INSTITUTE OF MARINE ENGINEERS

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SESSION  1902-1903.

Volume XIV.

ONE HUNDRED AND SIXTH PAPER

(OF TRANSACTIONS).

HOW THE ENGINES OF A LARGE STEAMER WERE LIFTED CLEAR OF THEIR SEATINGS AND REPLACED WHILE THE STEAMER WAS AFLOAT.

BY

MR. T. W. WAILES (VICE-PRESIDENT, BRISTOL CHANNEL CENTRE).

READ AT 3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, NOVEMBER 19th, 1902.

AND AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, JANUARY 12th, 1903.

PREFACE.

3 Park Place,
Cardiff,
November 19th, 1902.

A Meeting of the Bristol Channel Centre of the Institute of Marine Engineers was held here this evening. Mr. M. W. Aisbitt, Vice-President, took the chair, in the absence of Sir Thomas Morel, President.

After a discussion, it was decided to issue a circular to Members setting out the proposals as to the Companionship of the Institute, so that they might be well digested in time for the next meeting.

Raising of Engines.

Mr. T. W. Wailes, Vice-President, then read a paper on the raising of engines for the purpose of giving access to repair the seating on the tank top. The discussion which ensued was adjourned.

George Sloggett,
Hon. Local Secretary.

INSTITUTE OF MARINE ENGINEERS
INCORPORATED.

SESSION 1902-3.

President—D. J. DUNLOP, ESQ.
Local President (B.C. Centre)—SIR THOS. MOREL.

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HOW THE ENGINES OF A LARGE STEAMER WERE LIFTED CLEAR OF THEIR SEATINGS AND REPLACED WHILE THE STEAMER WAS AFLOAT.

BY
MR. T. W. WAILES (VICE-PRESIDENT, BRISTOL CHANNEL CENTRE).

READ AT 3 PARK PLACE, CARDIFF,
On WEDNESDAY, NOVEMBER 19th, 1902.

CHAIRMAN:
MR. M. W. AISBITT (VICE-PRESIDENT, BRISTOL CHANNEL CENTRE).

IN connection with some extensive repairs recently executed by the Mount Stuart Dry Docks Company has been the repairing of an engine seating, which necessitated lifting the engines a sufficient height to allow for repairs and renewals, with enough space

for men to work efficiently above the tank tops and inside of the tanks, and in describing the work in this short paper I have prepared, I hope to lay before you a subject of interest. I have prepared three sketches to illustrate my paper; one showing a cross section through the engine room, marked No. 1, one showing a general longitudinal elevation of the engine room, No. 2, and the third showing a plan of the engines, No. 3. You will observe that the engines are bolted down direct on to the tank top, and not on longitudinal girders. The former practice —which possesses many advantages—is, I believe, a peculiarity of the Clyde district; in fact, the vessel illustrated was built and engined by a very eminent Clyde firm. It is not my intention to deal with the relative merits of these two systems of engine seating. I merely make a passing reference to them, thinking what an excellent subject it would make for a paper, and I venture to hope that at no distant date some member will favour us with a paper on this most important subject, which would not only prove deeply interesting, but highly instructive and valuable. In connection with the vessel under consideration, certain defects were found, and it was decided to cut out the whole of the rivets in the engine room from tank side to tank side, extending from engine room bulkhead to boilers, and have the whole re-riveted with larger rivets, as well as strengthen the engine seat by means of additional girders worked longitudinally and fitted intercostally between floor plates, and riveted to the tank top and shell plating as well as to the floors. In order that this might be carried out, it was necessary to lift the engines to a height of 4 ft. clear above the tank top to allow the workmen room for the cutting out, drilling, and re-riveting. From the engine room all movable gear was taken away into the hold. The L.P. and M.P. pistons and rods were removed; the H.P. engine, being the lightest, and not attached to the condenser, it was decided to let this remain intact. All gratings and ladders were removed, as well as the whole of the

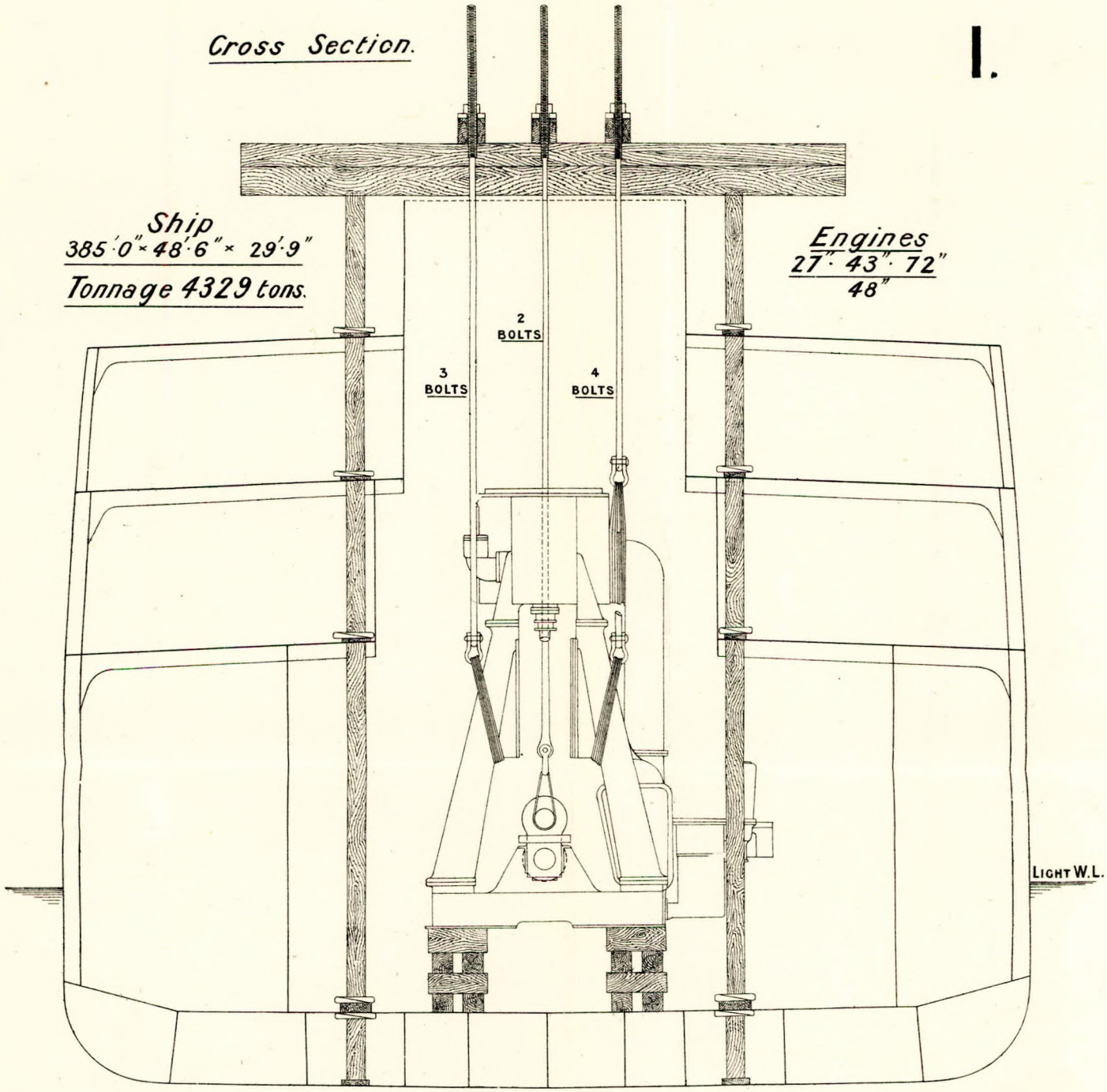
LIFTING ENGINES FROM THEIR SEATING ON BOARD SHIP.

Cross Section.

I.

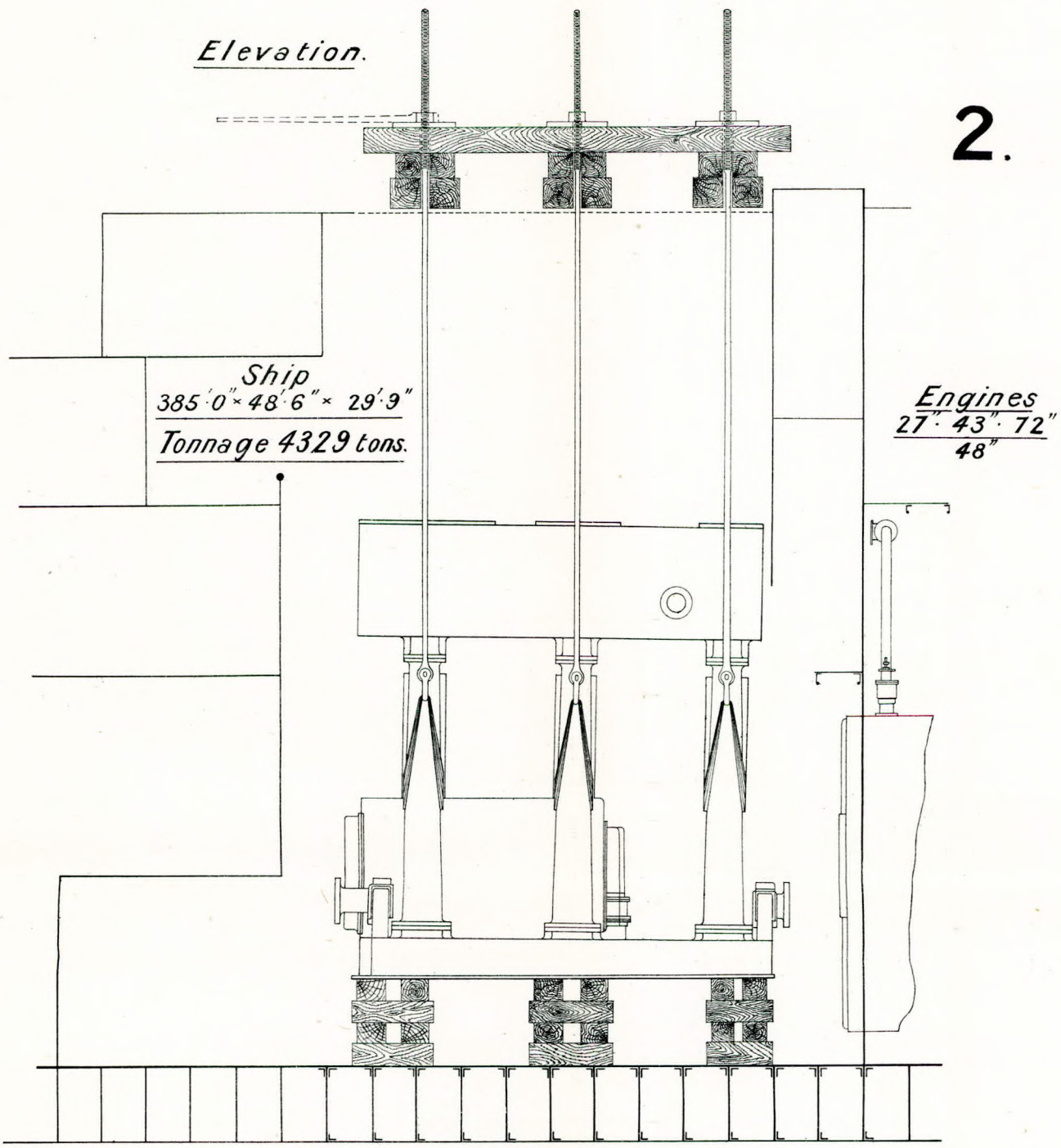
Ship
385'·0" × 48'·6" × 29'·9"
Tonnage 4329 tons.

Engines
27" · 43" · 72"
48"



LIFTING ENGINES FROM THEIR SEATING ON BOARD SHIP.

2.



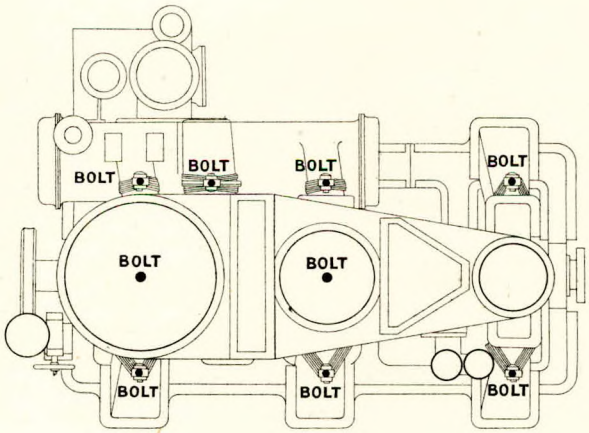
LIFTING ENGINES FROM THEIR SEATING ON BOARD SHIP.

Plan.

Ship
385'·0" × 48'·6" × 29'·9"
Tonnage 4329 tons.

Engines
27" · 43" · 72"
48"

3.



AFT

FOR^{D}

MAIN BOILER

MAIN BOILER

engine room floor plates and boards, also pump covers, rods, pipes, buckets, and valves; the evaporator was disconnected and lifted clear of the engines. The main steam pipe was also removed. Two crank shaft couplings were disconnected only —the L.P. and M.P. cranks were left in place to be used for lifting purposes. The whole of the holding-down bolts, numbering about one hundred, were taken out, and the weight of the engines then to be lifted was estimated at 140 tons. To lift this weight and to provide against all contingencies nine wrought iron lifting bolts were used, each 3 in. diameter, with a large eye on the one end to suit anchor shackles; the other end of the bolt was made larger for a Whitworth thread to give a diameter at the bottom of the thread equal to the body of the bolt, 3 in. diameter. Each bolt was about 35 ft. long, weighed close on half a ton, and the ultimate breaking strength of each was equal to the weight of engines to be lifted—140 tons. From the plan view of the engines it will be seen that of these 3 in. diameter bolts, one was fastened to each column of the engines, making six in all, one each to the L.P. and M.P. crank pins, for which purpose the couplings were disconnected (these two lifting-bolts were led up through the cylinders as shown), and the last bolt, making nine in all, was secured to the eduction pipe midway between the L.P. and M.P. cylinders and about the centre of the condenser. The engine-room skylight was removed, also a portion of the casing-top in way of lifting-bolts. Large double baulks of timber were placed across the top of the engine casings, the lower one about 18 in. by 18 in. and the upper one about 15 in. by 15 in., as shown in the elevation and the cross section. These were placed $4\frac{1}{2}$ in. apart, allowing just sufficient room to clear the lifting-bolts, which came up and passed through another timber baulk, about 15 in. by 15 in. running fore and aft, and resting on those placed athwartships. The latter, it will be noticed, are kept clear of the top of the casing—some 3 in.—by

vertical shores 12 in. square, so disposed that when the weight of the engines came on the transverse timbers it was well distributed over the decks, inner bottom, and shell-plating, none of the weight at all coming directly on to the casing-plates. I may here add that this work was carried out whilst the vessel was afloat, the water-line being a little above that shown in the cross section. Through the top fore and aft timber to which I have already alluded clearance holes for the lifting-bolts were drilled, and on the upper surface of the timber special steel bearers were fitted about 3 ft. long, 15 in. wide and 3 in. thick, faced true, also having clearance holes for the lifting-bolts, for which nine special nuts were made, 6 in. square and 5 in. deep, which gave ample bearing on steel bearers, thus preventing the possibility of seizing. Each of these nuts had a large groove cut across the face to admit of oil passing freely over the surface, also an oil-hole drilled diagonally from the side of each nut leading to the centre of bearing surface. Steel wire rope was used, taken six times round the six columns, the two crank pins, and the eduction pipe, wood packing-pieces and ample canvas parcelling being used to prevent the chafing and the cutting of the rope. The special extra flexible steel wire rope was obtained for this work specially from Messrs. Bullivant & Co., Ltd., of London, $3\frac{1}{4}$ in. in circumference, with an ultimate strength of $34\frac{3}{4}$ tons, the safe working load being $5\frac{3}{4}$ tons. For the purpose of turning the square 6 in. nuts, large ratchet braces were used, one on each nut, the leverage being about 10 ft., three men working each brace. In the raising of this weight of some 140 tons by means of the nine bolts, it was most important that as far as possible one bolt should take as much weight as another, in order to have a uniform stress, and with a view to the proper distribution of the weight over the ship's hull. This was accomplished by each set of men turning the nut of which they had charge, on receiving instructions, at the same time and to the

same extent, one quarter turn, the points of the square nuts being used as indicators. By this means a very steady and uniform pull and pressure was maintained, and the time taken to lift the engines 4 ft. was about one day. As a precautionary measure, when the engines were lifting, wood packing pieces and wedges, and afterwards blocks, were placed on top of the inner bottom and below the engines, thus relieving the weight on the suspension bolts when the engines had been raised to the required height of 4 ft. These blocks are shown in the elevation and also in the cross-section, and were placed in such positions as to allow access to the heavy plating of the tank top forming the engine seating, and as the work progressed these blocks were removed and replaced as required. The work of cutting out the whole of the rivets of the tank top in the engine-room was now proceeded with, amounting to some thousands. The holes were drilled out for larger rivets and re-countersunk. New intercostals were fitted immediately below engine bed, the whole of which was riveted, caulked, and made water-tight. Sundry repairs were effected to the engines. Some twenty-four holes were drilled in the sole-plate and in the flanges of the bed-plate for additional holding-down bolts, for which purpose the new girders in the double bottom had been fitted. Having completed satisfactorily the repairs to the tank top and seating plates, the next operation was to lower the engines into place, and the same method was adopted in the lowering as in the raising, the same points being kept in view, viz.: the uniform weight on each suspension bolt, the gradual removal of the blocks and shores, together with other matters of safety. The time taken in lowering was the same as when raising—about one day. Another point I may touch upon before closing. No doubt it has occurred to many present that there was some anxiety in connection with the ship's behaviour, looking at the large quantity of timbering used and placed at such a height, in fact, above the engine room casing,

all the 'tween deck shoring and timbering, the weight of the heavy suspension bolts, the spare gear and the movable portions of the main engines to which I referred, that is liable to be placed and accumulate in the 'tween decks, and the upper portions of the vessel, also the raising of the main engines of 140 to 150 tons to a height of four feet, coupled with the fact that the ship was light and in a "tender" condition, of which perhaps some present have had experience. I can assure you the stability of the ship and the keeping of her in a safe condition to carry out these important repairs was carefully considered and gone into before the work was taken in hand, and was constantly borne in mind during the whole time the work was in progress, with the result that our anticipations and investigations proved correct, the vessel at all times showing a good margin of stability—in other words "stiffness." Perhaps there may not be very much importance attached to this point, but when one comes to look back upon the many strange and unexpected things that have happened to ships and shipping it behoves us to take all and every possible precaution in connection with such undertakings, and I venture to think that under certain conditions it would be running a great risk, in fact, it would be courting disaster, if top gear and weight be placed on a vessel, and then a considerable amount of machinery lifted to a height, such as I have outlined this evening. I have pleasure in saying that to the vessels that have passed through our hands, having had their engines raised, and the seating strengthened and generally overhauled, no accident of any kind whatever has occurred; this vessel's behaviour during these extensive repairs gave us no trouble whatever; the ship in general and the engines and engine seating in particular have up to date given the owners and all connected with them every satisfaction.

(*See continuation of paper and further remarks on p.* 14).

DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, NOVEMBER 19th, 1902.

CHAIRMAN:

MR. M. W. AISBITT (VICE-PRESIDENT, BRISTOL CHANNEL CENTRE).

THE CHAIRMAN, by way of preliminary observation, said there could be no question but that the job described by Mr. Wailes was a remarkably good one, being the biggest of its kind undertaken at Cardiff. He should like to know what the stress on the rods was, their diameter, and the deadweight that was lifted. If they took the diameters of the triple expansion, the compound, and intermediate cylinders, they would find that they were exactly in ratio to the number of rods which Mr. Wailes put in. He repeated that they must all be gratified that, with the able assistance of Mr. Goldsborough, so big a job had been carried out by Mr. Wailes. It was at Cardiff, much more than in the North, that work of an unusual kind was offered them, and had to be undertaken.

Mr. SCOTT said the Paper must be an education to most of them.

Mr. ROBERTS did not concur with a passing observation of Mr. Wailes when explaining the views on the lantern-screen that cranes were out of date on account of the increased and increasing size of ships. On the Clyde were at least two 140-ton cranes, capable of lifting engines of that weight clear of the ship, and at the same time the swing of the jib was sufficient to plumb the centre of any vessel built up to date. In his opinion it would improve

Cardiff as a repairing port if the Bute Company could be induced to erect a powerful crane somewhere near the basin of the new dock, and thus obviate the expense of the method described by Mr. Wailes. Nevertheless, nobody could dispute that that method was very ingenious.

Mr. MORDEY said that, while endorsing what had been said as to the satisfactory way in which the job had been carried out, he considered the method adopted, as against lifting the engines out bodily, was merely a question of cost. In many vessels of a smaller type the engine castings would have to be removed to lift the engines out with a crane. He did not think the method was one which could safely be adopted in the majority of cases, owing to the top weight and the deterioration in old vessels, even if shored as illustrated.

Mr. WAILES desired to remind Mr. Mordey that the decks directly took no weight; the weight was taken to the bottom of the ship by means of the shores.

Mr. HENDERSON said it was very plucky of the Mount Stuart Co. to tackle a job of this kind. He was not aware of 140-ton shearlegs in England to have done the work.

Mr. NIXON was inclined to think it would have been cheaper to send this vessel where there was a sufficiently powerful crane.

Mr. WAILES said if the vessel had been put under a crane a lot of the casing and decks would have had to be taken away in order to get in their appliances. Then, how long were they going to keep the engine suspended by the crane? In lifting an engine like that, no deviation of centre must occur fore and aft and athwart ships, otherwise they would have to spend any amount of time and money in getting the engine back exactly where it was; but by the method adopted here there was not a hair's breadth deviation from start to finish.

The CHAIRMAN: What was the dead weight lifted?

Mr. WAILES: About 150 tons, irrespective of the gear.

The CHAIRMAN: Nine bolts for 150 tons?

Mr. WAILES: Yes.

Mr. ROBERTS mentioned a recent case in the North where the engines had to be lifted out. The total weight was 120 tons, and the crane available was a 70-ton crane. The cylinders were taken out, the column-head bolts, the condenser and sole-plate swung, and the engine was raised at the second lift. The section shown on the screen gave the width of the engine room top as equal to the sole-plate, so that in this case they could have lifted the sole-plate and condenser completely clear by removing the pump. (Mr. Wailes: That is not so. You would have had to tilt the sole-plate to get it out). Well, that was his impression, looking at the section from where he sat. In that case, it would mean taking the columns off the sole plate, tilting it, and bringing the whole thing up. This had been done. But he thought that the trouble to which Mr. Wailes had been put in this particular job was a strong argument in favour of getting a crane—100-ton crane, at least—at Cardiff. This was a point which ought to be insisted upon.

Mr. T. A. REED said he had the privilege of seeing these engines as they were being lowered, and the way in which this job had been dealt with was most creditable to Mr. Wailes and Mr. Goldsborough. It was all very well to talk about the stress upon the bolt. One bolt would probably have slung up the whole engine, but he did not think they would have succeeded in turning the nut. Therefore in a job like this they had to provide a great deal more than was necessary for the dead lift. There was the friction of the thread and the

lubrication difficulty. Too great a pressure would squeeze out the lubricant. All these things had to be weighed carefully—the means of lubrication and the number of bolts—so that the nuts might be turned without injury to the bolts. As to the crane question, it meant a cost of several thousand pounds, and it was questionable if it would pay at Cardiff. Was there not the risk of its rusting out and becoming a white elephant, like the old legs at Newport, or on the West Dock, Cardiff?

Mr. WILLIAM EVANS observed from the drawings that some bolts came down and were fastened to the crank pin. It seemed to him that this was scarcely a desirable place to subject to a severe strain.

Mr. GOLDSBOROUGH, replying to the Chairman's question, said the nine bolts were calculated to lift 140 tons, and there was a factor of safety of six. The bolts were 3 in. in diameter, and the weight lifted being 140 tons, they could work it out for themselves. As to Mr. Evans' question, about the bolts that went through the centre of the L.P. cylinder down to the crank pin and the M.P. cylinder, and connected there with the wire-rope, the strain would be a very small percentage compared with that of the power of the engines when working. In an engine like this, developing about 500 h.p., there would be a pull of the cranks at each stroke of 250 h.p.—far greater than the pull upon them in the case under notice. As to cranes, he had no doubt there were cranes that would lift the load and more, but they would experience difficulty in getting points of attachment without damaging something, and to have separated the engines would have been more expensive.

Mr. MORDEY failed to see why there should be any more difficulty in slinging the engines for lifting out *en bloc* than for putting them in as was done at many of the North Country engine works at present.

The CHAIRMAN would still like to know what was

the cut of Mr. Wailes' thread, and how it worked out. As to the comparative cost of the job, if this same ship had been taken alongside Newcastle Quay, and put under the 250 ton crane, he was quite certain the cost would have been greater than was this job at Cardiff. It was simply a question of scientific deduction as to their weights. The job carried out at the Mount Stuart works required great accuracy of calculation. When they lifted their engines and took the weight above the top of the casing, which was 26 ft. above the water line, the question became one of interest to shipbuilders.

Mr. T. A. REED thought safety and stability was secured by side-shoring the engine.

The CHAIRMAN : But you have lifted the centre of gravity 4 ft.

Mr. REED : But where are your ballast tanks?

The CHAIRMAN : They are bound to be empty.

Mr. REED : Only the engine room tank.

The CHAIRMAN : You want the vessel light.

Mr. REED : Not so, as she was in the wet dock, and I do not see that that comes in very much. With a big ship like that, 150 tons lifted 4 ft. is a bagatelle upon the total weight, and very often a great deal more bunker weight than that is left in the 'tween decks without hesitation.

The CHAIRMAN referred to the interesting character of the Paper, and proposed the adjournment of the discussion.

Mr. REED seconded, and it was agreed to resume the discussion on the 26th instant.

A vote of thanks to Mr. Wailes was heartily extended, on the proposition of the CHAIRMAN, seconded by Mr. Roberts.

A similar compliment to the Chairman, proposed by Mr. Mordey, concluded the proceedings.

DISCUSSION CONTINUED

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, NOVEMBER 26th, 1902.

CHAIRMAN:

MR. JOHN BODDY (VICE-PRESIDENT, BRISTOL CHANNEL CENTRE).

MR. T. W. WAILES: With reference to the discussion that took place at our last meeting, I should like to add a few words to supplement the paper.

Dealing again with the whole problem, generally, the weight to be lifted was about 140 tons, each of the nine bolts taking an equal weight of about sixteen tons. The bolts were three inches in diameter, with a sectional area of over seven sq. in. Taking bar iron at twenty tons per sq. in., gives an ultimate strength of 140 tons, this with a factor of safety of six, gives twenty three tons safe load on each bolt; with nine bolts there was a total safe lifting power of 207 tons. When the weight came on the top timbers, more particularly by means of the two centre bolts through the L.P. and M.P. cylinders and secured to the cranks, naturally the thwart ship timbers sagged. This was anticipated, and due allowance made in order to obtain a uniform pull of one-ninth the total weight on each bolt. Whilst dealing with these two centre bolts attached to the cranks; assuming the keeps to be of equal strength to their bolts, which were about $3\frac{1}{2}$ in. diameter and four in number to each crank, against these four bolts of $3\frac{1}{2}$ in. diameter we had one lifting bolt of 3 in. diameter, so that we had no anxiety there, neither did we think that any undue stress could come upon this particular part of the engine, which, when working under everyday conditions, is subject to many more times the stress we placed upon it. We contemplated at one time

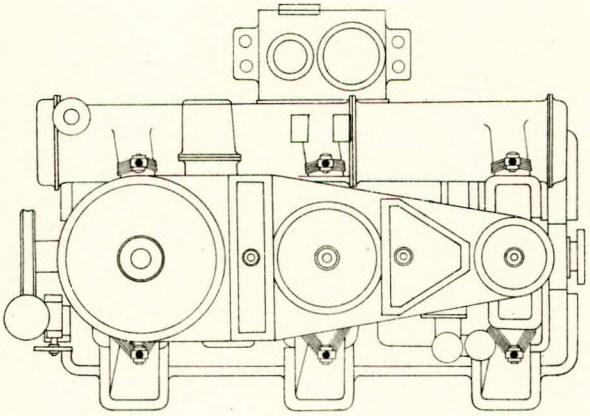
LIFTING ENGINES FROM THEIR SEATING ON BOARD SHIP.

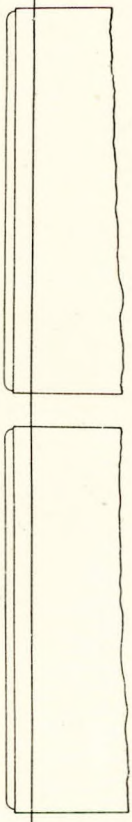
Plan.

C.

Ship
270'0" × 40'6" × 20'6"
Tonnage 1831 tons.

Engines
20½" · 33" · 53"
36"





the lifting of the engines bodily out of the ship, but when the question of cutting away so much internal work, the casings and casings top, the taking apart of the engines, the risk of fracturing and damaging the same during the process of lifting and whilst ashore, also the replacing and making good all such, at the same time considering the vessel would require to be away from our works, it was decided to abandon this method in favour of the one we carried out, with the result that the work was done at our own docks, entirely by our own men with our own appliances and gear all made at our own works, and I think with the minimum amount of disturbance to the ship and engines.

Referring to the latter portion of my paper, and Mr. Aisbitt's important remarks as to the care that should be taken in lifting a large weight of some 140 tons to a height, on board a vessel when afloat and in her light condition, also with such a small margin of stability, this case was perhaps an exceptional one in the respect that the ship had the whole of her coal bunkers full, and most of the weight was high up in the 'tween decks. This point I omitted to mention last week, but taken in addition to the others I dealt with at length in my paper, I think we were justified in taking the perhaps more than ordinary precautions we did, to guard against either a disaster or accidents of any kind whatever. I have prepared three other general drawings, marked A, B, and C, showing generally the method of lifting a smaller type of engines than that shown last week. The weight in this case was about seventy tons, and six bolts of the same size were used. You will observe that this vessel has girders forming the engine seat built on the tank top, and the engines were lifted to such a height as to allow of the repairs and the strengthening of the engine seating. Although these engines were much lighter, the idea of lifting them out of the vessel complete by means of a crane had to be at once abandoned owing to the very large amount of casings and 'tween deck work which it

would have been necessary to cut away, together with the removal and disturbing of cabins, storeroom, galley, etc.

The CHAIRMAN commented specially upon the case of the 70-ton engines referred to in the latter part of Mr. Wailes' supplementary remarks. Although, he said, the job was well done, he was inclined to disagree with the principle of lifting engines from above instead of raising and supporting them from the bottom. Although everything might appear all right and in substantial condition when the engines were reseated, there was strong liability of parts secured by bolts giving at the joints owing to suspension, necessitating the remaking of joints.

Mr. WAILES observed that the foundations of the engines were duly supported as the engines were being raised, the packing proceeding with the lifting. The bolts were the lifting medium, and the shoring underneath the support.

Mr. ROBERTS said, judging by the sections shown on the screen, the only projection inside the casing was the pumps, and if these pumps had been disconnected Mr. Wailes would have been able to lift the engines in three lifts, including the pumps. He could have taken the cylinders off in one piece, and slung the bed plate, even if it had to be canted slightly. This would have only necessitated breaking joints at the cylinder feet and eduction pipe. One of the joints affected in the way suggested by the Chairman in the slinging method described by the author would be that of the eduction pipe, because of the tensile strain on the bolts. As to the 70 ton job, the crane at the Roath Dock would have been able to carry the engines out in one piece, or after, for the sake of convenience, taking off the cylinders. Another feature of Mr. Wailes' method was its great expense, with its 35 ft. bolts absolutely useless for any other purpose than a job of this kind. Mr. Wailes might have used hydraulic lifting jacks, which were always

of use for the general work of a ship-repairing yard. With regard to the packing following the suspension, he did not think it was possible, in a job like that, to follow it up in such a way that the weight was wholly taken off the suspending tackle.

Mr. JOHN BRANDON thought the method adopted by Mr. Wailes might be warranted if the work had to be done, say, off Lundy Island as an emergency job. Why, he asked, go to all this trouble and expense when this work could have been done with hydraulic jacks in the absence of a suitable crane? Mr. Wailes spoke of disturbing the centre of gravity, but he had here a ship of 2,000 tons on board which to lift 140 tons, or a deviation of about 2½ in. on the whole mass. How often had they to put on board 600 or 700 tons 'tween deck bunkers, with perhaps half the ballast out?

Mr. FRED JONES recalled the lifting of a pair of engines somewhat lighter than those described by Mr. Wailes. The crank shafts were removed, and pitch pine baulks were fitted in the pockets. Three-inch bolts were passed down through the cylinders through the baulks, with washer nuts on underneath, thus obviating any strain that might be put on the crank pin. In this way the whole of the tank top was removed. He quite agreed with Mr. Wailes that it was cheaper to raise the engines than to take them out of the ship.

Mr. W. D. ROSSER described a job undertaken by his firm last year of raising 70-h.p. engines. Six short bolts were used, some short screws were made, there were plenty of strong shackles available; and wire rope was secured round the columns, well padded. Then the engines were lifted with the short jacks from underneath, giving them about 3 in. lifts each time, and tightening up the nuts on top. Of course the ship was well shored, and they had girders across much in the same way as Mr. Wailes had shown, except that the shoring could not be brought

down straight, a spur-shore being placed under and taken well outside the margin of the tank. The bolts used by Mr. Wailes would go into stock again to be made into forgings, so that their whole cost would not go against the job. As to the suspension strain, there might be a considerable amount of tension on the eduction pipe, but the bolts holding the cylinder feet to the top of the column would take off a certain part of the strain.

Mr. MASON thought the engines in question might have been lifted safely and more economically by a crane. He should not care for engines of his own to be raised and suspended in the way described by Mr. Wailes.

Mr. SCOTT considered that Mr. Wailes had adopted the only practical method in raising these engines when the ship was afloat.

Mr. T. ALLAN JOHNSON said a great deal had been said about the strains to which engines might be subjected by the plan adopted by the author of the paper, but the continuous strains upon engines while running seemed to have been forgotten. Then they had heard a great deal about the cost of these bolts, but nothing had been said on the other hand about the cost of hydraulic jacks. He had listened to the paper with great interest.

Mr. E. NICHOLL, R.N.R., did not think there was any chance of the tramp ship of to-day, with its enormous beam, capsizing by the lifting of engines double the height stated in the paper.

Mr. JOHN COMMON said the paper was highly interesting, because it described the carrying out of a job in a way that had not been executed before under the same conditions and circumstances.

Mr. T. MORDEY asked if it was possible for Mr. Wailes to have jacked these engines up; if so, the question simply resolved itself into one of cost. For his part he thought the jacks would have been the

cheaper method. The practical result of the paper was, whether or no this was the best method of lifting engines under similar conditions.

Mr. EVAN JONES remarked that Mr. Wailes obtained these contracts in open competition in the Bristol Channel, and it was surely reasonable to believe that he was satisfied with the engineering and commercial result of the first job, or why should he have adopted the same method for the second and the heavier undertaking? With regard to the employment of jacks, they had to fix them in such positions and work them in such a way as to ensure an even lift. If the cost of the shoring timber and bolts was so expensive an item compared with hydraulic jacks, could it be presumed that Mr. Wailes would have adopted the plan in the second instance? He was quite aware that at the Roath Dock there was one of the finest hydraulic cranes to be found in any port in the Kingdom, yet after he and his foreman had put their heads together, he came to the conclusion to give preference to the plan which he adopted, and he believed the superintendents were well satisfied. If superintendents specified the use of hydraulic jacks in a job of this kind, of course they knew what to do.

Mr. JOHNSON (Barry) did not believe they could find throughout Cardiff jacks of sufficient power to have raised these 140-ton engines.

Mr. EVAN JONES, however, pointed out that Mr. Wailes had hydraulic jacks capable of lifting three sets of engines of the size of these, and if he thought that was the best way, he would have adopted it.

Mr. RYDER concurred that Mr. Wailes' method was the most reliable and practical one to do the job he had in hand. As to the joints, it was a matter of detail; if they did not want to start certain joints, the engines must be attached in other places. It was the contractor's risk, and the contract would doubtless contain a protecting clause for the owner.

Mr. T. W. WAILES, in reply, said, as to the cost of the bolts, they were made of rolled iron, and had merely an eye welded on one end and a screw cut on the other, and every bar could be utilised afterwards for other purposes in the yard. Then the timber used was produced from the firm's sawmills, and had been cut up and used in other ways. So that, in both cases, it was merely taking from the stores a loan of the material and returning it. The cost was infinitesimal, compared with the magnitude of the work. The wire ropes had been used before, and no doubt would be used many times again.

On the proposition of the CHAIRMAN, seconded by Mr. T. A. REED, a vote of thanks was passed to Mr. Wailes.

The proceedings closed with a vote of thanks to the Chairman, proposed by Mr. NICHOLL, seconded by Mr. CHELLEW.

PREFACE.

58 ROMFORD ROAD,
STRATFORD.
January 12th, 1903.

A MEETING of the Institute of Marine Enginers was held here this evening, when a paper, entitled "How the Engines of a Large Steamer were Lifted clear of their Seatings and Replaced while the Steamer was Afloat," by Mr. T. W. Wailes (Vice-President B.C. Centre) was read, in the absence of the author, by the Hon. Secretary. This paper was read and discussed at Cardiff on Wednesday, November 19th, 1902. The chair was occupied this evening by Mr. J. E. Elmslie (Member of Council). Prior to the discussion, two sets of drawings, illustrating the method employed by Mr. Wailes, were handed round for inspection, and the manner in which the work had been carried out was further illustrated by means of a few lantern slides.

JAS. ADAMSON,
Hon. Secretary.

DISCUSSION

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, JANUARY 12th, 1903.

ON

THE RAISING OF ENGINES.

CHAIRMAN:

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

THE CHAIRMAN said, so far as he could see, the plan described in the paper and adopted appeared to have been simple and effective; 140 tons, the weight of the engines raised, was not a very great weight to lift. The only risk that he could see was in regard to the swinging of the engines when lifted; he could not see what means they took to prevent the engines moving like a pendulum, in the event of the ship taking a small list. The whole risk of the matter was in the question of stability.

Mr. W. LAWRIE said he thought the paper was one of considerable interest to engineers as showing how such an undertaking had been carried out in an up-to-date port. He did not think the work had been carried out entirely from an engineering point of view. The contractor would be obliged to consider the matter all round. One question would be that of cost, which entered very largely into all considerations of work. The majority of shipowners thought of that first. Looking at the matter from an engineering point of view, he was of opinion that the method employed by Mr. Wailes was hardly the way in which an engineer would have proceeded if he had

no other considerations to bear in mind beyond his own professional ideas. To lift a set of engines by the columns, crank, and eduction pipe, and suspend them as described was, he thought, setting up a condition of affairs, and putting a stress on the engines never calculated upon when the engines were designed. In that respect he did not think it could be at all good for the engines; such, however, might be a minor point. In the particular case under discussion they had brought their stress to bear upon the deck altogether, and by means of shores they had taken the weight off the tanks and transmitted it to the bottom of the ship. In one part of the paper they were told that the stress was distributed all over the deck and on to the shell plating; in another part, in reply to one of the gentlemen discussing the matter, they were told that there was no stress on the decks at all, but it was taken below. It was very doubtful to him whether or not they could carry the stress down so nice and even. He was afraid some of the stress would be on the deck. It would be more reasonable to start from the bottom, where the stress had got to bear. The author of the paper had told them that at one time they had the thought of lifting the engines out bodily, but he did not tell them that they ever had any idea of lifting the whole weight from below. One of those who had taken part in the discussion at Cardiff had suggested that method, and he would much like to know the reason why the system of lifting from below could not have been carried out. If the engines had been taken off the bed-plate they could then have been lifted with more advantage to the machinery. In his opinion the best way would be to disconnect the engines as far as possible, taking off the cylinders, then the columns and condenser, and finally the bed-plate. Then they could lift them out one portion after the other. By simply reading the paper it was rather difficult to see all the objections that might exist against that course. In lifting the engines out bodily it would

be necessary to clear away a great deal from the top. That might be against lifting them out bodily, and, after all, he did not consider that lifting them out so was the best plan. At the discussion in Cardiff it had been pointed out that to get a crane of the capacity would be next to impossible, and even if it were procured it would only prove a "white elephant." He would point out, however, that large cranes of that description were usually fitted with two, if not three loads, and it could be used for many other purposes. This was commonly done at many places. In one part of the paper, Mr. Wailes, in referring to the stability, says: "I can assure you that the stability of the ship, and the keeping of her in a safe condition to carry out these important repairs, was carefully considered and gone into before the work was taken in hand, and was constantly borne in mind during the whole time the work was in progress, with the result that our anticipations and investigations proved correct, the vessel at all times showing a good margin of stability"; but in the second part of the paper he says: "also with such a small margin of stability." It seemed rather strange to say that the stability was good, and in another part to say there was a very small margin of stability.

Mr. C. NOBLE (Member of Council) said he had not yet read the paper. There was, however, a similar job being carried out at the Albert Docks at the present time, the weight of the engines being about 70 tons; but the work was being carried out on a different system. First of all the boilers had been lifted out of place and taken to the forward hold; the engines were lifted up to a certain height by means of hydraulic jacks from the bottom; they were then placed on a carriage and run in beside the boilers. According to the discussion at Cardiff, it appeared to him that the weight had been concentrated right at the bottom, which he did not think was very safe. He thought they must have strained the ship con-

siderably by not diffusing the weight all over the decks.

Mr. W. McLAREN (Member of Council) said: With regard to the method adopted by Mr. Wailes, he would have had a fear of the whole job slipping. Possibly the tank top to which the engines were fastened was not safe enough to enable them to lift from the bottom. He would have preferred to use jacks, as Mr. Noble had suggested, and there were jacks in use at the present day which were very handy. He would like to know what the condition of the tank top was. Seemingly it must have been in a very bad state when it had to be renewed. The author had referred to the different systems of fixing up the seating, and it seemed to be plain enough that the style they had then adopted was what might have been followed at the first. Perhaps it was a question of cost, although the ships came from the Clyde. With regard to cranes of 150 tons lifting capacity, he thought they were becoming fairly common, even at out of the way places abroad. He had not read the paper through, but the discussion that had taken place at Cardiff would probably serve to bring many points to their minds regarding such work. The ship upon which the work had been carried out had a beam of 48 feet, and he did not think there should be any question of the stability even when the engines were raised to a height of four feet.

Mr. K. C. BALES (Member) said it appeared to him that Mr. Wailes, when writing his paper, did not have so much in his mind the idea of writing a paper to be discussed, as to explain the method adopted of executing certain work. Whether or not the method followed was satisfactory seemed to be answered by the fact that the work was satisfactorily done. In lifting weights of that description there were only two ways that could be adopted, either pushing or pulling, jacking up from underneath, or pulling from above, and he supposed that both of those methods were governed by the circumstances surrounding the

work and also by the question of cost. It seemed to him that the method adopted—as several of the members at Cardiff had said—allowed the material prepared to be used over again. The baulks of timber were always very useful, and they were not cut in any way that would prevent them being utilised for other work, while the long bolts were always serviceable to be cut up and used again. As most of the material could be utilised again, it did not appear that the expense would be very great. He did not think there were many points to discuss; it seemed rather that the author had given them the benefit of his experience in executing a particular job.

Mr. JOHN MCLAREN (Member) said he agreed with Mr. Lawrie in many points as to taking the strain of the weight lifted. He had seen a sole-plate lifted by hydraulic jacks at a Continental port, and was of opinion that it would have been cheaper to use jacks in the lifting of the engines. By so doing they would not run the same risk of straining the ship as if they lifted from above. The lifting of the sole-plate to which he had referred was carried out quite successfully, and the people who did the work had quite as many difficulties to face as Mr. Wailes had apparently had.

Mr. W. E. FARENDEN (Assoc. Member) said he wished the author had given them some particulars as to what effect the weight of the engines had on the decks and shell-plating through being lifted from above. It would also have been of interest if, as Mr. Lawrie had remarked, Mr. Wailes had told them the cost of doing the job, and what the condition of the vessel was when it was found necessary to carry out the repairs. He would like to know whether the ship was an old vessel, or how long she had been out before the repairs were required.

Mr. W. MCLAREN (Member of Council) observed that in replying to the discussion at Cardiff Mr. Wailes had said, "If the vessel had been put under

a crane a lot of the casing and decks would have had to be taken away in order to get in their appliances. Then, how long were they going to keep the engine suspended by the crane? In lifting an engine like that no deviation of centre must occur fore-and-aft and athwart-ships, otherwise they would have to spend any amount of time and money in getting the engine back exactly where it was; but by the method adopted here there was not a hair's breadth deviation from start to finish." He thought it very fine work to speak of hair's breadth on board ship when lifting such a piece of machinery. There was no doubt, now that the job had been done, that it was easy for them to criticise. If they lifted the weight by the central lines of the ship, they must have been working to something like mathematical theory.

Mr. THOMAS DREWRY (Member) said: This is a most interesting paper, and we should have been very pleased had Mr. Wailes been here to tell us more about some of the particulars. It would be most interesting to know why, in this case, hydraulic jacks were not used instead of the lifting screws, as Mr. Wailes doubtless has a very good assortment of jacks quite equal to this job, and he also has a very wide experience. Yet he preferred to make a set of lifting screws to lifting with jacks. I must say that if I had this job to do I should lift it with jacks, and yet before the job was completed I might prove to myself that Mr. Wailes' way of dealing with it was best. The paper states that these repairs were done while the ship was afloat. It also states that girders were fitted intercostally between floors and riveted to tank top and shell-plating, as well as to the floors. Now, if Mr. Wailes will tell us how he riveted these intercostals to the skin-plating while the ship was afloat he will help us a lot. Seeing that the work to be done was only fitting intercostals and re-riveting the tank-top, etc., it appears to me that the amount of work done in preparing for this was very great. I do not say that it could have been

done easier, but it is serious to think that so much preparation is required for so small a job. In most cases where the engines sit upon the tank-top, wood or cast-iron fitting-chocks are placed between the engines and tank-top. These chocks are generally thicker than the tank-top rivets are long, and many cases of re-riveting have been done by taking out the chocks, putting the rivets in from the top, and "knocking down" the rivet on the inside of the tank. This, of course, only applies to the rivets actually under the engine. Those outside the bed-plate or in crank and eccentric pits can be done in the usual way with the engines down just as well as with them up. I take it that with the vertical wooden supports resting upon the tank-top, and the packing under engines, etc., it would be very troublesome to renew the tank-top and floors by this way of lifting the engines, and that it is only suitable for re-riveting. It would be very interesting to know if the weight was ever lifted off the tank-top. Of course, with the shores perfectly fitted, and no packing pieces of soft wood, etc., the tank-top and ship's skin should have had the weight the whole time. But shores are seldom perfectly fitted, and packing pieces generally yield a good bit before the strain gets home, in which case the decks would get a strain at their weakest part. As regards the effect of raising the engines 4 ft. in a light ship, of course each case must be considered separately, but it is quite possible that the engines may be raised until the ship is in a state of unstable equilibrium, and if nothing happens to incline the ship the work may be completed and nobody be any the wiser or any the worse. In any case, every care must be taken to keep the ship upright.

Mr. W. LAWRIE thought that the tank top was in so serious a state that the packing suggested by Mr. Drewry would hardly be of any use.

The CHAIRMAN observed that Mr. Wailes in his paper said: "The foundations of the engines were

duly supported as the engines were being raised, the packing proceeding with the lifting." The engines were packed as they were elevated.

Mr. J. B. JOHNSTON (Member) said the main question was as to the distribution of the strain. He would not jack up from the bottom, as the strain should be spread round about, from the main deck as well as the bottom, and thus get a uniform strain all over the ship, which could not suffer if the strain were distributed along the frames; by so doing, any weight might be lifted. As to the ship heeling over, of course, such a job could not be done in a sea-way. In lifting a heavy piece of machinery at sea they had to be careful not to let it swing across and take charge, but he did not see why there should be much trouble in dealing with a heavy piece of machinery, even a whole engine or boiler, in still water, so long as the strain was distributed. They could get plenty of power either by cranes or hydraulic jacks to lift any weight they liked so long as they distributed the strain to avoid injuring the hull.

Mr. W. LAWRIE said it might prove a very useful education for all marine engineers to read the paper and find out how engines could be lifted. He thought it was a very good thing to have had the question brought before them for the sake of sea-going engineers, as well as for those on shore. They might differ as to their ideas on the subject, but they were anxious to get as many ideas as possible so that they might learn something from every one. By the use of jacks for the lifting of engines they could lift all round the bed plate. When he was a sea-going engineer he had, on one occasion, to lift a ship into the water of the Lagos river. She was a wooden vessel, and when they got her afloat there was very little copper left on her bottom. The job had to be done, and they only had black labour available. He considered that engineers could not know too much upon such a subject. He thought that some of the members might have given their experience regarding

the use of jacks. He had seen a 50 ton paddle wheel lifted with one jack, with just two screws to guide it. The nearer they could get the power to the foundation they were working from (the bottom of the ship), the better it was for lifting, and the better lift they got.

Mr. W. O. WALKER (Member) said that in the job described by Mr. Wailes, it was very likely that jacks could not be applied conveniently. They had to make their screws, and having made them they might as well go right through with them. When a man had the lifting appliance under his eye he could see that the job was properly carried out. But with jacks down in the engine-room they could not work with the same certainty. He thought the bolts were very effective in keeping the engine steady, and for his part considered that the simplest system had been adopted.

Mr. JAMES ADAMSON (Hon. Secretary) said that any questions they might wish to put to Mr. Wailes, outside, perhaps, the very pertinent questions of cost of contract work, would, he had no doubt, be answered by that gentleman. As Mr. Wailes had the choice of three different methods of dealing with the repairs under the engine seating, and he had chosen the particular way described as being the cheapest, and seeing that his firm got the contract for doing the job they might presume his method was the cheapest way of getting the work done. The author had pointed out that nearly all the gear used came in for use afterwards and went into stock in the workshop. He had hoped that some member of the firm doing the work would have been present to describe the details of the job that was then being carried out in the Albert Dock on the *Radnorshire*. He had only heard of it himself that day, too late to get particulars to lay before the meeting that evening. If the discussion were adjourned, he hoped they would have a few more particulars additional to those to which Mr. Noble had referred. He understood that the boilers were moved forward into the hold, the

engines were then also moved forward and overhauled, including boring out a cylinder; the tank top was cut away and renewed, all under cover, without disturbing deck houses or the upper structure in any way. A day sufficed to move the boilers forward and another day to move the engines. In connection with intercostals, they ought to know how the tank top was attached to the ship's side. It seemed to him that with a certain class of tank they could easily manage to put in intercostals, without interfering with the ship's skin. That was a point which, if they had a drawing showing a section of the tank top and the method of riveting the intercostals, the work done could be made quite clear. The question did not appear to have been raised at Cardiff at all, probably owing to the fact that most of the members were acquainted with the particular ship and knew exactly the system of tank and mode of fastening in the vessel.

Mr. W. LAWRIE observed that a point had been made of the fact that the gear could all be used again. Was there any system for carrying out such work where this would not apply? He did not know of any system where, after the job was done, the gear would be absolutely useless.

Mr. C. NOBLE, in referring to the work then being carried out on a steamer in the Albert Dock, said he believed the reason why they had adopted that particular method of shifting the engines was because the crane in the Albert Dock could not lift seventy tons. He did not think there was any saving at the rate of lifting by that crane. In the steamer he was referring to there was very little to cut away to get the engines out, and the only reason for adopting the plan followed was the lack of power to do the job by crane. He was not aware whether or not any other plan had been considered.

Mr. W. MCLAREN said that if the discussion on the paper were adjourned it would have to stand over until some evening in February.

Mr. G. SHEARER (Member) suggested that it would be much easier for any members who desired to discuss the matter further to do so in writing, and this suggestion was generally agreed to.

Mr. JOHNSTON proposed, and Mr. K. C. BALES seconded, that a vote of thanks be accorded to Mr. Wailes for his paper. The vote of thanks was cordially agreed to.

A vote of thanks to the Chairman was then proposed by Mr. W. E. FARENDEN and seconded by Mr. C. NOBLE.

Mr. WAILES' reply to the London discussion :

Dealing with the discussion that took place in London on January 12th, 1903, on my paper, " How the Engines of a large steamer were lifted clear of their seating, and replaced while the steamer was afloat," the chairman (Mr. J. E. Elmslie) was afraid the engines when being lifted might swing about like a pendulum in the event of the ship taking a small list.

This important point was by no means lost sight of or overlooked, and provision was made for this in several ways, amongst others, as I stated in the paper, as a precautionary measure against the swinging of the engines, packing pieces and wedges, and afterwards blocks, were placed underneath, which were driven in tight as the engines were raised and the reverse process was followed when lowering, thus taking all reasonable precautions against either the swinging of the engines or the giving out of the bolts or gear.

It has been asked, Why were not the engines lifted from below ? As these engines rested on the tank top the only method of lifting was by driving in iron wedges all round the bed-plate and forcing up the engines, thereby running the risk of fracturing the bed-plate and throwing oneself open to very serious

criticism. This risk of fracturing the bed-plate might be lessened by applying jacks to the cranks; but the same member thought that by lifting at nine points it was putting a severe stress on the engines. I dread to think what this gentleman would have said if there had only been three points of lifting.

With an easy and uniform lift on the nine points of suspension, and in a most natural way, where the slings were round the middle of the columns, leaving all the top and the bulk of the weight in compression, and the lower and lighter portion in tension, such as I carried out, I do not think the stress was at all out of the way, and most certainly nothing approaching that which the machinery is subject to under the ordinary conditions at sea.

The weight lifted, as far as possible, was transmitted on to the bottom of the ship—the decks directly did not take the weight. Fore and aft baulks of timber were placed on deck, as shown, with a view to the engine-room bulkhead and the bunker end bulkhead taking a portion of the weight and distributing it on to the ship's floors, etc., and this weight was so well distributed that it in no way affected the shell plating, decks, floors, bulkheads, etc., all of which were in the same condition as before the repairs were taken in hand.

Mr. Thomas Drewry deals at length with the question of engine lifting and ship repairs which were executed whilst the vessel was afloat, more particularly the shell riveting, which obviously would have to be done in dry dock, and advantage was taken of the vessel docking for painting, examination of propeller, tail end shaft, etc., to drill the holes in shell and putting in these comparatively few rivets. I cannot agree with Mr. Drewry as to his method of riveting the tank top inside of the tank, for in the first place I do not think it possible, and in the second place I do not think it permissible. The cast iron fitting chocks he mentions are about $1\frac{1}{4}''$ thick and the length of rivets used were over 3", consequently it was impossible to get the rivets in, but

previous to this the holes had to be drilled larger and re-countersunk as stated in my paper. Personally, I should take exception to tank top rivets being "beaten down" on the inside of the tank, and of all places more particularly so in the engine seat, and I think that the owners' representative, Lloyd's, and the British Corporation Surveyors would be of the same opinion.

I might remark that since the paper was read at Cardiff two cases of engine-lifting have taken place there, the method of doing so being identical to that carried out by me and described in the paper.

In conclusion, I desire to thank the members and all concerned for the friendly way in which this paper has been received, as well as the very able manner in which it has been discussed and criticised.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1902-1903.

President—D. J. DUNLOP, ESQ., J.P.

Local President (B. C. Centre)—SIR THOS. MOREL.

LECTURE

BY

MR. H. BRANDON (MEMBER),

ON

SHIPS & ENGINES,

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, DECEMBER 8th, 1902.

CHAIRMAN:

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

PREFACE.

3 Park Place,

Cardiff.

December 8th, 1902.

A meeting of the Bristol Channel Centre of the Institute of Marine Engineers was held here this evening, Mr. M. W. Aisbitt, Vice-President, in the chair.

It was intimated that a sorrowful duty had to be discharged in respect to the announcement that Mr. David Gibson, for many years a much-respected Vice-President of the Centre, and a member of the Centre from its formation, had passed away at his home in Sunderland. About eighteen months ago Mr. Gibson left Cardiff owing to ill-health, and returned to the north of England. At that time he sent in his resignation as a member of the Centre and the Institute. It was a source of deep gratification to them all that at the suggestion of the Bristol Channel Centre the deceased gentleman was made a life member of the Institute. It might, perhaps, be added that their honorary local secretary had the mournful pleasure of calling upon their old esteemed friend at his Sunderland home about ten days ago.

On the proposition of the CHAIRMAN, seconded by Mr. T. W. WAILES, Vice-President, a vote of heartfelt sympathy was passed, the members rising in their places.

It was then reported that at a meeting of the Committee it was unanimously resolved to ask Sir Edward S. Hill to accept the presidency of the Centre, in succession to Sir Thomas Morel, and a deputation, consisting of Sir T. Morel, Sir John Gunn, Mr. M. W. Aisbitt, Mr. T. Allan Johnson, and the Hon. Local Secretary, had waited upon Sir Edward that afternoon. They would be glad to hear that Sir Edward Hill had intimated his willingness to accept the position, and had stated that while he was afraid he should not be able to attend all the meetings, he would do his utmost to promote the welfare of the centre.

Mr. H. BRANDON (Member) then delivered an address on the subject of "Ships and Engines." Mr. Brandon reviewed some of the rules and data that were ordinarily employed by designers in proportioning engines for the propulsion of vessels of various dimensions. A brief discussion followed.

GEO. SLOGGETT,
Hon. Local Secretary.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION  1902-1903.

President—D. J. DUNLOP, ESQ., J.P.

Local President (B. C. Centre)—SIR THOMAS MOREL.

DISCUSSION

ON

"SHIPS AND ENGINES,"

HELD AT

3 PARK PLACE, CARDIFF,

WEDNESDAY, DECEMBER 8th, 1902.

CHAIRMAN:

MR. M. W. AISBITT (Vice-President).

MR. T. D. WIDDAS (Member), said the wetted surface of a vessel was not in itself a measure of the power required to propel her at a given speed. A ship could be so proportioned and shaped that her wetted surface would be a measure of resistance, but in the majority of cases there is the additional resistance of wave-making, which is a material factor in the resistance of a vessel. In some cases the wave reacting at the run of the vessel assisted to thrust her forward, while in others there was no such result.

Mr. T. ALLAN JOHNSON recalled that the late Mr. Blechynden discovered a more ready means of arriving at the actual wetted surface than was obtainable by Kirk's analysis, and it was described in a paper before the Institute of Naval Architects some years ago. His formula was simple, what might be called a trick formula, but the result was astounding in its accuracy by actual calculation of different forms of vessels. The formula, he believed, had been largely adopted by leading shipbuilders in preference to Kirk's. With regard to wave-making, he had the pleasure of studying for some time with a gentleman in Cork, who erected a model tank with a view to recover some of the power spent in driving a steamer which resulted very largely in wave-making. The idea was to have a boom rigged over the stern with a smaller propeller at the end of it. The wave behind the stern naturally exerted a force, and drove some power back again into the ship. The idea, theoretically, was pretty enough, but it was of no use for practical purposes.

Mr. WILLIAM SIMPSON (Member) thought Mr. Brandon had only calculated for a new vessel and had not made allowance for dirt, which he had found to take more off the power than a good many inches of surface. He agreed with Mr. Brandon that they lost power in expanding, although, as the lecturer had said, they in this way secured a better balanced engine. It was a point worthy of serious consideration how this loss of power might be regained.

Mr. J. F. COMMON (Member) agreed that the form of a vessel had much to do with the question, but the standard should be taken by the area of the immersed mid-ship section, which should be one-third in front of the middle length of the vessel. He had known vessels which, after being lengthened —and thus with increased surface friction—had been driven at the same rate with the same fuel consumption.

Mr. GRAHAM (Member, Barry) recalled the time when, full of theory, he induced the superintendent engineer to allow him to make alterations in the valves. He certainly got an increase in revolutions—four or five—but one day the third engineer came and asked him if he had looked over the stern recently. He replied that he had not. The third engineer sententiously remarked—" There's a blade off."

Mr. ROY CADOGAN (Member) said, with regard to the triple expansion not being economical—presumably due to difference in clearance and receiver drop—the gain which accrued from the latent heat of steam, being less at higher pressure, had been overlooked. As to the bilge keels, the pressure must vary according to their position.

The CHAIRMAN said of course skin resistance was one of the greatest factors in driving their ship through the water. It was a common experience that barnacles reduced speed seriously. An ideal skin would be of china, and the next best thing was to get a cover coat which was as nearly enamel as possible, and keep it clean. As to bilge keels, he did not apprehend there was much in the question of depth. In a vessel drawing 25 ft., the pressure was not more than half a pound to the inch. The bilge keel should be put on a diagonal line right through, because if it had a curve upward there must be great resistance, according to the height of the aft-end of the bilge keel.

Mr. BRANDON, briefly replying on the discussion, agreed that there must be a greater pressure caused by the bilge keel the lower it was put, the greatest pressure of all coming on the hanging keel.

A vote of thanks was cordially extended to the author for his paper, on the proposition of the Chairman, seconded by Mr. E. Nicholl, R.N.R., and the proceedings closed.

The next meeting was announced for December 17, when Mr. Jas. Adamson's paper on " Our Fuel Supply," would be read.