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On the Repairs to the Hulls of Iron and Steel Ships.

BY MR. ROBERT ELLIOTT, B.Sc. (VICE-PRESIDENT).

READ AT 58, ROMFORD ROAD,

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CHAIRMAN: MR. JOHN CLARK (MEMBER OF COUNCIL).

CHAIRMAN : I have very great pleasure indeed in intimating that Mr. Elliott will read us a paper on " Repairs to the Hulls of Iron and Steel Ships." I am perfectly sure that all of you who have an interest in ship construction—and I am very wide afield if every one present has not an interest in ship construction—will follow Mr. Elliott's paper with great pleasure. I have not had an opportunity of reading the paper, not having had a copy of it before coming to the meeting to-night; probably I am like most of you in that respect, and we will just have to follow closely while Mr. Elliott is reading it. It will perhaps be quite in place for me to mention that I have known Mr. Elliott for about twenty-five years, as he was for some years in the service of the British India Company before he joined Lloyd's Register. He was transferred to Glasgow, I think, on his first nomination, then he came back to London, and afterwards went to Greenock, where he still officiates. During the

last nineteen years he will, no doubt, have obtained a considerable amount of experience in connexion with ships and repairs, and I will now call upon him to read his paper, which contains some of the results of that experience.

REPAIRS to the hull of a steamer or sailing ship may be required on account of damage caused by stranding, through collision, fire, or other accident; or on account of wear and tear, the evidence of old age creeping on.

According to the nature of the damage and the parts of the vessel affected, the repairs may be done afloat, or possibly the vessel may require to be dry-docked for examination. If damage has been caused by grounding, an examination in dry dock is necessary, where all shell plates broken or severely indented would require to be renewed, while some shell plates not too severely injured could be removed, faired and refitted, and others, slightly indented, could be faired in place without removal. In some cases the fairing in place may be done by drilling a hole or holes in the deepest part of the indentation and using a screwed bolt and a "strong back" to draw it out fair. In the case of the plates removed, care must be taken in rolling the plates to fair them, so that they may not be stretched or elongated, otherwise the rivet holes in the plates would be unfair in replacing the plates. The rivet holes in all outside strakes of shell plating should be re-countersunk before riveting, and careful examination should be made of the plates between the rivet holes to ensure that the plates have not been fractured in driving out the rivets. With regard to plates, angles and other sections, those of steel will stand more punishment than those of iron, and are more easily faired or brought back to their original shape.

The frames, if broken, or severely bent and twisted, require to be renewed for whole or part length, according to the length of the frame damaged. Frames at the fore and after ends of a vessel, on account of their shape, are difficult to renew for their whole length, especially if there are not many shell plates in way of them coming off, and a satisfactory repair can be effected by cutting the damaged parts of the frames out, fitting new lengths for the parts cut out, care being taken that where a number of damaged frames are together, the butts of two

adjacent frames should be kept well apart, in a vertical direction. Bosom pieces, or short lengths of double frame, taking at least three rivets on each side of the butt, are fitted over, or in way of, each new butt made in the frames.

In the case of an extensive damage, where a large number of frames, adjacent to one another, are broken or severely bent and twisted, it is advisable to renew them for their whole length, as the part renewal of a large number of frames together does not improve the appearance of the vessel, and lessens her market value. Frames that are not broken, but bent or unfair, can be generally faired in place, especially when the shell plates in way of them are removed on account of damage, the methods employed depending on the section of the frames, and the facilities for heating them in place.

Reverse frames, stringer and keelson and other angle bars may be treated in a similar manner to the frames. It is easier to remove these for renewal or part renewal, and for fairing and replacing. In the case of part renewal of these bars, where the bars are long, a reasonable length ought to be renewed and not too short a length, as for instance a length of five or six feet.

Beams set up or deformed, on account of damage, require to be removed and faired, as their section (except in very small vessels, where ordinary angle bars are used) does not admit of fairing them in place. In the case of a collision damage, it often happens that only the ends of the beams on one side of the vessel are broken or severely bent. In such cases, instead of complete renewal of the beams, especially if there are only a few beams to deal with, an efficient repair may be made by cutting off the damaged part of each beam, fitting a new piece to each beam, and double butt straps or "fish plates," over the butt, with sufficient rivets on each side of the butt, care being taken to efficiently shift the butts of adjacent beams, and not have them all in a fore and aft line. Of course the same remarks with reference to the frames, apply to the beams, viz., that where several are damaged adjacent to each other, it is advisable to renew them completely. In cases where the beam knee alone is damaged, the knee, if welded, could be cut off and a plate knee, of sufficient thickness, riveted to the beam and frame.

Stringer plates, deck plating, tank top plates, bulwark plating and bulkhead plates, are dealt with similarly to shell

plates. Where the plates are in long lengths, and damaged only at one end, a new butt can be "raised" or cut in the plate, provided it is not too near other butts in its vicinity, and the butt strap covering it made broader, so as to get an additional row of rivets on each side of the butt.

Dealing next with damaged floor plates, either ordinary floor plates, or those in way of the double bottom, when broken or severely buckled, these require to be renewed, but in cases of less severe damage they may be removed, faired and replaced, or faired in place. To renew or remove those in ballast tanks, it sometimes becomes necessary to remove either some additional tank top, or shell plates, that have not been damaged. The floor plates in ballast tanks are generally fitted in two lengths, each length butting against the middle line keelson plate, and are therefore more easily dealt with. The middle line keelson plates and longitudinal girder plates, in tanks, bunker and casing plates, deck house and other plates, when damaged, are dealt with in a similar manner to floor plates, stringer and other plates.

The stem bar, if broken or severely twisted, in place of being entirely removed for renewal, in cases where a sufficient length (say, half the length) of the bar and the stem plates attached are uninjured, is often repaired by cutting a new scarph on the uninjured part of the stem and fitting a new piece in lieu of the damaged part. If the stem is set slightly to one side, and its cross section is not too great, by removing the stem plates in way of the set and heating it at this part it is possible to fair it in place. Where the stem bar has to be removed to be faired, particular care has to be taken that the bar is not elongated in the process, as this would make the holes in the stem plates unfair and result in their rejection. A keel bar may be treated in a similar manner to a stem bar, but being straight, is more easily renewed in one length.

The stern frame of a steamer is sometimes found to be fractured in the sole piece, and in such cases, an efficient repair may be made by fitting and riveting plates or slabs of sufficient thickness on each side of the sole piece, in way of the fracture. Where part of the sole piece is amissing, the stern frame would require to be removed and the lower part of the frame renewed, the welds being placed sufficiently apart in the propeller and rudder posts. In some large vessels the stern frame is made of cast steel, in one or more pieces. These, if

broken, cannot be easily repaired, and generally require to be renewed.

The rudder frame (of a double-plated rudder), when broken at its lower part, is removed, the plating unriveted and a new lower part welded in, the new scarphs being placed sufficiently apart. Where the head of the rudder is twisted or broken, the damaged portion may be cut off, and a new part efficiently welded to the frame. Where two or more parts of the rudder frame or stern frame are broken, it would be better to wholly renew the rudder or stern frame. If the rudder frame is simply bent, it could be faired on removal by heating—the plating if in way of the bend being removed. In single plate rudder frames the parts are more simply dealt with, as the parts are generally fitted separately and not one whole forging. Where the rudder frame is of cast steel, a break means its renewal.

In the above, each of the principal parts of the vessel has been separately dealt with, but of course, where a vessel is damaged by grounding—say, on examination in dry dock, the keel and bottom require to be carefully sighted by " sights " fixed in way of the damaged parts and also the undamaged parts for reference, and the whole of the damage treated generally, as well as separately, and this may entail the fitting of additional parts, not originally in the vessel, so as to strengthen some weak part or parts, or to compensate for some defect not easy, or perhaps impossible, to remove. An instance of this may be mentioned in the case of a vessel with a cargo of pig iron which shifted during heavy weather and seriously damaged the hull ; the shell and deck plating being out of shape, also beams, etc., and stanchions bent. A large number of shell and deck plates had to be removed to be faired, and other repairs had to be effected, besides which, before the vessel could re-ship the pig iron and carry it to its destination, an additional doubling strake of plating had to be fitted each side for about two-thirds the length of the vessel on the strake below the main shearstrake (an inside strake), an additional fore and aft girder (T bar) on each side, under the beams of both the lower and upper deck beams to strengthen them, and several additional hold and 'tween deck stanchions. Another form of damage, due to the working and straining of vessels, which was common a few years ago, was at the fore and after ends of bridges, as these were found to be fractured, and the shell plating in way

of the fractures had to be doubled and bracket plates fitted, attaching the sides of the vessel to the fore and after ends of the bridge. Many other cases of damage might be given, but each particular damage calls for particular treatment, on account of the different types and construction of vessels dealt with.

In iron vessels, the damage due to striking on rocks, or to collision, is always more extensive than in steel vessels, for the reason previously stated, viz., that iron plates will not stand the same punishment as steel plates, and consequently more of them are found broken than would be the case if the vessel were built of steel.

Repairs Due to Wear and Tear.—The principal cause of these repairs is due to the oxidation of the iron or steel, scale being formed and thus reducing the material in thickness. In some parts of the vessel, as between the frames and shell plating, or between angle bars and casing plates exposed to the weather, this accumulation of scale exercises such an enormous pressure that it breaks the connecting rivets clean through. The bunker plating, in way of coaling hatchways, iron or steel decks, the tunnel plating in way of hatchways (when not covered with wood sheathing) and other parts exposed to the weather, suffer most from oxidation, also ballast tanks under boilers, and plates covered with wood or cement where the water manages to get through the wood or cement covering. In dealing with repairs due to wear and tear, more liberty can be taken in fitting parts of frames or reverse frames, etc., also in fitting doubling plates over parts wasted, as most owners do not object to these in an old vessel, whereas in repairs due to damage, most of the parts damaged require to be renewed, or made equal to what the parts were originally.

Before examination of any parts of the vessel is made, care should be taken to see that all scale and paint is thoroughly removed. This is usually done with scaling hammers and chisels. A more effective manner was witnessed by the writer some years ago in London—the method consisting of a sand blast actuated by pneumatic pressure ; the same apparatus, with slight modification, was also used for blowing on, or covering plates and other surfaces with paint, and it acted admirably.

Dealing first with shell plates, after all scale and paint has been removed, tapping or " sounding " the different parts of the plates with a light hammer will be sufficient to find the thin

parts of the plates, and these parts are drilled and the actual thicknesses taken. The shell plates between the light and load draughts suffer most from oxidation, from the outside, and from the inside, those under sidelights, and in way of the fore and after peaks, and, generally, plates covered by wood lining, thus preventing examination. The landing edges of the plates forward are very often worn and chafed by the anchor chains.

When shell plates, also stringer, deck, bulkhead, casing and other plates, are much reduced in thickness over a large portion of their surface, they should be renewed. In some cases, as with shell plates of an inside strake of over $\frac{1}{2}$ in. in thickness, where they are not reduced very much, and where the plates of the outside strakes (above and below the inside one) are in good condition and do not require to be removed, an effective repair is made by fitting doubling plates (about the thickness of the outside strakes) on the outside ; the doubling plates being drilled so as not to interfere with the original frame and butt-strap rivets, and being carried, or lengthened, at least one frame space beyond the butts of the original plates.

If a shell plate is wasted or reduced in thickness locally—as under a sidelight—a doubling plate is fitted from frame to frame, and of sufficient length to cover the wasted portion of the plate. If a butt strap, in way of a sidelight or other space, is found to be wasted, and also the plate it covers reduced in thickness, the butt strap is renewed with one fitted from frame to frame. Where a shell butt is open and leaky and caulking becomes useless or unsatisfactory, an outside butt strap is fitted. A lapped shell butt, if leaky, can have its defective rivets renewed, or the edge of the plate pared and recaulked.

To prevent the lower landing edges of the outside strakes forward being wasted by chafing of the anchor chains, narrow strips of plate, secured by one row of rivets, are fitted close to the landing edges in way of where the wear is likely to take place. In small vessels with a forepeak tank, and often running in ballast trim, the lower landing edges of the plates forward have been found to be grooved, and a similar repair to the above has been effected—the narrow strips being more easily renewed than the plates. The cause of this " grooving " in the lower landing edges of the plates seems to be obscure. It has been suggested that when the vessel is light and pitching in a seaway, air is carried down with the vessel and imprisoned

under the landing edges, and the material is oxidized by the oxygen in the air.

Often the edges of the stem plates, in way of the forefoot, and the edges of the garboard strakes (where a bar keel is fitted) are found to be worn and thin. In such cases a shoe piece is fitted, covering the part of stem or keel affected, and secured by renewing the upper row of keel rivets (or inner row of stem rivets) in way of the shoe piece.

Sometimes a shell plate is wasted around the edge of a circular washer fitted on the outside of a sea cock or valve. The washer is renewed, where this occurs, with one larger in diameter, covering the wasted part, and secured to the shell plate by a row of rivets outside the wasted part.

When frames are found to be wasted, the parts affected are cut out and renewed, and the butts covered with a bosom piece of angle bar, taking three rivets on each side of the butt. Where the frames are thin only at a deck, and no reverse frames fitted above the deck, small brackets, attached to the frame and to the deck by a piece of angle bar, are usually fitted, taking three or four rivets in the frame, and in the deck bar.

If the one flange of the frame (the one attached to the reverse frame) is slightly wasted and its other flange good, a double reverse frame is often fitted—of a length sufficient to cover the wasted part of the frame and to extend a foot or two beyond at each end.

Wasted reverse frames and other angle bars are treated in a similar manner to the frames. Where the flange of the reverse frame (the one not attached to the frame) is only slightly wasted, a covering piece or "rider piece," the breadth of the flange, is fitted. This is also usually done on the upper flanges of the double reverse frames fitted to ordinary floor plates under boilers, when they are similarly wasted—the covering piece being the breadth of the two flanges.

Beams, except where exposed in bunkers or other parts, do not waste so much as other parts of the vessel, but their flanges or angle bars, especially of 'tween deck beams not covered with a deck, are often bent or broken by loading or discharging some kinds of cargo, such as pig iron, heavy timber, etc. The angle bars of the beams can be dealt with similarly to the frames and reverse frames, and in some cases may be heated and faired in place.

Deck plates, especially steel deck plates, are found to waste rapidly. When much wasted in thickness they are renewed, and, where not so much wasted, are doubled in some places, as at the end of a hatchway where the plates run into the bridge or poop. Deck plates in way of galleys or donkey boilers, when covered with cement, tiles or brickwork, require careful examination, as water often manages to get through and wastes the plates on the upper surface—the under surface appearing fresh. If the cement, tiles or brickwork is broken, or where water lodges at the lowest level, a small portion should be cut out for examination of the plating underneath.

When wood decks are worn from 4 in. to 3 in., 3½ in. to 2¾ in., and 3 in. to 2½ in. in thickness, they are also renewed. At times the ends of the planks, at the end of a hatchway, deck-house, etc., are found to be defective, while the remainder of the planks are good. Where this is found, the ends are cut back, say about six inches, and a margin plank, preferably of teak, is fitted along the ends of the planks—an iron or steel tie plate supporting the margin plank below, and serving to bolt the plank to. Minor defects in wood decks show at some of the heads of the bolt fastenings, due to "iron sickness," or the action of the iron bolt. These may be remedied by fitting small "graving pieces" in way of the bolt heads. To prevent this action the bolts are galvanized, and the head sunk about ¾ in. in the deck, with a grummet and white lead, and the recess made for the head filled with a wood dowel; but in some of these the water enters, destroys the galvanizing, and the iron then affects the wood in its immediate vicinity.

In bunkers, the casing plates, etc., in way of hatches and openings, where exposed to the atmosphere, also saddle-back plating, and the 'tween deck plates where water is likely to collect, are much wasted by corrosion. These are dealt with, as far as renewal is concerned, in a similar manner to deck plates, but the bunker casing plates, where locally wasted, are more often doubled over the wasted parts, as the patches do not look so unsightly here as when exposed on the deck of a vessel. Stokehold casing plates, especially those in way of the funnel, waste rapidly, and are treated in a similar manner to bunker and other light plating.

With bulkhead plating, greater care is necessary in renewal, and doubling should not be resorted to often, and the repairs ought to be tested by a hose for water-tightness.

Ordinary floor plates are usually found wasted in way of the limber holes at the fore and aft centre line of the vessel. This is caused by the continual wash of the bilge water, which wastes the material around the limber holes and continually enlarges the holes. Doubling plates are fitted to the floor plates in such cases, having new limber holes. Where the corrosion has not proceeded far and the holes are not much enlarged, cement, carefully applied, will prevent further deterioration. The intercostal plates, between floor plates, are also found wasted at their lower part, owing to the same cause, and these are doubled at their lower part. Where the angle or other bars forming the side keelsons (of which the intercostal plates form a part) require to be renewed, it would be easier to renew the intercostal plates, instead of doubling them, when found wasted.

In a vessel with a double bottom, or ballast tanks, the tank under the boilers, owing to the differences of temperature to which it is subjected, wastes more rapidly than any other part of the vessel, and in a large number of vessels the life of this tank has averaged between eight and nine years only, when it had practically to be renewed.

Where the waste is widespread, the boilers require to be lifted out of the vessel, or in some cases to be raised and secured to the strong beams in the stokehold, or, when the vessel is in a dry dock, to be shored up direct from the dock bottom or bottom plating with wood blocks supporting the bottom plating. When the boilers are lifted clear or removed, the floor plates, tank top plates, longitudinal girder plates (which are intercostal in cellular double bottoms, and in long lengths above the ordinary floor plates in tanks on the M'Intyre system) and margin plates with their angle attachments can be removed and renewed. The tank top plating is originally fitted in lengths running fore and aft, but in some repairs, where bulkheads intervene, it is found more convenient to fit them in lengths running athwartships. Where this is done, due provision is made for the shifting of the butts, so as not to have them too near each other, and the sides of the plates are double riveted instead of single riveted, the butt straps, or laps, of the ends of the plates, being treble riveted. When the tank top plates are not very badly wasted, the plates are doubled, the doubling plate being packed with canvas red-leaded, or other material, to ensure watertightness. Bolts and nuts, instead of rivets,

are used in some cases to secure the doubling plates, the bolts being fitted with grummets. Some floor plates and longitudinal girder plates are found to be reduced in thickness more at the upper half of the plate, and good at the lower half. The upper half of the floor plate or girder plate, in such cases, can be fitted with a doubling plate—the breadth of the doubling plate being limited by the size that will pass through the manhole door, when no tank top plates are removed. Sometimes the floor plates are only wasted around the manholes punched in them and, when this is the case, rings of a sufficient breadth, usually about 3 in., can be fitted around the holes to stiffen the floor plates. If some of the floors are thin, a temporary repair is effected by fitting thin doubling plates in two halves on each side of the floor, so as to pass through the manholes, and securing them to the vertical angle bars, by which the longitudinal girder plates (intercostal) are attached to the floor plates.

Margin plates of ballast tanks are treated similarly to tank top plates. Where the rivets of the margin plate brackets are started and leaking it shows signs of weakness, due to the vessel working, and, besides renewing the started or slack rivets, angle or tee-bars ought to be fitted at every third or fourth frame space, securing the brackets to the tank top plating. In ballast tanks fitted on the M'Intyre system, it is often found that the rivets at the ends of the longitudinal girders in each tank are slack, and the angle bars, securing the girders to the floors, wasted. Where the angle bars cannot be renewed, and in some cases where they can, bracket plates fitted at every third floor, on alternate sides of the girder, attaching the longitudinal girders to the reverse frames of the floors, compensate for loss of strength and make a secure attachment.

Particular attention should be paid to the condition of the boiler stools and chocks, and also to see that the boiler stools are fitted upon floors and not between them, and that the floors under the stools are in good condition.

The ballast tank under boilers is often a source of great expense to the owner of a vessel, and numerous methods have been tried to prevent corrosion and waste in this tank. A few of these methods will now be considered. A covering of Portland cement has been used, spread over the tank top to a depth of about two inches. Owing to the heat from the boilers and the large surface of cement exposed, the cement has cracked, allow-

ing water to get at the tank top and wasting it, the extent of which was not visible on account of the cement. An improvement on this method was made by fitting angle bars on the tank top, dividing the spaces up into squares of three or four feet and filling in the spaces with Portland cement. A layer of brickwork has also been tried, but owing to the number of joints in the brickwork offering possible passages for water, this method is not a good one. Bitumastic cement put on the tank top, while hot, gives good results. In some cases the tank top plates have been made of iron of a good thickness (about $\frac{7}{8}$ in. thick, which is practically double the usual thickness) and the plates galvanized. This, of course, is a very expensive method, but the extra thickness of plate would last a long time. The iron plates also do not corrode so rapidly as steel plates. Galvanizing the plates, no doubt, gives them a little protection, but the constituents of bilge water will soon destroy this coating. Another method is by covering the bottom of the boilers with asbestos blankets. The asbestos is a very good non-conductor of heat, but in most boilers leaky rivets or seams appear in the bottoms of boilers and in this method are hid from observation. In all the above methods their efficiency depends on the height of bottoms of the boilers from the tank top. Some years ago this height was not very great, but, in recent years, it has increased and is now often made between two and three feet. Where the height is two feet or over, the boiler stools require additional strength, and a fore and aft bracket is usually fitted to each half of each boiler stool. Coming now to the inside of the ballast tank, the usual method is to cover the surfaces of the floors, longitudinal girders and underside of tank top plates, with cement wash. Often this is done carelessly and blisters of cement form, containing water, and the consequence is that the plates are found pitted in way of the blisters. A good plan is to mix a certain proportion of lime with the cement wash. The lime has the tendency to absorb the water and the result is certainly better. Covering the surfaces of the plates with bitumastic cement has been tried, with satisfactory results. Another method, which is certainly effective, is to brush most of the mill-scale off the plates when the vessel is built, and then give them three coats of boiled oil. The oil could be again applied at intervals, on the appearance of any rust. White lead and tallow mixed and applied hot has also been tried for vessels trading in cold climates.

The shell plates of iron and steel vessels require great attention to prevent corrosion, and also the growth of barnacles and other shell fish, sea-weeds, etc. When the vessel is new it is usually coated with one or more coats of anti-corrosive paint, and over these a coating of anti-fouling paint. The mill-scale, which is formed during the process of rolling the plates at the iron or steel works, is continually falling off and carrying the paint with it. Great care is therefore necessary, especially during the first two years of the life of a vessel, to see that the vessel is dry docked at short intervals for examination and renewal of the paint. To remove the mill-scale the plates, after delivery from the steel works, are placed in a pickling tank or bath containing a dilute solution of hydrochloric acid. In some cases of expensive yachts, the plates, especially those between wind and water, after pickling, are also galvanized. Paint marks put on at the steel works while the plates are hot —to indicate the number of vessel and number of plate and dimensions—are found years after to be quite fresh and distinct, and it is suggested that if the plates were coated with paint while hot it might possibly protect them better than they are at present. After the usual painting of a vessel's bottom it is advisable to see that no globules of paint are left hanging on the lower landing edges of the plates, as this, no doubt, has a tendency to increase the resistance of the vessel through the water.

The growth of barnacles and other shell fish seems to proceed in spite of all the different paints used, and the question of their entire prevention is still one requiring solution.

Deck plates of iron or steel—when no wood sheathing or deck is fitted on them—require care on account of corrosion. Coating them with oil or paint is the remedy usually tried, but in a number of cases it is not begun early enough, and once the corrosion gets a good start it is not easily arrested. All surfaces of iron or steel would certainly be better preserved if coated with oil before paint is applied.

Formerly tunnel plating in way of hatchways was sheathed with wood, but now it is more general to increase the thickness of the tunnel plating in way of the hatchways and dispense with the wood sheathing, as water was liable to get under the latter and corrode the plates.

The riveting of diaphragm or division plates in fore and after peak tanks—attaching the plates to the beams and deep floors —is often found slack and requiring renewal. This is caused,

when the vessel is rolling, by the movement of the water striking the plate in cases where the tank is not quite full.

The parts of the rudder which receive most wear are the pintles. With the old-fashioned style of rudder with two plates, the pintles form part of the rudder forging, and, when any of the pintles require to be renewed, a " staple " pintle—viz., one with forked projections to enable the pintle to be riveted to the rudder forging—has to be fitted. With single-plate rudders, the new style, the pintles are fitted separately from the forging and can easily be renewed. When the wear of the pintles is not great, bushes are either fitted into the gudgeons, or shrunk on the pintles—the pintles being made as circular as possible. In some cases the bushes are made of brass or lignum vitæ, instead of iron. The thickness of the rudder plating, in a two-plate rudder, can be tested by a light hammer sufficiently to give an idea if it requires to be renewed. Sometimes the edges of the plates at the lower part of the rudder are found wasted, and these can be repaired by removing the rivets, fitting a shoe piece in way of the wasted part and renewing the rivets. The rudder head in way of the deck gland may be found worn, and, where this is not excessive and the rudder head of not too large diameter (say, 7 in.) it may be " jumped " up—i.e., by heating the worn part to a red heat and hammering the end of the rudder head, provided the steering gear will allow of the rudder head being somewhat shortened. With rudder heads of larger diameter it would probably be necessary to cut them and weld new ends on. In a single plate rudder, the head is a separate piece, securely bolted to the rudder frame, and can easily be renewed.

In all vessels it is important to examine the steering chains and rods for wear, and also to have them annealed in cases where they have been subjected to any severe straining.

Chain cables require attention, as the links wear, and often the studs are found slack or amissing. Hawse pipes also wear rapidly when the metal is soft, and require renewal.

With rigging, all nips, bends and splices, also all bolts, pins and other fittings require occasional examination for wear due to corrosion.

Iron or steel masts corrode, from the inside, also iron spars, especially at or near the ends, and bowsprits on the lower half near the end. The masts, spars and bowsprit should be sounded with a hand hammer, to get an idea of their thickness, and drilled where found to be thin.

With reference to damage to the shell of the vessel, it is of some importance to have a ready method of recording the damage, so as to waste no time in the examination, and the following, although not original, is suggested :—

STARBOARD (OR PORT) SIDE.

Strake.	⊕	△	□	Remarks.
A (garboard)	1, 2, 3, 4.	5, 7, 9.	6, 8, 10.	
B				
C				
D				
E				
F				
etc.				

⊕ denotes plates requiring to be renewed.
△ ,, ,, removed, faired and replaced.
□ ,, ,, faired in place.
The numbers—1, 2, 3, etc.—denote the numbers of the plates, starting from forward or aft.

DISCUSSION ON MR. ROBERT ELLIOTT'S PAPER "ON THE REPAIRS TO THE HULLS OF IRON AND STEEL SHIPS."

CHAIRMAN : You have heard the paper read, and I have no doubt a number of you will probably have suggestions to make or something to add to what Mr. Elliott has put before us. The meeting is now open for discussion.

Mr. R. BALFOUR (Member) : If no one else will set the ball of discussion rolling, and as it is getting late, I will endeavour, in support of my colleague, to take the initiative. In the first place I think the Institute is to be congratulated upon this valuable addition to its transactions contributed by our esteemed Vice-President, Mr. Elliott. And, speaking as a member, I may point out that this is another instance of the indebtedness of the Institution to the Committee of Lloyd's Register for their kindness in allowing their officers to come

here to give their experience for the common good. Mr. Elliott has put a lot of facts together, and given much food for discussion, which should extend to another evening, as the subject is of great importance and deserves much consideration. On page 7, Mr. Elliott states " that another form of damage due to the working and straining of vessels, which was common a few years ago, was at the fore and aft ends of bridges." I can endorse that statement. It was of common occurrence ; cracking the sheer strakes and even across the deck at these parts, probably due to the abrupt termination of the superstructure. That trouble, however, has now been overcome and is a thing of the past. Under the heading of wear and tear, I observe Mr. Elliott frequently uses the word " doubling." Nothing to my mind can be more abused than this method of repair. Though inevitable in many cases, in the main it is a makeshift, and should be avoided as much as possible. When absolutely necessary the old parts must be thoroughly scaled and coated, and the doubling attached to sound material. With regard to riveting rider plates to wasted reversed frames, the same remarks apply as in the case of doubling. With reference to cement and its application, although not a structural part this is of great importance, both in new and old vessels. Unfortunately, in these days of keen competition and " cut throat " pricing it seems to be a case of getting the job done as cheaply as possible. That being so, it is very difficult to get it carefully applied, apart from the quality of the material. The surfaces of the iron or steel must be thoroughly cleaned before the coating is applied, and this, in my opinion, should be put on thin and often. After all, the best is the cheapest. Reference has been made regarding the application of boiled oil and its success in preventing corrosion. From experience I am convinced that paints containing chiefly animal or vegetable oils will not adhere to nor preserve iron or steel surfaces, particularly where moist or high temperature conditions are to be met with. To my mind mineral oils should be predominant in the solutions. With regard to the mill scale on shell plating of vessels, all interested would like to get over this difficulty. Some new vessels have been allowed to remain several months without being properly coated below the load line, in hopes of the mill scale being removed, but this course met with little success. The landing of the plates and rivets suffered from the exposure to the action of the sea water,

as the mill scale on these parts had been removed by the hammering during construction.

I wish to express my gratification at seeing my colleague, Mr. Elliott, with us to-night.

Mr. W. LAWRIE (Chairman of Council) : I am afraid there is very little in the paper that I can, at any rate, find fault with. Most of the methods described by Mr. Elliott appear to me as being the best way to get over the difficulties mentioned. On the whole, I think the less a vessel is patched up the better. It is astonishing the difference of opinion among engineers on a subject of this kind. Of course if one belongs to one of the Insurance Societies he will have somewhat different ideas to those who happen to be servants of the owners, but in repairing a vessel where there are fractured plates or where deterioration is going on, it is generally the better plan, where one starts to take out a frame, to remove it altogether, although I know it does not always follow that this is the best course to adopt. My experience for some little time past has been confined to vessels light in structure, and the way I try to get out of difficulties of this kind is to endeavour to prevent the corrosion taking place as far as possible, and that of course means a good deal of time and trouble. Everything that is done must be done thoroughly. In the paper I see the author refers to "paint hanging in globules from the edges of the plates." Whenever that happens there is something wrong, and I do not think the painting can have been very well done. I agree with Mr. Balfour as to the value of oil. Where corrosion has been going on in places not very well got at, I always have oil applied, and I find that after it has been on for some time it is very easy to remove the scale; very likely it will be found in the bottom of the bilges. The paper is a very valuable one, but without going through it a little more carefully it is hardly possible to make many remarks upon it.

Mr. G. CAMPBELL (Visitor) : It gives me very great pleasure to be here to-night, and although I have not the pleasure of being a member of this Institute, seeing that I have been called upon to make a few remarks I shall be happy to do so. In the first place, I am very pleased to see Mr. Elliott and to hear the very able paper he has just read. It is a good many years since I had the pleasure of meeting him. I have no doubt

Mr. Elliott has had a good deal of experience in his work on the Clyde, and after what we have heard to-night it is quite unnecessary to say more on that subject.

With regard to the paper, one of the points that struck me very forcibly was in reference to the practice of doubling—the subject mentioned by Mr. Balfour. Doubling is a very important feature in the repairing of ships, and, like a great many more who have to supervise this work, the less I see of it the better I am pleased. At the same time it is very essential sometimes, and is a very convenient way of getting out of difficulties, but as a rule I think by putting doubling plates on to any local weaknesses it is simply covering up sore places which will perhaps give more trouble in time to come. The best way to do is to remove a bad plate altogether and put a new one in its place. By doing this the part is restored to its original strength and a first-class job is made.

Mr. Geo. Robson (Visitor): On page 13, the author says, "In ballast tanks fitted on the McIntyre system, it is often found that the rivets at the ends of the longitudinal girders in each tank are slack, and the angle bars, securing the girders to the floors, wasted. Where the angle bars cannot be renewed, and in some cases where they can, bracket plates fitted at every third floor, on alternate sides of the girder, attaching the longitudinal girders to the reverse frames of the floors, compensate for loss of strength and make a secure attachment." Is it Mr. Elliott's opinion that this method is a secure attachment, and compensation for the longitudinal strength lost? Is it a common practice to adopt this method? I should be glad if he would kindly tell us what he thinks of that, as I should like to have his opinion on the subject.

Mr. Elliott: Yes, it is a common way of compensating for the strength. Where the longitudinal bar is wasted it is impossible to get that bar out of the manhole door of a tank, and in that case, of course, it might be fitted in short sections, but in addition to that the longitudinal girder is secured to the tops of the floors by these brackets. Of course that is only the bottom angle of the girder, the top angle is all right. Where the bottom angle is wasted, usually the girder is secured to the floors by bracket plates on alternate sides of the girder fitted to every second or third floor. That seems to make a very

strong attachment, and in a number of cases that I have seen, years after the repair has been made in this way, it seemed to prevent the girder getting loose again.

Mr. Elliott illustrated this with blackboard diagram.

Mr. AITKEN BROWN (Companion): Mr. Elliott might have given us some little information as to the construction of ballast tanks; it would be useful. I think that in the experience of most of Lloyd's and the Board of Trade surveyors that is where the greatest trouble is felt, and in my opinion the sooner we get a flexible pipe to connect with the cast-iron pipe, the better it will be. I have had some experience in this matter, probably as much as any one in the room, but I find that, no matter what material is put at the ends of the cast-iron pipe, it goes time after time, and the great need is for a flexible tube to fix on the ends of the pipe to the bulkhead. Another thing is that, instead of putting studs through the bulkhead, bolts are used, which means clearing out two ballast tanks to get at one pipe. I have had trouble with this not once or twice but twenty times. These are things I should like to see remedied—as far as I am personally concerned, perhaps I do not—at the same time I think it would be a good thing if a flexible tube were used to connect the cast-iron pipes to the bulkheads.

Mr. H. RUCK-KEENE (Member): I have not read the paper before coming here to-night, and so am not in a position to criticize it, but Mr. Elliott has made things so very clear that I do not think there is much room for criticism at all. There are one or two points, however, which, after reading through the paper casually, I might draw attention to. One is with regard to the corrosion of the ballast tanks, mentioned on page 13. In the first place, the author remarks as to the best way of preventing corrosion in the tanks under the boilers. Of course it depends upon the height of the boilers from the tank top, but in my opinion nothing can be better for this purpose than asbestos blankets fitted on the under side of the boiler shells, blankets from $1\frac{1}{2}$ to 2 inches thick, as such certainly prevent the heat from getting down upon the tank top, and from my experience it is better than using the bitumastic cement on the tank top.

With regard to what is best for the inside of the tank, on

the whole I think there is nothing better than the cement in hold tanks, but in tanks under boilers I have seen very successful results with a mixture which I see Mr. Elliott mentions, of white lead and tallow, half and half, mixed with a little engine oil and applied hot on a perfectly clean surface. The best example I have ever seen of preservation of this kind was in Antwerp in the tanks under the boilers of a ship nine years old. First of all, I went through the tanks under the engines which were coated with cement as usual, and they were very good, but when I came to the tanks under the boilers I said to the engineer, " Whatever have you done here ? " They were quite clean, there was very little sign of wear, and the same thickness of plate as when new. It appeared that they had used this mixture of white lead and tallow mixed with engine oil and applied hot, and had renewed the mixture every eighteen or twenty months, with the result that the plates were absolutely clean.

Mr. Elliott mentions that paint marks to indicate the number of the plate are often found years after, on being opened up, to be fresh and distinct, and suggests that if the plates were coated while hot it would be a better protection. I can recall a case of an oil tank ship fifteen years old where the original marks, the charge number and the number of the ship could be seen painted on the plates, showing, of course, that by putting on the paint hot the plate is preserved in that part. But of course you cannot do that with a ship, as it would be quite impossible to heat the ship all over in order to put the paint on. It does, however, make a difference according to where and when the painting takes place. For instance, if the paint is applied in a cold, damp climate it will not adhere so well as if it is done in the tropics in fine weather. Mr. Elliott mentions about the growth of barnacles. I remember the case of a ship which had been out of dry dock for about 2½ years, and on being dry docked strings of mussels three feet long were found on the bottom.

There is one point here where Mr. Elliott has, I think, made a slight mistake, which I may perhaps be permitted to draw attention to. It is in the last paragraph, where references are given for the best method of recording the damage. Is he not wrong in the second and third items ? The triangle generally refers to " faired in place," and the square to " removed, faired and replaced."

Mr. Elliott : It is a matter of convention, you can have it whichever way you will. In some cases more elaborate marks are given.

Mr. Ruck-Keene : The mark for " renewed " is, I think, always the same, but I have always considered that the number of sides in the triangle and square corresponded with the number of words in the description of the repair which they represented, " faired in place " and " removed, faired and replaced " respectively.

I thank Mr. Elliott for the very valuable paper he has read to us.

Mr. E. Elliott (Member) : I have very little to say regarding the paper, but in connexion with the preservation of plates in the hull, I notice that no mention has been made with regard to putting in cement. In the bilges of a ship the cement is never placed high enough, and the floor plating suffers in consequence. Another place that suffers is where there is an angle in the 'tween decks. The cement is put level with the deck, and whatever water happens to get into that locality accumulates there, and the frames of the ship suffer, more especially the reverse frames. I have had a good deal of experience with this class of damage, and I find that it occurs there more than in other plates in the midship section. Of course, often in the 'tween decks, say in the bunkers, the chief engineer refuses to look after it, and the chief officer says that it is not his job, so between the two the matter is neglected. Another place that suffers from corrosion is the plating in the stokehold, and I do not see why it should not be doubled there, the wasted portion being taken off and replaced. With regard to repair by doubling, I consider it is, generally speaking, quite correct to say that it is better not to double, more especially with an outside plate ; but in an inside plate, where a great amount of expense would be caused in removing it, it does not matter so much about doubling it, because there are always the frames to hold the plate, so long as it is caught before the wasted plate gets too thin. In an old ship there is no risk in doubling an inside plate, but when an outside plate is affected, I would say remove the plate and replace it, because in an old ship there is the frame, liner and plate, and to put another plate

on means a four-ply plate, which requires very careful handling to get a good job made.

In the case of a broken rudder post, I have known it repaired by a brass casting, which made a cheap and very effective job. The casting was made and the flange bolted and riveted on, and years after, when examined in dry dock, there was not a bolt or rivet started.

Mr. G. Adams (Member of Council) : We have indeed had a very valuable paper from Mr. Elliott, but when one considers that he is a surveyor of Lloyd's Register, I think we could quite anticipate that. From the multitude of opportunities he has had, and the many advantages, that others do not possess, of being transferred from one centre to another, examining so many ships and the different methods of repairing, we could well believe that he would be able to gather the valuable amount of information that he has placed at our disposal this evening. At the present moment I am not prepared to go into discussion—the paper does not give an opening until one has had time to look into it more closely—but there are a few points that I would like to refer to. The double bottom has been mentioned, and the corrosion going on under the boilers. Now, in reference to the tanks of a vessel, most of us will agree that it is a matter of great expense to owners with regard to their upkeep. When the vessel is classed at Lloyd's it is important that the tanks should be kept up in a satisfactory manner, otherwise the class might be lost, which would be a serious matter for the owners. The question of cementing in tanks is a very debatable one, and much diversity of opinion exists as to whether the inside of the tank should be cemented or otherwise. Certainly the thin coating of cement is usually, in my opinion, a most estimable remedy for preserving the interior of the tank; a thin layer on the bottom would leave no opportunity for the water to lie and corrode the tank when empty. In fore and aft intercostals the cement, in many cases, is flushed up to the root angles for the same reason. In the tanks under the boilers its use is very efficacious, and it is surprising what a small cost is needed to enable it to be done to the satisfaction of the surveyors. The tanks themselves, first of all, are well cleaned out and washed down, coated with double boiled oil, then filled with fresh water and afterwards kept filled up to the top. The water in the tanks is never allowed

to be reduced in quantity, any loss due to evaporation or other causes being made up, and after a period of years, when examined from time to time, it is remarkable to find so very little deterioration of the interior. On the outside the tank is coated with bitumastic half an inch in thickness. The first treatment is with a thin solution to give it a flux, then the other material is added to the required thickness. I have seen that method applied, and it is found it to be very efficacious.

Mr. Elliott refers in the latter part of his paper to rudder heads. I know cases of vessels of equal size in which the rudder is constructed in sections, and the shank that goes up from the top of the rudder through the stern has one gland at the top in some cases, while in others there is a gland at the bottom and an adjustable bearing at the top. I should like to know whether Mr. Elliott considers it is better to have one, or two, of these bearings. It is obvious that the double adjustment has a steadying effect, but I should like Mr. Elliott to give his opinion on the matter. Of course the vibration is always felt, no matter whether the vessel is twin screw or single, and the jarring is often responsible for the wearing away of the rudder shank, which, as he says, necessitates a new end being welded on.

Another point that Mr. Elliott refers to has already been spoken of by Mr. Balfour, and is a matter that is not new to many of us. In the old days of square ports it was a common case of cracking at the corner of the ports amidships, and when it broke away at the corners, in many cases it was only made up by long doubling plates put on the outside in way of the ports.

I do not think there are any other points that I can speak of, as I have already said it will be necessary to read the paper through carefully.

Mr. A. H. MATHER (Honorary Treasurer): I think the Institute generally is very much indebted to Mr. Elliott for the very interesting paper which he has read to us to-night. We have had many papers dealing with engineering subjects, but not so many in connexion with the hulls of vessels, at least for some time past. The marine engineer generally, unless in a special case of damage at a foreign port, does not do the work of ship repairing, but we have had to-night a good opportunity of obtaining considerable knowledge of ship construction and, from the different repair jobs dealt with fully in the paper, of

seeing where the troubles are likely to occur. There is not very much that I have noticed to make special remark upon, or to criticize, but there was one little point referred to by Mr. Elliott where he mentions that strips of plate should be fitted close to the landing edges of shell plating in way of the cables. That might have been extended also to include the same position in way of the hatchways. That is a point which is just as liable to be damaged by cargo being pulled up the side of the ship. Another remark Mr. Elliott made drew my attention. In referring to the condition of the boiler stools and chocks he says that it is advisable to see that the boiler stools are fitted upon floors and not between them. That Mr. Elliott has found it necessary to make such a remark does not, I hope, mean that it is a common practice to fit the boiler stools between floors.

Mr. ELLIOTT : No, but I have found it to be the case in two or three ships.

Mr. MATHER : It is obviously not a good practice, but from the fact that Mr. Elliott has drawn attention to it, it is evidently done. The only other point I would like to mention is with reference to boiled oil being used as a coating for tanks. I think that boiled oil, being a drying oil, would not be a very suitable oil for this purpose, as it would be liable to flake off after it is dry; but for the interior of the tanks a mineral oil would be a far better preservative, as it would adhere more closely to the plate and retain its nature for a longer period. The condition of the plating inside the tanks of oil tank steamers is a very good proof of this.

Mr. F. M. TIMPSON (Member) : In relation to boiled oil being used to prevent corrosion on plates, Mr. Elliott once made several surveys of a ship that I was on, and on his recommendation we coated the frames with boiled oil, with very good results.

CHAIRMAN : Before calling upon Mr. Elliott to reply, I may also remark upon one or two of the points. On the whole, it seems to me that the doubling which Mr. Elliott referred to in part of his paper can hardly be avoided. I perfectly agree with Mr. Balfour that it is a very undesirable thing, but there are conditions and times, I am speaking now from the stand-

point of the repairer, when he has no alternative left but by doubling until he has a more favourable opportunity of removing the plates. Some interesting points were brought out in the discussion. Mr. Campbell endorsed the views which Mr. Balfour made in respect to doubling, and Mr. Ruck-Keene followed. I am perfectly at one with Mr. Ruck-Keene in his remarks on the preservation of the tanks under the boilers; the question of not having the boilers in close proximity to the tank is most important, and the greater the difference between them the better chance there is of the tanks being preserved. One point which has not been mentioned is in reference to the ventilation of these tanks. It appears to me to be a very important element, especially in tanks under the boilers where water has been carried. The rose box never goes to the bottom of the ship, and however much the tanks may be pumped, there is always a certain amount of moisture left. Heating and cooling is continually going on, with the result that moisture is created and, consequently, corrosion. In many cases a thorough system of ventilation meets the difficulty, not with the ordinary ventilation pipe of 2 inches diameter merely—that, in my opinion, is of no use—they should be nothing less than 8 inches in diameter, and instead of one or two, four pipes at least should be fitted, arranged in such a way that there would be cross-currents of air continually circulating at the bottom. I think a more universal method of ventilation under the boilers of ships should be adopted, especially where the moisture cannot be removed. Various methods of coating the tank tops were mentioned, one being by washing with cement. In some cases this is done with a solution of bitumastic and proves very successful. It is put on warm, a day is selected when the atmosphere is dry, and, when the cement is properly applied, on being examined years afterwards the plate is found to be in an excellent state of preservation. One gentleman remarked about the application of paint as a preservative. If it can be put on while the plate is hot, by all means let this be done, but if that is impossible it should be put on in a dry atmosphere. It is best done in tropical climates where there is no moisture in the atmosphere, and when the paint is applied under these conditions it has a superior value. Mr. Elliott has made some remarks about stern posts, and in connexion with this I might say that I had occasion once, on an emergency in Bombay, to fit a gunmetal rudder post. It had a fork at the lower part

and a socket at the top, and the original rudder post was dropped into the fork. That remained, to my knowledge, for over three years without alteration, but I expect, eventually, there would be signs of corrosion going on. I may also give an instance of doubling which took place more than thirty years ago, and which, I daresay, would astonish some of the surveyors to-day. An attempt had been made to forge an ordinary propeller shaft into a stern post. The shaft was heated in a furnace, and when in the condition necessary to enable it to be worked it was taken out of the fire, but then every one ran away from it; we could get no one who would stand up to it to have it forged, and in the end it was spoiled. A new method had to be adopted, and at last the difficulty was overcome by riveting together a series of plates 1 inch to 2 inches thick. There were no other means of getting a stern post, but this proved to be a first-class job and brought the vessel home quite satisfactorily. I will now call upon Mr. Elliott to reply to the questions that have been raised.

Mr. Elliott: With regard to the question of the use of boiled oil, which Mr. Balfour and, I think, Mr. Ruck-Keene mentioned, I may say that in writing the paper it was a matter of experience that induced me to put in that recommendation. I have examined the tanks of two vessels running out of London which have been so treated for four years, and the oil had not done them any harm. Of course, I agree with Mr. Mather that generally any vegetable oil is bad for steel or iron plates, and a mineral oil is much better, as there are acids in the vegetable oil, but I know that in these particular cases the boiled oil certainly did not cause any trouble. With regard to doubling, it is sometimes impossible to adopt any other method. The owner of a vessel is in a hurry and wants his ship away, and the repair must be done as quickly as possible. There are some plates where one cannot avoid the practice of doubling; for instance, in deck plates running from the hatches into the bridge. If the plate is wasted at the end of the hatchway, it would mean taking away part of the bridge to get the plate out. With reference to the question of having flexible suction pipes, I cannot say much about that, but I should think it would not be advisable where the pipes have to be carried through to the forward tanks.

Mr. BROWN : The pipes I referred to are only those connecting the cast-iron pipes to the bulkhead.

CHAIRMAN : I know of cases where lead piping has been introduced with advantage to give flexibility in the connexion with the bulkhead.

Mr. BROWN : We have tried copper, lead and almost every other material, but cannot improve it.

Mr. ELLIOTT : With regard to the use of asbestos blankets on the boilers, of course no one would object to that for the purpose of preventing the heat getting to the ballast tanks, but it has disadvantages also; for instance, if there happens to be a leaky rivet the asbestos blanket prevents it from being seen, and induces corrosion due to the moisture held to the plates. As a surveyor, I do not care for the use of them, unless the blankets can be easily removed at any time, to expose the bottom of the boiler for examination.

In my reference to putting paint on the plates while hot, I meant that this should be done at the steel works; of course it could not possibly be done on the ship. I have had some experience of steel works, and have noticed that paint marks put on the hot plates remain on for years, and possibly if the whole of the plate were painted while in that condition it would be a very good preservative.

Mr. Edward Eliott referred to the wasting of reverse frames, and in cases of this kind, as I have suggested, brackets should be fitted. Of course I should not suggest doubling outside strakes, but doubling the inside strakes is right enough, and in some cases doubling plates are used on account of damage in order to strengthen the ship at some weak part and prevent similar damage.

Mr. Adams asked whether it would be better to have one or two stuffing boxes or glands on the rudder head. I should think the rudder would be in a better condition with two than with one only. If one is at the top and one lower down I certainly think that is the better method.

With regard to the point raised by Mr. Mather as to the strips being fitted in way of the hatchways as well as the landing edges in way of the cables, of course that is a necessary corollary to the case I mentioned.

I do not know that I have any other questions to answer, but I should like to say that I am very much indebted to Mr. Clark for his valuable remark on the ventilation of tanks. When I came to read the paper I also came for information, and I am certain that other gentlemen present could give more information if they wished. It is a matter of experience, they have seen cases that I have not seen, and I should like to hear about them.

CHAIRMAN: With reference to the desirability of having both a stuffing box at the top and a gland at the bottom of the rudder head, I do not doubt that there is an advantage by having the two. An additional packing box at the bottom is very often an advantage, apart from the question of steadiness. Leaks might get in at that point and do damage in the after quarter of the ship, but if there is a gland there that difficulty is overcome, which I think is a distinct advantage. I am reminded by the Honorary Secretary that any gentlemen who are anxious to carry on the discussion a little further will have an opportunity of fixing a night for next month. There is a great deal to be said for this paper, and I am sure I am expressing the opinion of all in saying that we are exceedingly obliged to Mr. Elliott for having come all the way from Greenock to read this paper personally, and we are also indebted to Lloyd's Register, who granted him permission to come. I have known Mr. Elliott longer, I believe, than any other gentleman in the room. I have known him from the beginning of his engineering career, have watched him through the various places he has been in, and am very glad to see that Mr. Elliott, in all these places, has been highly recommended and appreciated. He is not a man given to be very boisterous in his manner, as we have seen from his collected and unostentatious ways this evening. I must say that I have appreciated the paper very much, and papers of this nature result in setting the mind thinking. This, I understand, is only the forerunner of a paper which he contemplates giving later on, and dealing with "Repairs to Machinery," a subject of considerable interest to all of us here. I do not know that I have anything further to say, except to call upon you to express our thanks to Mr. Elliott by showing it in the usual way.

Mr. W. E. FARENDEN seconded the proposal, which was carried with acclamation.

Mr. ELLIOTT : I thank you very much for the hearty manner in which you have received my paper, and I am only sorry that I shall not be able to come down to read the next one, and I shall have to ask our Honorary Secretary to help me out of the difficulty by reading the paper in my place.

Mr. BALFOUR proposed that Mr. Elliott's paper on " Repairs to Machinery " be read and discussed on November 18, as arranged, and that the discussion on both papers should take place on December 16. Mr. FARENDEN seconded, and the motion was carried.

A vote of thanks was accorded to the Chairman, after which the proceedings terminated.