INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1907-1908

PRESIDENT: JAS. KNOTT, ESQ.

Visit to the Engineering and Machinery Exhibition, Olympia, W.,

On Saturday, September 28, 1907.

ON Saturday afternoon, September 28, the members of the Institute paid an official visit to the Engineering and Machinery Exhibition at Olympia. The afternoon was spent in making individual inspections of the very extensive aggregation of working machinery of the latest types and other exhibits, after which the members assembled in the Lecture Hall, where a light repast was partaken of. Mr. W. Lawrie, Chairman of Council, presided over this function in the unavoidable absence of the President, who expected to be present on the occasion, but was called away on business to the Continent. Immediately afterwards, lectures were given before a large audience, on "New Methods of Effecting Boiler Repairs," by Mr. Harry Ruck-Keene, Member, and on "Ventilation, Heating, and Berthing," by Mr. A. E. Battle, Member of Council, both illustrated by lantern views. Various samples of welding by the processes which were the subject of his paper were submitted for inspection by Mr. Ruck-Keene. The chair was taken, on the occasion of the first lecture, by

Captain H. Riall Sankey, R.E. (ret.), Chairman of the Lectures Committee in connection with the Exhibition, and on the occasion of the second lecture by Sir Alexander B. W. Kennedy, LL.D., F.R.S., President of the Exhibition Advisory Committee.

In view of the interest shown in these lectures, the discussion on Mr. Ruck-Keene's paper will be resumed at the Institute premises, Stratford, on November 11, and on Mr. Battle's paper on December 2, 1907.

JAS. ADAMSON,
Hon. Secretary.

New Methods of Effecting Boiler Repairs.

BY MR. HARRY RUCK-KEENE (MEMBER).

READ AT

THE ENGINEERING AND MACHINERY EXHIBITION, OLYMPIA,
On Saturday, September 28th, 1907, *at* 7 *p.m.*

CHAIRMAN: CAPT. H. RIALL SANKEY, R.E. (ret.).

CHAIRMAN: In the absence of the President of the Institute of Marine Engineers I have been asked to take the chair [1] for the first lecture, from 7 to 8, on "New Methods of Effecting Boiler Repairs," evidently a subject of much interest, especially to marine engineers. These new methods are, I understand, based on the application of the oxy-acetylene blow-pipe and of the electric arc. To Engineers such methods seem at first sight rather dangerous, as, obviously, the great heat produced at the part welded would have a tendency to cause internal stresses, and it is only by experience that we can be sure that such methods are efficient and safe. It is on such points that we shall be pleased to hear what the lecturer has to say to us to-night. I might mention an experience of my own in connexion with the repair of cast iron by another method producing very intense heat, namely the "thermit" process. We had a repair made by this process and it did it admirably, but a very short time afterwards the casting

[1] In the capacity of Chairman of the Lectures Committee in connection with the Engineering Exhibition.

broke. We were then told that we ought to have raised the whole casting to a red heat before applying the process, but in view of the fact that the casting was 10 ft. long by 5 ft. wide by 2 ft. deep, you will agree that the easiest plan was to break it up, put it in the cupola and re-cast it.

With these few remarks I will now ask Mr. Ruck-Keene to give us his lecture.

The repairing of boilers is a subject which I think must always be of interest to marine engineers, and I propose in this paper to describe two processes of effecting repairs, by welding in place, which have so far given satisfactory results, and at the same time have effected repairs at probably less cost and in many cases in less time than by the ordinary methods of repairing. These processes are the Oxy-Acetylene and Electric systems of welding, whereby cracks in plates may be welded up in place, patches may be fitted and welded in place without forming new seams, as would be necessary if they were riveted, and wasted plates and landing edges may be built up to their required thicknesses. Now the ordinary form of welding can certainly not be called a new process, for though I have been unable to find who was the first discoverer of the art of welding, yet on referring to the fourth chapter of Genesis I find that Tubal Cain (who lived about 3950 years B.C.) is there described as "an instructor of every artificer in brass and iron," and so we may fairly conclude that the ordinary form of welding was known in those days. And by the ordinary form of welding in wrought iron or steel I mean that which consists of the parts to be united being heated to a suitable temperature at which they become plastic, but not actually fused, and are then united by hammering, squeezing or rolling. Although the metal itself does not become fused at this temperature, yet it becomes rapidly oxidized, but the oxide formed is liquid at this temperature and in properly made welds it is entirely squeezed out from between the surfaces to be welded. To render the oxide still more liquid and, therefore, more easily expelled from the weld, a flux of white sand (silica) is sometimes used ; this forms with the oxide a silicate of iron which has a lower melting point than oxide of iron, and although when a flux is used the iron or steel is probably less adhesive than it is at the temperature at which the oxide melts, yet the importance of using every means of getting rid of the scale between the surfaces to be welded justifies the use of a flux in most cases. But to come down from the days of Tubal Cain to more modern times, it was the practice of several well-known firms when making iron boilers to weld the longitudinal seams of the shell plates of boilers instead of riveting them, and in 1874 some exhaustive tests then made proved the efficiency of these welded seams to be about 70 per cent. of the solid plate. And I have only heard of one case in which the weld gave way, and that was in 1889, when a boiler, eight years old, was subjected to hydraulic test, after undergoing repairs, and the longitudinal seam cracked through the weld for a length of about six inches. When steel took the place of iron in the manufacture of boilers this practice of welding longitudinal seams was discontinued. But many firms still continue to weld the furnaces to the tube plates in steel boilers; and it is the universal practice nowadays to weld the longitudinal seams of furnaces, no matter whether they be of the plain, corrugated or ribbed type. So that it will be seen that welding, though decried by many engineers, is still extensively used in the manufacture of boilers. In the Oxy-Acetylene and Electric processes of welding, though the surfaces of the metal to be welded are heated up to practically the same temperature as in the ordinary methods of welding, yet the subsequent hammering, squeezing or rolling is dispensed with, except in that process of electric welding which I propose to describe where a certain amount of hammering is still used in making the weld. For the purpose of repairing boilers by the Oxy-Acetylene process the necessary apparatus practically consists of a steel cylinder containing oxygen gas and another containing dissolved acetylene, both under pressure, a special blow-pipe, flexible tubes for transmitting the gases from the cylinders to the blow-pipe, and small bars or rods of iron or mild steel about $\frac{3}{16}$ in. diameter, which are fused and attach themselves to the parts to be united. The oxygen and acetylene gases in these cylinders are led to the blow-pipe by means of the before-mentioned pipes and there ignited at the nozzle, the resultant flame giving out an intense heat. Where plates are wasted away by corrosion or otherwise, the wasted parts are first thoroughly cleaned to remove any dirt or grease, and are then heated to a welding heat by means of the flame from the blow-pipe; the iron or steel bar is in the meantime held in this flame until a small portion at the end of the bar is melted off and attached to the part to be repaired, and this process is continued until by the addition of drop after drop sufficient metal has been added to bring the plate up to its required thickness. When a crack in a plate has to be welded up, the metal on either side of the crack is cut away to form a V-shaped groove and thus enable the flame to penetrate to the bottom of the crack and heat the surrounding metal to the required temperature, metal being at the same time added from the small bar to fill up the groove, in the same way as the wasted plate was built up. In a similar manner, by chamfering away the edges, two plates can be welded together. Naturally in all these cases great care must be taken to see that each and every piece of metal added becomes firmly attached before adding more metal to it. This process has been very satisfactorily employed in this country for many purposes, and more especially for welding flanges and branches on iron and steel pipes (which have to withstand high pressure), but so far it has been little used for effecting boiler repairs. In Marseilles and Genoa quite a considerable number of boiler repairs have, however, been carried out in the last few years by this process with satisfactory results. Among other repairs I may mention those carried out to two marine boilers, where the bottom plating of the combustion chambers and the lower part of the combustion chamber back plating, and also parts of the furnaces ($\frac{19}{32}$ in. thick) were considerably wasted by corrosion, the defective parts were cut out, patches made to suit, and instead of riveting them on, they were welded in place by this process, thus avoiding the making of additional riveted seams in the furnaces and combustion chambers, which often give so much trouble in boilers. The landing edges of the lower part of the back end plates of these boilers were also considerably wasted, and these were made good and built up to their original thickness in the manner I have already described. These repairs were carried out under the supervision of my colleague (Mr. Jones) at Marseilles in June, 1906, and after twelve months' work they were again examined in July last and found to be quite satisfactory and showing no signs of leakage. In another case eighteen furnaces of the main boilers of another vessel were so badly wasted by corrosion on the water side near the line of firebars, that in the ordinary way these furnaces would have had to be renewed, but by this process the wasted parts of these furnaces were built up to their required thicknesses by welding on sufficient metal piece by piece, thus saving the time and expense of renewing the furnaces. In another case the furnaces of some other boilers were badly wasted and cracked, and these were satisfactorily welded up by the same process ; there being in all about 100 cracks in the two furnaces and the repairs taking about three weeks. Figs. 1 to 3, I think, explain these repairs better than I can describe them on paper. I could cite many more cases, but I think those I have mentioned will give some idea of what can and has been done in repairing boilers by this process. After the welding operation it is usually considered better to heat the surrounding plate by means of the blow-pipe flame to counteract, as far as possible, the strains that might be set up by the intense local heat. Naturally if it were possible it would be better to properly anneal the plate dealt with. This process has also been very usefully employed in the cutting out of defective and damaged plates, the flame from the blow-pipe melting and thus cutting a groove about $\frac{3}{16}$ in. wide, in much the same way as would be done by a band-saw, the separation being quite as cleanly and accurately done and in much less time than by the ordinary methods of hand cutting. The following are results of tests, made in June last, from samples taken from a plate welded by the Oxy-Acetylene process, and are the same as those I gave in a paper read at the Engineering Conference of the Institution of Civil Engineers.

Oxy-Acetylene Welding.

	Breadth	Thick-ness.	Area.	Tons, Total.	Tons per sq. in.	Extension in 4 in. per cent.
	in.	in.	in.			
Not annealed .	1·5	·62	·93	22·85	24·5	30 } Solid Plate.
Annealed . .	1·5	·62	·93	22·35	24·0	36 } Solid Plate.
						Extension in 8 in. per cent.
Not annealed .	1·5	·62	·93	22·9	24·6	28 } Broke away from the weld.
Annealed . .	1·5	·63	·945	22·1	23·3	29 } Broke away from the weld.

Cold Bends.

Not annealed	180°
Annealed	180°

These show not only the efficiency of the weld, but also that the ductility of the surrounding metal in way of the weld has not been distressed by the intense local heat. It will be noticed that the tensile strength of the welded plate is the same as that of the solid plate, the elongation per cent. is also the same, and the bend tests are quite as good as those which might be expected from the solid plate. There are several systems in use for welding by electricity which have been employed for a number of years, and are used, among other things, for welding tram-rails in place, in making good blow-holes, etc., in steel castings, and also in welding together pipes, more especially those for refrigerating plant which have to withstand high pressures. But as with the Oxy-Acetylene process, little use has so far been made of these processes in this country for repairing boilers. In the last few years, however, electric welding has been used abroad for this purpose, more especially at Gothenburg in Sweden, where quite a number of boiler repairs have been carried out by this process. The process there employed is somewhat smiliar to the Oxy-Acetylene process, but the heat is generated by the electric arc instead of by the flame from the blow-pipe. The plant there used consists of a barge containing two dynamos of 45 Kilowatt power driven by a steam engine, and a third dynamo of 3 Kilowatt power for feeding the magnets. The voltage used is between 80 and 120. There are two sets of cables leading from the dynamos, so that work can be carried out at two different places at the same time. The cable from one pole of the dynamo is connected to some part of the boiler and the cable from the other pole is connected to the welding bar (which consists of a bar of specially prepared steel about $\frac{3}{16}$ in. diameter). This welding bar is fixed in an insulated holder, and on being brought into contact with the article to be dealt with and then withdrawn a short distance, an electric arc is formed, which rapidly heats the parts in close proximity to the arc, and at the same time the end of the bar is heated to almost a molten condition ; this is then pressed against the parts to be welded, and they being now heated to a welding temperature, a small portion of the end of the bar attaches itself to them, in a similar manner as an almost melted piece of sealing wax is made to adhere to paper ; after this small portion of nearly melted metal is attached the bar is withdrawn, thus breaking off the electric current. The added metal is then hammered to ensure its being thoroughly united with the parts to be welded. The welding bar is then again brought into contact with the parts being dealt with, and then withdrawn a short distance to again form an electric arc, and the surface of the metal and also the previously welded metal are again heated to a welding temperature and another small portion from the end of the bar is added and hammered as before, and so the cycle of operations continues until sufficient metal is added for the opening between the two pieces of metal to be entirely filled up, in the case of welding two plates together, or the wasted portions of a plate have been brought up to the required thickness. The following are the results of tests made in June last from a plate welded by this process (and as in the case of the Oxy-Acetylene test samples, are the same as those given at the Institution of Civil Engineers).

ELECTRIC WELDING.

	Breadth	Thick-ness.	Area.	Tons, Total.	Tons per sq. in.	Extension in 4 in. per cent.
	in.	in.	in.			
Not annealed .	1·0	·56	·56	15·35	27·4	12 } Broke through weld
Annealed . .	1·0	·55	·55	14·5	26·3	14 }

COLD BENDS.

Not annealed . .	58°	Showed signs of fracture at weld.
Annealed. . .	160°	

It will be seen that after annealing much better results were obtained than before annealing. But unfortunately one cannot anneal a boiler in place. Some cases of repairs carried out by this process can, I think, be better explained by showing sketches of them. Figs. 1, 2 and 3 are, as already stated,

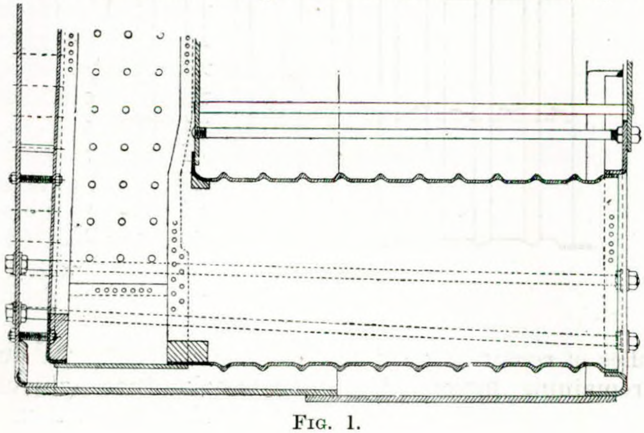


FIG. 1.

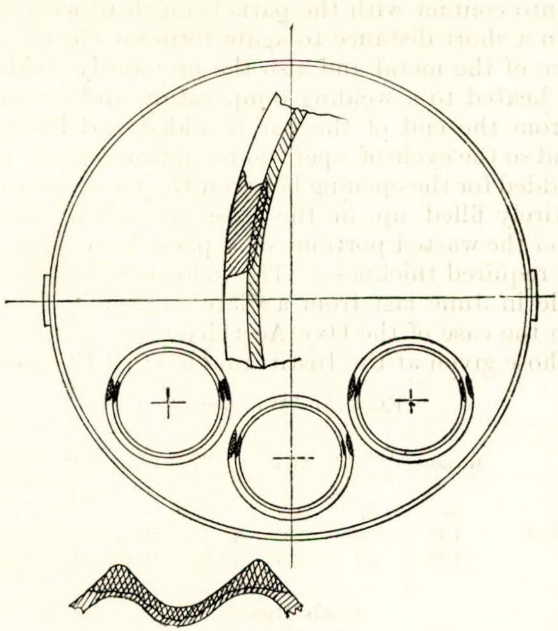


FIG. 2.

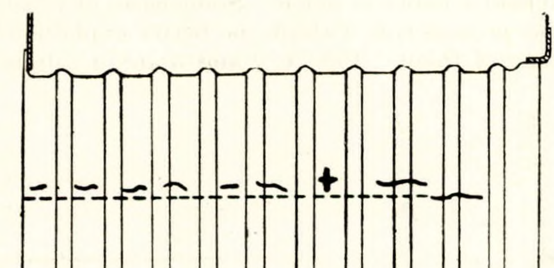


FIG. 3.

sketches of repairs carried out by the Oxy-Acetylene process, the remaining figures showing repairs carried out by the

Electric welding process. Fig. 4 shows the repairs carried out to the two main boilers of a well-known Swedish vessel. It will be seen that these are double-ended boilers. Some-

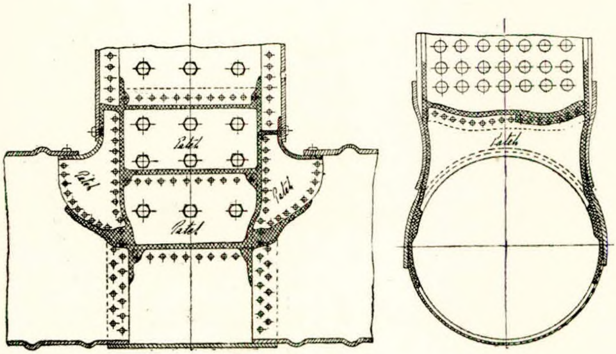


FIG. 4

what extensive repairs were carried out about three years ago (the boilers are fifteen years old) to the combustion chambers and furnace saddle plates, but they had given trouble by leakage,

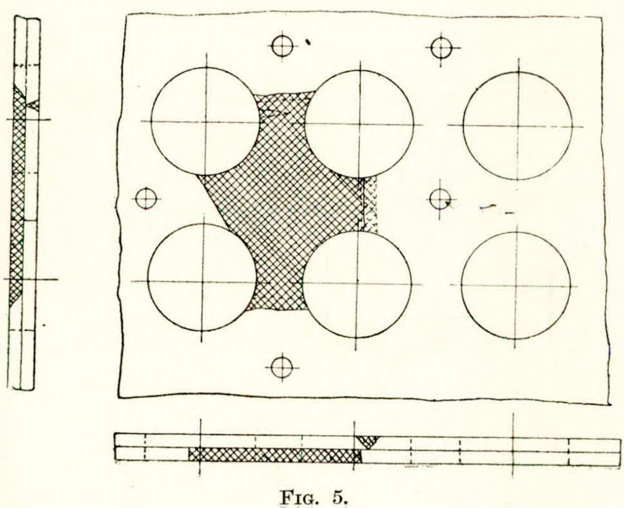


FIG. 5.

and at the beginning of this year the landing edges of all these patches and also several leaky rivets and local corrosions were welded up by this process ; some joints were, as you see, welded up from the under side. I inspected these repairs after the vessel had been running about three months and found there was not a sign of leakage anywhere. Fig. 5 shows a laminated tube plate repaired by this process ; the greater part of the lamination was cut away and the plate built up to its required thickness as shown ; the small screwed pins shown were put in as a safeguard to avoid any opening up of the lamination, in case it developed beyond what was thought to be its extent. Fig. 6. The landing edge of the lower part of the furnace and

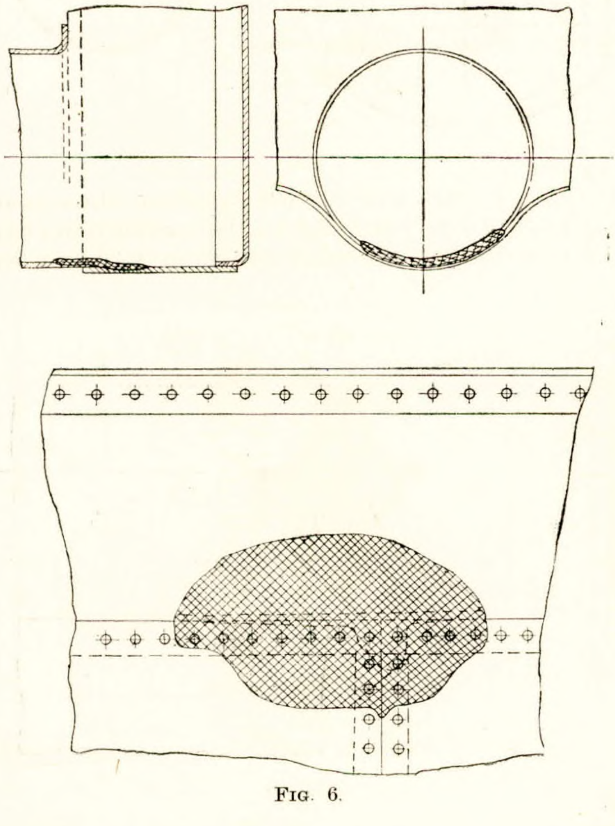


FIG. 6.

also the combustion chamber plating of this boiler in way of same were wasted away, together with the rivet heads, and these parts were built up to their original thicknesses, the rivets themselves being so fused to the plates as to become integral parts of the same. Fig. 7. The landing edges of a

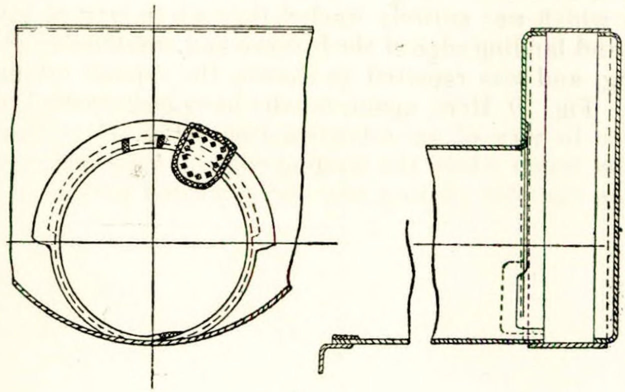


FIG. 7.

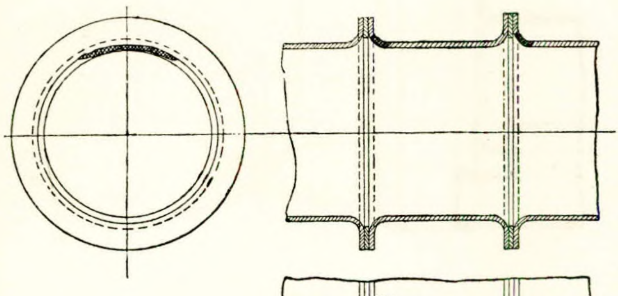


FIG. 8.

leaky patch in the centre furnace of a small boiler were welded to the adjoining plating as shown, also two cracks in the furnace plating and a wasted portion of the bottom seam of the furnace was built up to its required thickness and welded to the adjoining plating. Fig. 8. The plating of this furnace was cracked through and wasted in way of the Adamson rings and repaired as shown. Fig. 9. This shows the furnace of a small boiler which was entirely wasted through in way of the butt-strap and landing edge of the furnace and combustion chamber plating, and was repaired as shown, the repairs taking three days. Fig. 10. Here, again, repairs have been carried out to a furnace in way of an Adamson ring. Fig. 11. This shows another repair where the landing edge of a furnace and combustion chamber plating and also a wasted portion of a tube

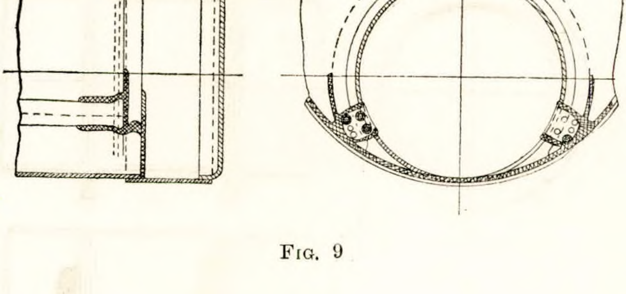


Fig. 9

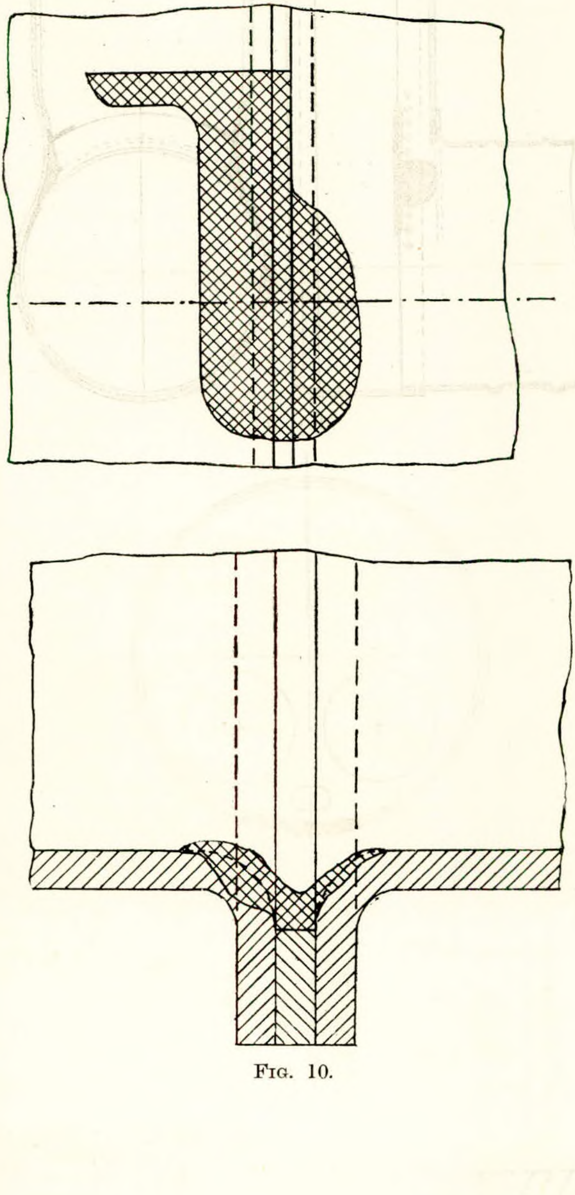


Fig. 10.

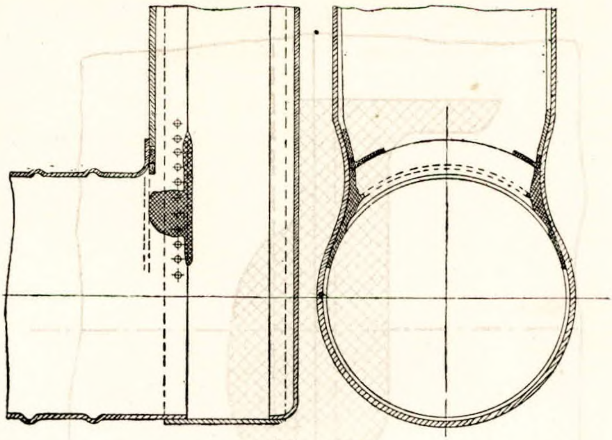


FIG. 11.

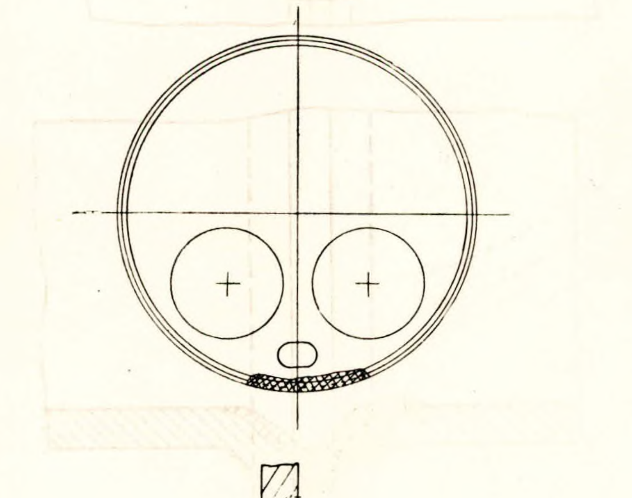
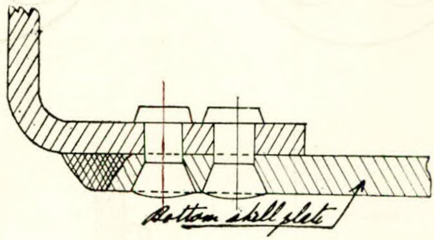


FIG. 12.

plate were repaired. The tube plate is not rightly shown, as it was on the water side of the furnace. Fig. 12. This plate shows the repairs carried out to the wasted portion of the lower front plate of a marine boiler. It will be seen that the rivets were here welded in to form integral parts of the plate. Fig. 13.



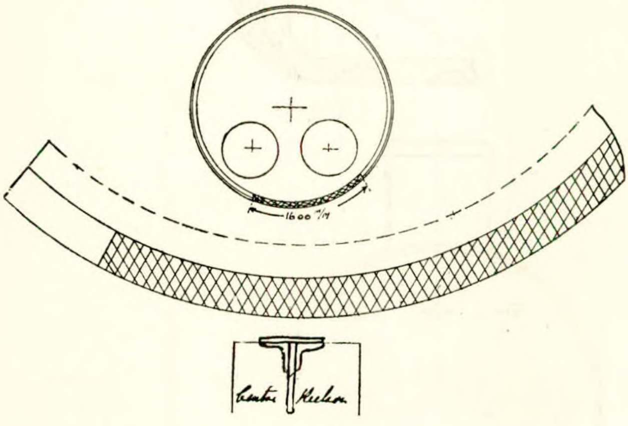
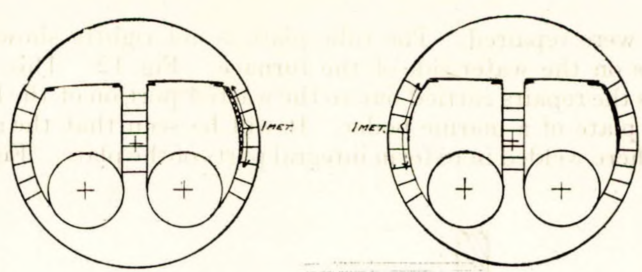


FIG. 13.

This plate shows a repair carried out to the wasted landing edge of the bottom shell plate of another main boiler, where a length of about 5 ft. was built up to its original thickness. Fig. 14. This shows repairs carried out to the combustion chamber plating and tube plate of two boilers which were, as will be seen, considerably wasted and pitted by corrosion, in each case the defective parts being about 3 ft. in length.



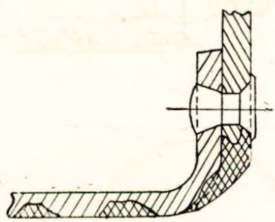


FIG. 14.

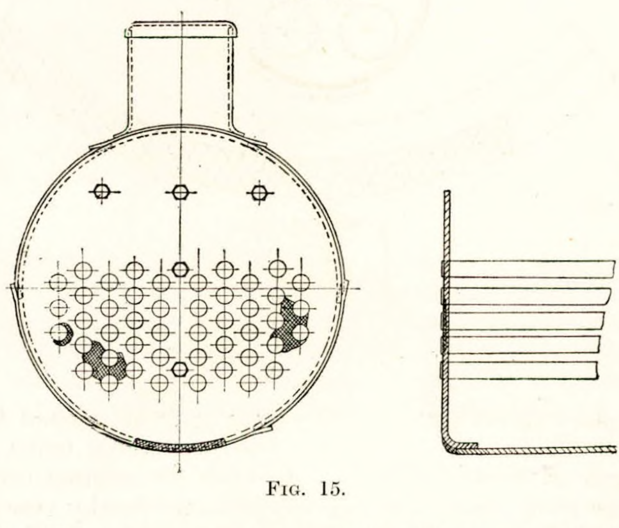


FIG. 15.

Fig. 15. This shows repairs carried out to a wasted tube plate of a land boiler and also to the wasted landing edge of the

shell plating. Fig. 16. This shows repairs carried out to the wasted seam of a land boiler. In conclusion, I should

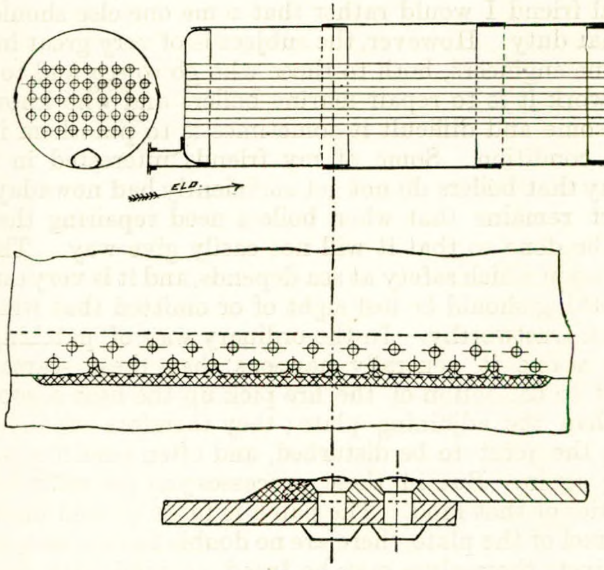


FIG. 16.

like to express my thanks to my colleagues, Mr. Bülow at Gothenburg, and Mr. Jones at Marseilles, who have given me the greater part of the information on which this paper has been written.

CHAIRMAN : I am sure we are all very pleased with the lecture we have heard. It has been most interesting and has brought to our notice a subject which is of great value from an engineering point of view. In the few minutes we have left if any gentleman would like to say a few words on the subject or ask a question Mr. Ruck-Keene would be pleased to answer.

Mr. E. HUTCHINS : In figure 14 Mr. Ruck-Keene shows a double-ended boiler which he says was welded by this process from the underside of the plate. How is the glowing metal applied in this position ?

Mr. J. T. Milton: I am afraid I am not the person who ought to speak first upon this paper because, much as I may desire to express our thanks to Mr. Ruck-Keene, as he is a personal friend I would rather that some one else should perform that duty. However, the subject is of very great interest to marine engineers, both to those who go to sea and to those whose work it is to repair marine boilers and who know how troublesome and difficult it sometimes is to put them in seaworthy condition. Some of my friends interested in repair work say that boilers do not get sufficiently bad nowadays, but the fact remains that when boilers need repairing the work should be done so that it will not easily give way. This is a matter upon which safety at sea depends, and it is very essential that nothing should be lost sight of or omitted that will make the work trustworthy. In the ordinary way of patching with riveted seams it generally happens that these seams when exposed to the action of the fire pick up the heat a good deal more than the adjoining plate; they therefore expand more, causing the joint to be disturbed, and often resulting in them leaking again. But in these processes you get away from all difficulties of that kind. The patch is fused on and made part and parcel of the plate, there are no double thicknesses, and the leaky rivets themselves may be fused up solid with the plate in the process.

But there is one thing to be remembered. The method seems very pretty, and when we see how simple it is we wonder why it was not done before; but as our Chairman said, it is important to know whether this great heat strains the plate. In dealing with a metal like cast iron, with very little ductility, when an intense heat is applied, the contraction on cooling produces a very great strain in the metal, the parts immediately surrounding the repaired part not being able to contract, and although the metal may hold on under the strain for a short time, when it is put under stress it parts. It must be something similar with steel, but in most of these cases where the repair has been applied there is sufficient yielding in the parts to modify the contraction effects. Of course the size of the work has to be considered—it would not be possible to repair a split in the middle of a large armour plate without causing a strain which would prove serious, but in small plates of such shapes as we have in boilers, although the strains are there they are not dangerous, and in any case welded up cracks and welded on patches are better than cracks stopped up with studs and the caulking tool and patches which expose double thicknesses to the fire. There is one point which, in a commercial centre like London, ought not to be overlooked. If the method has a value as a means of repairing boilers London should not be behind smaller towns like Gothenburg in the facilities afforded for this kind of work.

A Visitor : Can the lecturer please say the comparative cost between this system and the ordinary patching ?

Chairman : Before calling upon Mr. Ruck-Keene to reply there are one or two questions I should like to ask him myself. He does not give any idea which process he prefers, the oxy-acetylene or the electric arc. I notice a very distinct difference between the results of tests as given in the two tables, and I think the lecturer himself called attention to them.

Then in the case of the electric arc, would not the carbons——

Mr. Ruck-Keene : No carbons are used in the process.

Chairman : In that case the question I was about to ask has no force.

Mr. E. Hutchins : There is one more question I would like to ask. Would the steel pass the Board of Trade or Lloyd's Surveyor ?

Mr. Ruck-Keene : The first question asked was how the underside of a boiler plate is welded in position. This was done by the electric process. The end of the bar is not actually melted off, but both it and the part to be treated are heated until they are almost in a molten condition and then the metal is applied, not drop by drop but pressed on just as sealing wax may be applied, although not entirely melted.

With regard to the cost, not being a boiler-repairer I am afraid I am hardly the person to say, but I may mention that in the case of these cracks in the furnaces where over 100 little parts were welded up, it took three weeks to do and the cost was £60. In the case of the eighteen furnaces which were built up to their original thickness, there was one hundredweight of steel bar used in adding on the metal. It took a month to do and cost £480, which works out much cheaper than putting in new furnaces. As to the comparative cost, I do not know the cost in other systems, but I believe it works out about the same as hand labour ; but of course if a great saving in time is effected this is a point of much importance when ships are kept lying idle during repairs.

The Charirman has asked which process I prefer. I am not prepared to say either one or the other. They are both good but I am not here to say which is the better.

With regard to passing the Board of Trade and Lloyd's I cannot speak for the former, but some of the work has been done to the satisfaction of Lloyd's Surveyors. But it must done in a proper manner. It is not a thing to be played with. A very intense heat, which will bore a hole through a plate in a very few seconds, is used, and until men are trained to use the processes it is useless to try to do repair jobs with them. But there is no reason why they should not be used here as well as in other countries. Men are trained to be boilermakers, and they can be trained to use these processes, and if the work is properly done we know the jobs are perfectly satisfactory.

I do not think there was any other point raised and I will conclude by thanking you for the interest you have shown in the subject.

CHAIRMAN : It only remains to propose a hearty vote of thanks to the lecturer, which please show in the usual manner.

A vote of thanks was accorded by acclamation to the author and to the chairman.