INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1900-1901.

President—COL. JOHN M. DENNY, M.P.

Volume XII.

EIGHTY-EIGHTH PAPER.

TWENTY YEARS OF PROGRESS IN CARGO-BOAT MACHINERY,

BY

MR. J. F. WALLIKER (MEMBER B.C.C.).

READ AT PARK PLACE, CARDIFF,
ON THURSDAY, FEBRUARY 1ST, 1900.

AND AT

THE INSTITUTE PREMISES, 58 ROMFORD RD., STRATFORD,
ON MONDAY, FEBRUARY 12TH, 1900

PREFACE.

58 Romford Road, Stratford,

February 12th, 1900.

A meeting of the Institute of Marine Engineers was held here this evening, when a paper by Mr. J. F. Walliker (Member) on "Twenty Years of Progress in Cargo-boat Machinery" was read on behalf of the Author by the Hon. Secretary. Mr. F. W. Shorey (Treasurer) presided. The Paper was previously read by the Author at the Bristol Channel Centre premises in Cardiff. The discussions follow the paper.

JAS. ADAMSON,

Hon. Secretary.

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By Mr. J. F. WALLIKER *(Member, B.C.C.).*

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Chairman—Mr. T. W. Wailes *(Vice-President B.C.C.)*;

AND AT

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Chairman—Mr. F. W. Shorey *(Hon. Treasurer).*

Verily the history of Marine Engineering in general for the two decades 1879 to 1899 is the history of the adoption and triumph of multiple expansions and of high pressures.

It is stated in Chambers' *Information for the People,* published in 1849, that Stephenson saw a boiler on board an American steamboat on the River Ohio worked at 138 lb. pressure; but at the same time it is well to remember that high pressures and multiple expansions were not unknown here before

1879, but had been in a sort of suspended condition for some years. Looking through the pages of *Lloyd's Register* for that year we find a few cases bearing on this question of dates and pressures. There is recorded the little *Enterprise*, engined by Wilson, of London, in 1872, with a pressure of 150 lb.; the *Sexta*, engined by the Ouseburn Engine Works of Newcastle-on-Tyne in 1874, with a pressure of 120 lb., and with triple expansion engines working on three cranks; the *Propontis*, engined in the same year by Messrs. Randolf and Elder, of Glasgow, likewise fitted with triple expansion engines, and others. Mr. Perkins' tri-compounds came out in the Seventies, the *Isa* (yacht) in 1879, with a pressure of 120 lb., and a few others of which the writer has no certain data. With the exception of the *Isa*, all the others may be well designated experiments that failed, and it was owing to the success of this little yacht that the possibility of the ordinary boiler for still higher pressures suggested itself.

Revert to the *Propontis*, for one minute, to look at her history. Built in 1864, she was re-engined and fitted with tri-compounds and new boilers in 1874. The boilers (of the water-tube type) were a failure, and were replaced by cylindrical boilers in 1876, at a reduced pressure of 90 lb. With these she worked till 1884, when they were again renewed, and at the present day she is registered at 145 lb. pressure, and with the 1874 engines! This difference or improvement is clearly due to the boiler alone, and on this point Dr. Kirk, at a meeting of the I.N.A. a few years since, expressed his conviction "*that the want of a proper boiler had delayed the introduction of the triple expansion.*" The writer believes that the credit of introducing what, at the time and since, has fulfilled that want to a most satisfactory degree is due, firstly, to Mr. Alexander Taylor, of Newcastle-on-Tyne, in adapting the ordinary boiler to the higher pressures, and secondly, to the firm of Messrs. Fisher, Renwick & Co., of the same town, for their foresight in fitting them into one of their vessels and for thus bringing the multiple expansion engine, once and for all, from the rank of experiments to accomplished and deserved success.

From the foregoing it will be seen that the much-maligned, and by some discredited, Scotch boiler was the founder of the success of the engine of to-day. Called by its detractors extravagant, heavy, and expensive in manufacture (it has even been designated a tank), it still holds its own in the mercantile marine, is practically universal, and does not appear to have a rival in the particular sphere in which it has been so extensively used. It is believed that the water-tube boiler is still in the future so far as the tramp steamer is concerned, and that it will take a good deal of successful application before it supersedes the well-tried favourite. In certain large and first-class firms, where the engineers are engaged in a fixed trade and grow old in the service, the use of water-tube boilers may be admissible ; they require delicate handling and a continuity of experience and service. These conditions, however, are not common, and the leaven of the old saying "that there are more ships than parish churches" tends frequently to changes in the engine-room, for small and inconsiderable reasons, even among the better class engineers of to-day. For the above and many other obvious reasons a boiler with which a certain amount of liberties can be taken is a necessity and it may be cited, as one of these, the difficulty often experienced in inducing those in charge to make an intelligent and continuous use of the evaporator. It was recently given as a reason for its discontinuance that it increased the consumption from 12, to 14 tons per day and without any countervailing advantage ! This and such as this form the factors which have militated against any general change in the form of the present boiler ; they cannot be ignored by the owner of to-day who has to work against ever-increasing competition at home and abroad, and who is obliged to use what will give him reasonably economical results and at the same time protect him from possibly ignorant or incompetent men.

It is not to be understood from the foregoing that the water-tube boiler is in any way condemned or even disparaged. Its conspicuous success in our own and other navies would at once refute the ridiculous assertion, if the writer had had the temerity to make it—he only suggests that it is too delicate for the rough handling to which it might possibly be subjected in an ordinary cargo boat.

The introduction of the Siemens-Martin process in the manufacture of steel for ships and boilers and the strict though sensible rules introduced by Lloyd's Register, regulating its testing and manipulation, gave confidence to the engineering world generally and certainly hastened its general adoption. Plates of 5 tons in weight and upwards are in common use for boiler shells, and the strides made in this branch alone since 1881 may be shown when it is stated that no firm on the north-east coast who was consulted either could or would undertake to build a boiler for 150-lb. pressure. That order was subsequently given to Messrs. Douglas & Grant of Kirkcaldy, who have thus the honour of having made the first high-pressure Scotch boiler. This was for the *Claremont*, Messrs. Fisher, Renwick & Co.'s first triple, and an illustration of her engines will be found at the end of the discussion. Considering the enormous number of boilers now made of steel, it has been a splendid justification for its universal use to find the few failures that have occurred—indeed, in these latter days they are almost unknown and then are more often due to faults in manipulation than in manufacture. An instance of the fine quality of this material, even in the early days, may be noted. In 1882, when the main boiler of the *Albertina* was being lifted on board, the sling broke and it fell some distance on to the seating, considerably bending the shell at the circumferential seam but without fracturing the plate; this as a matter of precaution was fitted with a strap and the boiler did its work well until this year, when it was replaced. A curious coincidence here occurred. The sling of the new boiler broke under the same circumstances as in the case of the old one but with an unfortunate loss of life. The injury to the boiler, however, was only of a character which could be easily made good, and it is now in successful use.

On the whole, steel boilers after a long experience are doing good work. In the majority of instances they are kept free from corrosion, and the writer's forecast that many would last for at least thirty years, when intelligently cared for, seems to be on a likely course for fulfilment.*

When the triple engine was found to be a commercial success, a large number of old vessels were converted and fitted with new boilers while others were re-engined as well. In many of these cases ingenious devices were tried so that the altered or new engines should only occupy the same, or at least, only a slightly increased, bedplate length relatively to those generally fitted.

Many firms superposed the third or new high-pressure cylinder on the top of either the forward or the after engine; one firm, Messrs. Gourlay, of Dundee, utilised the mid-eccentric pit for the third cylinder, the valve gear of the three engines being worked from two sets of eccentrics only; while in the cases of those who could afford the room, a third engine was attached complete at the forward end of the bedplate. Messrs. Palmer, in the *James Joicey* (a picture of which is appended), and others, fitted an interchangeable crank shaft with the crank pin of the centre engine, made with a coupling at each end to fit into a recess in the web. It was seen at quite an early stage of tri-compounds that the three-crank engine, with cranks at equal angles, from its easy turning moments, would be the most satisfactory, and

* "Notes on the Maintenance and Repair of Marine Boilers" (Proceedings North East Coast Institute of Engineers and Shipbuilders for 1896).

its universal adoption in new engines was only the work of a very short time. At present in new vessels, where there is a super-abundance of engine room space, due to the tonnage laws, the valve gear has, as a general rule, returned to the old double eccentric link motion; a notable exception to this, however, is to be seen in the large cargo-boat engines of Messrs. Hawthorn, Leslie & Co., in which the valves are worked by a special gear (see illustration) designed by Mr. F. C. Marshall. These engines, indicating 3,000 H.P. and with a W.P. of 160 lb., have been fitted into 21 large cargo steamers. Unquestionably the most advanced type of multiple expansion is in the five-crank engine (see illustration) first designed and introduced by the late Mr. Mudd of West Hartlepool, and manufactured by the Central Marine Engine Works. It is stated that engines of this type are propelling a vessel of 5,800 tons at an average speed of nine knots, on $13\frac{1}{2}$ tons of ordinary coal, being at the rate of 1 lb. per I.H.P. per hour.*

The average coal consumption was stated by Mr. F. C. Marshall in a paper read before the I.N.A. in 1887 to have been in 1872 2·11 lb. per I.H.P.; in 1881 1·828 lb. per I.H.P.; while to-day the ordinary cargo boat averages 1·5 lb. per I.H.P. for all purposes.

This further economy is due doubtless to an aggregation of improvements, but firstly and principally to the small range of temperature in the cylinders. Whether the initial cost and upkeep due to duplication of parts will ultimately pay is a question for the future, and which owners, who are the final arbiters in the question, will have to decide.

The average working pressure in 1881 was only 77·4 lb.; but, out of 179 sets of engines classed in *Lloyd's Register* since July last, 80 per cent. were above 160 lb., 8 per cent. above 200 lb. and none below 100 lb.

Appended is a table showing the percentages of pressures in 1879 and 1899 :

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* See discussion on performances of two steamships, Paper No. LXXXIII, Vol. XI.—J. A.

BOILER PRESSURE IN THE MERCANTILE MARINE IN TWENTY YEARS, AS SHOWN IN "LLOYD'S REGISTER."

1879		1899
3·5 per cent.	Below 20 lb.	—
6·9 "	20 lb. to 30 lb.	—
4·2 "	30 " " 40 "	—
3·3 "	40 " " 50 "	—
3·3 "	50 " " 60 "	—
32·5 "	60 " " 70 "	·5 per cent.
36·1 "	70 " " 80 "	6·6 "
9·4 "	80 " " 90 "	12·3 "
·9 "	90 " " 100 "	4·2 "
—	100 " " 150 "	10·2 "
—	150 " " 165 "	45·2 "
—	165 " " 200 "	16·6 "
—	200 " and above	3·7 "
Five are recorded at 100 lb., two at 120 lb., one at 150 lb.		Over 5,000 steamers are registered with a pressure above 100 lb.

Comparing a first-class cargo steamer of twenty years ago with one of to-day is very interesting, and shows fully the necessity for the engineer in charge and his assistants to be as qualified as the more advanced rules of the Board of Trade regulating their initial training and their examination demand. At the time referred to, and indeed for some few years after, with the exception of steam reversing and turning gear the staff on board had little to trouble them outside the main engines. Certainly steam steering gear and steam capstans were used, but as the vessels were of small size compared with those now in vogue their inclusion was by no means universal. Forced draught and other elaborations were rarely seen. At the present day, however, we frequently find in a first-class tramp steamer, besides a larger set of engines than many an old P. and O. liner possessed, engines for reversing, for turning, for forced draught; for centrifugal pumps, for feed pumps, for auxiliary pumps; for ash hoists, electric light engines, etc., many of which are in duplicate; to these add such trifles as evaporators, feed heaters, feed strainers, reducing valves, etc., and there can be small wonder that the spare time of the engineers in charge has been wofully encroached upon.

Both electric lighting and refrigerating machinery —which latter is another phase of our change and improvement—have become so largely adopted that special rules for their fitting and subsequent examination have been formulated by *Lloyd's Register*. At the present time there are 285 vessels recorded as fitted with refrigerating machinery, and their number is gradually growing. The work on these is so extensive and demands such special knowledge and attention that it is entrusted to a separate staff.

What may be called the principal drawbacks of the engines of the present day are two in number; the screw shaft and the steam pipes. The defects of the former were thoroughly discussed last session by the members and have been productive of much comment in all technical papers dealing with the science of marine engineering; still it cannot be too often emphasised that the fact of them failing is not without reasonable cause, and that some alteration and amendment was required either in their design or construction or both. Two things, however, have always appeared inexplicable—first, that this shaft should be the only piece of machinery in the ship supposed to be capable of running with water alone, and the other that, when one form of shaft has failed (sometimes several times) in the same vessel, an alteration in form and design was not adopted but the old certain error repeated again and again. With regard to steam pipes the writer can only express his disappointment at the slow progress apparently being made in the use of the expansion gland. It being practically a universal joint, and not liable to give trouble in any way whatever, seemed to suggest that it would come into constant use, after the trouble experienced by pipes breaking at the flange, through stress, had been thoroughly appreciated. This, however, is not so, but it is believed that its day will come, and that the custom of depending upon bends alone for the necessary elasticity and expansion will be sooner or later a thing of the past. The use of this gland with iron or steel pipes is imperative, and it is perhaps a matter for surprise that this material has made such slow progress in view of the fact of its success even in the earlier triples.

The enhanced importance of the machinery, since the practical abolition of the masts, has been so generally recognised that it may not be out of place to predict a time when the master will also act as chief engineer; and as a step in this direction it is suggested that engineers be encouraged to pass an examination and receive a certificate for proficiency in navigation in the same way that deck officers are at the present time enabled to pass one in steam.

In one other respect there might easily be a change for the better, and in that English owners (with a few exceptions) might take a lesson from some foreign-owned steamers, where the chief engineer is allowed two berths—one for a bedroom and the other for an office in which to transact the clerical work necessary to his position. When it is remembered that the master has, besides a well-fitted and commodious cabin, with all necessary adjuncts, a chart-room, as well as a saloon generally reserved for himself alone, a small concession such as above indicated would not be out of place and would assist and encourage the continuity of service in the engine-room control, which is invariably found to be the largest factor in its general economy and successful working.

In conclusion, and reviewing the progress of the last twenty years, it appears that we have replaced iron by steel in boiler manufacture, adopted 3-, 4-, and 5-crank engines, increased the working pressure, reduced the coal consumption, increased the average size of, improved the machinery used for manufacturing, the engines and boilers (and especially the latter), practically eliminated corrosion in boilers, and in many respects added to the responsibilities and duties of those in charge.

PREFACE.

3 Park Place, Cardiff,

February 1st, 1900.

A Meeting of the Bristol Channel Centre of the Institute of Marine Engineers was held here this evening. In the absence of the President, Sir John Gunn, by illness, the chair was taken by Mr. T. W. Wailes (Vice President B.C.C.). A Paper on "Twenty Years of Progress in Cargo-boat Machinery" by Mr. J. F. Walliker, was read and in part discussed. The discussion was adjourned till February 15th. A report of the full discussion follows on.

Announcement was made that arrangements were in progress for a "Smoker" on a large scale, to be held shortly in the Lesser Park Hall.

GEO. SLOGGETT,

Hon. Secretary B.C.C.

TWENTY YEARS OF PROGRESS IN CARGO-BOAT MACHINERY.

DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

THURSDAY, FEBRUARY 1st, 1900.

CHAIRMAN:

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

MR. DAVID GIBSON (Member) thought the principal credit for the progress reported by Mr. Walliker should be set down to steel, which had made such great developments possible. He did not believe there was much economy in the five-crank engine itself. Whatever economy there was, was to be found in the boiler and in arrangements for the superheating of steam. The expansion gland mentioned by the author was a very desirable fitting and essential to high pressures. The running of tail shafts in oil had been found very beneficial. He was strongly impressed with the importance of continuity of service by ship's officers, who should be properly housed and decently paid.

Mr. M. W. AISBITT (Member) said they should not look at the economical side of the question, i.e., the coal consumption, as being the whole factor in economical ship management. On long voyages the less coal to be burned enabled a larger cargo to be carried, but on coasting voyages coal consumption was not the whole question of economy involved. Many compound engines at 120 lb. were more economical than a triple engine at 160 lb., but in the case of a vessel carrying 5,000 or 6,000 tons, and voyaging, say, to Bombay, the triple engine was the more economical. As to the utility of the five-crank, the modern tendency was for the very large vessels, carrying up to 16,000 tons, to become not five-crank but twin screws, or practically a six-crank. As they increased their power they were bound to subdivide it. A single engine to develop a high indicated horse-power would be too heavy for the vessel to carry. On the other hand, there was more wear and tear with the different machinery; but there was a limit beyond which they could not go in the development of power out of a certain quantity of material. It was all a question of what speed they wanted to get and the power they could run. The *Paris*, of which they had heard lately, had three cylinders on each engine and twin screws. She was not an economical boat, but if she had three propellers and her 22,000 horse-power divided into three, at the same time increasing the pressure, he was confident she would burn less coal. Of course, it would not pay to have these multiple propellers upon an ordinary cargo boat, whose speed was supposed to be only from nine to ten knots an hour. Mr. Walliker had referred to the circular boiler, which he called the Scotch boiler. The fact was, however, that this boiler was a Tyneside boiler. The Scotch boiler was a haystack one. As to water-tube boilers, for land work and where the water supply was perfectly pure, there was no doubt the tubular boiler of Messrs. Babcock and Wilcox did very effective work, but for steamships the circular boiler was the best at the present day. As to compound *v.* triple-expansion engines, he thought the economy was due to using steam at a higher pressure, and also through the running of engines at an equipoise from three points. In the case of vessels running to Malta and back, it would pay to have compounds at 120 lb. with two cranks better than to run them at 150 lb. on the triple expansion. As to tail-end shafts, he was glad to see that some good was accruing from their discussion of this important subject, and that there was a growing practice to run them in oil or vaseline instead of water. There would be fewer fractures of tail shafts in the future than in the past. As to expansion joints, he was confident that steel was the proper material for steam pipes, and this being so there must be expansion joints. As to the status of engineers, in the Scandinavian mercantile service masters were obtaining a knowledge of engineering and the engineers of navigation. He thought the time was coming when the master of a ship must have engineering knowledge, or the engineer would have to be familiar with the science of navigation. Nowadays they could not afford to devote the whole of their time to one particular subject. A dry dock manager must know not only how to manage the engineering and repairing departments, but to run the concern as a whole.

Mr. A. YOUNGER (Member) said the question whether the five-crank engine should be fitted in a ship was essentially one to be settled by the shipowner. In the first place, what the shipowner wanted was not an engine which would drive a ship on a consumption of so much coal per indicated horse-power, but at what expense was he able to propel through the water a certain amount of deadweight, because, after all, this was the basis upon which the money-earning power of the ship depended. The introduction of many cylinders, pistons, connecting rods, and working parts was bound to add enormously to the wear and tear. The economy usually attributed to the five-crank engine was largely made up from fittings entirely outside the engine itself, while a large proportion of the economy was doubtless owing to the reduction of range of temperature in the cylinders, a considerable portion of which was due to feed-water heaters and forced draught and one or two other matters, the fittings for which required to be kept in order and entailed much additional work on the engineer. On this account the engine-room staff had to be increased, which in itself was a permanent charge on the ship. As to the future of water-tube boilers, one well-known firm on the East Coast had adopted them in many of their boats, although it was only right to say that these boats were running between fixed points and came regularly under the personal supervision of those who were responsible for their up-keep. When the time arrived for the general adoption of water-tube boilers in ships, the question of the corrosion of boilers would become even more important than it was now. He had known new steamers which had to be re-tubed within the guaranteed time (six months), and corrosion to such an extent in water-tube boilers would be infinitely more disastrous than in the case of the usual circular boiler, which he agreed with Mr. Aisbitt was a Tyneside production. The majority of the failures to tail-end shafts were due to corrosion at the end of the liners, but indications were not wanting that, perhaps by increasing the diameter of the shaft, abolishing the liners, and running the shafts with solidified oil or vaseline, with some fixing at the end of the stern tube, the problem would be solved. With regard to Mr. Walliker's observation as to the repetition of the same kind of tail-end shaft, he knew of a seven-years old steamer which was now running with her fifth tail-end shaft, and all these were more or less duplicates, and all broke within a short time. What was exactly wrong had not been definitely settled, but it appeared to have been partly owing, at all events, to an enormously heavy propeller weighing something like $8\frac{1}{2}$ tons, while the diameter of the shaft was only about $10\frac{5}{8}$ in. That propeller had now been removed.

Mr. T. JACK (Visitor) mentioned a case in which corrosion was cured. The tail shaft ran in a bronze shield and the shaft itself was hollow. After a few months he found pronounced corrosion. Inside there was a long space which he filled up with vaseline and put on a German filler. He had not the slightest trouble afterwards, and after the tail shaft had been continually submerged in salt water for four years he found it as good as ever.

Mr. MASON (Member) said it was owing to the improvement from iron to steel that they had been able to adopt triple-expansion engines. As to the Marshall gear, it was a modification of Hackworth's. As to coal consumption, he was one of those who did not believe in the consumption per I.H.P. He knew of two sister ships, identically the same in every respect. Both had compound engines, and one came out at $1\frac{3}{4}$ lb. of coal and the other at $2\frac{3}{4}$ lb., although they were doing exactly the same work. Much depended upon the propeller. As to the subdivision of engines above 1,000 horse-power, he had always understood that one of the chief reasons for adopting twin screws was on account of not being able to get their power on a single propeller. Then the Atlantic liners were fitted with twin screws for safety. As to expansion joints, they needed to be well looked at after every voyage. If neglected they might cause a very serious accident. As to tail-end shafts, he had run them in oil for nearly ten years past.

The discussion of the paper was adjourned till the next meeting—a fortnight hence—on the motion of Mr. W. SIMPSON, seconded by Mr. EVAN JONES.

A cordial vote of thanks was accorded Mr. Walliker, on the proposition of the CHAIRMAN, seconded by Mr. AISBITT.

CONTINUED DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

THURSDAY, FEBRUARY 15th, 1900.

CHAIRMAN:

MR. M. W. AISBITT (VICE-PRESIDENT B.C.C.).

MR. WILLIAM SIMPSON (Member) agreed that engineers ought to have better accommodation on board ship than was provided for them in very many cases. More satisfactory work would be got out of the engineer were he properly housed. As to the suggestion of the author that, in the future, ships would be entrusted to the man who combined in himself both mariner and engineer, he was inclined to demur to this, because it would mean that a man would have to serve two successive apprenticeships, which would take too big a slice out of a man's lifetime. If any change were to take place, it would be in the direction of putting the commercial man over both captain and engineer. Even at the present time a ship had to be run too often according to rules laid down in the office, and despite fog and other circumstances so many revolutions had to be made and a certain course had to be steered. As to engineers' accommodation on board ship, his own engineers had as much right to use the saloon as the captain. With regard to tail-end shafts, he agreed that one long liner was a considerable improvement upon two short ones. With the latter they had two sudden breaks, and the shaft usually gave way at the far end of the after liner, which was the weak spot. He did not see any necessity for a liner on the shaft. He had seen a parallel shaft without a liner that had been running for thirty years. This was in a Swedish ship of about 1,200 tons. He was an advocate of steel steam pipes and expansion joints. As to the introduction of triple-expansion engines, he did not see that they had saved anything in consumption. No matter how careful they might be, they lost a certain amount between the boiler and the H.P. valve chest; and after it had done its work in the H.P. valve chest, they lost a certain amount between the H.P. and the Intermediate. On the other hand, they certainly had a much better balanced engine in the triple, and a better running machine, than in the ordinary compound. As to the five-crank engine, the makers had not yet got over the trouble of the single shaft. With regard to Mr. Aisbitt's point as to weight, he agreed that twin screws and a double set of engines would be a considerable improvement on an ordinary single with one shaft for long voyages, but for those coming frequently into dock he was afraid it would be a good job for the dry dock owners.

The CHAIRMAN said a breakdown was a breakdown whether the voyage was long or short, and with a single propeller towing would be necessary.

Mr. SIMPSON, continuing, said makers were steadily improving water-tube boilers, but he only hoped that his (ordinary) boilers would last until they were more perfected.

Mr. EVAN JONES (Member) said during the last ten years they had made very much bigger engines, but so far as the economy was concerned they were not much further ahead, unless it be in the Mudd engine, about which they required to know more. Leaving out the latent heat of steam, there was no doubt the modern marine engine was a perfect machine, and if the boiler were anything like so perfect much better results would accrue. Although they had been able to improve the boiler to carry higher pressures with safety, yet the efficiency of the boiler itself was practically the same to-day as it was thirty years ago. That was to say, of a given weight of fuel put on the grate no more heat was got out of it than was done then. He thought he was safe in saying the best water-tube boiler makers would guarantee only 10 lb. of water per lb. of good Welsh coal, and this could have been got thirty years ago. If they were to see any great progress it would be from a chemical point of view. The atmosphere was composed of oxygen and nitrogen — mechanically, not chemically mixed—in the proportion of 1 to $3\frac{1}{2}$, and for every 1 lb. of coal burnt on the grate they required $2\frac{2}{3}$ lb. of oxygen, and to pass through it $9\frac{1}{3}$ lb. of nitrogen.

To consume a ton of coal on the grate they had to pass through $9\frac{1}{3}$ tons of nitrogen, and to raise the temperature of the nitrogen from the temperature of the atmosphere to 650 or 700 degrees, was equivalent to imparting, perhaps, 5,600 or 5,700 degrees of heat to one ton of nitrogen. Here was a tremendous loss. If by chemical means it was possible to separate the oxygen from the nitrogen, they would gain all the heat that was now lost, and they would also require very much smaller boilers and furnaces. As to the engine, he thought the progress made chiefly consisted of improved design and better material. The propeller question had been treated from a mathematical point of view, and now when a propeller was put in a ship they knew what could be got out of it, which was not the case twenty years or so ago. As to tail-end shafts, although Lloyd's demanded a severe test for the steel for the boiler, they said nothing about the material of which a tail-end shaft should consist. The composition of the material of one and the same shaft often showed great difference. In his opinion a great improvement could be made if the diameter of the tail-shaft was increased, the liners made longer, and with less over-hang.

Mr. FRAZER agreed with the author of the paper that the so-called Scotch boiler was not a Tyneside boiler, as Mr. Aisbitt contended, but was first made at Kirkcaldy; he had the handling of one in 1875.

Mr. A. YOUNGER (Member, Glasgow) said in a great number of cases evaporators were fitted in a very absurd fashion, the general idea evidently being to get water regardless of cost. The high-pressure steam was led into the apparatus and the steam discharged, in many cases, directly into the condenser. They threw away the latent heat, and of course the method was obviously most uneconomical. A much better plan was to use the steam generated as a feed-heater, and put it directly into the hot well and condense it there. He had listened with pleasure to Mr. Evan Jones regarding the combustion of coal, but he did not quite understand how his idea was to be practically adapted to modern requirements. It was a very laborious chemical operation to separate oxygen from nitrogen. Supposing this was done, the union of the oxygen and the carbon of the coal would give rise to such an intense heat that no ordinary boiler plate would stand it. As to the five-crank engine, it had still to be proved whether the resulting economy was sufficient to pay for the extra capital expenditure, the extra charge for so much additional haulage, and the additional engineer usually carried. As to the lining of boilers, by the general practice inevitable corrosion was set up in the tanks and directly under the boiler; one-third of the boiler was left entirely free to radiate the heat on to the tank-top. A double saving would result from lining the boiler all round, both tank-top and floors being protected and greater economy resulting from the heat, which produced the deleterious effects, being saved to do good work in the engine. As to the captain-engineer suggestion, a little knowledge was proverbially a dangerous thing. He was reminded of a captain who had "passed in steam" and became marine superintendent. Asking one of the chief engineers to explain some delay, he was told that certain boiler tubes had burst and been repaired, a tide being lost in consequence. The captain who had "passed in steam" said: "That's all right this time, but next time you are troubled in the same way don't bother to repair the tubes; work her as a common jet."

Mr. David Gibson (Member) did not consider that forced draught had proved an unqualified success; and as to water-tube boilers, they were not adapted to sea use because they required absolutely fresh water. The greater part of the economy in the adoption of the high-pressure boiler and triple-expansion engine was due to the temperature and not to the tripling.

Mr. Evan Jones (Member), referring to the table of pressures in the paper, said he should like to ask Mr. Walliker how far he would be prepared to go. They had it on very good authority that with the use of the best mild steel for boiler purposes a temperature above 430 degrees Fahr. became dangerous—or a steam pressure of about 350 lb.

Mr. J. T. SHELTON said I.H.P. was misleading. He had known instances where with a decreased H.P. the speed of the ship increased. It was better to know how much fuel was used per mile. As to economy in consumption, this was due to many different improvements other than increased pressures. He did not think the use of expansion joints would come in generally. It was more economical—and was certainly less trouble to the engineer—to have steam pipes up to a certain size made with bends, but larger pipes and of steel were better with expansion joints, especially the main steam pipe. One main steam pipe which came under his notice was $2\frac{1}{4}$ in. longer when steam was up. White metal for the tail-end shaft, to which reference had been made, seemed too dangerous a thing. He knew of one instance where it all ran out.

The CHAIRMAN, reverting to the question of weight, said anyone experienced in modern marine engineering recognised that a simple engine of a given horse-power was heavier than the compound of the same power. If they were to have a five-crank it was more economical to add another cylinder and divide the two and have two triples of three cylinders each. It was true they had extra shafting, but the two engines with the two propellers were bound to weigh less than one with the five cylinders. As to engineers' accommodation on board ship, in the modern type of cargo boat there was always a lot of enclosed space not used which might as well be given to the engineers for extra accommodation, especially with 32 per cent. off the engine-room. If the chief engineer did not enjoy the status that he ought to do, it was chiefly due to the fact that he depreciated himself, and forgot that he was the practical manager of the ship of which the captain was the commander. As to the valuable remarks of Mr. Evan Jones, he agreed with that gentleman that they had not made any headway with the boiler beyond the materials of its manufacture. If, as Mr. Jones suggested, they could get rid of the nitrogen by some means, they would effect a very great improvement in the consumption of boilers, irrespective of triples, compounds, or five-cylinder engines. As to tail-end shafts, glycerine or any lubricant of a heavy nature—not oil, which was too thin—had answered admirably, and he was glad to think they would be using tail-shafts by-and-by which would not have brass liners upon them. He had known two or three tail-shafts lubricated with glycerine or petroleum jellies which had been running for three years, and there was not a sign of deterioration. At the time he read a paper on this subject before the Institute, two or three years ago, he expressed the opinion that the fracture was caused by chemical action. This theory was combated by his colleague, the late Mr. Nesbitt, who thought that the fracture was originally due to malformation, that the shaft first of all fractured mechanically and then the chemical action set in. Mr. Nesbitt was right. Shafts which were made perfectly parallel were not so likely to fracture. As to water-tube *v.* circular boiler, the latter was the most economical up to the present time. The only question was how could they get more steam out of it, and that depended upon Mr. Jones's idea about the extraction of the nitrogen. As to Mr. Frazer's reminiscence of Kirkcaldy, well, he saw a circular boiler being built on the Tyne in 1862, and he still maintained that the so-called Scotch boiler had a Tyneside origin. As to the evaporator, to use live steam was a very extravagant way of heating water. With regard to fresh water being essential to water-tube boilers, the idea of using salt water for any type of boiler was obsolete, unless of course the water had been condensed. Mr. Younger's remarks about lining the boiler at the bottom were quite correct.

Mr. Boyd said his experience was that to heat water with live steam was the most economical method known.

The CHAIRMAN could not agree, but Mr. Boyd's contention met with endorsement from Mr. YOUNGER, who, however, admitted that it seemed like robbing Peter to pay Paul.

The discussion was adjourned, and the proceedings closed with a vote of thanks to Mr. Aisbitt for presiding, the proposition being made by Mr. JONES, seconded by Mr. W. SIMPSON.

DISCUSSION CONTINUED

AT

3 PARK PLACE, CARDIFF,

ON

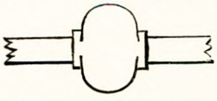
WEDNESDAY, FEBRUARY 28th, 1900.

CHAIRMAN:

MR. M. W. AISBITT (VICE-PRESIDENT B.C.C.).

MR. EDWARD NICHOLL, R.N.R. (Member) said: Mr. Walliker's paper, all will agree, is a very interesting one, but it is not a paper that lends itself to criticism, especially such as some people get. I think it should be said the introduction of high pressures was facilitated by the invention of the Fox corrugated furnace more than anything else, especially as at that time the triple engine was introduced, and until quite recently the Board of Trade and, if I mistake not, Lloyd's also, objected to furnaces thicker than $\frac{5}{8}$ in., the idea being that a thicker plate would become overheated. Now we know that plates $\frac{3}{4}$ in. and in some cases I believe as much as $\frac{7}{8}$ in. have been used successfully. I do not wish it to be understood that I would recommend such thick plates, but I would certainly prefer a plain furnace to a corrugated one. I quite agree with the author that the Scotch boiler was the founder of the success of the engine of to-day, and it is in my opinion superior in durability and economy to any water-tube boiler yet introduced. I have never known anyone to seriously claim economy for the water-tube. I have always understood that the water-tube boiler would stand much worse treatment than a Scotch boiler ; for instance, you may raise steam in less than half-an-hour from cold water, which you certainly could not do with the Scotch, for any such attempt at firing it means ruin, leaky seams, etc.—the water-tube boiler is yet a long way from the mercantile marine. I think rather too much is being made of this idea of using fresh water in boilers, and to say that the use of salt water in any boiler is obsolete is overstating the matter. There are hundreds of boilers running to-day, some of them in use for years, using nothing but salt water, and, as far as I have seen, are equally as well preserved as those fed with fresh water from evaporators.

It would be interesting to know to what the remarkable results obtained by the five-crank engine mentioned are due. I understand it is a triple engine, or rather three-stage-expansion engine, with two low-pressure and two intermediate-pressure cylinders and a high pressure. If that is the case the economy cannot be due to the range of temperature in the cylinders, as that would be practically the same as in an ordinary triple.

I agree with the author that the modern steamer requires a higher order of intelligence than did the steamer of fifteen years ago, but the Board of Trade does not appear to have realised that the examination for engineers is almost identical to-day with what it was fifteen years since. I think it is a pity that the examiners do not see that the engineers are really what they make them, for as long as those stereotyped questions set year after year are not modified to suit present-day ideas there is no incentive for the young engineer to study. The author mentions two principal drawbacks in the present-day engine, viz., tail shafts and steam pipes. Now he says the former has been thoroughly discussed, but with this I beg to differ; and if it has been thoroughly discussed, we do not appear to have benefited much by it, for we still go on in the same way. However, I do not intend to say more at present, as it is my intention, if I find time, to bring this subject again before the Institute in the form of a short paper before the end of the session. With reference to steam pipes I quite agree with what has been said, that iron steam pipes would be much more reliable than copper, and I think the time is not far distant when iron or steel will entirely supersede copper for this purpose. The principal difficulty has been with pipes fracturing at the flanges, due to vibration in the machinery, and to the pipes being too rigid. Now for overcoming the latter defect. I cannot say that I am enamoured of the usual expansion joint with a stuffing box and gland. I venture to say that if nine out of ten expansion glands in ships three or four years old were examined, you would find them stuck fast and as rigid as the solid pipe. Of course you might retort that this was carelessness on the part of the engineer in charge, but there are many here who have had experience of those things and know the difficulty in keeping them tight, and perhaps some here like myself may have had a few drops of hot water down the back of the neck when walking around the engines; then the engineer uses unparliamentary language and of course takes a spanner and screws up the gland until it leaks no more—result, a fixture. No, I much prefer some form of flexible joint, such as a copper bellows, thus:  or even a properly designed bend; but the fault is, that bends are generally made too small, and therefore are not efficient. I certainly cannot agree with the author that the engineer should become proficient in navigation. I would much prefer that the present examination should be made much more searching and make a better engineer of him, for that I think would take up all his time, and would be the most sure way of improving his status. I say this now, assuming all here have their certificates. I certainly would also say that a chief engineer should be allowed the use of the saloon when he desires to read, write, or study. And his accommodation should certainly be improved, but unfortunately even twenty years has shown very little improvement in this respect. It is all very well saying superintendents should see to it that it is improved, but other questions have to be considered, viz., £. s. d., the first cost of ship. But I hope we shall combine to improve the position of our engineers at sea, and keep on asking owner and builder to see that his accommodation is made as comfortable as it is possible to make it, and at the end of another twenty years we shall at least see him in apartments, and in the esteem of his employers equal to that of the master.

Mr. G. F. MASON asked whether the item of 13½ tons for the five-crank engine referred to coal merely used for the engine or for the ship on the voyage out per day. His experience did not tally with that, although so far as the rate of 1 lb. per I.H.P. was concerned he recalled an instance, occurring nine years ago, where this was got with a triple engine—two cranks, three cylinders—and the pressure was 100 lb. With regard to expansion joints, a good plan was to fit separate steam pipes to each boiler where they had a range of two or three boilers, and carry them right away to the engine-room.

Mr. J. F. WALLIKER said, in reply to the discussion, he wrote the paper mainly for two reasons. He thought in the first place the subject he had selected would be a popular one, and in the second place because he wanted to emphasise the fact that to Mr. Alexander Taylor should be allocated the principal credit for the practical adoption of the triple-expansion engine, while Messrs. Fisher, Renwick & Co. should also have the credit of being the first shipowners to have a commercially successful triple-expansion running. The *Claremont*, run and owned by Tynesiders, went her first voyage in March, 1882, and up to the time of her loss through collision in 1891, did excellent work. She carried 850 tons. He had a photograph of the *Claremont's* engines, which he hoped would appear in the Transactions together with reproductions of other typical engines, the photos of which had been lent him. With regard to the questions which had been addressed to him on the economy of the five-crank engine, he could tell them nothing beyond the information set out in the builders' statement. It was, however, only reasonable that a multiplication of cylinders should give a certain economy, but how much relatively of the economy was due to that multiple expansion he could not say. Mr. Nicholl had spoken of expansion glands getting out of order. In his (Mr. Walliker's) opinion, Blair's Expansion Gland was next to perfection. He had known only of one or two instances where it had given any trouble, and this had been due to gross negligence by those in charge. The expansion gland was a universal joint, and when it was intelligently used there was no doubt whatever that it could be made satisfactory in all respects. If the engineers would but look after expansion glands as well as they look at top and bottom ends, he did not think there would be any trouble. Mr. Aisbitt had spoken on coal consumption as a factor in long and short voyages. The only time when it was not a factor was when it meant saving a tide, but in other circumstances coal consumption was a large item. It was a significant fact that steam trawlers were fitted with triple-expansion engines at high pressures. As to comparing compounds with triples for economy, he admitted that with careful engineers some compounds had done as good work as many triples, but with careful engineers in both cases he thought better results were obtainable from the latter. He was sorry Mr. Arthur Cay was not present because he had relied upon him to say a few words with regard to the *Monte Rosa*, which, he believed, was the only cargo boat that had triple-expansion engines working at 80 lb. pressure. He understood that the cost of putting a third cylinder on to that ship—and she was running with her original boilers—was saved in a very few months, and Messrs. Cay, Hall & Co. had been thoroughly satisfied both with her consumption and running. Mr. Aisbitt had said also that the compound with two cranks at 120 lb. would pay better on a long voyage than an ordinary triple. This was not within their general knowledge. The remarks of Mr. Henry Radcliffe at the Centre's "smoker" on the previous Saturday as to marine engineers having good commercial knowledge were well worthy of serious consideration. Sound commercial knowledge added to the technical education and training of the engineer must be of immense service. The best proof of an economical engine was that it was a commercial success and continued to be adopted, and this he claimed for the triple-expansion. Mr. Younger had made a point of this, and it was the crux of the whole question. He had also spoken of over-hung propellers. This was a most important factor in the breaking of shafts. Mr. Younger instanced the case of a $10\frac{1}{2}$-diameter shaft with $8\frac{1}{2}$-ton propeller. He could only say it was a wonder the propeller had not removed itself long before it was found necessary to remove it. When the over-hang of the propeller was reasonably short they did not experience much trouble with it. As to evaporators, they certainly got a clean boiler from their adoption, and when connected to the hot well they derived much benefit from them. But the gain was mainly indirect. As to the lagging of boilers, this should be efficiently done. The heat on the top of the boilers when steam was up was now a great loss. Mr. Mason had referred to the differences between sister ships. When triples first came out, he (Mr. Walliker) had the comparing of two sister ships, one fitted with triple-expansion engines and the other with compound. The compounds burnt more coal per I.H.P. than the triples, but the gross consumption was about the same, and they could only put it down that the difference was due to some possible fault in the propeller, although the propellers were made as nearly as possible alike.

As to the engineer-mariner question, he had merely raised the point in order to get an expression of views upon it. He did not think there would be any necessity for serving two apprenticeships. If the chief engineer were allowed to qualify for a certificate in navigation, it would be of assistance to him and afford him pleasure. Mr. Evan Jones in the course of his remarks had declared that Lloyd's Registry had no tests for forgings in the manufacture of shafting, but he contended that it was as severe as it ought to be.

Mr. EVAN JONES said that what he wanted to convey was that although Lloyd's asked for severe tests for boiler plates, they did not ask for any particular strength in the material of which the tail-end shaft was composed. The torsional strength of the material of one tail-end shaft might be 15 tons, while that of the material of another might be 25 tons, although both had passed Lloyd's.

Mr. J. F. WALLIKER replied that the materials of which the shafts were made were always carefully examined, and if it did not meet with the approval of Lloyd's representatives it was condemned in the forge. He thought, therefore, they ensured a very fair material without any further testing. Mr. Jones had asked how far high steam pressures should be allowed to go. Some years ago he looked after a small yacht called the *Salamander*, fitted with triple-expansion engines on Perkins' patent, and the valve was set at 600 lb. That was the highest working pressure he had ever seen, but he should not venture to suggest it for any ordinary working. Now, Mr. Shelton had spoken of a decrease of horse-power and an increased speed. That was possible. The propeller might have been over-running itself, making a positive slip in one instance and a negative slip in another. Then in steam pipes Mr. Shelton preferred bends, but he (Mr. Walliker) was strongly in favour of expansion joints for all purposes, and was very much averse to putting heavy strains on to anything but an expansion joint.

Mr. SHELTON said his point was that, up to a certain size of pipe, expansion bends should not be done away with.

Mr. WALLIKER (continuing) said with regard to what Mr. Nicholl had said about Fox's flues, he (the speaker) was on the trial trip of the *Albertina* in 1882, and heard Mr. Sampson Fox say that he was glad triple-expansions had come in, because they meant Fox's Corrugated Flues. Nevertheless, plain flues had been very successful, and of late years had been in great request. With regard to thickness, Mr. Nicholl was not quite accurate in saying $\frac{5}{8}$ in. was the thickest furnace crown fitted, because a great many years ago he had known them fitted up to $\frac{3}{4}$ in. thick. In Cardiff some of their friends had been renewing their furnaces with $\frac{3}{4}$-in. plates, and so far as he had learned they had given every satisfaction. He had never heard of a $\frac{7}{8}$-in. plate, but he was not sceptical that it would give any more trouble than a $\frac{3}{4}$ in. The Board of Trade examinations of engineers, he quite agreed with Mr. Nicholl, could advantageously be made more stringent. As to troubles with crank shafts, they had been reduced to a minimum, due in some measure to the introduction of white metal. In addition, the impulses in a triple-expansion were very much more even, while the alignment and machining of the shaft were better.

Mr. W. SIMPSON asked Mr. Walliker whether the less liability to crank-shaft defect did not arise rather from their departing from the solid to the built shaft?

Mr. WALLIKER replied that the introduction of the built shaft had been an undoubted benefit, but that he considered the better machinery and use of white metal were the largest factors.

The CHAIRMAN proposed a vote of thanks to Mr. Walliker for his paper.

In seconding, Mr. T. W. WAILES recalled instances of collapsed furnaces wherein, while the plain showed no fracture, the corrugated ones were split. As to crank-shafts, he agreed that the renewal of these was nothing like what used to be required.

The vote was carried by acclamation.

A vote of thanks to the Chairman concluded the proceedings.

DISCUSSION

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, FEBRUARY 12th, 1900.

CHAIRMAN:

MR. F. W. SHOREY (HON. TREASURER).

THE CHAIRMAN: Short papers like this are always acceptable. Personally, I have found that when we have very long papers covering a great deal of ground we are liable to get away from the main points. An author who can put into a short paper like this what has been done in cargo-boat machinery during the last twenty years deserves great praise. However, it is now for you to discuss it, and I hope there will be no delay.

Mr. W. C. ROBERTS (Member of Council): Although, as the Chairman has just said, this is a very short paper, it embraces a large number of subjects, any one of which would by itself be sufficient for a good long discussion, such as the introduction of the triple-expansion engine and modern high pressures, the different ways of tripling old engines, the drawback owing to propeller shafts giving so much trouble, and the trouble experienced with steam pipes—each of these subjects would be sufficient for a good discussion. It is certainly a very excellent paper in every possible way. With regard to this five-crank engine referred to by the author, it is stated that engines of this type propelled a vessel of 5,800 tons at an average speed of 9 knots on $13\frac{1}{2}$ tons of coal, being at the rate of 1 lb. per I.H.P. per hour. This seems a somewhat marvellous performance, and I have not come across any experience of that kind myself. It reminds me a little of a story of two old captains who met in a public-house, and in reply to an inquiry as to the speed of his vessel one of the two replied: "About 9 knots at sea, but about 12 knots in a public-house." There seems to be a good deal of that kind of thing about this coal per I.H.P. I am afraid that the result given in the paper was not the result arrived at by the owner of the ship who had to pay for the coals. With these few remarks I have nothing more to say, except to congratulate the author of the paper, which is well worth discussion.

Mr. BASIL JOY (Member): This is a paper that wants a good deal of thought before one can grasp it fully, and the author goes into such generalities that one may very well wander in any remarks that one may offer upon it. I only wish that upon some of the points raised some of our sea-going members would give us shore men the benefit of their experience. Sea-going engineers get information and experience at sea which we have no chance of getting on shore. They know a tremendous lot that would be of great value and interest to us, and if they could only be induced to give the benefit of their experience it would be of the greatest service to those ashore. With regard to the remarks of the author as to the improvement in the material of which boilers are constructed, I was at Hull recently, and came across a tug that was sixty-five years old. She had had several new boilers and several new engines. Her present engines had been taken out of a trawler that was wrecked off Margate, while her boiler was out of a trawler that had been wrecked on the Yorkshire coast. There was a dent in the boiler about eight inches deep, leaving only a very small amount of clearance between the shell and the furnace, extending over an area of several square feet. When the trawler went ashore the rocks on which she struck dented the boiler in that way, and yet they were working it at 90 lb. pressure, and they had been so working it for two years without a leak showing anywhere. That was a pretty good test of the quality of the material of which the boiler was made. The author then goes on to refer to the tripling of old-fashioned compounds, and I happened in my early experiences to come across that sort of work a good deal. I do not quite follow, however, what the author means when, referring to the tripling of old compounds, he says that "one firm utilised the mid-eccentric pit for the third cylinder, the valve gear of the three engines being worked from two sets of eccentrics only." If the three cranks were at the usual 120 degrees, I do not see quite where they got their motion from. With radial gear, and cranks at these angles, a rocking lever from the L.P. gear to the H.P. gear will of course give the correct motion for the M.P. gear, and this has been done in a number of cases. The author then goes on to say that with the present superabundance of engine-room space the valve gear has, as a general rule, returned to the old double eccentric link motion. In the early days of triple-expansion engines this question of saving space fore and aft in the engine-room was of very great importance, and the radial valve gear came in just at the right time, but now, with the new measurement regulations, the same considerations do not apply. I believe, however, that the real reason why this radial valve gear went out of fashion was that as a rule the engineers in the engine-room did not understand it. At Liverpool some years ago the expression of this belief provoked some very wrathful remarks by an inventor of radial gear, who was most indignant that the progress of marine engineering should be retarded by the lack of knowledge on the part of the engine-room staff. But whether it was true or not, at this time—about 1885 —the reason given to me on many occasions for the omission of radial valve gear was that the ship's engineers did not understand it, and it was said to be rather unfair for superintendent engineers to place in the hands of sea-going engineers a piece of machinery which they did not understand. Mr. Walliker alludes to "valves worked by a special gear, designed by Mr. F. C. Marshall," but Mr. Marshall has himself disclaimed any credit for this gear. He admits that it is Hackworth's gear. It is very often spoken of as Marshall's gear, but it is not so. In another part of his paper Mr. Walliker writes: "What may be called the principal drawbacks of the engines of the present day are two in number—the screw shaft and the steam pipes." To those two drawbacks I should like to add a third, and that is the valve gear, which is a source of almost daily trouble to many engineers. I think Mr. Roberts will bear me out in this statement. The screw shaft or steam pipes only break down sometimes, but the valve gear is always giving way and requiring renewing. I think you may fairly say that it is one of the troubles of the engine-room. During the last four or five years I have come across an enormous number of cases where the valve gear has been a great cause of trouble. Then the author of the paper recommends that engineers should be encouraged to pass an examination and receive a certificate for proficiency in navigation. I was interested to learn that in France the skipper of an ordinary merchant ship is obliged before he can hold a captain's certificate to pass a very stiff course in engineering; and in conversation with the chief engineer of a large French steamer, whose trials I was attending, I was very much astonished to learn the amount of knowledge possessed by the skipper of that ship. It would, I think, be a very excellent thing if the captains of our own ships were obliged to go through a course of engineering. It would save a great deal of friction on board ship. At present the captain knows very little of the difficulties of the engine-room, and if he does not get exactly what he wants he loses his temper. If he knew more of the difficulties that the engineers have to contend with he would be more considerate.

Mr. W. LAWRIE (Member): With the general statements contained in the paper, and also with the conclusions that the author arrives at, engineers generally will, I think, find little fault. The history of marine engineering during the last twenty years has been mainly through the increase of steam pressure in the boiler and its multiple expansion in the engine. On page 6 of the paper the author says: "The writer believes that the credit of introducing what, at the time and since, has fulfilled that want to a most satisfactory degree is due, firstly, to Mr. Alexander Taylor, of Newcastle-on-Tyne, in adapting the ordinary boiler to the higher pressures; and secondly, to the firm of Messrs. Fisher, Renwick and Co., of the same town, for their foresight in fitting them into one of their vessels and for thus bringing the multiple-expansion engine, once and for all, from the rank of experiments to accomplished and deserved success." After reading a statement like that, one naturally looks for some details. Of course we can ferret out the information for ourselves, but in a paper of this character it would be more interesting if we could have some more details in support of a statement such as that. Reference is made in the paper to the quality of the steel used in the earlier days, and the author points to two instances where the shells of the boilers had been damaged and yet worked very well. When steel was first introduced for boilers it was not in the shells that we found trouble but in the tube plates round to the combustion chambers. On page 12 of the paper the author, referring to the great increase in machinery on board ship in recent years, says that the spare time of the engineers in charge has been wofully encroached upon; but I can say, in my engineering days at sea, twenty years ago, I certainly had very little spare time, and if the engineer of to-day has any less time for sleep and rest, then he must be very hard pushed indeed. The reason that the author gives for the modern engineer being so hard worked is that there are so many auxiliary engines on board ship, but surely he does not mean to suggest that these auxiliary engines are constantly breaking down and so keeping the engineer at work at sea. I believe that the engineer at sea to-day has a much better time than was the case twenty years ago, when it was no uncommon thing for an engineer to have to remain below some two hours or more after his watch was done to get the water out of the stokehold and engine-room. Owing to the small height of the engine-room skylight and fiddley gratings above the decks the water frequently found its way below in large quantities. Allusion has been made to the relative positions of captain and engineer. I do not know what they do in France. They may do things better there than we do, but I know this, that in all my experience this idea of a master or chief officer passing in steam is a mere farce. Nothing would cause more trouble than this state of things on board ship. An engineer wants a lifetime to know his business, and if he knows it thoroughly he has done very well. And I say the same with regard to the navigation of the ship. By the time an engineer has complied with the new regulations of the Board of Trade for a chief engineer's certificate and properly learnt his business he will want a rest and feel inclined to leave navigation alone. The author also makes some remarks about steam pipes, but in most good cargo boats that I have seen recently the steam-pipe difficulty has been pretty well solved. Most of the ships are fitted with expansion joints and the steam pipes give no trouble.

Mr. W. H. Moss (Visitor): This paper is chiefly historical. It reminds us of the early stages of the marine engine of to-day—the triple-expansion type—but it leaves little to debate. The history of the *Propontis* should compel many of us to recognise what a remarkable man the late Dr. Kirk was; he influenced marine engine practice and progress more than any other engineer from the early seventies right up to to-day. In addition to Dr. Kirk, Mr. Alexander Taylor at Newcastle, and Mr. Seaton at Hull, were both paving the way for the new type of engine, but the difficulty was a boiler. The engine had to wait for the boiler, and the boiler for the steel makers. Once steel plates in which confidence could be placed came to be produced, boiler progress was fairly rapid, and there was nothing to prevent the general adoption of the triple system and 150 lb. working pressure. Mr. Walliker speaks well of the cylindrical boiler, especially as compared with the water-tube type, and I quite agree with him. I have seen the Belleville boiler at work on a long voyage in a Messageries Maritime steamer, and I cannot conceive how a competent marine engineer could be in doubt for a moment as to its inferiority to the cylindrical type. The water-tube boiler for marine purposes is wrong in principle. We want a boiler in which the fire, the source of power, can be efficiently controlled, and in which the water can adapt itself to its circumstances. We get both these requirements in the cylindrical boiler. The water tubists go to a great deal of unnecessary trouble to make the water move in certain directions, while they put the fire under conditions unfavourable to the efficient combustion of coal. In short, we take care of the fire and let the water go its own way. The water tubists do exactly the opposite. Since the introduction of mechanical draught—the Howden and the Ellis-Eaves systems—the supply of air to the furnaces is much more under control, the combustion more perfect, and the superiority of the cylindrical to the water-tube boiler more pronounced. Personally, I do not think that the water-tube boiler has any chance of general adoption in our mercantile marine simply on its merits. Mr. Walliker refers to the devices resorted to in many early triple engines to save space, one of them being the use of radial valve gear, and Mr. Joy seems to suggest that this type of gear was subsequently dropped because the engineers did not understand it. I think that Mr. Walliker's explanation is the real one: that as the tendency of cargo steamers was towards greater size, more room became available for engines, full advantage being taken of the tonnage laws. In a triple engine the steam can be expanded a sufficient number of times without an early cut-off in any of the cylinders, and it is only when a very early cut-off is required that a good radial gear shows to advantage compared with the link motion. So the radial gear became unnecessary, and as far as my experience at sea with them goes they have disadvantages. Mr. Walliker refers to the five-crank engines of the *Inchmona* and their economy in coal. I understand that the consumption on a whole year's work averaged 1·16 lb. per I.H.P. per hour, both the owners and builders having a chief engineer on board to watch the result. But coal is not the only expense, and it is conceivable that what is saved in coal may be eaten up elsewhere. The paper also refers to the large number of auxiliary appliances which are really necessary nowadays to the successful working of the engine and boilers, and which are costly to buy and keep up. I am very much afraid that in the immediate future the only progress we can make is by attention to detail.

Mr. J. R. Ruthven: I suggest that when Mr. Walliker replies he should be asked to make it quite clear what he means when he speaks of a coal consumption of "1·5 lb. per I.H.P. for all purposes." He states that in the ordinary cargo boat the average coal consumption is about 1·5 lb. per I.H.P. for all purposes. Will he kindly make it quite clear what this 1·5 means, what it represents, whether it represents the whole of the power developed on board, including the auxiliary engines, divided by the whole of the coal consumed. Then there are two points very much affected by the progress in marine engineering during the past twenty years which are not touched upon by the author. The number of revolutions has been increased considerably in the last twenty years, probably from fifty-five to eighty or ninety per minute, or at any rate by a very good percentage; and piston speeds have very nearly doubled. The author has not dealt with either of these two points. Otherwise I am very pleased that we have had a paper like this brought before us, and I have no doubt it will be well discussed before we have finished with it.

Mr. HULME (Member): Reference has been made by one of the speakers to the lot of engineers in the engine-room years ago, and there can be no doubt that in those days engine-rooms were very often so badly constructed that engineers had to crawl about almost on their hands and knees. It was impossible to stand upright in many places. I cannot agree with our friend Mr. Moss with regard to water-tube boilers, for I have a lot of confidence in them. I have done a good many journeys with the Belleville, Yarrow, Thornycroft, Reid, and other water-tube boilers, and I am distinctly in favour of boilers of this type. That they want a little management I admit, but looking at the facilities for technical education, for the education and training of the coming race of engineers, there should be no difficulty in getting them to manage water-tube boilers. With regard to piston speeds, there is an idea that has been running through my mind for many years, and I believe that the next departure in this connection will have to be in the construction of engines so that each of the pistons will have to travel at a speed corresponding somewhat to the flow of steam that is admitted into that particular cylinder. In other words, the high-pressure piston will travel faster than the intermediate piston, and the intermediate faster than the low-pressure. Of course, the only way in which that can be done is by having different lengths of cranks, but I do believe that if it was tried an economy would be found in it. The use of auxiliary machines in the engine-room has now become very extensive, and the firm that I am serving with is making an evaporator to use the exhaust steam from all these engines, so as to secure further economy. Speaking generally, I agree with the author of the paper on many points but not on all, and I should be very glad if he could define more clearly the statement about the use of an evaporator having increased the consumption from twelve to fourteen tons per day.

Mr. McLaren (Member) said he was somewhat struck by one passage in the paper which read, "The leaven of the old saying that 'there are more ships than parish churches' tends frequently to changes in the engine-room for small and inconsiderable reasons, even among the better-class engineers of to-day." That statement might be true of some ports, but he did not think it was true of British shipping generally. It would be a pity if it should go forth that the marine engineer was a man who was here to-day and gone to-morrow. He could confirm what had been said as to engineers having to crawl about on their hands and knees, for in one ship on which he was serving he had occasion to do something to the stern gland, and he had to crawl along the tunnel shaft on his hands and knees. He was glad to say, however, that there had been a great improvement in this respect in recent years. With regard to the suggestion that engineers should become navigators, he entirely agreed with Mr. Lawrie in condemning any such idea. He believed that engineers had quite enough to do to learn their own business properly, and that any disposition on the part of engineers to become navigators would lead to the greatest friction on board ship. They would know far too much of each other's business. The further they kept apart the more they would respect each other's power; there would be more sociability aboard and it would be better for the ship.

Mr. HALLIDAY (Member): Mr. Moss some ten or twelve years ago told us a good deal, and I was one of his readers. I derived a certain amount of information from him, but in these later days he has got considerable prejudices against many modern improvements in marine engineering. The water-tube boiler is apparently his pet aversion. With regard to coal consumption, Mr. Moss speaks of an average consumption of 1·16 lb. per I.H.P. in the five-crank engines of the *Inchmona*, but I am afraid that wants confirmation. The records which are published by the Admiralty for various kinds of boilers do not, I think, give us anything below 1·59, and I am afraid that 1·16 is something beyond practice.

Mr. MOSS: I wish to make it clear that I did not refer to the *Inchmona* as typical of present-day burning of coal in a cargo boat. She and her new sister are cases in which very elaborate arrangements are made to secure a low consumption in lb. of coal per I.H.P. per hour. I think about 1·5 lb. is the average—in some later ships with Howden's draught it is 1·4 or even slightly less. But a ship may have engines economical in coal and her owner get very little satisfaction from it. About three years ago Mr. Alexander Dalrymple discussed this point in a letter to the *Engineer*, and contended that on a basis of deadweight carried in proportion to coal burned, a ship he mentioned burning 1·24 lb. per I.H.P. per hour was more economical than the *Inchmona*. This is a question of the mechanical efficiency of the engines, and one which, however, is not very serious in the slow, moderate-powered cargo boat with engines running fairly easily. It is a most serious question for the owners of fast mail ocean steamers constantly exerting a high power, and they have not reaped anything like the advantage from triple engines and high pressures that the cargo-boat owner has. In fact, the anticipations of high speeds at sea at a moderate cost formed some fifteen years ago, have not been realised.

Mr. HALLIDAY said that Mr. Hulme had dealt with the question of increased piston speeds, and this was a question that was gone into a good deal some years ago, but he did not believe that the form of engine which Mr. Hulme had suggested would prove a very great success.

The CHAIRMAN: Can Mr. Moss give us the coal consumption per ton displacement per mile in the case of the *Inchmona* ?

Mr. MOSS said he would endeavour to obtain the information before this discussion closed.

Some conversation followed, and in the result the discussion on the paper was adjourned until Monday, February 26th.

Mr. RUTHVEN proposed a hearty vote of thanks to Mr. Walliker for his paper, and Mr. McLAREN having seconded the motion, it was carried unanimously.

A vote of thanks to the Chairman concluded the meeting.

DISCUSSION CONTINUED

ON

MONDAY, FEBRUARY 26th, 1900.

CHAIRMAN:

MR. F. W. SHOREY (HON. TREASURER).

THE CHAIRMAN: This paper was read and partly discussed at our last meeting, and to-night we continue the discussion. To begin with I believe that the Hon. Secretary has a communication to read to the meeting.

The Hon. Secretary: There were several points raised at our last meeting a fortnight ago, which I referred to Mr. Walliker, the author of the paper, and he has replied to them briefly meantime by letter. He will reply more fully when he has more leisure. The first point referred to Mr. Walliker was as to the *Claremont*, and the second was the statement as to the introduction of the evaporator raising the coal consumption from 12, to 14 tons per day. Mr. Walliker says: I hope to be able to reply to the discussion when completed, but meantime will do what I can with the points raised in your letter of the 13th instant.

First.—The first successful cargo boat fitted with triple-expansion engines was the ss. *Claremont* built in December, 1881, by Messrs. T. & W. Smith of N. Shields and engined by Messrs. Douglas & Grant of Kirkcaldy from designs furnished by Mr. Alexander Taylor of Newcastle. Her engines were $14\frac{1}{4}''$, $20\frac{1}{4}''$ and $40'' \times 33''$; and 150 lb. W.P. To show these engines, an illustration was sent for and will doubtless be ready for exhibition before our next meeting for attachment to the paper.*

Second.—*The evaporator.* I am afraid my point in this matter was missed altogether. What I intended to convey was that the adoption of the water-tube boiler was delayed by the ignorance of some of the men in charge who would fail to use what was certainly of great use in one type and an absolute necessity in the other on the certainly false grounds in the case cited that it raised the consumption about 16 per cent. The statement carrying its contradiction on its face to any ordinary marine engineer made it in my opinion unnecessary to add anything in the way of explanation.

Third.—Compound engines tripled with old bedplate. In this case the eccentric pit was so large that there was clearance for a crank-shaft. The vessels were altered by Messrs. Gourlay of Dundee and include the *Recta* and *Kairos*.

Fourth.—Coal consumption includes, so far as my information goes, all that is used for main and

* See end of discussion.

auxiliary engines and in many cases has been taken by firms during a series of years so as to give a real average.

Fifth.—With regard to the statement of economy in five-crank engines I have nothing further to say than the bare statement given me.

The CHAIRMAN: There is one point in this paper that I should like to touch upon, and that is as to the boilers. The author, I find, seems to be greatly in love with the Scotch type of boiler. Most of us, I think, can say the same. We have been with it all our lifetime. But I cannot follow the author when he says that the water-tube boiler has been a failure. It has not had a fair trial; the Scotch type of boiler was not perfect when first introduced, nor was any other type; and I think that Mr. Walliker does an injustice to water-tube boilers when he says that they are almost an utter failure in every respect, although he qualifies that statement somewhat by what he says at another part of the paper. He also says that the Scotch boiler has been much maligned, but I have not heard of it, and it seems to have proved about the best type of boiler up to the present. The author admits that the pressures have gone up considerably. You find that in 1879 there were 3·5 per cent. of the boilers in the mercantile marine working at less than 20 lb. pressure; and on the other side, in 1899, 3·7 per cent. were working at pressures above 200 lb. So that very great strides have been made. It stands to reason, however, that, working at the present high pressures, we cannot go on indefinitely with the old Scotch type of boiler, and I believe that some form of water-tube boiler will eventually be brought into the market, and that that will be the boiler of the future.

Mr. G. HALLIDAY (Member): I would like to refer again to the question of the coal consumption per I.H.P. It will be noticed by the members that the small consumption of 1·16 lb. of coal is claimed per I.H.P. per hour for the five-crank engines of the cargo steamer referred to in the paper. I have made numerous inquiries as to the lowest consumption obtained in the mercantile marine, and I cannot find anything lower than about 1·5 lb. per I.H.P. per hour. On trials, it is true, this has been beaten, but not on an average. Counting in the consumption due to the auxiliary machinery, the consumption per I.H.P. per hour mostly exceeded this figure. I accepted the statement made with regard to the performance of the *Perthshire*, and the record was placed in my book on steam boilers, but that result has not been accepted as conclusive by the superintendent engineers of the various lines. It has been mentioned here in the present discussion that engineers object to water-tube boilers because the water disappears so rapidly in the gauge-glass should the pump happen to stop. With the same H.P. the water would disappear quite as rapidly in the Scotch boiler. The total area of the surface of water in the steam drums of a set of water-tube boilers of a certain H.P. is only a very little smaller than the total area of the surface of water in Scotch boilers. If you assume a fall of water of five inches in the gauge glasses of two such sets of boilers, the time taken by the water in the Scotch boilers to fall five inches will only be three minutes longer than it is in the water-tube boilers. It is interesting to compare two such sets of boilers as those of the *Pearl* and the *Proserpine*. At full power both give 7,000 I.H.P. The pressure of steam in the four double-ended Scotch boilers of the *Pearl* was 160 lb. on trial, the heating surface 11,025, and air pressure 1·4 when developing 7,469 I.H.P.; while the water-tube boilers of the *Proserpine* had a pressure of 221 lb., the heating surface being 20,508 square feet, the air-pressure 2·9 when developing 7,145 I.H.P. The relative weights were 314 tons and 172 tons respectively. Had they been cargo steamers of 5,000 I.H.P. easy steaming, it would have shown a saving of boiler weight of 142 tons, which, at £10 per ton a year, is £1,420. With careful stoking the consumption of coal would probably be the same, and it would become a question whether £1,420 per year would cover the cost of repairs of the water-tube boilers. The higher air pressure in the case of the water-tube boilers would probably mean that there was less grate area, and the greater heating surface means that in the case of water-tube boilers the surface is not worked so hard. Opinions appear to differ with regard to the large tube type of boiler. In the United States Navy, battleships of 16,000 I.H.P. are fitted with small tube water-tube boilers. Our own Admiralty will not put them into vessels over the third-class cruisers. The expansion of steam into four or five cylinders is a very old question, but the advantages of quadruple and quintuple expansion have not been accepted by the best authorities. Up to pressures of 250 lb. the Admiralty and the leading engineers of the mercantile marine still hold to triple expansion in three or four cylinders. The question raised by Mr. Hulme was gone into long ago, and it has not been found that there is any advantage from rapid motion of the piston in steam engines after about 1,000 ft. Lowering the speed at lower pressure is not followed by a gain, but by a loss.

Mr. W. LAWRIE: It has already been stated that this paper is largely historical, and in the second paragraph the writer, in looking up the earlier efforts at utilising the higher pressures of steam, gives the names of four vessels. He also tells us that "with the exception of the *Isa*, all the others may well be designated experiments that failed." But from what he tells us of the *Propontis* in the next paragraph, that certainly seems to me to be one of the most successful failures I ever read of. The author of the paper then says: "The much maligned, and, by some, discredited Scotch boiler was the founder of the success of the engine of to-day." The Scotch boiler has, no doubt, helped the introduction of the triple-expansion engine, but I think it should not be forgotten that the water-tube boiler really created the triple-expansion engine. In the course of a discussion on a paper read by Mr. W. Parker before the Institution of Naval Architects in 1887, Mr. A. C. Kirk, after referring to Mr. Dixon's resolve to give Rowan's water-tube boiler a trial, said, "It was his adopting these boilers that really brought up before me the question of the triple-expansion engine, because it fell on myself to propose an engine capable of utilising the high pressure of steam that would thus be got." This extract bears out the statement I have made that the water-tube boiler was really the cause of the triple-expansion engine being brought into use. In his communication that has been read here this evening the author says that the first successful cargo boat fitted with triple-expansion engines was the *Claremont*, and that she was built in December, 1881. I will not dispute that, but in the paper which he read before the Naval Architects in 1887 Mr. Parker put the *Aberdeen* before the *Claremont*. I find from the records of Lloyd's Register that the *Aberdeen* was put out in December, 1881, and it seems to me that in putting the *Claremont* in front of the *Aberdeen*, which was a very much larger steamer, Mr. Walliker is hardly doing justice to his case. I think I am right in saying that the *Claremont's* engines had cylinders of $14\frac{1}{4}$, $20\frac{1}{4}$, and 40 inches by 33-inch stroke, while the cylinders of the *Aberdeen* were 30, 45, and 70 inches by 54-inch stroke. Of course the *Claremont* had a working pressure of 150 lb., as against 125 lb. in the case of the *Aberdeen*, but still having regard to the character of the two boats, I scarcely think that the *Claremont* should have been put before the *Aberdeen*. With all due respect to Mr. Alexander Taylor—because there can be no doubt that he has been in the forefront—and Messrs. Fisher, Renwick and Co., there is another gentleman who is entitled to a large share of the credit for introducing triple-expansion engines into the mercantile marine. In the course of the discussion at the Institution of Naval Architects in 1887, to which I have already referred, Mr. Parker said :

"But there is another gentleman who is deserving of even greater praise, and that is Mr. Cornelius Thompson, of Messrs. George Thompson and Co., of London. When making a departure from sailing ships to steamers he consulted Mr. Kirk and myself as to whether he would be justified in adopting this description of engine, in which he understood we had confidence. In face of the opinion of a great number of his shipowning and engineering friends who advised him against venturing upon any such novelty which had already failed, and which, it was contended, could not be so economical as represented, Mr. Thompson had the courage to order a large vessel of 3,600 tons, and to have her fitted with triple-expansion engines of 2,000 I.H.P., and to his action more than that of any other man in the kingdom we are indebted for the benefits accruing in the shape of economy of fuel, &c., from the use of this description of engine."

With regard to the question of water-tube *versus* cylindrical boilers, I do not know that I can say anything more about it. Mr. Halliday has given us certain calculations, but these calculations are very much like the calculations of some of our military friends before the war commenced—they have a knack of not working out in practice. From men who are working water-tube boilers I have heard that it is worse than Mr. Halliday says. I have heard them say that the water will go two or three inches down the glass while you are looking at it. But one thing that surprises me a little is that we have not more up-to-date information on the subject. Seeing that within our own membership we have gentlemen who are very well qualified to give us absolute facts in the matter, I think it much to be regretted that they are conspicuous by their absence.

Mr. MATHER (Member) said he thought it an important and attractive feature of Mr. Walliker's paper that it dealt historically with the machinery of merchant vessels, and a paper of this kind was especially interesting to the younger members who heard the experiences of men who knew, from actual experience, what took place at the times referred to. With regard to water-tube boilers, a great difficulty was to keep salt water out of the boilers.

Mr. W. LAWRIE: Mr. Halliday gave us some figures about the working of water-tube boilers and cylindrical boilers in the Navy, and I do not doubt those figures for a moment. But we must remember that in the Navy they have never been able to run a Scotch boiler, and they admit it. Under those circumstances I do not think it is fair to accept the comparison given.

The CHAIRMAN: Mr. Halliday compared two boilers in the Navy. It was not a comparison between a boiler in the Navy and a boiler in a merchant ship.

Mr. LAWRIE: Is Mr. Halliday prepared to say that the heating surface in the water-tube boiler is as efficient as the heating surface in the cylindrical boiler, square foot for square foot?

Mr. HALLIDAY replied that on the question of heating surface the comparison was in favour of the cylindrical boiler.

Mr. McLAREN (Member) said he thought the author of the paper was rather wide of the mark on one point, and that the steamers of the present day were carrying ten per cent. more cargo with fewer engine-room hands than they were twenty years ago.

Mr. J. B. JOHNSTON (Member), alluding to a reference by Mr. Halliday to the consumption of a gas engine per h.p., said the power of gas engines was represented, not in indicated horse-power but in brake horse-power, and it would be interesting to know exactly the difference between these two methods of measurement. Referring to the mention by another member of the nitrate of silver test for ascertaining the presence of salt in water, Mr. Johnston said that the discolouration caused by salt was also caused by other substances in the water.

Mr. MATHER: The nitrate of silver test, if salt is present, will give a white precipitate, which is very well known, and no other impurity in the water will give the peculiar shade of precipitate that you get with salt.

Mr. HALLIDAY: The difference between brake horse-power and indicated horse-power is this: The brake horse-power gives the horse-power really transmitted by the shaft to the propeller. The indicated horse-power is the power given by the steam to the piston. The brake horse-power is less than the indicated horse-power, by the loss of power in the friction of the engine. The brake horse-power is thought to be more satisfactory because it is really a statement of the work given out by the engine. The indicated horse-power is the work put into the engine by the steam. In the case of the gas engine the friction is said to be very much higher than in a good steam engine, and therefore there was a demand made to measure the power of the gas engine always by brake horse-power.

Mr. J. B. JOHNSTON: Then any comparison between indicated horse-power and brake horse-power is altogether misleading.

Mr. HALLIDAY: A brake horse-power is from fifteen to twenty per cent. less than an indicated horse-power. It was Mr. Froude who introduced the question. He tried to get the exact power at the propeller by getting the power that was transmitted from the shaft. It has relation to the amount of power sent through the shaft, and is a more real measure of the power transmitted.

Mr. JAMES ADAMSON (Hon. Secretary): There are other causes besides those mentioned in the paper, to which the economy of the modern marine engine is due, and the author himself observes in one of his paragraphs that "this further economy is due doubtless to an aggregation of improvements." There is much in the paper that reminds us of the large benefit which the country is deriving from the Institute of Marine Engineers, and Mr. Lawrie has thrown out a remark in which I was very much interested, and which I hope will have some effect. I think that our meetings might be largely attended by members who could give us valuable information on such points as those under discussion. Several remarks have been made about I.H.P. as a measure of economy in working. I do not believe in pounds of coal per I.H.P. I think such a measure is one of the most misleading we have got in connection with the marine engine, except the nominal horse-power. More attention is now paid to the covering of pipes and cylinders with non-conducting material. Twenty or twenty-five years ago, too little attention was paid to keeping the steam pipes and cylinders coated with non-conducting cement. This is a matter in which great improvement has been effected in recent years, and I hope that still further improvement will be brought about. Then there is the use of fresh water in the boilers. I should fancy that at the present day there is seldom a steamer leaving port without having fresh water in her boilers, and that has contributed largely to economy. More careful attention is also devoted to undue losses of water. Members, no doubt, remember the time when the firemen used to go to the feed-pump and help themselves to hot water for washing purposes. That is a practice which has been done away with entirely. More attention is paid to exhausts and drains, and I am glad to say that gradually, what I have often called in our discussions here, the barbarous exhaust tank, is being done away with. The auxiliary condenser is being fitted in its place, and that I consider is a very great step in the right direction. Formerly many drains were carried into the bilges, but now these drains are very carefully watched, and either led into the hot well or the condenser. Another point that was very often lost sight of was the importance of seeing that all the non-conducting scale was scraped off the furnaces and fire boxes. This is a point in which there has been good progress in the direction of economy. Fire boxes are now very much more carefully scraped at the end of a voyage than used to be the case, and I have been told that in a set of land boilers the results from experiments and trials made showed a marvellous difference in the consumption due to the scraping of this black scale off the heating surfaces. Great progress has likewise been made in auxiliary machinery, and everyone is insisting on the lowest consumption with the highest efficiency in each machine. Then we have had the introduction of feed heaters and evaporators; and in connection with that matter it would be extremely interesting if we could get some reliable data, showing, with regard to a set of compound or triple engines, the results before and after the fitting of the feed heater or evaporator. Take a steamer not originally fitted with a feed heater or evaporator, and compare the consumption and other results before and after the fitting. Then there is the question of piston speeds. There has been a very great increase in piston speeds within recent years, and owing no doubt to the diminished radiation of heat, these higher piston speeds have resulted in a considerable economy. With regard to this matter, I am sorry that Mr. Hulme is not here to-night to explain the idea that he put forward at our last meeting. These five-crank engines are exciting a good deal of attention among engineers just now, and if we could get some reliable data as to what they are doing it would be very interesting. There are two points in the paper that have not been touched upon at all in the discussion. One is the use of the expansion joint which Mr. Walliker has urged very strongly, and the other is the question of steel pipes *versus* copper pipes, and in connection with that matter there was a very interesting article in a recent number of *Feilden's Magazine.* I read it with a good deal of pleasure and interest, and I think it is an article which members will find very profitable reading.

Mr. HALLIDAY : About these five-crank engines, which Mr. Adamson says are exciting a good deal of attention at the present time, I should like to ask what engineer of any standing is considering them at the present time ?

The CHAIRMAN : I understand they have been fitted on two steamers—the *Inchmona* and the *Inchkeith.*

Mr. MCLAREN asked the object of five-crank engines. Were they designed to run on an economical consumption, or to do away with vibration ?

Mr. HALLIDAY said that a properly-set triple-expansion engine gave almost a perfect turning movement, and a five-crank engine could hardly improve on it.

The CHAIRMAN : I was under the impression that the object of five cranks was to get a greater ratio of expansion.

After some conversation :

Mr. MCLAREN moved that the discussion on the paper be adjourned until the next meeting, but

Mr. HALLIDAY moved, as an amendment, that the discussion be considered closed, and that any further contributions on the subject be forwarded to the Hon. Secretary in writing, so that they may be included in the Transactions.

Mr. JOHNSTON seconded the amendment, which was carried, and

A vote of thanks to the Chairman for presiding concluded the meeting.

(Contributed by correspondence.)

Mr. T. F. AUKLAND (Companion): I do not intend to attempt to say a word in criticism upon this admirable paper, because, as a non-professional engineer, I am not in a position to do so. I can endorse the object for which, I take it, the paper was written, viz., that of bringing out very clearly the advantages which have been gained—in the cargo boat portion, particularly, of the mercantile marine—by the introduction of the triple expansion system. This fact is proved to me every day in mercantile steam circles where I have to do business. Tripled boats are the order of the day there, and many a good boat has been altered to meet the present-day requirements in that respect; but I wish to call attention seriously to the last paragraphs upon page 13, which treat with the possibilities of the future in the absence of masts and sails that it will only be necessary probably to have one man to act in the dual capacity of navigating master and engineer. The paragraphs referred to read as follows, and following that the opinion which I most strongly entertain, that such a system is not only absolutely impossible, but the most undesirable that can possibly be imagined, both in the interest of owners of ship and cargo, and more particularly of the lives of those on board:

"The enhanced importance of the machinery since the practical abolition of the masts has been so generally recognised, that it may not be out of place to predict a time when the master will also act as chief engineer; and, as a step in this direction, it is suggested that engineers be encouraged to pass an examination and receive a certificate for proficiency in navigation in the same way that deck officers are at the present time enabled to pass one in steam."

"In one other respect there might easily be a change for the better, and in that English owners (with a few exceptions) might take a lesson from some foreign-owned steamers, where the chief engineer is allowed two berths—one for a bedroom, and the other for an office in which to transact the clerical work necessary to his position. When it is remembered that the master has, besides a well-fitted and commodious cabin, with all necessary adjuncts, a saloon reserved for himself alone, a small concession such as above indicated would not be out of place, and would assist and encourage the continuity of service in the engine-room control, which is invariably found to be a large factor in its general economy and successful working."

The engineer is a mathematician and a calculator of the highest class; so must a navigating officer become. But, while everything should be—and, indeed, must be—done to educate our navigating officers, and even seamen, in the paths of the highest educational attainments according to their stations, *it will*—and I feel *very, very* strongly that it must—always be that the two professions of sailor and engineer can never on any consideration become one.

It is, to my mind, as absolutely impossible for a navigating officer to become an engineer, as it would be for an engineer (however gifted) to become a navigating commander; and, therefore, the two professions must be for ever distinct and separate, for life is not long enough for any one man, genius though he be, to learn all that he ought to know in both professions.

I contend that for a commander of a steamer to be a successful one, it is absolutely necessary that he should have been brought up in a sailing ship in order that he may have attained that character of fearlessness, resourcefulness and capacity for ingenuity to keep out of, or, if in danger to get out of it; for we must remember that steamers often break down, broken shafts and other casualties arise which, while engineers are either powerless to repair, or if capable of repair, the vessel herself has to be kept safe while it is being done, and as these casualties mostly occur during bad weather, it becomes of the utmost necessity that a thoroughly capable sailor should be on deck, otherwise the possible repairs cannot be done, unless the vessel is kept in a condition for doing them, by keeping her steady with sea anchors, or with what little sail power they may be possessed of, from falling off into the trough of the sea and running a very serious risk of being overwhelmed, or if, as in many cases happens, the damage to the engines is such that it cannot be repaired, keeping her from drifting out of the track of ships that might come to her assistance, or actually using sail power to continue her course towards destination, or until picked up and towed. Nothing but a resourceful, capable and ingenious sailor should be in command of a steamer. I maintain you cannot teach a man to be a thorough sailor by only steamship training, and if you cannot do this you certainly cannot teach an engineer to be a practical seaman as well as being a thoroughly practical engineer; and you cannot possibly give any sailing master, however ingenious and clever he may be, sufficient knowledge to control the engine-room successfully. Each must learn his own profession up to the hilt, and each must have as juniors, men trained as they have been in the two several but absolutely distinct professions, for then, and only then, will steamers be navigated with anything like reasonable safety and success.

I sincerely hope that the outcome of this exceedingly valuable paper, and the discussion it has given rise to, will have the effect of calling the attention of the Board of Trade to the absolute necessity of requiring far greater proficiency educationally before granting mate's, master's, and extra master's certificates in the future.

Mr. WALLIKER in reply to the discussion writes:

In introducing my paper to the members of the

B. C. Centre I stated that in my opinion the principal point to be arrived at was not so much the individual opinion of the writer as the aggregation of experience of the members, and it appears that the result in the interesting and valuable discussion that has taken place has quite justified my choice.

In answering Mr. Roberts and also many others who have made a similar enquiry, I wish to state that I take no responsibility for the statement as to the five-crank engine; it was furnished me by the makers themselves, but I have every reason to believe that the result as shown is by no means exaggerated. The experience of Mr. Basil Joy with an injured boiler is quite on all fours with the case of the *Albertina* as quoted by me, and is another proof, if any were really needed, of the fine quality of the steel in daily use. I think I already replied to the enquiry as to the working of three-slide valves from two sets of eccentrics in the engines tripled by Messrs. Gourlay for the *Rimpha*, etc. I may add that Messrs. Wigham Richardson, of Newcastle, in their four-crank engines had four-slide valves worked off three sets of valve gear. The rival merits of the Hackworth and other valve gears have been fought out many years ago, and I think the general consensus of opinion strongly favours the ordinary link with good adjustable heads and with plenty of surface; at the same time it is only fair to say that I frequently come across patent gears that give great satisfaction and have done so through a long course of years.

I am not astonished to hear that Mr. Lawrie had little spare time when he was at sea, as much depended on the vessels, their trades, and many other factors patent to us all, but it seems hardly worth arguing that of a necessity the duties and work of the engineers have increased in a marvellous degree, and I have only to refer to the list of engines which I quoted to give point to my contention.

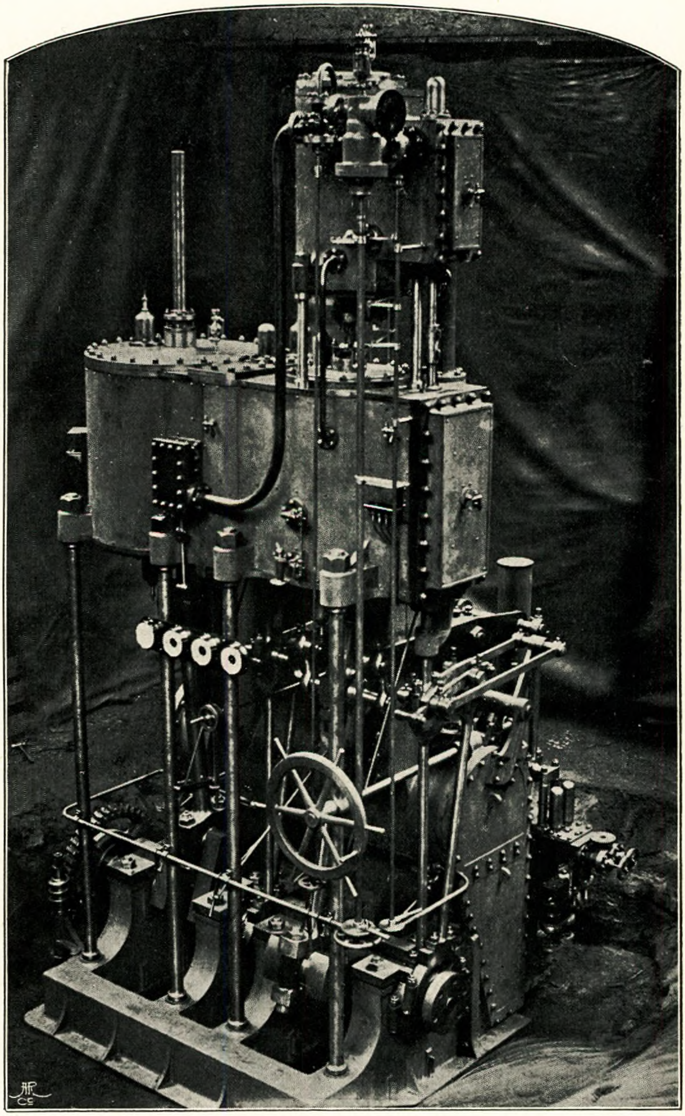
Mr. W. H. Moss, I find, utterly condemns the water-tube boiler for the mercantile marine, and I see also that Mr. Shorey and others at the adjourned discussion have attributed to me similar opinions. I take this opportunity of totally disavowing the soft impeachment and would refer to my paper for corroboration. What I stated and now reiterate is that water-tube boilers are not in my opinion suitable for the every day work of the ordinary cargo boat, and instanced as a difficulty likely to be met with the engineer who would not use his evaporator because it added so enormously to his consumption with the necessary consequence of course that his boilers got covered with scale, burnt more coal, and had to be cleaned at considerable cost when he reached a convenient port. I consider them suited to the Navy and certain fixed trades, and said so.

Mr. Ruthven's query is a very pertinent one with regard to the exact quantity of coal consumed and as to how the 1·5 lb. per I.H.P. is arrived at. I have had several statements showing the total amount consumed for the voyage by the main and auxiliary engines working at sea only, and these have varied from 1·4 lb. to 1·7 lb. per I.H.P. This has been taken from the average H.P. of the engine running at sea and excluded any used for shore purposes and cooking, etc. I have no hesitation in saying that the amount stated is within the experience of a large number of our members who are superintendent engineers, and who could show statements which would fully bear out the economy which I said had now been attained.

In the very interesting speech of Mr. Hulme there was one suggestion made which might be of great value if put in practice, and that was "*different strokes for different cylinders and pressures*," but this is of no good as a suggestion *only*, and it requires to be borne out by hard facts to be of any real utility. If Mr. Hulme would read a paper on the results obtained from this type of engine I am assured that it would prove of great interest to all connected with the marine engineering profession.

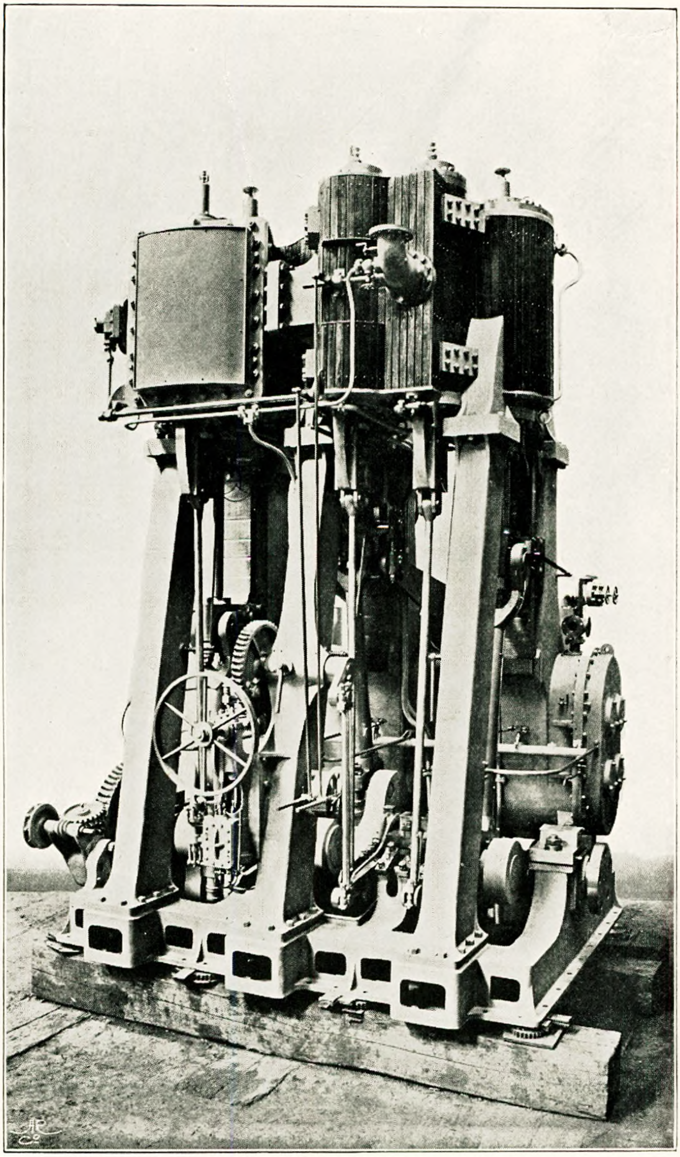
It is good for Mr. McLaren that he believes it is only in Cardiff that there are changes in the engine room for "small and inconsiderable reasons." I have only spoken of what has come under my own observation (not necessarily confined to Cardiff) and reiterate that continuity of service is not so universal as it should be, and that the owners' best interest lies in making the men as comfortable as the circumstances of an arduous and hazardous business will allow.

I feel that my replies to the discussion on my paper have grown to such an inordinate length that anything further I may add would appear superfluous. Generally, however, I may say this: that the remarks made and the general history elicited from those well qualified to speak have thrown many important sidelights not only on the introduction of the triple engine but also on many points of engine progress during the last twenty years; and to those gentlemen who have given these, the results of their valuable experience and criticism, I have to express my most sincere thanks.



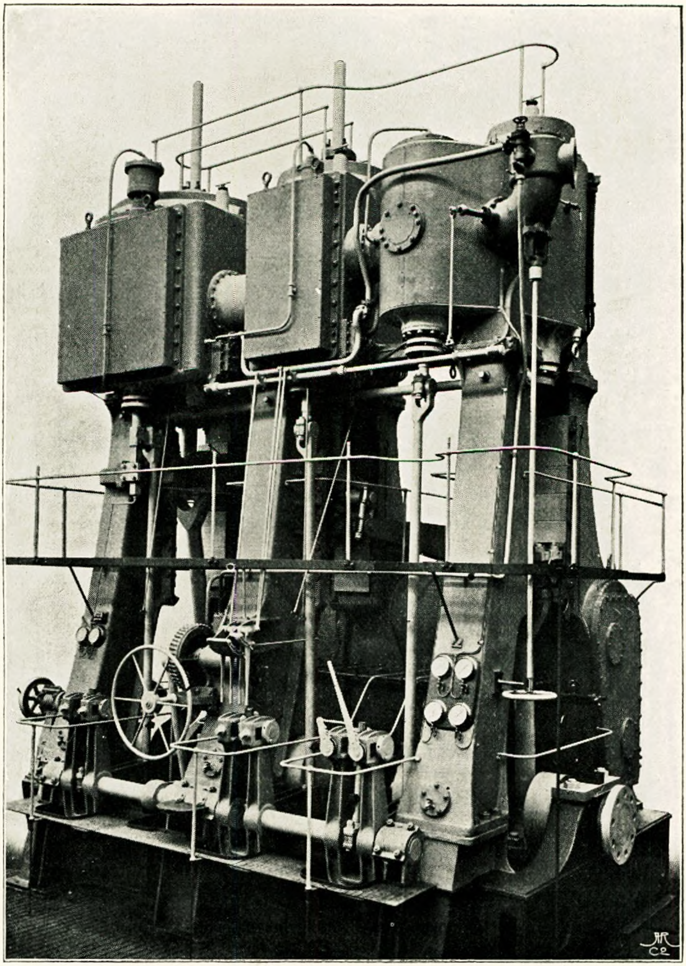
ENGINES OF SS. *CLAREMONT.*

Owners, Messrs. FISHER, RENWICK & Co., Newcastle-on-Tyne.
Designed by Mr. ALEXANDER TAYLOR, and constructed by Messrs. DOUGLAS & GRANT, Kirkcaldy, N.B., in 1881; 150 lb. W.P.



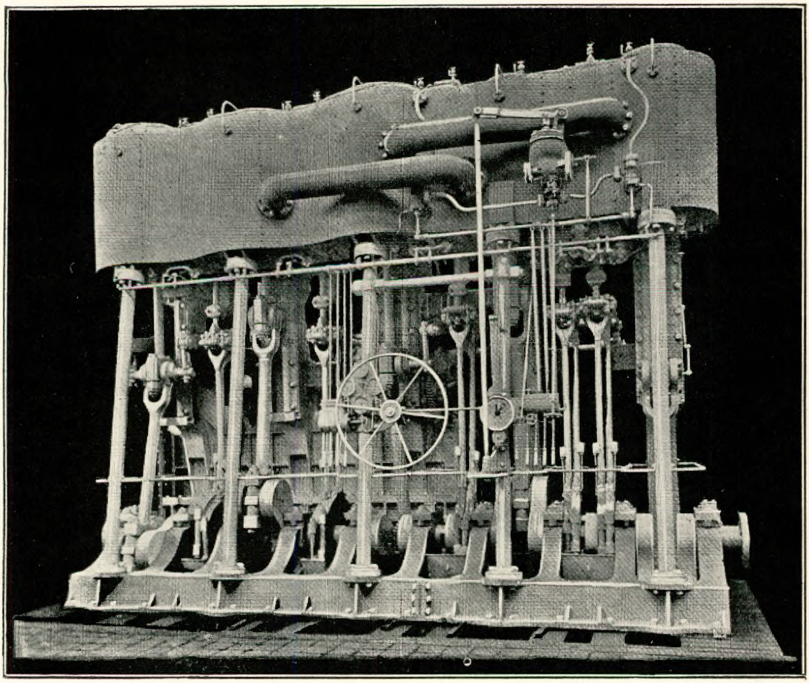
TRIPLE EXPANSION ENGINES FOR SS. *JAMES JOICEY.*

Messrs. PALMER'S Shipbuilding & Iron Co., Ltd., 1885.



TRIPLE EXPANSION ENGINES.

By Messrs. HAWTHORN, LESLIE & Co., Newcastle-on-Tyne; 3,000 I.H.P.; 160 lb. W.P.



PATENT FIVE-CRANK ENGINES OF THE
SS. *INCHMONA* & *INCHKEITH.*

Constructed at the Central Engine Works, West Hartlepool.