in his opinion, not in the best interests of either trade or commerce. In some of the pumps referred to, either the metal was bad, or it was too weak in structure to stand the swell or swirl of the water. The valve seating was perhaps the most troublesome part, also the passages leading to the valves, where the corrosion very soon set in and cut the bars through ; the spaces being small it was difficult to make a patch of any service, with the result that the efficiency of the pump was interfered with beyond redress. A good substantial job was the most economical in the long run ; the first cost of a cheap pump would very soon be doubled by the constant trouble and patching. He had recently seen an interesting model of the Mumford patent pump, and had asked for it to be exhibited at the meeting. This had been passed round. It was, in a sense, a valveless pump on the steam side, as shown very clearly by the diagrammatic model. He understood this class of pump worked satisfactorily so long as the piston rings kept steam-tight. One advantage it had was few working parts, in that the pistons formed the admission and cut-off valves for one another. He was inclined to think that the reason why the duplex pump was not a favourite in the experience of some engineers, was on account of the cutting down of the metal and general weakness of the parts, leading to inefficiency and troublesome patching. The old fly-wheel double-acting pump, of substantial make by a good maker, would be hard to beat. He granted the weight was considerable; but in his experience they were very reliable, and perhaps deserved the reproach, if such could be called a reproach, of being heirlooms, in that they served the lifetime of a ship.

Mr. JAS. G. LATTA (Member): A single-acting air pump is always more efficient than a double-acting one. The reason for this is that in the double type of pump it is necessary to have large passages both at the top and bottom of the barrel connecting the necessary suction and discharge valves. The consequence is a large increase of clearance, which is detrimental to the efficient working of the pump. The single-acting type has none of these disadvantages, and consequently is a much more efficient and better working pump than the double-acting.

Mr. McLAREN said he was interested in a pump that was then working at a wharf. It was single-acting, and had a water seal. They had to be very careful as to the water seal to get a good vacuum, say about 28 in. The pump was very slow working, and about 12 in. in diameter.

Mr. HULME: I think Mr. Adamson said that the Mumford pump was a valveless pump?

The CHAIRMAN: On the steam side.

Mr. HULME: Are there not small valves fitted under the covers, and those valves require very careful manipulation, although the piston works much the same as an ordinary slide valve.

Mr. ADAMSON: There is a small opening for an impulse of steam at each end of the cylinder.

Mr. HULME: There are small valves that are fitted under the covers. If you take the covers off the end of the pump those valves will be seen at the end of each cylinder. I have found in the working of these pumps, where we had an air and circulating pump driven by a pair of cylinders, that we had to take the cylinders off to get at those small valves. The Edwards' air pump also has some small valves for relieving the pump when starting, although we have had some excellent results from these pumps.

The CHAIRMAN said the subject under discussion was a very interesting one; there were so many kinds of pumps. With special reference to emergency pumps, he thought the centrifugal pump was useful for pumping water out of a vessel in the event of collision or anything of that nature. Those pumps were well known. There were air, circulating, feed, and bilge pumps, and every engine was usually fitted with them. It was a question of cost with shipowners, more especially as to the pump requirements that would pass the Board of Trade and Lloyd's Register. The pumping arrangements had to be inspected and passed as efficient for the purpose intended. The author had not referred to the "bilge injection" of which Mr. Shearer had spoken. The "bilge injection" was a very useful thing in the event of water getting into the engine-room or any part of the ship, but in all his experience at sea he had never had occasion to use it except as an air valve.

Mr. SHEARER: You have been very fortunate.

The CHAIRMAN, continuing, said that as nearly every vessel was now fitted with a double, or cellular, bottom it was a great safeguard against water getting into the ship or into any part of her. The top of the tank of the cellular bottom was almost as strong as the outside plates of the ship, and when the vessel was loaded the weight on the top of the tank gave it extra stiffening, so that it became just as strong as the bottom of the vessel. Many vessels had made voyages after sustaining considerable damage, the tank tops being sufficiently strong for the ship to make the passage in safety. His firm bought the steamer *Denton Grange* after she had been ashore. The bottom of the steamer was almost entirely ripped away, but as her tank tops were strong and tight they managed to tow her from Las Palmas to Newcastle-on-Tyne in safety. She floated all right, and they only had to pump her slightly, in fact, only a few times. There was no doubt that the pumping arrangements were very important, and he was sorry the author of the paper was not present. He hoped to be present when Mr. Terry came to give them a few more of his thoughts on the improvements he had suggested in pumping arrangements.

Mr. SHEARER said: I know, of course, that the Board of Trade and Lloyd's Register have to pass these pumps under present conditions, but would it not be a benefit for owners, in regard to insurance, if they were to put those large main pipes of which I have spoken into their ships?

The CHAIRMAN: No. It is Lloyd's Register that is put before all underwriters, and when a vessel appears as 100 A1 and passes their requirements, that regulates the insurance at once. You must conform to Lloyd's Register and the Board of Trade, or not get your vessel insured at all.

Mr. SHEARER: If those mains were put into a vessel it would certainly add to the safety of the ship. Although the present rule of the insurance companies may be to take everything through Lloyd's and the Board of Trade, I do not see why, in the event of some improvement being made, that improvement should not be taken into consideration when it adds to the safety of the vessel.

The CHAIRMAN: Every shipowner looks to get his ship built as cheaply as possible, and he is satisfied if it conforms to the present regulations. The question of first cost is a very important one.

Mr. W. H. FLOOD (Member) said he had noticed right through the evening that the efficiency of the pump alone had been mentioned; there had been no mention of the engine driving it. Could any gentleman present give him any figures as to the steam consumption of the engine that drove the pump? He thought that was a very important part of the question. At the present time he was interested in the driving of pumping and auxiliary machinery electrically. He would like to have some figures as to the comparative economy of the two methods of driving.

Mr. J. G. LATTA said it was difficult to give an answer to the question raised by the last speaker, unless they knew the pressure and the kind of pump that was to be used. For example, a feed pump would be a very different thing from a circulating pump. Speaking roughly, an ordinary steam-driven feed pump would run an electrically-driven pump very closely. There might be some 10 per cent. difference between the two when they were working at full power and maximum speed. The difficulty with electrically-driven pumps was that when they were working at half speed they had to by-pass half the water and use the same power to do that work. In such conditions the efficiency of the steam pump was, of course, much higher, but the great advantage of the steam pump was that the heat of the steam used for driving the pump could be turned back into the water again.

The CHAIRMAN, referring to a remark that had been passed about the duplex pump, said there was no doubt the valve chest was so intricate that it was very difficult to get a sound iron casting. There was, however, no difficulty with brass, which would last almost for ever if kept in proper order. He was very pleased to see so many present that evening and hoped they would have as large a meeting on the next occasion. The further discussion on the paper would be postponed until the fourth Monday in October.

The business of the evening concluded with the usual votes of thanks.

APPENDIX.

Letters to the Editor of the "Engineer."

THE FOUNDERING OF THE *AMERICAN*.

SIR,—In the detailed accounts of the loss of the Union Company's steamship *American*, near Cape Palmas, I notice three facts which appear to me to be of special significance: (1) That the ship remained afloat for seven hours and twenty minutes after the injury to the screw shaft tunnel. (2) That the Downton and donkey pumps were only in working order for a portion of that period. (3) That in the three hours immediately following the accident the water rose 18 ft. in the after-hold. From these facts I make the following deductions: (1) That had the ship been fitted with really powerful pumping machinery, she could have been kept afloat sufficiently long to reach a place of safety, either by being towed or under canvas. (2) That the pumping apparatus must be so constructed as not to get out of order. (3) That the pumping machinery must be so designed and arranged that it can be instantly set to work at full power, even though (as in the case of the *American*) the main engines cannot be moved.

Downton pumps and donkey pumps, as usually fitted on board ship, appear more adapted for supplying a small volume of water under pressure—for washing decks and fire purposes—than for raising large volumes of water under comparatively little pressure—for the lift seldom exceeds 30 ft.—which is what is necessary in a bilge pump, if it is to be of any use when a ship has received an injury to her skin, admitting perhaps 10 tons of water a minute. No reciprocating pump of this capacity can be produced of a sufficiently moderate size, weight, and cost as to commend itself to shipowners, consequently some other form of pump must be looked for. One which seems to combine all the essential qualities enumerated above is the centrifugal pump and engine combined.

A combined engine and pump capable of raising 2,800 gallons per minute to a height of 30 ft. costs less than £300. Such a pump would have removed from the hold of the *American* 12½ tons of water per minute, or 750 tons per hour. The *American* was of 2,474 tons. It will thus be evident that in three hours one such pump would have removed from the ship a weight of water nearly equal to her tonnage, and inasmuch as she remained afloat for more than seven hours almost without the use of pumps, it is tolerably clear that she would not have foundered at all had she possessed pumps of the capacity, or even of half the capacity, I have spoken of, thus saving to the company and the country a fine ship, cargo, mails and specie, and to the passengers much discomfort and danger, for exposure in open boats in the tropics for several days and nights, on short allowance of water, is not without its danger to life, even if the weather be moderate.

I would suggest that the combined engine and pump should be arranged so as to take steam from the main boilers; it could then be started instantly.

An additional donkey boiler placed at a much higher level would also be advisable; in it steam could be raised in the event of the fires in the main boilers being drowned out before the pumps had got the water under control.

It should be part of the routine of the engineer on duty to see that the centrifugal pump was in working order once during each watch. The suction pipes of the pump must, of course, be arranged to draw from each compartment of the ship. If vessels were so fitted, collisions and breakages of screw shafts would lose half their danger, and many lives and much valuable property would be saved.

Before concluding, I must express my entire concurrence with the views expressed in some of the daily papers as to the great advantages which would be derived in case of shipwreck by the presence of one or more steam launches amongst the ship's boats. This would especially be the case in moderate weather in hot latitudes.—STEPHEN H. TERRY, May 19th, 1880.

SIR,—Mr. Terry in his letter suggests employing more powerful pumping machinery for keeping under the water that may enter a vessel through the effects of an accident to her hull, and also that the machinery can be instantly set at work and not get out of order.

Will you kindly allow me to mention that very powerful pumps are now employed on most of the large steamers belonging to the various steamship companies. These pumps are intended to prevent the loss of the vessel in the event of her springing a leak and the water entering any of the holes.

No doubt powerful pumping machinery may keep down the water admitted through a small hole, but can a pump keep down or throw out a greater quantity of water than may be admitted through a larger orifice than the discharge pipes of the pumps themselves; if not, the water will gain on the pumps, and sooner or later the vessel will be in the same position as if there were no pumps, consequently in this case it would be only delaying the vessel sinking, and not preventing it. A very ingenious leak stopper has been devised and used, which consists of a plate, a toggle, and a piece of felt varying in size from a few inches to some three feet, which can be bolted over a hole in the side of a ship in case of need. This may prove useful in certain cases, but suppose the hole larger than the stopper, or that the stopper did not fit the hole, it might prove a treacherous thing to depend upon for the safety of a ship. Now, is it not possible that something may be done to prevent sinking, in the arrangement and construction of the ships themselves?

The suggestions mentioned above may be admirable auxiliaries, but do not seem absolute safety, because in the event of the water gaining on the pumps or the leak stopper refusing to act, the water so gaining would cause the vessel to sink. Would it not be possible, and it surely does seem desirable, that some reserve at least of buoyancy should be formed in the vessel herself—that, supposing the original buoyancy to be destroyed, should come into action and maintain and keep the vessel on the surface of the water? The pumps then might be brought to bear to clear out the water, and the leak stopper placed over the hole at convenience; at least there would be some reserve of safety, and a positive protection in addition to those mentioned to prevent the ship from sinking.—"J. A.," Lewisham Road, May 24th, 1880.

SIR,—Your correspondent seems to have missed the point of my letter in your issue of May 21st, in which I state "That had the ship been fitted with really powerful pumping machinery she could have been kept afloat sufficiently long to reach a place of safety."

As to what is and what is not powerful pumping machinery various opinions may exist, but your correspondent will, I think, agree with me in the undeniable fact that the pumping machinery of the

American did not keep her afloat, and if he will take the trouble to read my letter again I think he will find I have clearly proved that a pump of the power stated would have kept her afloat as long as her coals lasted; for it would have been capable of removing water more than twice as fast as the leak admitted it, or, as I purpose to prove, nearly four times as fast as the leak admitted it.

The registered tonnage of the ship was 2,474 tons; she may therefore have carried about 3,500 tons of cargo and coals, water, etc., and her total displacement at load draught may have been nearly 5,000 tons. Her freeboard I have no means of ascertaining, but it is probably correct to state that an additional weight of from 1,000 to 1,500 tons would be more than sufficient to cause her to founder, and this weight, or something less than this weight of water, was all that had to be removed in the seven hours and twenty minutes, which would not merely have "delayed her foundering," but would have kept her in the same trim as before the accident; in other words, a pump capable of removing 220 tons of water per hour would have kept pace with the inflow, and one of 750 tons per hour capacity would have removed as much water in one hour as would flow in during three and a half hours.

As to whether a pump can throw a greater quantity of water than that which would enter through an opening equal in area to that of the discharge pipe of the pumps, will of course depend upon the situation of the opening, i.e., its depth below the surface of the water, and consequently the head of water, as also upon the shape of the opening; the nearer the shape of the opening approaches to that of a circle the greater will be the flow of water per inch of area, but the cases in which injury to a ship's skin from collision or other cause take this shape are exceedingly rare.

Generally there is a cracking of the plate and a long rent or tear is produced, through which the water does not come at more than from a quarter to half the velocity due to the head, in consequence of the friction.

Leak stoppers would seldom be of much use in injuries of this kind, although for stopping shot holes they may be invaluable. Leak stoppers could probably be devised which would retard the inflow of water, provided the situation of the injury permitted of their use in the interior of the ship; for it must be borne in mind that external appliances which require the presence of a diver are useless in the tropics on account of sharks.

Your correspondent does not give any figures, and only says generally that powerful pumps are now employed in many ships, a fact which I am well aware of, but it would be interesting to know what proportion the ships so fitted bear to those which are merely supplied with pumps to enable them to scrape through a Board of Trade inspection, when the expenditure of £300 would give them, without adding three tons to the weight of the machinery, the power of raising three tons of water every fifteen seconds.

With reference to what "J. A." says about pumps "merely delaying" the foundering of a ship, I would like to point out to him that even ten minutes gained might make all the difference between the loss or safety of all hands; and the power to keep a ship afloat for an hour might in cases of collision near the coast enable her to be beached.

I do not understand what your correspondent means by "reserve buoyancy," unless it be air tight compartments, which, on account of their great bulk and space unprofitably occupied would be quite inadmissable on board ship.

A more thorough carrying out of the water-tight compartment system would meet the difficulty, for a ship's water-tight compartments should be sufficiently numerous to permit of any two becoming full without causing her to founder, as an injury to the skin of the ship may take place at the junction of the bulkhead with the side of the ship, which would admit the water into two compartments.

In concluding, I must tell you, sir, that from my own personal experience, and that of friends—officers in the mercantile marine—I feel convinced that in the majority of cases the proportions borne by the pumps to the capacity of the ship are altogether inadequate, and require to be increased manifold if they are to be of service in saving the lives of sailors and the property of the nation.

I could quote the case of a ship recently arrived after a long voyage, fortunately with favourable weather, which leaked soon after she was at sea at the rate of 700 tons in twenty-four hours.

The whole of this water had to be moved by hand pumps, as she was a sailing ship, carrying passengers, however, and a valuable cargo, which was much damaged by the water, part of the loss occasioned by which falls on the officers of the ship. Had this ship been fitted with even a windmill pumping engine, as used in nearly all Norwegian vessels, the labour and cost of keeping the water down would have been reduced to nil.

I trust that this question—of such vital importance—may not be allowed to drop.—STEPHEN HARDING TERRY, June 4th, 1880.

SIR,—Will you allow me a small space in your valuable columns in reference to pumps, etc., as concerned especially with the steamship *American*, a letter about which I read in the *Engineer* some three or four weeks ago, written by Mr. S. H. Terry.

There can be no doubt that pumps generally in ships are not of sufficient power to displace even the water caused by a leak, if it be at all a bad one, without in most cases great manual labour. About this I feel that I can speak with confidence, having lately served as an officer on board a well-known leaky vessel, which required on an average during the homeward passage at least nine hours' pumping per diem, all done by hand.

Mr. Terry wisely recommends the adoption of centrifugal power pumps as being simple, and also as being so very powerful in the displacement of water. A correspondent, in answer to Mr. Terry, somewhat ridicules the idea of powerful pumps. Probably he has never sailed in a leaky ship, or he might think otherwise. He also proposes a most ingenious (?) patent, consisting of indiarubber, toggles, etc., which, if I understand right, will work very much as the doors in boilers do; but he must have forgotten that there are many places in a ship where it is perfectly impossible to adopt this plan, provided even that the scuttle, plug, or whatever name it goes by, corresponded in any degree with the dimensions of the aperture. In fact, it is so thoroughly impracticable that it may at once be put on one side as useless.

This is my idea—that pumps must be, by Board of Trade regulations, of such power that they will in three hours remove the amount of water which the vessel to which they are attached would be capable of holding, viz., in a vessel of 300 tons burden the pumps be capable of removing in three hours' time the amount of water that that vessel will hold, and in the case of a larger vessel the pumps must, of course, be on a larger scale. By a rough calculation, the water displaced by our pumps last voyage was about 240 gallons per minute—that is allowing one revolution of the fly-wheel per second, and an average of two gallons for each of the two boxes.

Now this, in the case of an accident, would be of little use; but where powerful pumps were used it might, at least, save the crew, by allowing more time for leaving the ship, even if the vessel herself were lost.

At all events, there is more chance of safety for both crew and cargo if the ship be kept afloat two days instead of two hours. Of course, shipowners will ridicule the idea of expensive pumps, on the principle that what has answered hitherto will answer now; but there can be no doubt that with the aid of centrifugal force many lives and much property would have been saved, and by the adoption of it will be still so.—JOLLY JACK, July 2nd, 1880.

DISCUSSION CONTINUED

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, OCTOBER 26th, 1903.

CHAIRMAN:

MR. W. LAWRIE (MEMBER OF COUNCIL).

THE CHAIRMAN: I will call upon Mr. Terry, whom we are glad to see with us to-night, to give a few comments on each of the points raised in the former discussion, and I hope that members will rise to the discussion to-night without loss of time.

Mr. TERRY, in opening the discussion, said Mr. Shearer had spoken of the main drain for supplying the water for the pumps, and had said that in the past in many cases they were far too small, and did not give the engines and pumps a chance of delivering the water. Mr. Shearer had said that in most large ships those drains were from 18 to 20 in. in diameter. He was afraid that if they took the average cargo boat of, say, 5,000 tons and upwards, they would not find that the water mains would be so large. Perhaps in exceptionally well-designed passenger steamers they might find them fitted. Mr. Shearer had said: "If one of the compartments becomes flooded where it is not possible to get to the valve, anyone has free access from the deck. Most of the big steamers employ centrifugal pumps for circulating nowadays, and those pumps can be connected to the main drain the same as the ordinary bilge suction." Mr. Shearer would imply, apparently, that they were in many ways fairly satisfactory. In his paper he had referred to the losses of various steamers—the *Clan Macduff*, *Bristol City*, etc. At that time it was an absolute fact that passengers used to drop exhausted from the pumps, which were removing only a miserable few tons of water per hour. He had pointed out that they wanted something really powerful. Referring to the recent collision between H.M.S. *Prince George* and H.M.S. *Hannibal*, there was no doubt that the *Prince George* had powerful pumps. She was run into by the *Hannibal*, and which vessel was in fault it was possible they might never know. The vessel was in great danger, but was afterwards saved. It was stated that the crew, not only of the *Prince George*, but also a large draft of the crew from the *Hannibal* were employed to work the hand-pumps. That showed something wrong in the method in which the pumps were connected with the different compartments. In a vessel with that enormous engine power, it was, he thought, absurd to employ 100 of the crew to remove the water out of a ship of that size, when they had boilers capable of producing 15,000 to 20,000 horse power. It was time that more serious attention than had yet been given should be given to the way in which the steam pumps and their connections, the suction and discharge and steam pipes leading to the pumping machinery, were arranged. If a vessel had a hole in one or two of her compartments she should be able to work her steam pumps, and it would be scandalous if she had to employ her crew to keep her afloat. If the boilers got drowned out, the sooner they put one or two donkey boilers above the level to which the water might rise the better, if such a place could be found. It was not necessary on a war vessel that those donkey boilers should endanger the ship when under fire, and it was possible they might have to be protected with armour. A boiler containing perhaps 8-10 tons of boiling water should not be placed in such a position that a shell could strike it. In times of peace there should be donkey boilers fitted in the war ships available for the work, so that they should not hear of the crew being exhausted by pumping. The men could only remove 50-60 tons of water per hour, which was ridiculous in a ship of that size, where they might want to remove 1,000 tons per hour. Passing on, Mr. Shearer referred to the steam pipes; that was a class of pipe to which he (the speaker) had given considerable attention, and he had written a paper which was published in *Fielden's Magazine* on "Steam Pipes Ashore and Afloat."* Referring to the question of forced draught, he had some experience of forced draught on the steamer *Rome*. Forced draught had been a great success, but at the time of the trial of the *Rome* it was not at all a success, because of the water that accumulated in the steam pipes. The engines were single crank enclosed tandem compound with no relief valves on the low pressure cylinders, although this omission had been pointed out to the maker by the author, who, however, preferred always to buy his experience. The fan wheels were direct coupled, keyed to the shaft, and were 6 ft. 6 in. in diameter, and weighed 10 cwt. each, and ran at 350 revolutions. The engines having piston valves, and very little clearance, the water came in such doses that the engines could not swallow it. The trial was run down the Clyde, and when they took the last turn round with the ship at the Cloch, she heeled over to port in turning to starboard, and as she heeled the water ran over to port and gave them some slugs in the fan engines. They could not swallow the water, and three of the connecting-rods were bent. That showed the enormous force that was let loose. The rods were $\frac{7}{8}$ in. by $4\frac{1}{2}$ in. section. They

* See April Number for 1901.

were some 2 ft. 6 in. in length. One of those rods was bent like a dog's front leg, another like a dog's hind leg, whilst the third was bent into a perfect bow across the $4\frac{1}{2}$-in. section—in fact, across the depth of the web. That showed how very instantaneous must have been the resistance caused by the water, and the rotary effect of the crank suddenly drove all the lubricant out, and the brasses must have been adhering to the crank-pin, and the great strain bent the rod to a perfect bow. Water must, under no circumstances, be admitted into the steam pipes of auxiliary engines, because it might cause the ship to break down in her main engines. A great deal of fuss was made about the bending of the rods on the *Rome*, and they were told that the engines were going to be thrown on the scrap heap. There was a certain amount of friction between all concerned, but by saying very little and doing a good deal, they got the rods off and into Messrs. Caird's smith's fires next morning. By the aid of needle gauges fixed into a small plank they managed to get them within a very little of right, and by 10.30 next morning the engines were all running again. He came round with the ship from Greenock to Gravesend, and would have liked to go on to India with her, and he believed those engines were in the ship to-day. The lesson he learnt was the necessity of carefully providing for the getting rid of all the water. In his paper he had said that it was an important thing to carry the steam pipes to summit level as soon as possible after leaving the boiler. There should be a steady fall and never a rise or flat place between the boiler and the engines, so that water should travel in the same direction as the steam. Water was very heavy, and steam light, and if a pipe were bent they might be certain that the water, under the influence of centrifugal force, was going round the bend on the outer side with the steam. In large steam pipes, by having a drain fitted they could get some of the water away. The best way, however, was to carry the steam pipe for the last two or three feet in a vertical direction downward with a pocket below. That, he considered, was a proper sort of water separator. If the steam went absolutely downwards the water could shoot past the stop valve opening into the engine; that arrangement would get rid of nearly all the water that was there, either as slugs or drops. He was afraid, however, that he was not following Mr. Shearer's question as closely as he ought. That gentleman seemed to agree, on the whole, with what he had said. If piston valves became more and more common for auxiliary engines, as they were becoming for main engines, they should be made without too many springs in them, and of a fairly good fit working in renewable bushes. They were easily removed when worn out. They were no better when fitted with spring rings and small springs, which require lubrication. The auxiliary machinery had to run at a high speed, and they did not want grease in the condensers. Mr. Bruce, whilst appearing not to object, said that there was no particular need for engines being constructed single acting. He (Mr. Terry) was not interested in any one particular kind of high speed engine, but he still rather believed in the single acting engine, although he had nothing to do with it or its makers. The reason he believed in it was because the pressure being always downward even with a considerable amount of slack they got no knocking. They would all appreciate the advantage of a quiet engine-room. In the old days steam pipes were much too small, and the bends much too rapid. Even with large pipes there was a tendency towards auxiliary engines causing trouble because of the wear they got, and also because they got a good deal of grit. He considered that a single acting enclosed engine was the engineer's best friend, granting that, if closed in, it must be easily accessible. Two turns of the wrist ought to enable them to get at it. If a proper joint were made with a Compound ring of copper and asbestos inside they could have a joint practically oil-tight for all they wanted. That would enable them to have a grand system of bath lubrication, so that the whole of the crank pin and brasses would all be in a bath of oil and water for the whole time, and no grit or dirt could get in. Some time ago in an electric lighting station at the Naval and Military Club there was some trouble with one of those closed engines, resulting in a little friction with the man in charge, and he got discharged by the secretary. Before that man left he put in some bricks and road sand and tea leaves and then closed up the engine. The next man in charge soon found the brasses nearly melting, and then the things that had been put into the engine were discovered. The man who had been discharged came to him and asked for a job. He took his name and address and told him that when he wanted an engine wrecked he would send him a wire. But such things as that never happened on board ship. Years ago, when he was serving his time at Messrs. Aveling and Porter's engineering shop at Rochester they sold a ploughing engine, and the man in charge of it, a labourer, went into a public house, leaving the engine outside. That engine blew up, and the man having lost his job, came to the late Mr. Aveling seeking employment. He told him that if at any time he wanted an engine blown up he would send him a wire. Mr. Bruce rather seemed to think that he ought not to have said so much about the single acting engine. It was true that the double acting engine for auxiliary purposes was better made at the present time than it used to be. All the necessary means of adjustment were provided, together with a much better system of lubrication, either automatic, with copper pipes and sight-feed, or forced. Something had been said about the single acting engine being less economical. Well, they could run it a great deal faster and get the same or higher piston speed, and there ought not to be any difference in the matter of economy. In auxiliary engines the question of economy was a very important one. He had known cases where a great deal of trouble and anxiety, due to the frequent necessity for coaling, had been caused owing to the enormous amount of steam consumed by the auxiliaries on ships of war. On those vessels the amount of steam used by the auxiliary machinery for generating electric power and ventilating purposes was enormous enough, indeed, to propel a tramp steamer. Mr. W. McLaren had raised the question as to whether his paper was a continuation of Mr. Roberts's paper. His paper was independent, so he thought he could not discuss that gentleman's paper further than to say that he coincided with nearly all that he had said. He thought they held very much the same views. Reference had also been made to the single acting pump as an air pump. He was not dealing so much with air pumps. He had had no personal experience with the Edwards air pump, although he had seen and worked a model of it in Mr. Edwards' office. It worked most beautifully, and he had reason to believe that it was "going strong." He had at times thought that something could be done with a compound air pump. It had been found very efficient in getting very high vacuum in experimental work for laboratory work research. Compound air pumps had been made that gave good results. He was aware that it was supposed there was no particular advantage in getting a vacuum much beyond twenty-six to twenty-eight inches, because there was such a fall in temperature. Still, in these days of make-up feed and feed-heaters he thought any disadvantages due to fall of temperature caused through getting a better vacuum would be more than counterbalanced by the facilities with which they could get back the heat through the feed-heaters. Where they had feed-heaters he thought it was worth while going for as good a vacuum as they could get. It used to be said that it did no good to get a vacuum of more than twenty-six inches, but he thought that did not apply in these days, when they could put back all the heat by heating the feed-water. Mr. Hulme had recommended a double set of suction valves. That, he thought, was a very good idea; if made to work alternately it would enable them to clear out one set whilst the other set was running. An additional set of valves would give extra large openings in the strainers, thus affording less velocity of the water, and the risk of choking would be less. In big steamers where they spared no expense he thought it would be worth while to use gun-metal in the construction of all working parts, including the fan wheels of centrifugal pumps, more than they did. The centrifugal circulating pump was really the life and soul of the marine engine; without them nothing could be done. He thought they ought never to grudge making them of the best material and of the utmost accuracy, so that they would run with the least possible attention or repair. Also, if choked, they should be easily got at. That was generally looked to, but sometimes new firms making centrifugal pumps overlooked those details. Mr. Adamson in his remarks had said that an American had said that "they did not manufacture heirlooms in America." He was somewhat amused at that remark, for he rather fancied that the Americans came over to this country for heirlooms. Some of their manufactures, such as sewing machines and typewriters, were very useful, but in most machinery they were very much inclined to cut the thing too fine in the matter of strength. For example, they cut things too fine in rudder pintles. He remembered seeing the *St. Louis* lying in the floating basin at Southampton, and he had a look at her rudder head and pintles. There was a sea-going engineer passing at the time. He did not belong to the ship, but the author noticed that he was looking at a certain point in the ship. He attracted his attention to the rudder and pintles, asking him if there was anything there that he did not like. "Yes," replied the engineer, "those pintles and the rudder head are nothing like strong enough." That steamer had previously made several voyages across the Atlantic, but the next trip she carried her rudder away. The rudder head and the pintles were all too light. That was a case where lightness had been made the first consideration, but surely strength ought to be considered before lightness. If they could combine strength with lightness, so much the better. If American pumps were imported largely into this country for use on board ship, they hoped they would make them stronger, or marine engineers would have rather a bad time with them. He thought they had better be satisfied with pumps made in Great Britain. Mr. Latta in his remarks dealt chiefly with the question of air pumps, and he had not specially dealt with them. He (Mr. Terry) had thought more of the removal of the water out of a ship's hold and the circulation of the water through the condensers. He noticed that in the discussion that took place when his paper was first read, Mr. Roberts had said that then it was a question of cost with shipowners as to the size of the pipes and the fitting of the pumps, and more especially as to the pumps required. That gentleman had said: "It was a question of cost with shipowners, more especially as to the pump requirements that would pass the Board of Trade and Lloyd's Register. The pumping arrangements had to be inspected and passed as efficient for the purpose intended." That remark, he thought, was made with regard to the question as to whether any reduction would be made in the insurance premiums, and whether any saving could be expected by making the pipes larger. There was no doubt that the larger the pipes were, in reason, the safer the ship would be. At the same time, they could hardly expect Lloyd's to differentiate. For purposes of insurance they took the classification of the vessel which was built in accordance with certain rules. Any slight improvement of the kind suggested would greatly improve the efficiency of the ship and add to her safety in time of danger, but it would be some time before they could expect any reduction in the rate of insurance premiums. Such improvements would have to be made in the first instance at the expense of the builder or shipowner. They must not expect to reap immediate reward in pounds, shillings and pence. If those suggestions were given effect to, they would find that the vessel in time of danger was saved instead of being lost. With regard to the *Denton Grange*, there was, he thought, in the history of that vessel as a transport only one thing that was satisfactory. The whole story of that disaster was enough to make Englishmen disgusted. There was a steamer loaded up with all sorts of war stores and traction engines and transport wagons, and they went and ran her on the only rock in the bay. It was a navigation question, and they might leave it. It was, however, satisfactory to find that the ship was so beautifully built and the tank tops so tight that she was able, when raised, to steam to England with only a few times pumping. That spoke well for the builders and designers, but good designers and builders could not make up for bad navigation. At the previous discussion Mr. Shearer had said: "I know, of course, that the Board of Trade and Lloyd's Register have to pass these pumps under present conditions, but would it not be a benefit for owners, in regard to insurance, if they were to put those large main pipes of which I have spoken into their ships?" To that the Chairman replied: "No, it is Lloyd's Register that is put before all underwriters, and when a vessel appears as 100 A1 and passes their requirements, that regulates the insurance at once. You must conform to Lloyd's Register and the Board of Trade or not get your vessel insured at all."

He (Mr. Terry) assumed that the Chairman had meant that they could not expect to get any reduction in the rate of premium, or to get the vessel easier insured at first, in regard to those improvements. Then Mr. Flood had asked as to the efficiency of auxiliary engines. He was not prepared to give any figures on that point at the moment. He might say, however, that in recent years the auxiliary machinery was much more economical than it used to be, and it would have to be yet more economical before it was perfect. It ought always to be compound and condensing, and if possible it ought to be so arranged as to deliver into the low pressure steam-chest of the main engines, and then it would form a part of the triple or quadruple engine. Unless special care in designing the pipes were taken there might be danger in that course from the water lying in the pipes, which sometimes caused trouble when those connections were suddenly turned over from one to the other. The auxiliary machinery ought to be made more economical than it was, and he would advise the more efficient cleading of the pipes leading to it. They ought to lag the flanges, and so far as possible there should be some insulation where the pipe touched any metal part. All the pipes should be insulated. If pipes were insulated for heat as copper cables were for electricity, they would get drier steam. There would be loss of temperature where any metallic contact took place or where copper flanges were exposed. Copper was a splendid conductor of heat, as of electricity.

The CHAIRMAN said he thought Mr. Terry had enhanced the value of his paper by the remarks he had made that evening. The subject was one with which marine engineers were well conversant. He knew that many of them had good ideas on the subject, and it would be as well if they would let them have the benefit of those ideas as early as possible.

Mr. J. R. RUTHVEN (Member of Council) said he was very glad to hear a paper connected with the pumping out of ships. He had long thought that the pumping arrangements in the ship were perhaps more important than any other machinery on board, not even excepting the main engines, because the pumping primarily was closely connected with the life not only of the ship but also of the crew and passengers. Mr. Terry had spoken of the small suction pipes; by small he meant something less than twelve or fifteen inches. Some years ago he was associated with a ship that had a 6 ft. suction pipe, and she discharged 350 tons of water per minute, thus propelling herself by that discharge. With regard to auxiliary pumping engines, he thought it would be a very valuable thing to instal centrifugal pumps, or any water pumps, of far greater capacity than was the present custom. He would suggest that they should be ten times the present capacity, and the water thus discharged would be useful as an auxiliary for propelling purposes. That discharge would be useful for assisting the main engines or for propelling the ship when the main engines were broken down, or for taking the ship about in port when they did not want to turn the engines. It was quite possible with a discharge from a pump to get a propulsive force of about ten pounds for every indicated horse-power. Auxiliary pumping machinery of 100 horse power would therefore give them a propulsive force of half a ton, say, for moving the ship to her berth. He had often been surprised that the discharge from the pumps had not been turned to advantage, and he thought they might very well turn it to a good use. Even the present pumps might be used to give considerable assistance to the ship. It appeared to him that they wasted a good deal of water by throwing it out at right angles, if directed aft it would enable them to get a considerable propulsive force. With a modern high speed engine he thought very little space would be required over and above what was at present used, and if larger quantities of water were used it would mean economy in many ways, they could pump the ship out quicker and propel it at all times when they wanted to. It would be an increase to the initial cost, but if there were to be no extra advantage to shipowners for extra expense there would be no incentive to spend that extra money, and if Lloyd's did not take any notice there was no direct incentive to those improvements of which Mr. Terry's paper was full. He thought that it was a most important point that the improvements made by engineers and shipowners should be fully recognised from a financial point of view. If that were not done there was not sufficient incentive simply to save Lloyd's.

MR. JAMES HOWIE (Member) said that on page 1 of his paper Mr. Terry mentioned the admission of a few hundred tons of water into a ship, and said that the provision of efficient pumping machinery, requiring no more than ten horse power, would keep her afloat for an indefinite period. That, he thought, was very low; if that was all the horse power that was going to be required, it would be a very cheap arrangement. He quite agreed with Mr. Terry in his remarks about bulkheads and compartments. With regard to suction and discharge pipes, he noticed that Mr. Shearer went in for one large pipe, to go the length of the vessel, having, he supposed, branches to each department, about ten times the capacity of tank pipes, say an 18 in. pipe. He thought, however, that that would not be quite an independent arrangement. If by any means that pipe became unworkable by bad jointing, piping, or otherwise, then the whole of the suction pipes would be immediately shut off. He could not quite fall in with that suggestion, but he agreed with Mr. Terry's remarks that they should have independent suction pipes for each compartment, but there might be one discharge pipe, thus making the arrangement complete. With regard to the suggestion that they should have the pumping engines on a higher platform, he thought that must be essential, if the full benefit of the machinery was to be obtained. Having the engine put on a higher platform, the efficiency of the pumping arrangements, especially in the case of a heavy leakage in the engine room. would be higher. It might be suggested to carry pipes to the engine room from the holds with sluice valves on the ends adjoining the engine room bulkhead. These pipes, when charged, would empty themselves in the engine room, the water then would be taken by the main engine pumps through the main bilge suction and condenser, and discharged overboard. With, say, a loose grain cargo, there would be trouble with the condenser, and interference at a critical moment with the working of the main engines. If, however, they had independent pumps, that danger would be obviated. It would seem that with very great leakage the independent pumps only could be acceptable. The pump suggested by Mr. Terry capable of discharging 1,000 tons of water per hour was a very big pump. Mr. Terry, he thought, had large ideas, and wanted to have them carried out thoroughly. He was rather tickled with the idea of a syphon for the discharge, but he thought it was really a capital suggestion. Of course, to some extent, it is so worked at present. Mr. Ruthven had referred to the discharge at right angles from the vessel. He thought the idea put forward by that gentleman was a capital one. With regard to the arrangement of the pipes as drawn out by the draughtsman, it was probable that the draughtsman was complimented if in designing the pipes he was able to save a certain amount of money. He would say that in most cases, especially in large drawing offices where young draughtsmen were employed, they did not give the attention required, and so there were faults in those pipes. He quite coincided with the remarks that Mr. Terry had made that evening as to the advisability of getting as much vacuum as possible. In some cases engineers were specifying for 29 in. of vacuum. He thought it was somewhat hard to make a guarantee of 29 in., but at all events there was an attempt to get it, although it must be at the cost of the condenser, etc. The Worthington pump had been somewhat maligned in the recommendation that they should stick to the pumps made in England and Scotland. He had heard so much, and he had seen a little, of the working of the Worthington pump that, although he would prefer to have it made in England, yet its efficiency and working ability were such that they could not cast any aspersions on it whatever. He thought they must give a great deal of credit to those pumps for their efficiency, and also for the fact that their later patterns were a delight to look upon. Regarding Lloyd's, the greatest difficulty that Lloyd's had with the shipbuilders was to get them to put in enough suctions. If they would put in plenty, and large enough, they would not object. The difficulty arose when they put in too few. When the efficiency was worked up to its highest degree Lloyd's would never object, but if they asked for compensation that was another matter. Then, he thought, they would object.

Mr. W. McLaren (Vice-President) said that Mr. Terry had referred to the great efficiency of the double-acting pumps for experimental purposes. The special pump that he had spoken of at their last meeting worked, on an average, nine hours per week, and it had been working ten years before he had anything to do with it. The efficiency of that pump was very great, and they reckoned to get twenty-eight inches of vacuum out of it, but they had to be perfectly sure of its being water sealed. That was why he had mentioned the water seal in connection with that pump. Referring to the collision that had recently taken place between H.M.S. *Prince George* and H.M.S. *Hannibal*, any seafaring man would know that in such cases in the Navy, no matter what machinery they had on board, Jack was always put to do the job, either to send him out of the road or to keep his time occupied. It was done in order to keep him employed, and it did not say much for the discipline or supervision that was carried on in the Navy. That, perhaps, would coincide with some of Mr. Terry's remarks as to utilising human skill and strength to pump out a ship when they ought to have ample machinery on board to do the work. With regard to single acting engines for auxiliary purposes, the difficulty with that type was that it would not act with varying loads. It always had to be kept at a constant load, such as dynamo machinery. The water question greatly upset that engine's work. There was no doubt that the double acting engine had helped itself forward through being always able to struggle with a varying load. Mr. Terry had referred to the bending of the connecting-rods on the P. & O. steamer *Rome*. He was surprised that they bent the rods instead of smashing the piston-head or covers. His experience had never been like that except when the connecting-rod ends got heated. With reference to the system of drainage, in the majority of ships with which he had been acquainted every compartment had a well, and there was always a service of pipes which were connected up to the various pumps, and even to some of the auxiliary feed pumps, such as the wheel pumps. Of course, they had now gone in more for the direct acting pumps. With regard to the lagging referred to in the paper, he thought that was a matter that was fairly well looked into. They had had a hint on the same subject at their last meeting from Mr. Balfour, who had told them that the Institute could not go in for a better thing than the study of insulation questions. He might mention that they would only be too pleased if any of the members would send them samples of insulating material for experimental purposes. He would also like to know, in regard to any samples that might be sent in, what thickness of cover was necessary, and what efficiency had been got from it.

Mr. CROMWELL J. E. WALKER (Assoc. Member) said that Mr. Terry had mentioned a paper of his on piping which appeared in *Fielden's Magazine*. He remembered that paper. At that time he was engaged in getting out the plans for a light and tramway station, and his chief gave him a copy of the paper, advising him to get out a separator on the lines suggested by Mr. Terry, using for the purpose some old steam piping which was going to be scrapped. Acting on that advice, he took a 6 in. pipe and drilled it with holes from which the burrs on the inside, due from the drilling, were not removed. That he placed inside a 14 in. pipe so arranged that the stem passed down the 6 in. pipe and through the holes and out at the top of the 14 in. pipe. The particular feature which was obtained from Mr. Terry's paper was the leaving of the burrs on, thus preventing the water of saturation which was caught on the inside of the 6 in. pipe dripping across the holes and being caught again by the steam. Another idea of Mr. Terry's contained in the same paper was the leaping weir for separating water from steam. That had been used for maintaining a steady supply of water to an air pump of a well known class which acted perfectly so long as it did not get a big rush of water, but in opening up a piece of exhaust pipe which had been standing and which had got full of water, owing to the slight passing of valves, it was found impossible to prevent a rush of water. The weir was so arranged that the normal water supply went one way direct to the pump, while the excess leaped the weir into a reservoir and was gradually removed by the pump as a slight prolonged addition. In the West Ham new station Mr. Terry would find that the auxiliary plant was below the level of the boilers, but the pipe was drained and trapped before it reached the plant. Also, as superheated steam was used, no condensation was expected even when all the auxiliary machinery was stopped, for any steam that was condensed would be converted into steam again, obtaining the necessary heat from the superheated steam which would flow into the pipe to take its place. That implied, of course, a perpetual circulation of steam even when the plant was standing.

Mr. D. S. Lee (Member) referring to the collision between the *Prince George* and *Hannibal*, said it was the custom in the Navy to employ the crew on the hand pumps, no matter how much auxiliary pumping machinery there might be on board. It was not absolutely necessary to have hand pumps fitted, because of the small quantity of water they threw. In the case of collision or fire stations the steam pumps were set going at the same time. He would like to ask Mr. Terry whether it was not now the practice to fit small auxiliary machinery with slide instead of piston valves. He had had a great deal of trouble with piston valves, and the slide valve engine was preferable. He had always found it a good practice to have the exhaust of auxiliary engines all leading into the receiver of the low pressure cylinder, so using the exhaust steam in the low pressure cylinder, thereby getting the full benefit of H.P. exhaust on the L.P. piston. It was much better than compounding the small engines, which were as a rule difficult to start in port, where there was no auxiliary condenser. One difficulty he had experienced with Gwynne's pumps was that they would never lift above 10 or 12 ft. If they were charged from the sea sometimes they would catch the water and sometimes not. If a hold were flooded he would not rely very much on the Gwynne pump; except it was placed low down in the vessel and the water flowed to it by gravitation the ordinary reciprocating pump did not take out the quantity of water to be of much use in the case of stranding. Another plan he had seen was to have a deck suction-hose fitted, to be let down to the different holds with a steam pump connected to it. That gave very good results in getting the water out of the vessel. With reference to a main drain running the whole length of the ship, it was only fitted in war vessels. He had never come across it in merchant ships. It seemed to be very efficient when connected with valves from the deck, so that any flooded compartment could be immediately opened up and the water drawn from that particular compartment. With regard to the radiation from the steam pipes, it would be very useful if they could get an unbiassed record of the different insulations in the market at the present time. Every one recommended his own insulation as being the best.

Mr. J. E. ELMSLIE (Member of Council) said that unfortunately he had not read the paper. In cases of serious damage he was of opinion that the pumps were perfectly useless, and they would have to depend on the bulkheads and double bottoms. If they got a hole only 12 in. diameter knocked in a ship's side, at 16 ft. below the water line it would admit about 2,500 tons of water per hour. It was hopeless to rely on the pumps for serious damage. They could not get pumps big enough for such cases.

Mr. RUTHVEN: Yes, they have been made big enough.

Mr. W. E. FARENDEN (Assoc. Member) said Mr. Terry had referred to the advisability of placing the centrifugal pump high up in the main engine room so that it would be really efficient in the event of the flooding of that compartment. He knew that it was generally placed about, or a few feet above, the level of the engine room floor at all times. He would like, however to ask Mr. Terry where, and at what height above the engine room floor he would place the pump, as if it was too high up it would lose its water, and would not do its work. A portable pump of the pulsometer type, which could be placed in any compartment of the vessel and used as required for pumping out, would, he considered, be the most suitable. A boiler would also have to be placed high up in the ship, so that it could be used at any time, in the event of the main boilers being drowned out.

However, the double bottom and the number of water-tight compartments that are fitted to vessels of the present day, and the means provided for automatically closing the watertight doors with sureness and rapidity, tend to make vessels very safe against the ordinary perils of the sea.

Mr. Terry had also spoken of a steamer fitted with forced draught fan engines in which three of the connecting rods were very much bent. He understood him to say that this was due to the water in the steam pipe, but considered the cause should be looked for elsewhere, as for the connecting rods only to be bent seemed rather peculiar, water in pipes usually leading to broken pistons or cylinder ends; and in this connection he would like to know what the escape valves were doing, as in a properly designed engine there should have been ample to have relieved the engines of any water that may have got into the cylinders.

Mr. K. C. BALES (Member), speaking to a question raised by the last speaker, said he had that day seen in a works the insulation of steam pipe flanges very simply carried out. The pipe was exposed to the weather, and the insulation used was, he was told, plastic mica, and it was covered entirely with a galvanised iron casing, which was made in halves and hinged, and being fastened or locked with a sliding wire, could be taken off without any trouble. So far as trouble with insulating flanges was concerned, it disappeared into thin air with such a simple arrangement as that, which entirely covered the flanges and bolts.

Mr. W. BRANDER (Member): As Mr. Terry had said, in the Navy it was a case of all hands to man the pumps in emergencies. In some vessels they had the pumps right down below, and if they got flooded in the compartment where the pumps were fitted what could they do even with a donkey boiler up above? One system was to lead the bilge connections up to the top platform, having a pump on deck, but he did not think that system would do much in saving a ship. In some of the modern ships, where all the boilers were below, he thought it would be a very good thing to have a small donkey boiler and pump above, to be used in cases of emergency with connections from the compartments. He was sorry he had not had an opportunity of reading the paper, so that he could give his ideas more fully.

Mr. G. SHEARER (Member), referring to Mr. Howie's remark that "engineers liked to carry twenty-nine inches of vacuum in the present day," said that so far as his experience went he had always obtained the best results with twenty-six inches of vacuum with the ordinary compound engines. He was speaking of the days when he was keeping watch, which was a considerable time ago. He found that he could always get more revolutions out of his engines with twenty-six inches of vacuum than with twenty-eight or twenty-nine inches, which he was capable of getting at that time. Of course, it entirely depended on the temperature of the water they got in the condenser. They lost it in the vacuum, but they gained in the heating of the feed water. It might be said that they had feed-heaters, by means of which they could bring the temperature up to, say, 220 degrees, as he had himself done at times. But there was a great difference. They were taking steam away from the low pressure engine, and supposing they got the advantage in their high pressure and intermediate cylinders, still there was the loss to the low pressure engine by supplying the feed-heater. He had found that he could always get a better result by working the condenser at the height of vacuum he had mentioned. He had tried it in every possible way at all heights varying from twenty-nine to twenty-five inches, and his experience had been that he could get the best results out of those engines with twenty-six inches of vacuum. Of course, as he had said before, it was a matter of the condenser—the proportion of the condenser to the engine. There was one question he would like to ask regarding the reciprocating pumps. There was one peculiarity in all double-reciprocating pumps, and he must say he had never got at the foundation of it. He admired those pumps; he liked them much better than the ordinary wheel and crank pump, and years ago he had wondered what engineers were thinking about that they should put in crank shaft, bearings, crosshead and wheels, and one thing and another to get the work done when they could simply get that reciprocating motion and direct action. There was nothing so economical as a direct movement. But here was the point: those pumps worked all right so long as they had plenty of water, but supposing the water varied, immediately that pump lost a quantity of water the stroke of the engine wobbled up and down. An engine say with a 12-in. stroke would reduce herself to a 3-in. stroke and would simply keep slipping about the centre of the stroke. What was the cause of that? His idea of a pump was, if there were no water there that the steam would send that piston right to the end of the stroke, and strike the end of the cylinder. But with those pumps they found it was fortunately quite the revers- in practice. In raising that question he was speaking of when taking the suction from the bilges or some other portion of the ship where there was a variable load. With regard to the mains of which he had before spoken, he might mention that he agreed with Mr. Elmslie as to it being the safest method to put in plenty of bulkheads and double bottom. There was no getting away from the fact that that was the salvation of the ship. But even then they must have pumps, and the best system was that in vogue in the Navy, where they had a main pipe running fore and aft connected to the centrifugal pumps in the engine room. At the last meeting he had asked Mr. Roberts a question with regard to insurance, and would again draw attention to the subject by referring to the remarks made on that occasion. Lloyd's Register and the Board of Trade had their rules, but were they to stand in the same position for ever? Why could they not have reform there? They could see points, perhaps, that even Lloyd's or the Board of Trade could not see; in fact, it was they, as marine engineers, that gave them their experience. They (the engineers) pointed out all those things, and they simply brought them up to the surface. That was the point. As Mr. Roberts had observed, "What the Board of Trade said was law: they could go no further." Then what was the use of making improvements if they put down their foot and said, "We won't have it?" Surely if those large drains were put into a ship, which they knew would reduce the danger in case of very heavy leakage, why should not an insurance company reduce the amount of their premium on that ship? It was a point of safety, and if they stood still and allowed them to keep to their point and say nothing about it, what was the result? They must move on a bit. The first cost was a big item, but at the same time he did not see that it was such an enormous amount of money to put into a large ship when they were rendering her so much safer as compared with the old style. Those large mains were only cast-iron pipes, and cast-iron pipes were cheap. If they had the large pipes the centrifugal pumps could be used by simply connecting them up.

The CHAIRMAN said that so far as insurance was concerned he did not think that the case had been altogether fairly put. Premiums were regulated more by the claims than by any other factor that he knew of. They might put the most recent improvements into a vessel, but Lloyd's Register could not give them more than their best classification, as Mr. Roberts had explained. If they went to an underwriter and told him that they had introduced some such improvement as had been discussed that night, that would save him (the underwriter) a great deal of money, and asked for a reduction of premium, the first thing he would say was, "Well, where is your proof? Show to us that there will be a reduction in the amount of claims made, and we will think about reducing our premium." The insurance was not altogether regulated by Lloyd's classification. The rates of premium differed in different trades. In some trades the rates were very low, whilst in others, such as the St. Lawrence, it went up at once. Insurance was not the simple matter that they imagined it to be; it was a question of £ s. d. with the underwriters. Those underwriters did not understand improvements; they were not practical men in that sense. They were only practical so far as their own business was concerned. They could not make improvements and then go and say there should be a reduction in premium. It was a very wide question, and unless they could show that the use of those pumps would result in less claims being made, he was afraid there was not much chance of a reduction of premium, and that was where the question came in. They saw the number of well found ships; they were not a very great proportion of the whole. He was afraid it was not the question of fitting pumps that would get them a reduction of premium.

Mr. SHEARER: As to results, there is no man who is going to put a pump into a ship, and then strand her for the purpose of showing what that pump can do.

The CHAIRMAN: No one suggested such a course.

Mr. SHEARER, continuing, said that weekly and monthly they had instances taking place where they knew that if they had had pumping power in those ships they would have been saved. Consequently, for the want of that pumping power they were lost. He was not going to mention any particular instances, but they all knew of some. Then someone might say that there was no limit to that. But there was a limit, as Mr. Elmslie had said. The double bottom and bulkheads were the salvation of the ship. Mr. Shearer, by means of a blackboard drawing, here referred to the double bottom in ships. Referring specially to the sad loss of the *Drummond Castle*, he said he thought that vessel was lost through rubbing along some shelving rocks. Referring to the bilge-tanks in the diagram, he said they were the only wells they had for bilge water. He thought it would be much better to carry the double bottom straight across and leave a channel-way in the centre. It was not necessary for the channel to be a very deep one. It would keep the carpenters' eyes open in case of excess of bilge water.

Mr. W. McLaren: What about the ship listing over?

Mr. Shearer: We have had instances where a ship has had a constant list. Supposing the ship did take a list, the water would flow fore and aft. Of course, it was not absolutely necessary to carry that channel without a break the entire length of the ship. In the plan of the ship there could be a cross channel and a well in each compartment, and only gutters in the wings.

Mr. W. McLaren: That would compel you to carry a great deal of dunnage to save the cargo.

Mr. Shearer: No, only half the quantity you have to carry at the sides. That was a point for shipbuilders, but he only made it as a suggestion.

Mr. Elmslie said that if a ship got ripped along her side by a rock, the chances were that the rock would rip right through two or three of her thwartship bulkheads, and perhaps tear a hole from 50 to 100 ft. in length. In the case of H.M.S. *Apollo*, the ship did get a rip of that sort, the outer bottom or skin of the ship being, so far as flotation was concerned, practically destroyed for a length of about 250 ft., there being some half-dozen large holes, two of which were respectively 70 ft. and 24 ft. in length.

The Chairman said he thought they ought not to discuss the question of bulkhead arrangements on board ships that got on the rocks. No shipowner would think of putting a salvage plant on each vessel. He thought they had quite exhausted the discussion so far as the members present were concerned. It was too late for Mr. Terry to commence a reply to what had been said that night. It would take him quite half-an-hour to get through, and it would be a pity to make the attempt unless he could finish. He thought it would be absolutely necessary to appoint another evening, if they could find a corner to put it in, in order to get Mr. Terry's reply as fully and as clearly as possible.

Mr. W. McLaren, referring to the suggested adjournment of the discussion, said he was prepared to propose, if it suited Mr. Terry, that they should continue the discussion on the following Monday evening, seeing that their programme was so full right up to the end of the year. With reference to the question raised by Mr. Shearer regarding the reciprocating double-acting pump shortening its stroke for want of water, he was of opinion that it was caused by the fact that the reverse cylinder or pump or part of the pump regulated the other's steam supply, and when the first plunger lost its water it did its stroke with such speed that it cut the other one off before it got its stroke completed with its full quantity of water, and each stroke being shortened the two danced about, owing to the valves being barely on the cover, and because they had not a positive working valve. They had to depend greatly on the flow and resistance of the water with the steam so regulated to the piston to give them a steady load. He made that mention of that pump because he thought it might enlighten them for their discussion next week.

Mr. Howie said there was one point that had not been spoken of, and that was the hydraulic system of water-tight doors, which, in effect, was a pumping arrangement. The want of that system probably lost the *Victoria*, but the use of it saved an Atlantic liner by preventing the water from rushing from the bunkers to the engine-room.

The Chairman said he thought they had had an interesting meeting, which it was then his duty to bring to a close. It had been proposed by Mr. McLaren that they should take up the discussion again next Monday night. Mr. McLaren had been good enough to forego the fuel testing experiments, and Mr. Terry had kindly consented to come, so he thought the arrangment was a very good one. The writer of the paper had told them that it would have been more full of detail and less retrospective if it had not been written against time. That fact, he thought, rather increased their obligation to Mr. Terry for the great trouble he had taken to write that paper at such very short notice, and he thought he was only expressing the feelings of every member present when he said that they fully appreciated the efforts he had made on their behalf.

Mr. K. C. BALES proposed a hearty vote of thanks to the Chairman for presiding.

Mr. J. E. ELMSLIE seconded the proposition, which was carried unanimously.

This concluded the business of the evening.

DISCUSSION CONTINUED

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, NOVEMBER 2nd, 1903.

CHAIRMAN:

MR. W. LAWRIE (MEMBER OF COUNCIL).

THE CHAIRMAN said that Mr. Terry would open by replying to the remarks on his paper that were made at the last meeting. He hoped that when Mr. Terry had finished his reply the members would be alert in saying what they had to say, so that Mr. Terry might reply to them before he left.

Mr. Terry said he believed Mr. Ruthven's father as nearly as possible invented the centrifugal pump, and it had been a grand machine for all of them. Whether used on board ship as an emergency pump in cases of stranding, or for the more homely, but none the less useful work of keeping the condenser cool, the centrifugal pump had been a grand machine for the marine engineer, and had enabled him, conjointly with the naval architect, to get such magnificent speeds at sea. Nothing distinguished man from the ape tribe more than the magnificent conquest he had made in being able from the iron ore of the ground to fashion an ocean going steamship. He believed that Mr. Ruthven, Senior, was an instrumental person in the building of the early centrifugal pump, and that pump, as installed in the *Water Witch*, moved, he believed, 350 tons of water per minute. That was about thirty or forty years ago, and at that time Mr. Ruthven, Senior, wrote a paper called "The Steam Trials of the *Water Witch*." That showed how far ahead they were in those days over the reciprocating or other class of pump. No doubt larger centrifugal pumps had been made since that time, but when that pump was made it was the biggest machine for propelling water that had ever been made. Something had been said about the horse-power of pumps, and on that point he had prepared a few figures. The efficiency of centrifugal pumps varied considerably. It was efficient for ordinary work to a height of 30 ft. and it was also used for sewage work up to 70 ft. Beyond that it was not very efficient unless treated as compound, with the delivery of one, entering the suction, then on to the discharge of the other. Now that they had a further use of electricity he saw no reason why pressures of enormous power should not be obtained by making that pump quadruple instead of compound where they had one suction delivering into the other. At the last meeting it was mentioned that 1,000 tons of water was an enormous quantity to lift. It was a lot, but they dealt with big things nowadays. 17 tons a minute was $4\frac{1}{4}$ tons in fifteen seconds, or 600 lb. weight per second; in other words, 10 cubic ft. per second. In a 10-in. pipe having half a square foot area the velocity would be 20 ft. per second, which was ten times the pumping velocity used in waterworks mains, which was only 2 ft. per second. With a 14-in. pipe, equalling, say, 1 square ft. in area, the velocity would be 10 ft. per second, which was five times the waterworks velocity. Eighty-four cwt. was 9,408 lb. per minute, or approximately 10,000 lb., and to lift that weight of water from the bilges of the vessel to above the water level—say a distance of 33 ft.—would require 10 horse-power. They might have to allow for the efficiency of the pump as being only 50 per cent., which would mean 20 horse-power (say 40 brake horse-power, or 48 indicated horse-power), and that would lift 1,000 tons of water per hour out of the ship. Many ships now at the bottom of the ocean could easily have been kept afloat had they had such a pump. Probably two-thirds of the ships that had foundered might have been saved had they been so equipped. He had seen plenty of pipes 10 in. in diameter, and he wanted to give them some figures based on manufacturers' catalogues. Suppose they were dealing with a pump guaranteed to lift 600 tons per hour: that meant 10 tons, or 200 cwt. per minute, or 374 lb. per second; 6 cubic ft. per second equalled a velocity of 12 ft. per second through a 10-in. pipe, and that was six times the speed allowed in waterworks. One of the most eminent firms of makers had adopted a velocity of water through the suction and discharge that was equal to six times what the waterworks engineers thought suitable for sending water through the mains. It had been found that 2 ft. a second was a tolerably economical speed, because they had to consider the first cost of the mains, and the larger the mains were the greater would be the cost. At that velocity the resistance was small, and he suggested with centrifugal pumps, that, if they insisted on the suction and discharge being somewhat larger, say to the extent of 20 or 30 per cent., that would vastly increase the efficiency of the pump in times of danger when it was called upon to save the ship. A large number of the pumps that were fitted on board ship were crippled by reason of the velocity with which the water was expected to travel through the pipes. With regard to the question raised by Mr. Ruthven as to the efficiency of jet propulsion, that was such a large subject that he thought it hardly came within the scope of his paper, which dealt with auxiliary machinery and pumps for ordinary services on board ship. He knew that the *Water Witch* as an experimental vessel achieved a remarkable speed at the time of her trial, but the other vessel at that trial was not a sister ship in regard to her lines, and he thought it was possibly one of those cases where judgment had been arrived at after an unfair trial had been made. He might mention that he had several times seen a float barge, or lighter, having a horse drawn road steam fire engine on board, which was used to propel the barge, by means of jets, across the river or dock. It was thirty years ago that he had seen that odd craft with the horizontal fire engine with the wheels chocked-up on board, and the men were propelling it very efficiently, and guiding it amongst the other vessels, in the vicinity of Miller's Wharf, St. Katharine's Dock. The men managed to propel her very well against a fairly strong tide. She had a hose pipe with two jets, one on each side, which were pointed at the disadvantageous angle of forty-five degrees to the water, so that a good deal of the power was expended in reducing the draught of the craft. Still there was sufficient force to propel the boat, and there they had an instance of the simplest possible form of hydraulic propulsion. A good deal had been said about the recognition of improvements that were made in a vessel. It had been suggested that if the owners, builders, and others, chose to equip a vessel with certain improvements which would increase her safety, such extra expenditure should be immediately recognised by those who had the control of the premium rates of Lloyd's in the form of a reduction of premium. He could give them instances that had come within his own experience where vessels that were equipped with improved ventilating appliances had been immediately recognised by Lloyd's. He had had a good deal to do with vessels that carried petroleum in bulk, and conjointly with Sir Fortescue Flannery he had invented the system of ventilation that was then in use on board all the ships of the fleet owned by The Shell Transport Co., whose chairman was Sir Marcus Samuel, the present Lord Mayor of London. That system consisted of putting in extra large suction and discharge mains for the oil. Those mains were put in in duplicate. Those ships were fitted with 10 in. mains, whilst some of the more recent steamers had even larger mains. He had insisted on having mains not less than 10 in. in diameter, although it had been suggested that 7 in. mains would be large enough. The difference in area between a 7 in. and a 10 in. main was very serious: it would mean in section a quarter of a square foot and half a square foot respectively at area. Those mains were used for loading the oil, and as soon as the oil was discharged they were utilised for sucking the petroleum vapour out of the holds. They had found that petroleum vapour was three times as heavy as air, and twice as heavy as carbonic acid gas. Carbonic acid gas, as they all knew, was so heavy that it could be poured from one glass to another like water, and petroleum vapour was even heavier. For this reason the idea of blowing air into a hold with a view of getting rid of the petroleum vapour was soon abandoned. So they arranged a system of suction pipes that would serve to load the oil, and which could also be used for drawing out the impure vapour. When they wished to exhaust that foul air they coupled the mains up to a very efficient fan that had been especially designed for the purpose. These fans were 6 ft. 6 in. in diameter and 10 in. on the vanes. Those fans had now been fitted throughout the whole of the fleet of the Shell Transport and Trading Co. That system of ventilation had enabled them to entirely remove the whole of the explosive vapour immediately the oil was out. Within an hour the smell of the oil could be entirely removed, and the hold would be so sweet and clean that such cargoes as rice, coffee, tobacco, tea, and even spices had been carried in those vessels without being tainted in the least degree. In fact, they were in better condition than if they had been shipped in ordinary vessels that had no means of artificial ventilation. The first vessel fitted with that system of ventilation was the *Murex*, the first vessel owned by the Shell Transport and Trading Company. At that time there was a grave question under consideration whether vessels carrying oil in bulk should be allowed to pass through the Suez Canal. The early history of the oil tankers had been disastrous. The *Petriana* blew up and killed Mr. Fawcus, the partner of Mr. Fortescue Flannery, as he then was, and the *Tankerville*, another tanker, had been in serious trouble. One owner of four or five oil boats had his insurance premium raised from four to fourteen per cent., in one or two cases, on the value of the boats and cargo. There was no profit to be obtained after paying such heavy insurance premiums. One owner, for a year, ran his boats uninsured, and by good luck and great care on the part of the captain and crew no accident happened for a year. So bad was the name of the early oil boats that it was a grave question on the part of the Suez Canal authorities whether they should allow them to go through the canal. The canal authorities feared that an explosion might occur that would obstruct the canal. He might say, however, that since the invention by himself and Sir Fortescue Flannery of the system of ventilation of which he had spoken there had never been an explosion or a fire in any one of the fleet of steamers of the Shell Transport and Trading Company. When those oil boats were first started they paid a premium of eight per cent., and, as he had mentioned, the insurance on the boats of one particular firm was already at that time as high as fourteen per cent., so great was the fear that Lloyd's had of those bulk-oil carriers. With the Shell Transport Fleet, however, from 8 per cent. the premium fell to 6 per cent., then to 4 per cent., and now at the present time it was below 2 per cent., while special permission was given to the Shell Fleet, when fitted with the Terry-Flannery system, to pass through the Canal; that occurred in 1892. That, he thought, would prove to them that the efficient arrangements for the safety of a vessel, either in regard to ventilation or fire extinction, or it might be better means of pumping out the ship, were recognised by Lloyd's, and the installing of those improvements was not money thrown away. It was always better to do things as well as they could be done, so that in the future somebody, perhaps not themselves, would reap the benefit. Therefore, he believed that in due course Lloyd's would recognise those improvements that had for their object the efficiency and improvement of safety of life at sea. Mr. Howie had raised a question as the horse-power; he thought he had pretty well answered that point. In his paper he had more especially dealt with the centrifugal pump on board ship. With regard to the single acting pump, where water in large volume had to be lifted in short lengths of main on board ship and from moderate heights, the machine that moved the water in one direction was the machine they wanted. Mr. McLaren had referred to the bending of the rods of the fan engine of the P. and O. steamer *Rome*. That gentleman seemed to think that the rods should have been so constructed that they should not bend. He (Mr. Terry) was very thankful that they did bend. Their bending saved the cylinder covers, and they were able, by taking accurate needle gauges, to get them into Messrs. Caird's smith's fires ashore, where they were straightened out, and they got them so nearly right that there was very little trouble in getting them back into their places in the ship next morning. If those rods had been rigid every cylinder cover would have been smashed, and then the vessel would not have been running at 10 a.m. next day. That accident had taught him one very useful lesson, and that was, to put an extra large relief valve on the low pressure cylinder. He was very glad to hear what Mr. Walker had said, that a little sketch of his on steam pipes, etc., had borne fruit in the form of making an efficient and very cheap water separator by following the lines suggested in his article in *Fielden's Magazine* for April, 1901. That gentleman had also taken advantage of the leaping weir, an appliance that was very useful in dealing with the sewage of towns and large water supplies where in times of flood the water might be very muddy. The civil engineer made good use of the leaping weir, but it was not much used by the marine or mechanical engineer, but he thought it ought to be. He thought they ought to get no more trouble with water in the steam pipes, because it could be so easily dealt with. Mr. Lee had said that he thought the slide valve engine preferable to the piston valve engine. Well, he (Mr. Terry) thought he would not alter his opinion about piston valves. It was a matter of controversy, and as they knew, "A man convinced against his will was of the same opinion still." That gentleman had also said that he had found it a good practice to have the auxiliary engines to exhaust into the intermediate cylinder, so using the steam in the low pressure cylinder and thus getting the full benefit of it. That was probably correct. The only difficulty was that if they wanted to use the auxiliary engines when the main engines were not running it would be wasteful, and they would be turning a lot of hot steam into the condenser. He had also spoken of the necessity of properly protecting the steam pipes and their flanges. That was very necessary now that they had such high pressures of steam. The steam pipes were capable of imparting much of the heat to the atmosphere. Mr. Elmslie seemed to think that if ships had extra large holes torn in the bottoms the pumps would be useless. He was sorry that he could not agree with him there. They might take the case of the foundering of the steamer *American* as an example. He had written a leading article on that loss, wherein he had showed that had that vessel had a pump that would lift 350 tons of water per hour she would not have gone down. That ship was seven hours in foundering. The engines were stopped, and she only had small auxiliary donkey pumps and two 7 in. reciprocating pumps. The passengers turned to, and by using the hand pumps managed to lift about fifty tons per hour, which was no good at all. With regard to the position of the centrifugal pump, and the suggestion that an emergency pump and donkey boiler should be fitted at a high level so as to be worked when the main boilers were drowned out, that was a question that required some consideration. Many years ago donkey boilers were so fitted in the Castle Line. He had himself seen donkey boilers very near the level of the main deck, and if the pumping engines were of the closed type they would be able to run even with a foot or two of water in the engine-room. If they had the pump too high up they lost the water, but that difficulty could be got rid of by efficient foot valves, and also by the adoption of duplicate suction pipes, so that if one got choked the other would act. That point should not be allowed to go merely because there were one or two difficulties in the way. Mr. Bales had mentioned an arrangement that was now being made for enclosing pipe flanges. That arrangement was hinged and fastened with a slight catch so that the whole of the flange could be exposed without trouble. If they put any composition over the flange they could only tell in a general way the condition of that flange, but by means of the system Mr. Bales had described they were able to tell at a moment. Mr. Brander, he noticed, had spoken of the advisability of having pumps and boilers high up in the ship. Then they came to the question of vacuum, which was a very important point. Mr. Shearer, when speaking on that question, had said that he got better results with 26 in. than with any other vacuum. That, however, was a point that he had dealt with in his remarks at the previous meeting. That gentleman also spoke very much to the point when he urged that the fitting of those better appliances, better pumps, and larger pipes should be the subject of consideration on the part of Lloyd's underwriters. Many of those underwriters were capable men so far as their business was concerned, but they knew nothing of ships except insuring them, although that, perhaps, was less the case to-day than formerly. It was due to the fact that those who invested their money in insuring ships were non-technical men that so many ships had been so inefficiently fitted. About twenty years ago he wrote a paper on that subject for Mr. Samson Barnett, which was published by him in his catalogue of the Submarine Exhibition held at the Agricultural Hall in 1881. That exhibition was followed by the Metal Trades Exhibition in 1882, and those two exhibitions did more to improve the equipment of ships with auxiliary machinery than anything that had happened before or since. In those days steam steering gear was almost unknown, but people then had an opportunity of inspecting steam steering gear, and within three or four years from that time there was hardly a large tramp steamer that did not have steam steering gear. A great number of people connected with the Navy or the mercantile marine took the greatest interest in his paper. In that paper he proved that if a little more money, amounting, perhaps, to 10 per cent., were expended in fitting the proper number of bulkheads properly constructed and stiffened to withstand the pressure of the water, that extra money would be well spent. They had some terrible gales in 1881-2-3, resulting in great loss of life and great hardship on the part of the few survivors. Had those improvements been in vogue at that time there would have been a reduction in the number of lives lost. The cause of those disasters was inefficient design in the lost vessels: indeed, everything about that time seemed to have been pretty bad. The Chairman had clearly dealt with the position of Lloyd's Register in regard to the matter, so that there was no point left for him to answer. It only remained for him to say that he agreed with what the Chairman had said. Of course, no pumps would be effective in the case of two vessels colliding at full speed, but with moderate leakage good pumps would prevent danger. In conclusion he thanked them very much for the kind way in which they had received his paper. The Chairman said he thought it would be to the interest of the discussion if some of the members who had information on the subject would give them their views without unnecessary delay.

Mr. J. R. RUTHVEN (Member of Council) said: I have nothing further to say except to express my extreme pleasure with the paper. I have no doubt that, as in former times, Mr. Terry's remarks will bear fruit in regard to the safety of life and property at sea.

Mr. JAMES HOWIE (Member) said he also rose with pleasure to endorse what had already been said in regard to Mr. Terry's paper. He had had some experience of the oil boats in the past, and they could not but give credit to Mr. Terry and those connected with him for their successful scheme in regard to the ventilation of those boats. With regard to the figures just given by Mr. Terry he would take no exception. Taking them casually, he had no doubt they would ultimately agree with him, although they pointed to a high efficiency—much more than had been adopted in some vessels. Regarding the 10 horse-power spoken of by the author of the paper as being sufficient for the discharge of a few hundred tons of water per hour to save a vessel, he would like to make a few remarks. Speaking from memory, a standard maker of centrifugal pumps once asked for 50 to 60 horse-power to drive a 7-in. pump. Allowing for inefficiencies, they might allow of 300 ft. of water per minute through the pipes. That might be considered low, but roughly that would give $2\frac{1}{4}$ tons per minute, or 135 tons per hour. Of course, that pointed to heavy work for the engine and showed a great loss—a considerable difference when compared with Mr. Terry's figures. It might be said that the circumstances were certainly exceptional in that instance—it might be taken as an extreme case. In an ordinary case, with free pipes 7 in. in diameter, as just stated, a pump of a good size and running 300 revolutions per minute, probably 20 indicated horse-power would be asked for. That size of pipe could not, of course, be considered great for salvage purposes. He was of opinion that a 7-in. pipe delivering 150 tons per hour—that was taking it at 300 cubic ft. per minute —would be high enough for a centrifugal pump. It seemed to him that from Mr. Terry's figures there was a great loss. That, he thought, was about all he had to say on the subject, although he could not but endorse the general remarks in the paper. Mr. Terry's experience extended over thirty or forty years, and when it became scheduled that he had on two occasions given them the benefit of that experience, it redounded to the love that he entertained for the subject.

Mr. A. H. MATHER (Member of Council) said that as centrifugal pumps had been brought forward so prominently, and as the author had referred to them in his reply to Mr. Ruthven, he would be pleased if Mr. Terry, from his large experience, would give an expression of opinion on two points which had always been a source of argument. The first was as to the relative advantages of pumps with impellers with shrouded vanes working in a casing which was clear of the impeller all round except for a narrow fitting strip at the outlet, and those with open vanes working within a completely fitting casing. The second was the debatable question of the proper shape or profile of the vanes. Some makers curved the vanes far back in the opposite direction to that of rotation, and others, as in a case he had heard of a few days ago, made the tips of the vanes radial. It seemed to him that a good many pumps had the vanes curved very much too far back, as that had a tendency to throw the water out radially, thus losing some of its velocity, by striking the casing and then being deflected towards the discharge, whereas if the vanes were made more nearly radial at the tips the water would be thrown out tangentially, and would enter the discharge pipe with less loss of velocity.

Mr. W. E. FARENDEN (Associate Member) said he had one question to ask Mr. Terry regarding the velocity of water through the pipes at waterworks. The author had given figures relating to the speed of water through the waterworks mains as 2 ft. per second, or 120 ft. per minute. He thought that was rather low output for modern centrifugal engines, and would like to ask if 300 to 400 ft. would not be about the figure generally used for the velocity through the pipes, or would he suggest going beyond that?

The CHAIRMAN said he felt inclined to say a few words on the paper. He would rather the members had something to say than that he should speak himself, but as he had made one or two notes perhaps he had better say a word or two. He noticed that early in the paper they had a description of the pumping arrangements for removing bilge water from the holds of vessels such as were fitted on board steamships twenty years ago. The author had summed them up as being "commensurate with the watering of greenhouses or the washing of decks." A few lines further on the author added: "It is satisfactory to realise that any British built well-equipped vessel of over 1,000 tons, and many of much smaller size, are now almost certain to be fitted with centrifugal pumps." But the author's satisfaction was immediately qualified by the statement which followed, and that was practically a condemnation of the pipes and piping arrangements that were fitted to the centrifugal pumps as being totally inadequate. In fact, that fault was so pronounced that one was almost inclined to ask if the second position was very much better than the first. Before leaving the subject of the earlier pumping arrangements he would like to refer to a case that came under his notice some fifteen years ago. The vessel in question was an Atlantic liner. On the voyage home from North America a very serious leak occurred in the engine-room, and the inflow of water was so very great that the bilge pumps and the donkey pump were absolutely unable to cope with it. The suction of the circulating pump was requisitioned, and after several days of very strenuous work on the part of the engineers the vessel was brought safely into port. Upon examining the hull of the vessel in the graving dock they found that the whole of the landing of two of the bottom plates was very badly started and sprung—so much that it was possible to insert the blade of an ordinary penknife between the landings of the plates, whilst the rivets could be moved with the finger and thumb. He was not prepared to say how much of the Atlantic strayed into the vessel, but he did know that there would have been a very wide margin left after watering the most extensive greenhouse he had ever seen or washing the decks of a large Atlantic liner. He made those remarks because he did not think the old pumping arrangements had quite had justice done to them. He knew it was rather a difficult matter to put every point, but in the olden days the pumping arrangements were rather better than the paper gave them credit for. He did not wish it thought that his remarks were in any way in opposition to the centrifugal pump. Engineers, he thought, would agree that, where they had a large body of water to deal with, especially where there was an admixture of more or less solid matter, the valveless pump was the correct thing to use. That was the proper way of getting rid of large masses of water, and so long as the centrifugal pump was used as an aid to the main engines there was no difficulty at all, but when they came to use it as a salvage pump, then their troubles began. He did not say that because there were difficulties they should not try anything of the sort. He quite agreed with the author when he said that the pump ought to be fitted well up in the vessel. In his opinion it should be fitted at quite the height of the water level outside the ship. But it was very little use placing the pump in that position unless a boiler for supplying it with steam were placed on the same level. They knew that in many ships, owing to the exigencies of quick loading and discharging, the donkey boiler was discarded, and they used the main boiler instead. That did not apply to all ships, and if they had a good centrifugal pump on deck, with a boiler to produce steam for it, they were certainly introducing an element of safety into the vessel. But that brought them to another question—the stowage of fuel. It would be necessary to have a supply of fuel upon the same deck as the boiler, for it is just possible they would want to use the centrifugal pump when they were nearly run out of coal, and if the bunkers were flooded they were no further ahead without coal. That, however, need not preclude all ideas of having the pump. He believed it was a very good thing, but, of course, when they bought a pump of any great size it led into an appreciable expense, and, whatever their feelings might be, those who paid the money had a very large say in the matter. With regard to the pumping capacity, he did not know that it would be advisable to fit a single pump with a capacity of delivering 1,000 tons per hour. A pump with 14 or 15 in. suction and discharge pipes would be required to deal with that amount of water. It was a difficult matter to handle. At one time 12 in. was the largest size used, but he believed salvage companies were going in for the larger sizes nowadays. He thought they could hardly expect on board steamers to have pumps equal to those supplied by the salvage companies. A pump with a 10 in. suction and discharge pipe was a fairly good sized pump, and would deliver something like 480 tons of water per hour, or 500 if driven fast. That was with the engines running something like 380 revolutions per minute, according to the size of the pumps, such as some he had had to deal with. Different makers gave different sizes, but he thought they would find that pretty near all of them got the same speed at the periphery of the impeller, and 450 or 500 ft. per minute was a very good speed and gave very good efficiency. If they went beyond that he did not think they would do much good. A suggestion had been made about putting mains from the fore end of the ship to the stokehold, and from the after end to the engine room. He did not know how that would work out. It would be rather expensive and rather in the way, and as soon as they got it in the way the naval architect and the shipbuilder they had something to say on the subject. Even a 10 in. main would have to be covered to the size of its flange, taking up a good deal of space in the centre of the ship. Mr. Shearer had referred to the ordinary valve for connection. A 10-in. valve did not seem much to use, but it was a big piece of machinery, and it wanted a good space to put it in. The main would be useful enough if there, but he was afraid the question of cost, and would preclude the adoption of it on board ship. The after main would be possible under the tunnel, but in the fore part of the ship he scarcely thought it was likely to be fitted. Then Mr. Terry had referred to the high speed engine and the terrible noise made by at least some of them. He thought that a properly designed and properly adjusted engine gave very little trouble in the matter of noise. There were engineers and engineers. He had seen a high speed pump make a terrible row, and the engineer in charge blamed everything and everybody, but so soon as another engineer took charge a cure was effected, and the engine ran very nicely. In those things the human element had to be considered as well as the machinery. The author had referred to "a small undersized centrifugal pumping engine running beyond its proper speed," and there the advantage of the single acting engine came in. He had never met an engine that did any good when driven beyond its proper speed. If the single acting engine was driven beyond its proper speed they would have trouble. He thought it was more a question of having a proper engine to do the work, with all ideas of false economy eliminated, when the engine was in course of construction. With regard to Mr. Terry's remarks about steam pipes; that was one of the details that escaped designers very often. He thought his remarks on that point ought to be pondered over, for they were to the mark, and if they had their steam pipes designed on the principle suggested by Mr. Terry they would have much fewer fractures and less trouble with the engines. It was sometimes almost amusing the way that designers would put a twist in a steam pipe instead of taking a fair and open course. If the steam pipes were taken down to the engine in a proper way it would save the engineers a lot of trouble and worry, as Mr. Terry had said. He hoped some of the other members would give them their views on the subject, so that Mr. Terry would have an opportunity of replying as early as possible.

Mr. J. E. ELMSLIE (Member of Council) said he thought his remarks on the last occasion were slightly misunderstood. He did not intend to say that pumps should not be carried, or that they should not be as large as available. What he did say was that in the event of serious damage to the ship no pumps that could be carried would be of any possible use. The figures he had given at the previous meeting were pretty nearly correct. A hole

12 in. in diameter, 16 ft. below the surface, would admit 2,750 tons per hour. That was rather a large question to deal with. Sennett, who gave those figures in the *Marine Steam Engine*, page 366 (last edition), said: "A comparatively slight hole would be sufficient in the bottom of a ship to absorb all the available pumping power that could be provided." Again, Sir William White, on page 24 of the *Manual of Naval Architecture* (last edition), shows as an example that practically a hole with an area of 2 sq. ft., 12 ft. below the surface, will admit 5,680 tons per hour, and he summed up as follows: "A consideration of the preceding formula for the rate of inflow of water will show that it is hopeless to look alone to the pumps to overcome leaks that may be caused by grounding, collision, etc., the area of the hole broken in the skin admitting quantities of water far too large to be thus dealt with." The same authority also said on page 592 of *Naval Architecture*, in referring to the availability of the jet propeller to deal with the inflow of water caused by serious damage, that "The efficient realisation of the idea that the centrifugal pumps should be available for pumping the hold spaces involved the necessity of very serious interference with water-tight subdivision. By common consent the maintenance of that subdivision is admitted to be of greater importance to the safety of ships than any possible increase in pumping power." Mr. Ruthven had referred to the advantage the jet propeller would give in the event of damage to the hull by the large amount of water it could remove. Theoretically that might be so, but practical difficulties put it out of the question. The large suction pipes that would be required to be carried through the various compartments, putting aside structural difficulties, would in the event of damage quite possibly be the means of flooding other compartments. He could only repeat what he had said at the previous meeting, that in his opinion, in the event of serious damage, the safety of the ship depended not on pumps but on subdivision.

Mr. W. McLaren (Vice-President) said that from a maker's catalogue he saw that a pump with a 10-in. suction pipe, working at 450 revolutions per minute, would deliver 1,600 gallons per minute, which was nearly equivalent to seven tons per minute. He would like to point out the pulsometer of the same area of suction and of the same diameter. The pulsometer had a 10-in. suction pipe and a 9-in. discharge pipe, and it delivered six tons per minute with a 2-in. steam pipe. There was no mechanism connected with that pump, except to meet the case of the valve tumbling over from one side to the other. He thought that pump was a very efficient machine on board ship, and it occupied so much less space. It was not necessary to so rigidly fasten it as the centrifugal pump, with the danger and liability to damage from the water and steam. Speaking on the subject of steam piping, he had that summer paid a visit to an institution where they had a range of steam piping 2,290 ft. long. If he remembered rightly it was a 4-in. pipe, and the drop of pressure on the gauge was from one to two-and-a-half pounds. That, he thought, was somewhat remarkable.

Mr. Terry: What was the pressure?

Mr. McLaren: At the boilers, 120lb. Continuing, he said the insulation was carried in a subway, which, he thought, was five or six feet by four feet. The temperature in that subway would be about 120 degrees, but was variable. There were a few ventilators here and there. He would like to ask Mr. Terry a question about the system of ventilation employed on the oil ships: Was it under pressure, or was it by suction?

Mr. Terry: By suction.

Mr. McLaren, continuing, asked whether there was any test applied to those holds for the purpose of finding out if any vapour had been left in them. If any petroleum vapour were left in the holds it might taint the next cargo, which was often composed of very sensitive goods. If the cargo became tainted that taint would repeat itself when the goods were brought to the produce market. Referring again to the centrifugal pump of which he had spoken, the horse-power, presumably at the spindle of the pump, was 9·6.

Mr. RUTHVEN: On the point Mr. Elmslie raised, quoting authorities as to what pumps should be fitted on board ship, I would like to say that the late Andrew Murray, engineer-in-chief at the Admiralty, said that he saw no difficulty in making pumps to discharge 2,000 tons a minute.

Mr. JAMES HOWIE said he also remembered a pipe 400 ft. long, four inches in diameter, and some-one, perhaps the chief engineer, turned the valve on so suddenly that the water came along with such tremendous force that it blew the valve cover off. It was covered with a non-conducting composition. He could hardly realise that reduction of 2 lb. in 1,000 ft.

Mr. TERRY then replied to the various questions that had arisen that evening. Mr. Howie, he said, had spoken of a pump that he had had to do with in which the delivery was 300 cubic feet per minute, whilst the pipes were 7 in. in diameter. He had said that they had found the horse power to be altogether different to that mentioned by him as sufficient to lift the volume of water 33 ft. That 7 in. pipe would roughly have an area of a quarter of a square foot. If that pipe had been one square foot in area the velocity of the water would be, at 300 cubic feet per minute, 5 ft. per second; but as the pipe was only 7 in., equal quarter of a square foot in area, the velocity would be 20 ft. per second, ten times the waterworks velocity and about four times faster than he thought the marine practice ought to be. He need hardly tell this Institution how to calculate the horse-power in the centrifugal pump, but as a basis he might say that 1,000 lb. or

100 gallons lifted 33 ft. high from the bilge over the ship's side equals 33,000 ft. lbs. equals I.H.P. in water lifted, allowing a combined efficiency of pump and engine of 33 per cent., every such volume raised per minute would require 3 h.p. Thus 1,000 gallons per minute would require 30 I.H.P. in the cylinder of the centrifugal pump engine. With regard to the questions raised by Mr. Mather, he would say that his paper did not profess to be a mathematical one. That subject would require two or three papers to deal adequately with the points raised, and at that late hour he was afraid he could not deal at all efficiently with the matter. He had had a good deal to do with the designing of fan engines, and the general principle in regard to the blades was to so design them that the water entered in such a way that it should flow on to the blades with as little shock as possible. The proper shape was one in which the water did not meet the blade near the centre of the fan at right angles. The water should run up the root of the blade, and at the tail end run off the tip. It had been found useful in fan engines, and the same must be true in centrifugal pumping machinery, to provide fixed guide blades where the water was entering, so that there was imparted to it a velocity somewhat in the direction that it would have to go when the moving blades got hold of it. A good deal of shock was thus avoided, and the same velocity was imparted to the water before it formed part of the resistance that the engine had to meet. The subject, however, was really one that ought to be dealt with in a special paper. Mr. Farenden had spoken of the velocity of the flow at 300 or 400 feet per minute. He had looked up some particulars of a pump that had delivered 600 tons per hour, and he found that the size of the mains of that pump was 10 in., and that pump required a velocity of 12 ft. per second. So they would see that when he referred to pumps as having a velocity five times that of the waterworks he was right. Here was one with a velocity of six

times. In the instance he had just mentioned they had people selling pumps with a guaranteed delivery, and requiring a velocity of 12 ft. per second. He thought that a great deal of the trouble and blame that had been attached to centrifugal pumps was due to the fact that they were so often crippled in the suction and discharge pipes, which, in many cases, were too small, and the bends too acute. Those bends were the cause of eddies being set up in the pipes. The water as it flowed along was invited by a valve to go at right angles, and in passing the bend the water leaned outwards, and so wasteful eddies were set up, and the power was wasted, and the delivery of the pump was crippled because of those eddies. He did not suggest that the pumping speed on board ship should be limited to the velocity of flow adopted by waterworks engineers, viz., 2 ft. per second; he thought any velocity over 6 ft. per second too high, and when sharp bends accompanied that velocity the action of the pumps was crippled. Mr. McLaren had referred to an institute where they had a range of steam piping 2,290 ft. long, 4 in. in diameter, carrying steam at 120 lb. pressure, and having a drop of only 1 to $2\frac{1}{2}$ lb. in the full length. He supposed that was a hospital or a workhouse, but he assumed that Mr. McLaren did not test that gauge.

Mr. McLaren: I did not try the temperature.

Mr. Terry, continuing, said Mr. McLaren probably took the reading of the two pressure gauges that were fixed there, and they might not be correct in their reading. But in a large pipe with a comparatively slow flow of steam and well drained of water and with an adequate boiler pressure, he was quite prepared to believe there was no greater drop of pressure. When they had a boiler at one end to keep plugging steam down the pipe he did not think that there was anything very remarkable in there not being any more fall in the distance mentioned. In that tunnel the air no doubt was heated to 120 degrees. Mr. McLaren had also asked a question as to what tests they had to show the efficiency of the fans employed in sucking the air out of the holds of oil steamers. At present they had no very efficient test, but there was one test they never used, and that was a lighted match—obviously unsafe. That was a very sure test, but in a hold partially full of petroleum vapour, and with a temperature of seventy or eighty degrees, he thought the person who made that test would never be able to give them the results of the experiment, as his next address would be the nearest mortuary. He was afraid that up to the present they had not invented a test. The exhaust fans ran at certain revolutions and sucked up a known quantity of air, so they approximately knew when they had exhausted the foul vapour. For example, from a given sized tank or hold, with a suction fan exhausting 5,000 cubic feet per minute, the contents of a 400 ton tank, of which there would be twenty in a 5,000 ton oil boat, would be exhausted in two minutes, or the entire contents of the whole ship could be discharged twice in one hour. Still, if someone would invent a reliable test for the holds of those vessels it would be an advantage. The flame test could not be employed with regard to the horse-power for the pumps—he had touched upon that point before. Six hundred tons per hour equalled ten tons per minute, or three cwts., or 374 pounds per second, and that was six cubic feet per second in a pipe having an area of one square foot. If the pipe had an area of only half one square foot, then the velocity would be doubled, that was, it would be twelve feet per second. That was exactly six times the speed employed by civil engineers. With regard to the statement that centrifugal pumps, as distinct from reciprocating pumps, either coupled to the crank shaft or not, lost their water, he would say that the ordinary pumps could lose their water if they did not let the water get to them, or if they were too far down the limit of the water and not able to get a vacuum. The proper course was to provide foot valves and double suction pipes, and the foot valve should be placed where they could get at it. Many things were liable to choke the pumps, such as shavings, dunnage, old gunnie bags, seaweed, and cargo from the holds. Any kind of rubbish was liable to choke them, and it was not right to blame the centrifugal pump for a trouble that might arise with the reciprocating pump. They ought to so provide that the pump was certain to get its water, and to do that they should have double suction pipes with proper strum boxes fitted and have the foot valve so that it could be immediately got at. The question of fitting the branches to pumps should also be gone into much more carefully than it was at present. Those branches should flow in gently, and not come in at right angles.

The CHAIRMAN, referring to the question of the angle of the fans, remarked that what Mr. Terry had said was pretty well correct. He knew of an engineer on the Hooghly some years ago, and on his steamer they had some difficulty in getting all the water they wanted for the condenser, and the pump had been overhauled and adjusted in every way and they could not improve it. One genius thought he would reverse the angle of the blades, and, marvellous to relate, when that was done it was a great success, and all the other vessels of the Company were treated in the same way. It was no use having a centrifugal pump for pumping bilges unless they had a foot valve at the bottom of the suction pipe. If they had that foot valve the best thing to do was to have a small branch pipe fitted to the discharge of the pump, which could be connected with a hose to the donkey pump and by this means flood the whole of the pipes and pump before starting. In one case, where a vessel had got on the dock sill at Tilbury, the pump was worked from the deck. They got down to 36 ft. After they had pumped the bilges dry they charged the pump whilst the water was gathering and then went on pumping again. There was no difficulty in charging the pump. It only wanted a little experience.

He would like once more to express their obligation to Mr. Terry for the amount of trouble he had taken to come there and give them the benefit of his experience and knowledge, which he was sure they all appreciated to the fullest extent. They hoped to have the pleasure of seeing Mr. Terry at some future time with one of his very good papers, which, he was pleased to see, interested their members very much.

Mr. RUTHVEN seconded the vote of thanks. He said he had been extremely interested in the paper, and had learned many points that he had not known before.

The vote of thanks was carried by acclamation.

Mr. TERRY, in acknowledging the vote of thanks, said it did not require any further inducement for him to come down to Stratford, where at one time he used to be a more frequent visitor. If, however, he did require any further inducement, he thought he had already got it in the kind way in which he had been treated that night, and on the previous night when Mr. Adamson had read his remarks, which had led to an interesting discussion. He hoped he would come there to learn. He looked upon his paper as a bottle for them to throw the pebbles of their discussion at, and he was glad to say the bottle appeared still unbroken.

A vote of thanks to the chairman, proposed by Mr. FARENDEN, seconded by Mr. ELMSLIE, and carried unanimously, concluded the meeting.

INSTITUTE OF MARINE ENGINEERS
INCORPORATED.

SESSION 1903-1904.

President—SIR JOHN GUNN.
Local President (B.C. Centre)—LORD TREDEGAR.

VOLUME XV.

ONE HUNDRED AND TWELFTH PAPER
(OF TRANSACTIONS).

AUXILIARY PUMPING MACHINERY ON BOARD SHIP.

WITH SUGGESTIONS FOR ITS IMPROVEMENT.

BY
STEPHEN HARDING TERRY (MEMBER).

DISCUSSION

AT
3 PARK PLACE, CARDIFF,
WEDNESDAY, NOVEMBER 25th, 1903.

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

MR. CHELLEW began the discussion by endorsing the views expressed by the author as to the trouble frequently experienced with hand pumping arrangements. If the Downton pump were introduced it should be placed on a separate platform, so that the pump should draw.

Mr. CHAS. JONES: Having carefully read this interesting paper, I would like to call attention to the deck pumps fitted on board steamers as required by Lloyd's rules. In all modern steamers, steam suctions are provided for all the bilges and wells in the holds where water may accumulate, but in addition to this Lloyd's also require hand pumps, which are fitted on deck and led to the various compartments. The chambers and pipes leading from the deck to the bilges, etc., have to be cased in with wood casings, which in addition to taking up a large amount of cubic capacity, are also a continual source of danger, through grain and dirt finding its way into the wells, and expense for upkeep, through breakage when loading heavy cargoes, stowing cotton, etc. When a ship goes through survey the hand pumps are fixed up in their respective places and worked to the satisfaction of the surveyor, who, as a rule, is most particular in seeing them in good order. After the survey is completed the pumps are carefully stowed away, the holes in the deck or pump chambers carefully plugged up and at the next survey four years hence the same performance is again conscientiously gone through and the ship certified as fit to carry dry and perishable cargoes. In my own experience I have known serious damage caused through water finding its way into the holds through these deck pumps when not plugged up, as it often happens that in bad weather the decks are flooded for days together. Lately Lloyd's have allowed a "Downton" pump to be fitted in lieu of these hand pumps, but I cannot understand what practical use a small hand pump is to draw water from a bilge or well, say, 150 ft. away, and lift it, say, 20 to 30 ft. This pump has to be connected to the various wells, etc., through the steam suctions, the distributing valves for which are in the engine-room. Such tends to complicate the already intricate arrangement of valves, etc. A steamer having cargo on board invariably has steam up or the means of obtaining same quickly, which can be used for keeping the ship dry, and I think if a general concensus of opinion were taken as to the desirability of fitting and maintaining these pumps, we as a practical body would vote for abolishing them. By doing so it would save the shipowner a substantial amount, not only in first cost but in upkeep, and would lighten the duties of Lloyd's surveyors. Shipping at present is in a depressed state, and if we can lessen the cost of production and upkeep in the smallest degree it will be to our mutual benefit.

Mr. METCALF recited an experience in mid-Atlantic with a ship in ballast, and the difficulty and futility of hand pumping, and having at last to resort to the vessel's own steam.

Mr. HENDERSON thought Mr. Terry had over-estimated the necessity of pumping arrangements in comparison with the Board of Trade requirements. The comparative cost *less* Mr. Terry's suggestion, was more to the shipowner's mind. With regard to syphoning, he found that a large number of steamers were provided in this manner, the discharge pipe being led to a double branch hood above water level. The pumping arrangement to prevent flooding of steamships suggested by Mr. Terry was certainly abnormal to everyday practice and also above the actual requirements of the Board of Trade. On a passenger steamer of, say, between 5,000 and 6,000 tons, the usual fittings were two Downton pumps or like design placed on main deck, arranged to drive by hand or fitted with sprocket wheels and chains led to winch adjacent, the suction pipes being led into bilge system in engine room, the spindles of the valves on the system being extended with rods to main deck. This arrangement in itself would cost about £200. The centrifugal pump as suggested would require to have systematic attention, not only the pump, but, no less important, the strums. Mr. Terry does not in-