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Application of Oxy-Acetylene Welding for the Repairs of Marine Boilers and Hulls

By MR. LEONARD M. FOX (Member)

READ

Monday, February 21, 1910.

Chairman: Mr. J. G. HAWTHORN, Hon. Minute Secretary.

Chairman: We have met to-night to hear a paper by Mr. Leonard Fox on "The Application of Oxy-Acetylene Welding to the Repair of Marine Boilers and Hulls." There is no doubt the system before us is one which is going to revolutionize, to a great extent, the work of repairing boilers. Many of us have had some very bad experiences of this kind of work, and if any one can devise a means of relieving us of some of the troubles they will merit our thanks. I will now call upon Mr. Fox to read his paper.

As one of the obligations of Membership is that of reading a paper before the Institute, it struck me that I could not deal with a subject which would be of greater interest to Marine Engineers than that of the Application of Oxy-Acetylene

Welding for the Repairs of Marine Boilers and Hulls, inasmuch as this process has come very much more before the notice of Marine Engineers within the last two or three years than any other relating to boiler repairs. I understand that one of our Members read a paper before you bearing on this subject some two and a half years ago, but at that date very little had been done in this direction in this country. My excuse for pursuing the subject, however, at this date is the fact that big strides have been made since then; many of which I have been personally associated with.

The process of autogenous welding by means of the oxy-acetylene blowpipe dates back to 1901, when the use of compressed acetylene was made possible in this country by an Order in Council dated April 10 of that year, authorizing its compression into cylinders containing a porous material of fixed porosity. The high pressure system was the first in use, and from this numerous low pressure systems have been evolved. Autogenous welding permits the fusing of iron and steel without any previous heating up to thicknesses of 1 in. to $1\frac{1}{2}$ in. in plates, and 4 in. to 6 in. in circular or rectangular pieces, without altering in any way their chemical composition, and yields, in the welded portion, a homogeneous metal which, in order to possess mechanical qualities similar to those of forged or rolled, only requires to be subjected to a forging operation or to a thermic treatment analogous to that which is employed in the case of steel castings and which may be carried out in a very simple manner by means of the blowpipe itself, which has already served to execute the welding. Metal may be added to the part to be welded in any desired quantity by means of a piece of steel or iron wire, which is fused in the blowpipe flame.

It will be gathered from the foregoing that an infinite number of applications are involved by this possibility of fusing iron and steel without altering their nature and of adding metal at will to any piece of work. It will be gathered that in marine boiler work, wasted landings can be built up, in any position, to their original state when worn by corrosion or when fractured; new pieces may be welded in to replace unserviceable parts in furnaces; pipe connexions can be finished without joints; all kinds of receptacles of whatever shape can be made so as to be absolutely tight, and rivets in this connexion can be dispensed with.

During the last few years a new process, that of cutting metals by means of an oxygen jet under pressure, has arisen to complete the new working methods inaugurated by the introduction of autogenous welding. By this process it is possible to cut plates $\frac{7}{8}$ in. to $1\frac{1}{4}$ in. thick at the rate of about 30 ft. per hour, and pieces 8 in. to 12 in. in diameter in four or five minutes. This process has its special applications, such as demolition of metallic frame work, boilers, ships' hulls, etc., but in numerous cases it is a valuable auxiliary of autogenous welding, and permits of rapidly preparing a piece of work which has to be subsequently welded by means of the blowpipe.

We will now pass to the difference between the two systems employed in oxy-acetylene welding, that is, between the high and low pressure systems. In the former case, in which dissolved acetylene is used, the two gases are both under pressure, the acetylene pressure being about $5\frac{1}{2}$ lb. per square inch, and the oxygen being regulated to give the correct flame, the method of which will be shown later, when it will be noticed that although it has to be done by eye there is a strongly defined condition to arrive at.

In the manufacture of dissolved acetylene, before the gas is pumped into the cylinders it is thoroughly washed, dried and purified; all impurities, such as phosphorus and ammonia, are removed; and it follows that with this system a more reliable weld can be obtained. In relation particularly to repairs effected on board ship, the safety of this system as compared with the low pressure one should not be lost sight of. This is a highly important point, as the confined conditions of a ship's stokehold do not admit of a low pressure generator being introduced there without a great element of danger. With this system the adjustment of the flame is much easier than with the low pressure, as both gases are under better control, and once the adjustment is made it remains correct, even though the blowpipe tip should get partially blocked. A higher working efficiency is obtained on account of the intimate mixture of gases taking place. With both gases under pressure it is found in practice that great gas economy is obtained. Lastly, the plant being entirely portable can be taken anywhere; in fact can be taken inside the combustion chamber of a marine boiler and so placed out of the way of the workmen effecting repairs in the ship's stokehold.

In the low pressure system acetylene is drawn from a generator, and oxygen from a trade cylinder. The oxygen is used at about 15 lb. to the square inch, and draws the acetylene into the blowpipe on the injector principle. The intense heat generated by the oxy-acetylene flame, which is about 3,500° cent., has been well known for years; but until a satisfactory method of storing acetylene was discovered, advantage could not be taken of the oxy-acetylene flame, which, up to that time, did not compare favourably with either the oxy-hydrogen blowpipe nor yet the electric method of welding. Nowadays it certainly does, inasmuch as an electric welding plant, even on the smallest scale, is very expensive and necessitates considerable capital outlay, the results are somewhat uncertain, the weld being almost invariably left brittle after annealing, and the working costs being very high. The oxy-hydrogen flame for this purpose has drawbacks which preclude its general use ; amongst others may be mentioned the limits of temperature, about 1,500° cent., and the difficulty of judging the exact mixture of gas, an error in which, however slight, causes the flame to be either reducing or oxidizing, according to the excess or shortage of oxygen.

When Acetylene is used with oxygen in a properly designed blowpipe it splits up into its component parts hydrogen and carbon at the base of the flame, carbon only taking part in the burning, due to the fact that hydrogen will not combine with oxygen at the temperature at which carbon will, consequently the hydrogen remains free and forms a protecting zone at the blowpipe tip where the carbon is burning. The high flame temperature obtained, combined with the fact that there is a zone of free hydrogen, renders the flame very reducing and extremely suitable for many operations which would otherwise have to be carried out by a more costly and probably less efficient method, and in some cases would be altogether impracticable.

From the foregoing remarks it will be gathered that the temperature of the oxy-acetylene flame is much higher than that of the oxy-hydrogen one, the former being limited by the dissociation temperature of carbon monoxide, whereas the latter is limited to the dissociation temperature of steam. Examples of the types of blowpipes used with both systems will be found on the table.

The two processes just outlined (welding and cutting) render the greatest service to the ship repairing industry, more particularly in relation to the repair of marine boilers ; in fact, they permit the execution of these repairs not only more economically than by any other process, but also more rapidly.

The very great importance of repairs to marine boilers by autogenous welding results from the following facts :—

(1) Repairs can be executed very quickly, without prolonging the period of detention of the vessel, and they can further be effected during the time the vessel is obliged to remain in port for operations of unloading and loading cargo.

(2) Repairs by autogenous welding restore the part repaired to its original condition; consequently, by effecting the repair as soon as a defect is discovered, a boiler can always be kept in good condition, and it can be asserted that a boiler repaired methodically and regularly will have a much longer life than could otherwise be obtained. It will not become necessary to replace it until it is worn out generally, when hitherto one has been compelled to condemn boilers when a part only was worn out, whilst the remainder was still in good condition.

(3) It happens frequently that the hull and boilers of old vessels do not reach simultaneously the degree of wear necessitating their condemnation. By the ordinary processes of repair one can quite well prolong the life of the hull by two or three years when the boilers are still in good condition, but it is not the same in relation to boilers. When these are worn out while the hull is still sea-worthy for some years to come, one is under the necessity to either condemn the vessel entirely or go to heavy expense for replacing the boilers, which will still be in good condition when the hull has to be condemned. Autogenous welding avoids this renewal during the last years of the life of a vessel.

The principal boiler repairs made possible by these processes are internal and external corrosions, wearing away of the landings by oft-repeated caulking, and lastly cracks. With reference to internal and external corrosions in furnaces and also cracks in the same, there has not been a great deal of this class of work undertaken in this country owing to the more or less sceptical attitude taken up by the various Surveys. There has, however, in Marseilles, Genoa, and Antwerp, been quite a considerable amount done successfully from time to time, and I am glad to note a disposition on the part of the Authorities in this country to allow these repairs to be undertaken here. Repairs under this heading can be successfully performed at quite a nominal cost, thus obviating in many cases the replacement of the furnaces in question, or alternatively the fitting of patches, which are, I think, admittedly a constant source of trouble to the Marine Engineer.

It is probably needless for me to enter into a description of the practical method employed in making a weld to repair cracks, as this will be demonstrated to you at the termination of this paper. It may be well, however, to mention here that welding by this process can be undertaken in any position, that is to say, it is possible to thicken wasted surfaces overhead if necessary; but needless to say for this special class of work it is essential it should only be undertaken by men with great experience. Whilst we are speaking of the inside of a boiler it will probably be as well to point out that any class of corrosion of the combustion chamber or furnaces can be successfully thickened, and in some cases corrosions or cracks arising in the tube plate at the tube ends can also be successfully treated. There is considerable difficulty, however, with this latter form of repair owing to cracks arising during contraction. In regard to repairs of corrosions of boiler fronts and shells, these of course are quite simple, and are effected at a very small cost. This equally applies to corrosions arising round man-hole doors, the repairing cost of which is very small.

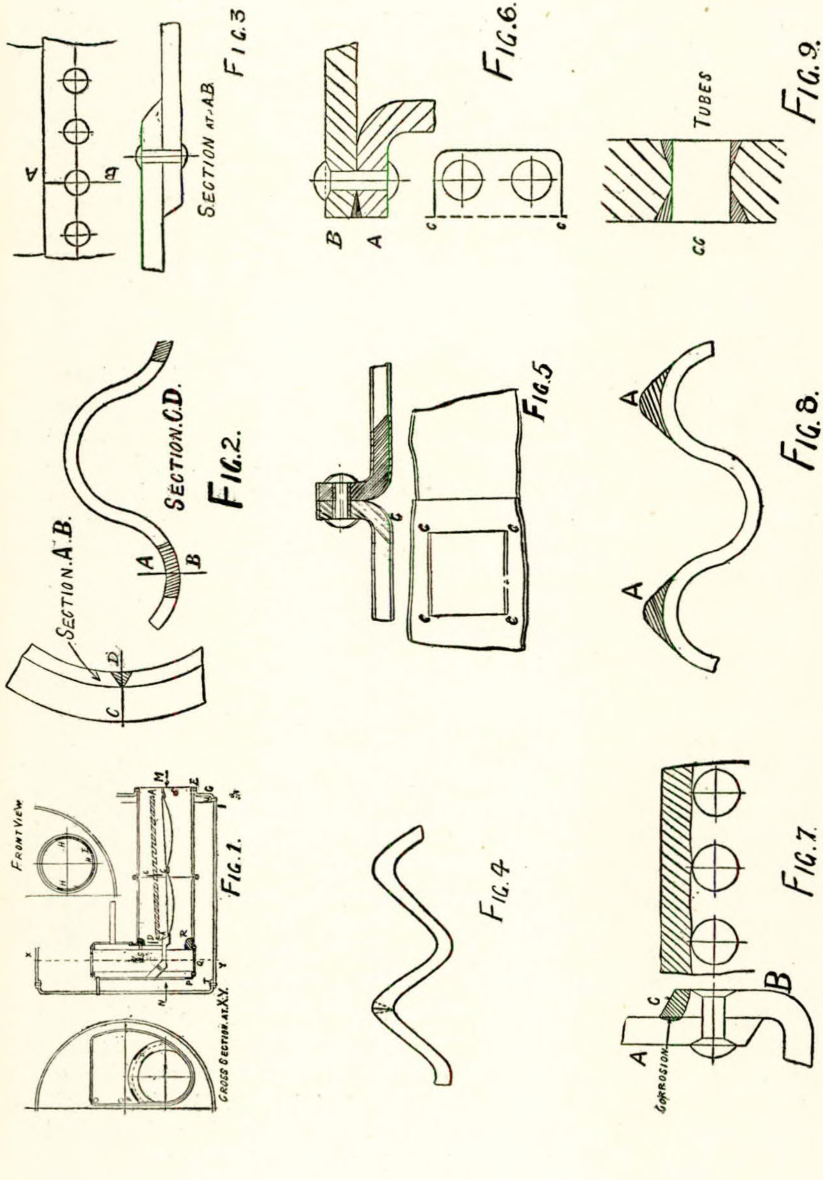
The applications of autogenous welding for repairing hulls of vessels are far more limited than those relating to boilers. They consist mainly in a series of minor repairs analogous to the work done in boilersmiths' shop, and do not require very great skill. It should be noted in the first place that the materials used in ship building are much inferior in quality to those used in boilers, and consequently many repairs which can be effected on boilers will not be successful when dealing with inferior metal such as ship plates. Welding ships' frames, which is a fairly frequent occurrence, does not always prove successful unless the frames are liberated over a great length. Generally speaking the results obtained in this class of work depend solely on the quality of the metals to be dealt with. On the other hand there are small repairs of fairly frequent occurrence; for instance, repairing the corrosions on the hull, building metal on the outer edges of plates which are corroded, occurring frequently on the plates fixed on the stem or on the stern post, putting on new material on the rudder braces, and repairing all sorts of iron mountings.

In repairs necessitated by stranding or collision, welding permits of retaining a certain number of plates which can be restraightened and which only have unimportant fractures, generally at the rivet holes. This class of minor repairs can be successfully undertaken. In relation to stems and stern posts, autogenous welding permits of repairing them when fractured. With reference to stems which are always of relatively small section the work presents no difficulties. At the point of fracture an incision is made on both sides, the bottoms of the two incisions meeting in the middle of the thickness, and the welding is then undertaken from both sides simultaneously, new metal being laid on in successive layers. With reference to stern posts, they present of course greater difficulties by reason of their dimensions, but the same method is pursued in relation to these repairs with great success.

At this portion of my paper I should like to point out there are a few classes of repairs made possible by the process of autogenous welding in relation to the engine-room. As an illustration of these I will give you a pump cross-head. There has been undertaken successfully the building up of the journals of a pump cross-head even to as large an extent as welding on $\frac{1}{2}$ in. of metal. The cross-head in question was then taken to the lathe and re-turned to the original diameter of the journals. This class of repair can be carried out on almost any journals such as winch shafts, windlass shafts, etc., and in such cases it is quite possible to make the journals equal to those to be found on a new shaft.

Another branch of the autogenous welding industry is that of burning out rivets. For this purpose a cutting jet is brought to bear on the rivet head, which is quickly melted, and the rivet is then driven through. It is possible to burn rivets out with a blowpipe jet consuming 600 litres, given a rivet of ordinary dimensions at a speed of 100–120 per hour. For the purposes of illustrating some of the common forms of repairs referred to in this paper I will now show you a number of lantern slides prepared in relation to repairs executed recently in this country and on the Continent.

Fig. 1 shows a furnace of the current type from which our examples generally will be taken. Corrosion often takes place on the line a little above the fire grate, and has a width of from 4 in. to 8 in., this can be seen at *AA* (Fig. 1). To repair this form of corrosion the plate must be thoroughly cleaned of dirt and scale and then built up to the original thickness by


FRONT VIEW
CROSS SECTION AT X.Y.
FIG. 1.
SECTION A.B.
SECTION C.D.
FIG. 2.
SECTION AT A.B.
FIG. 3
FIG. 4
FIG. 5
FIG. 6.
CORROSION
FIG. 7.
FIG. 8.
TUBES
FIG. 9.

adding metal in one or more layers, according to the amount required to arrive at the original thickness.

Fig. 2 shows another common type of defect in furnaces, namely, cracks ; these occur most frequently in or about the same region as corrosion; this work is done from the inside of the furnace, and during the execution of the same it is found that far more cracks develop than were originally discovered. As the cracks in question start from the outside of the furnace, they only become apparent from the interior on heating up.

All this class of repairs are first cut open to a V shape and then filled in by introducing new metal. A common method used for temporarily remedying this defect is of course caulking and patching, both of which methods are distinctly unsatisfactory. Cracks in boilers are of course found in almost any situation ; the most frequent ones besides those already referred to are (*a*) cracks issuing from rivet holes (Fig. 3) extending to the edge of the plates—repairing of these does not present any difficulty ; (*b*) vertical cracks which form principally in furnaces with ribs (Fig. 4). Through the depth of the ribs the repair of these is rather difficult on account of their situation, and also owing to the thickness of the ribs, which of course gives unequal expansion and contraction. In order to facilitate this class of repair it is better to heat the ribs with a blowpipe from the interior of the boiler, while the welding is done from the interior of the furnace.

(*c*) Vertical cracks—*CC* (Fig. 1)—in furnaces of plain plate made up in sections vertically. It should be noted (Fig. 5) that after having welded up these cracks it is necessary to take up the rivets which join the two sections of the furnace ; this sometimes presents great difficulties owing to the nearness of the furnaces to each other, or to the boiler shell, one is led in that case to cut a hole in the crown inside of a furnace as desired, in order to gain access to these rivets, and after having taken them up, to weld the piece in again. This operation has been carried out repeatedly.

In all systems of furnace fractures are found very frequently at *D* (Fig. 1) at the back end or flange by which the furnace is fixed to the tube plate ; as you are very well aware this part is under great strain owing to the expansion and contraction of the furnace. The repair of these fractures presents no particular features, but this part of the furnace frequently exhibits other damage resulting from corrosion or from wear by caulking, and instead of contenting oneself with welding up a crack, one is frequently led to cut away the whole bad piece and weld in a new piece to replace it. This course commends itself, in particular, in old boilers where cracks of this kind have been covered over by a riveted patch ; the plate of the furnace in that case is cut up by a large number of rivet holes, and frequently eaten away by corrosion caused by leakages arising continually with such riveted patches.

Fig. 6 shows the front end of a furnace riveted to the front plate of a boiler. This joint is under great strain from expansion and contraction, hence arise leaks which corrode the plates and necessitate caulking, which shortens the landing by about $\frac{3}{32}$ in. every time it is done, and consequently this landing has after a time to be built up again. The best way to execute this repair if there are corrosions in the part *A* is to cut away a piece—*CC* of the furnace plate *B*—repair plate *A*, then weld in a new piece *CC*.

Another source of leakage is in the joints at the combustion chamber end of a furnace. These defects usually occur in the part *F* (Fig. 1) and appear as shown in Fig. 7. The plate *A* gets corroded through leakages, and the landing of plate *B* gets reduced through caulking. The corrosions in *A* are first repaired, then metal is added on to *B* to restore the landing *C* to its original depth. Care must be taken not to weld it in with plate *A*, as this will give a very bad result. The rivets which have become loosened by this operation are removed. The flange *C* is set to bear hard on to *A* and the rivets are replaced. In some cases the rivets are removed before carrying out the repairs.

Fig. 8 shows a plate thickened up ready for insertion in a furnace with thickened-up ribs, where it has been found necessary to replace a bad part from corrosion or from numerous cracks in a small area, when it is often found better to replace the whole affected part than to repair by the method already described. It is sometimes desirable to replace a whole furnace. This can be easily done by cutting the old one out with a cutting blowpipe. A new furnace is prepared in three or four pieces, put into place, and bolted up firmly ; then the various pieces are welded together, when a new furnace is formed identical with the one removed as to dimensions, and presenting the advantage of not having any riveted joints.

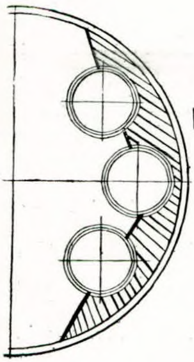


FIG 12.

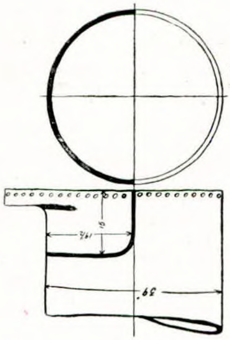


FIG. 15.

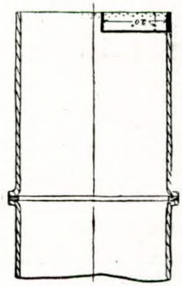


FIG. 18.

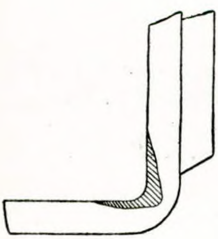


FIG 11.

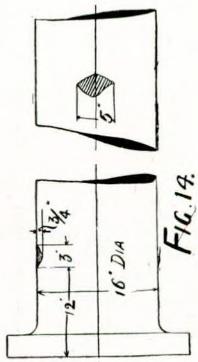


FIG. 14.

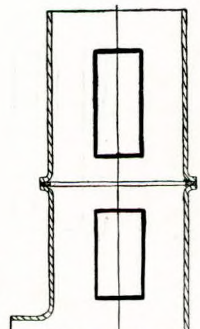


FIG. 17.

FIG. 10

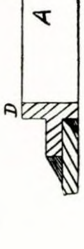


FIG. 13.

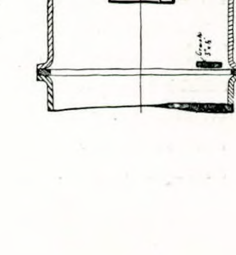


FIG 16.

Combustion chambers are subject to the same defects as furnaces, such as corrosions and cracks.

In Fig. 1 are shown several repairs to a combustion chamber ; these were carried out on the s.s. *Marsa* and are as follows :— A patch *P* was inserted at the back—a piece *Q* of the bottom plate and two pieces *E* and *S* on the landing at the bottom of the furnace and on the tube plate flange respectively (each of these pieces being about 20 in. wide and 3 ft. long) were inserted.

Fig. 9 shows a tube plate corroded through leakage at the tube ; these corrosions are usually found on both sides of the plate, but are more pronounced on the combustion chamber side. These corrosions can be repaired by autogenous welding

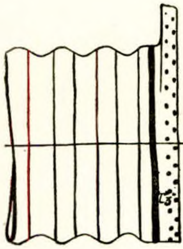


FIG. 19

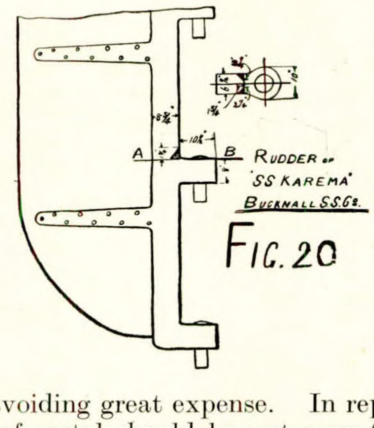


FIG. 20

fairly successfully, thus avoiding great expense. In repairing these corrosions a sheet of metal should be put over the far end of the tubes to prevent a draught being set up, otherwise the repair would be almost impossible.

In the tube plates cracks arise, extending from one tube to another, as shown in Fig. 10. These cracks are very difficult to weld up because they are in the very place where the width of solid plate is least, and the full effect of contraction is brought to bear on this line ; these cracks, fortunately, do not often occur.

Fig. 11 shows the corrosion at the point *T* (Fig. 1) of a boiler. This repair was executed on the boilers of the *Marsa* at the same time as the repairs to the combustion chamber referred to above. These corrosions take place at the bottom of both front and back plates, especially in badly kept boilers, where they always occur, and have frequently been repaired. External corrosions of the front plate of a boiler are caused through leakages or by the action of bilge water or wet ashes adhering to the boiler. Ordinary corrosion at the joints are treated, as pointed out in Fig. 7. Sometimes, however, it is found advisable to replace a portion of the front plate. This is shown in Fig. 12, the two pieces are strongly jointed together by the furnaces and the welds are very short. In the ordinary course these corrosions should be repaired by building up. The joints of man-holes and mud-holes after about six months

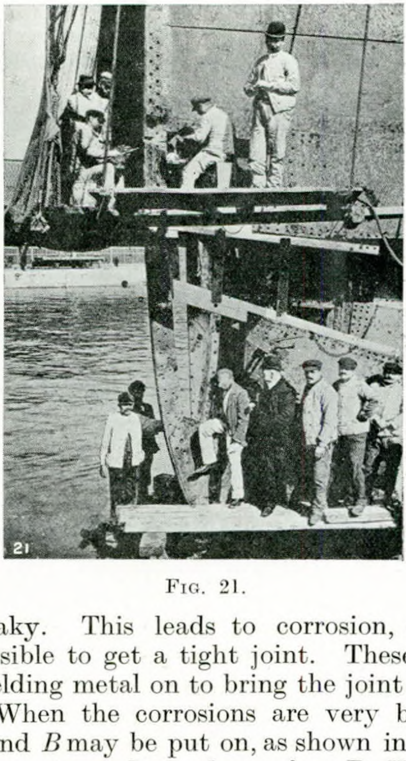


FIG. 21.

are usually leaky. This leads to corrosion, which in time make it impossible to get a tight joint. These can easily be repaired by welding metal on to bring the joint up to its original height. When the corrosions are very bad a piece *A* welded to *C* and *B* may be put on, as shown in Fig. 13. The joint of the cover is made at the surface D, E.

In Fig 14 is shown another repair to the *Marsa*; the tail shaft was rejected because it contained a flaw, as shown. This was welded up and passed, thus obviating the expense of a new shaft. To weld a job like this it is necessary to get the parts to be welded up to a red heat with a coke fire before starting on the repair. One—sometimes two—blowpipes, consuming about 90 ft. of acetylene per hour each have to be used on this large work.

Fig. 15 shows a new furnace which was cut, as shown, to enable it to be put into place; it was then welded up, being as good as before cutting.

Figs. 16, 17 and 18 show badly corroded or cracked places in furnaces repaired by means of welded patches in place of building up or filling in; this is the best method of dealing with these defects when they are very bad. Fig. 19 shows a furnace which was cracked almost all round the neck; it was welded completely round and was as good as new.

Fig. 20 shows a repair effected on the rudder of the s.s. *Karem* recently undertaken in Glasgow. It will be observed that two cracks or rather deep corrosions have taken place in this particular rudder, and they were successfully repaired in the space of about four hours.

Fig. 21 shows repairs being effected on the stem of a French steamer which should prove interesting. In the lower portion of this stem will be noticed a weld completed, while higher up the men are actually working on another joint. It may be pointed out that the piece between the two welds is a new one entirely.

Figs. 22, 23, 24 and 25 show pretty clearly the method of working adopted in furnaces, both overhead and otherwise. This work was carried out on the s.s. *Oxus* belonging to the Cie des Messageries Maritimes, in Marseilles, and is the most important Continental work undertaken up to the present time. It comprises the replacement of eighteen furnaces by furnaces made in sections and welded together. In addition to this all the corrosions existing in the interior of the six boilers were repaired, together with a large number of corrosions, cracks, etc., in the tube plate. In the right-hand corner will be observed the total plant required to carry out this work.

I should like to point out to you that cast iron can be welded with a fair degree of success, but one is never certain how a particular casting is going to turn out, and it is not advisable to risk this method of repair where strength is needed, unless a good surplus of metal can be added and left on the weld. Copper can also be welded, but the cost is a great deal higher than that of welding steel owing to its high conductivity, a blowpipe of about twice the consumption having to be used on

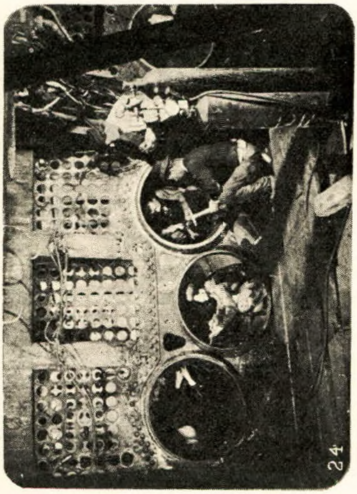


FIG. 24.

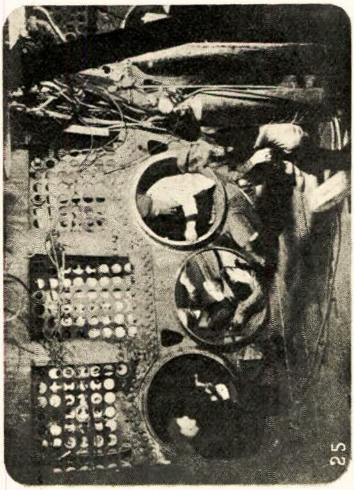


FIG. 25

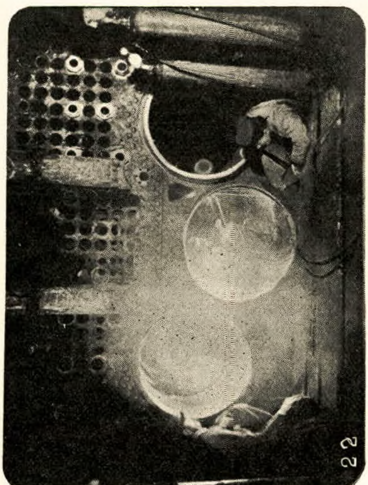


FIG. 22.

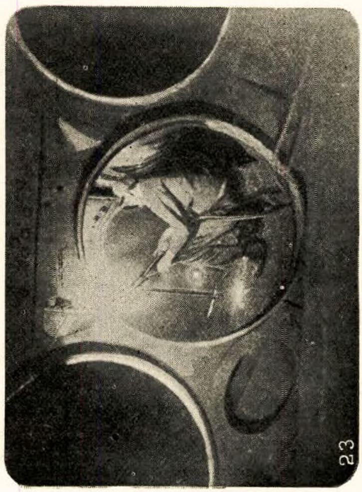


FIG. 23.

a plate as against the same thickness of plate in steel. With reference to repair of aluminium, welding has been tried, and in a few cases has been successful, but it has been found that soldering is the best method to employ, the main reason being that the work has not to be heated to such a high temperature as for welding, consequently the risk of cracking or distortion whilst cooling is greatly lessened ; this soldering makes the repaired part almost as strong as it originally was.

I have heard it suggested by several gentlemen interested in this class of work and associated with the shipping industry, that the time is not far distant when a small welding outfit will be considered a necessary adjunct to the equipment of a marine engine-room, just in the same manner as an anvil or a portable forge. There is no doubt that there are several classes of minor repairs which can be successfully dealt with by this method, with an engineering staff of average intelligence. Having dealt somewhat fully with the classes of repairs undertaken from time to time in relation to ship repair work, I propose demonstrating to you practically how this welding is done, and also at the same time to show you the speed at which cutting can be accomplished by means of a jet of oxygen and acetylene.

DISCUSSION

CHAIRMAN : Mr. Fox will answer any questions while the apparatus is being put into order for the demonstrations.

Mr. G. T. WILLIAMS : Is it necessary that the metal which is welded on should be the same as the part welded ?

Mr. FOX : It is usual to use Swedish iron, which of course is slightly softer and more ductile than the metal to be welded.

Mr. WILLIAMS : I suppose there is no disadvantage in using the Swedish iron ?

Mr. FOX : There is not such a high percentage of strength, but the metal is more ductile.

Mr. WM. MCLAREN : I should like to ask Mr. Fox what he terms the high and low pressures. What are these pressures per square inch ?

Mr. Fox: The difference between the high and low pressure systems is that in the case of the latter only one gas—oxygen—is under pressure, while in the high pressure system both gases—oxygen and acetylene—are under pressure. The pressure of oxygen for the cutting process is about 50 lb. per square inch.

Mr. McLaren: Is the author quite certain that the process does not affect the nature of the metal?

Mr. Fox: Absolutely, if it is annealed.

Mr. McLaren: With regard to the question of dispensing with rivets; can you dispense with them wholly, or is it only under special circumstances?

Mr. Fox: The point I had in mind was in connexion with petrol tanks in motor omnibuses which were formerly riveted, but are now almost universally acetylene welded.

Mr. McLaren: With regard to cutting metal, that is decidedly an advantage. It is an operation I have not seen. I note we are to see it to-night. But in connexion with welding a new piece of metal on, is any preparation required on the face of the metal?

Mr. Fox: None other than chamfering. We always work with the metal in V formation.

Mr. McLaren: With regard to judging the flame mentioned in your paper, I suppose that is one of the experiences with which you have great difficulty?

Mr. Fox: Hardly, as you will observe when the blow-pipe is used; there is a clearly defined flame which it is impossible to mistake.

Mr. McLaren: With regard to the cost of repairs; can we glean anything from what will be done to-night as to what will be the cost of welding, say, for so much an inch or foot. There is no doubt the initial cost will play a great part in the total cost of welding. If the welding costs, say 15*s.*, and a new job would only be about 20*s.*, it might be better to renew, and that fact is one, I think, which will be detrimental to this system. I should think so, at any rate, from my own experience of cast iron principally.

Mr. Fox: You are referring to castings. As an instance I might give the case of a motor-car cylinder. The average cost of repairing a cracked water jacket is 20*s*. to 30*s*., while the initial cost of the cylinder is £10 to £12.

Mr. McLaren: A question was asked with regard to the class of metal used. I have not heard it brought forward that either iron or steel is being fairly successfully welded.

Mr. Fox: Are you referring to boiler plates?

Mr. McLaren: No.

Mr. Fox: There is a good deal of difference in the quality of ship plates. Quality is the governing factor. Ship plates are not as good as boiler plates generally speaking.

Mr. McLaren: I have had a few castings upon which I have trials made, and I had to abandon the process. I do not think it was the flame altogether, but the results were not what was anticipated. There was one case of a motor-car starting handle which had 1¼ in. welded on a day or two ago, which I hope will be a good job. It was rather a soft piece of steel we put on, and whether it will stand the strain or not I do not know. I think it will finish up with a motor wagon shaft, about 3½ in. diameter, which is to be welded. The people we have tried up to the present are doubtful as to whether it will make a sound job and would rather not tackle it. That is a job open to any commercial firm that can do it in oxy-acetylene welding.

Mr. Fox: You say it is about 3½ in. diameter.

Mr. McLaren: Yes. I should think the shaft will weigh about 6 to 7 cwt. Some of the differential wheels would not be taken off. The firm I have tried declined the work.

Mr. Fox: I should like to have an opportunity of seeing the shaft.

Mr. McLaren: I think the possibilities of this system are very great, and it would be well to find out who is really the inventor of it, as there are so many who claim to be. We have had brine drums welded from end to end. They only run to a very small gauge, 10 to 12 gauge, and have been done very successfully.

Mr. Fox: The cylinder we are using this evening is acetylene welded, and it has stood a test pressure of 600 lb.

A demonstration was then given of the filling-in process, and a crack about $\frac{3}{4}$ in. wide by $\frac{3}{4}$ in. deep was filled in with metal to a length of about $1\frac{1}{2}$ in. in about eight minutes.

Mr. G. T. Veness: What is the objection of the classification societies to this process?

Mr. Fox: The only objection is that it is a departure from established precedent, which is no objection at all.

Mr. Veness: Is it not the fact that the heat on the metal to which the Swedish iron has been added has affected it detrimentally?

Mr. Fox: That could not be the case.

Mr. Veness: In one or two cases in London that difficulty was experienced. So far Swedish iron only has been used, has it not?

Mr. Fox: That is so; it is the best medium.

Mr. Veness: Taking all the metals one comes in contact with?

Mr. Fox: Yes, it is better than steel, it is more consistent in character.

Mr. Veness: Has there been any analysis made of the piece treated? Mr. Fox: I do not know of any.

Mr. Williams: It is a reducing flame that is put on the metal, I suppose? Mr. Fox: Yes, that is so.

Mr. Williams: It would reduce steel then. That is to say, if you had almost any sort of metal, it would oxydize and you would come down to the equivalent of Swedish iron in any case.

Mr. Fox: That is true.

Mr. Williams: And I suppose it is essential to the process that it should be a reducing flame? Mr. Fox: Undoubtedly.

A demonstration was then given of the cutting process, a piece of steel $\frac{3}{4}$ in. thick and about 8 in. in length being cut through.

Mr. WILLIAMS : What is the time usually taken to cut through steel of this thickness ?

Mr. FOX : About 8 to 9 ft. per hour.

Mr. VENESS : What particular blow-pipe are you using ?

Mr. FOX : It is the "Pyrocopt," a French make.

Mr. VENESS : What is the advantage of having a single central flame ?

Mr. FOX : The central is undoubtedly the best ; it gives a cleaner cut, which is a most important thing, and it can also be worked in any direction.

Mr. VENESS : That is another difficulty, the question as to which is the best pipe to get, the market is flooded with them. The same companies send you different kinds, and it is difficult to choose.

Mr. FOX : The central cutting pipe is always best in our experience.

Mr. VENESS : Another difficulty is, of course, with respect to the welding, so few people can do it. A special expert of one company is, I hear, in much request. I do not see from the demonstrations given this evening that there is any very great difficulty, but so far it seems as if these companies had arranged it so that no one else could do the work but special men in the companies' service.

Mr. FOX : There is no doubt some firms do the work successfully, while others merely play with it.

Mr. VENESS : It does not pay to play with boilers.

Mr. P. M. WATTS : What Mr. Veness wants to arrive at is whether a firm like yours is open to do a job properly.

Mr. VENESS : The point I wish to know is whether we can get the work done when we want to get it done and under reasonable conditions. Is the number of men who can do this work limited.

Mr. FOX : Yes, and it is always likely to be limited. Only a certain number of firms can keep men in regular employment on that class of work. If a man is merely employed "on and off" he produces bad work. It is a specialist's work.

Mr. Veness : For cutting out I do not think he would require to be constantly at work.

Chairman : Do you think this will come within the range of boilermakers' work ?

Mr. Fox : No, for no matter what yard the boilermaker is attached to he will not be regularly employed ; that is to say on intricate work. For minor repairs he may be able to use it.

Mr. Williams : The difficulty is to get men to repair boilers, and I know of one or two cases where they could not get a man. If that condition of things should continue, it will no doubt prevent the system from being more widely used. It appears to me that a boilermaker could be taught to do it and kept at different yards for that purpose. As soon as the classification societies admit it, workshops of any importance will have a man continually employed.

Mr. Fox : The firm I am associated with have men all over ready to undertake work at any time.

Mr. D. Hulme : I think there are works in London which employ the ordinary boilermaker to do this work. To my mind a man who knows what a weld is, no matter what means are employed to obtain that weld, will be able to use it. So far as jets are concerned, the commercial traveller may give his opinion, but the intelligent workman will very soon tell you which is the best for his purpose. We are using these jets daily, and the men in the shop and even the boys pick them up and do the work straight away. Any intelligent man who knows how to put two metals together in a homogeneous mass will be able to use this method, in my opinion.

Mr. Williams : I should think a blacksmith would be a better man for the work than a boilersmith.

Mr. Hulme : The blacksmith may know "round hand" or "square hand," but he does not know much about large plates as a rule.

Mr. Fox : For certain classes of work the blacksmith would be more suitable, and for others the boilersmith.

Mr. Williams : I have known of blacksmiths being selected because they knew the temperature of the metals better. I was referring to the boilermaker, not the boilersmith. In works the boilersmith may be a better man.

Mr. Wm. McLaren : I should think a tinsmith would be as good as either. Instructions for working would be given with the plant, and it would not matter very much what trade the man is.

Mr. Veness : I should like to see the system more widely used, but that can never happen if the knowledge of how to make good welds is confined to a few men.

Mr. Fox : Of course it is a comparatively new method, and men have to get used to it.

Mr. Veness : Yes, but when it is approved by the classification societies it will go ahead.

Mr. Fox : There is no doubt about getting that approval before very long.

Mr. J. H. Redman : Are there any regulations against the use of acetylene in stokeholds ? Mr. Fox : None whatever.

Mr. Redman : I should think there would be great difficulty with the scale in cutting out.

Mr. Fox : It cracks in advance of the flame.

A demonstration was then given of cutting a hole through a $\frac{3}{4}$-in. steel plate.

Mr. Redman : What is the reduced pressure of the acetylene now ? Mr. Fox : $5\frac{1}{2}$ or 6 lb.

Two pieces of pipe were then welded together.

Mr. J. Howie : Could the cutting be done with coal gas instead of acetylene ? Mr. Fox : Undoubtedly it could.

Chairman : Is there any reliable test as to the tensile strength of the weld in reference to the bar or plate itself ?

Mr. Fox : Yes, we have had several carried out, and the tensile strength varies in relation to the metals put in, but if the same metal is used as the plate itself, it comes to about 92 or

93 per cent. Of course the elongation is not so good—one cannot get the two conditions at the same time.

CHAIRMAN: We have had a most interesting demonstration of welding, cutting and preparing rivets for knocking out by this process. It is a very interesting thing to see undoubtedly, but when looked at from a commercial point of view, as has been said, the difficulty is to get the individual who is capable of doing it and of doing it properly. It is in the nature of a speciality, and the question arises, who is the best man to do the work. I myself think the blacksmith would be the best trained man for the work, inasmuch as he is more used to this class of work and has the best knowledge of the characteristics of different metals at critical temperatures.

Mr. JAS. ADAMSON (Hon. Secretary): By a singular coincidence one of our members is to read a paper on this subject in Glasgow to-morrow evening. I had a proof copy of the paper sent to me and was rather struck with the coincidence that a kindred Institution in Glasgow should have a similar paper, written by one of our Members, Mr. Scott Younger. I have seen a fair amount of work done by this process, and I was sceptical as to its merits at first; but from the work I have seen, I have every evidence for thinking that a good job can be made of welding by the process even in boilers. I have seen the combustion chamber bottoms $\frac{15}{16}$ in. thick cut out of a boiler and was astonished at the speed with which the flame cut through the metal; the process saved an enormous amount of time. The plates were cut out and new plates put in at another port in that particular case. In both the Albert Docks and the Victoria Docks I have seen repairs executed by this process. In one case the shell plate was wasted away at the manhole door and the plate was built up to its original thickness. I have also seen cracks welded up in furnaces. Subject to the position of the defects which are proposed to be made good, neither the Board of Trade nor Lloyd's have any objection to this process so long as they have an examination of the boiler and have approved of the work being done under supervision before it is attempted. In one particular case I saw a very large amount of work done, under the supervision and with the entire sanction of Lloyd's. It was tested afterwards by hydraulic pressure and proved satisfactory. In another case I saw the landing-places of the back ends built up by this process. Due to the leakage of the tubes, the metal was eaten away near to the rivets, and in that case the landings were built up to their original dimensions satisfactorily. I had nothing to do with the job personally, but had the opportunity of seeing the work done and took advantage of it. In this case the repairs were done to the satisfaction of the classification society. The Board of Trade will allow the process to be applied to boiler repairs so long as the parts treated are not on the direct heating surface. I believe the Board hesitate in regard to furnaces, but if satisfactory facts can be put before them they will discuss the subject rationally and decide the case on its merits.

Mr. H. A. B. Cole : I should like to make one remark about this process in a commercial aspect. I think it is rather an important point that it is not so much a question of what this work costs as what it saves. People may consider it rather an expensive job to undertake, but how much will it save ? For instance, in the case of a cracked furnace the choice is very often between using the system and condemning the furnace, which means perhaps a fortnight's delay for the ship. This is an important aspect from the commercial point of view.

Mr. Jas. Howie : One point occurred to me with regard to welding the hull. We have very good plates in the hulls at the present time, and unless you are afraid of welding the old material, I do not think there should be any fear of the new. I have seen these plates used for boiler shells and last the lifetime of the boiler, and when they are put through the tests they give good results. Lloyd's will not approve them unless they have a high tension, and one cannot always tell the extent of deterioration ; the process finds out that weakness. I have had some experience of cutting out furnaces of a boiler under this system. We wanted to weld the furnaces in several places, but Lloyd's objected on account of deterioration, therefore it was not attempted. That was on account of the scale, and also probably on account of the process finding out the weak spots in the metal, the plate remaining not being so sound as desired. The cutting was done with the coal gas system, but after seeing this process I certainly approve of it more than the other. What Mr. Cole says is quite true as to the commercial aspect. Why that slow and, to my mind, inferior system should be adopted when this was extant I do not understand, but it was successful in reducing the time of cutting the furnaces out by hand and getting new ones.

Mr. W. E. FARENDEN : I would like to ask Mr. Fox, with regard to his experiments, whether at any time he has cut a piece out of a furnace plate and taken the tensile strength of the material before the crack has been filled up, and whether he has taken a piece out and tested the metal after the repair has been effected ; that is to say, whether a test has been made of the metal both before and after the process has been used to see whether there is any difference in the tensile strength.

Mr. FOX : We have had test pieces taken out which has shown a matter of about 80 to 82 per cent. of the original tensile strength of a furnace seven or eight years old. Of course that is only the tensile strength of the furnace in place in the boiler ; that is to say, it was 82 per cent. of the furnace plate when originally manufactured some seven or eight years before.

Mr. G. T. WILLIAMS : Mr. Fox, I believe, said there was a difficulty in making a weld if the landing edge joined on to the plate.

Mr. FOX : That depends, to some extent, on the skill of the welder.

Mr. ADAMSON : With regard to Mr. Farenden's question I may say I have seen an attempt made to weld a back end on the line of rivets at the landing edge of the wrapper plate of the combustion chamber of a boiler, and it was a failure. It was evidently due to the steel which had apparently altered in texture and hardened from the time it was put into the boiler, as the original analysis and test of the plate showed everything that could be desired, and yet the welding process could not be applied in that particular case. It was a very peculiar case, and it is still being investigated as to the cause of the cracks which were attempted to be welded by this process.

Mr. W. McLAREN : How would electrical welding compare with acetylene with regard to price that it would cost to make the weld and in time saved ? We once had the privilege of a demonstration some years ago at Pimlico for this Institute and learned that they had to generate twenty horse power to weld a 1 in. square bar.

Mr. Fox : In first cost, of course, the acetylene process is very much cheaper.

Mr. McLaren . And the upkeep ? Mr. Fox : That also is much cheaper.

Mr. Veness : With regard to the question of the commercial point of view and the cost of plant, I have had some experience on that point. In cutting out the combustion chamber bottoms of four furnaces by this process, the saving in time for cutting was sufficient to pay for the whole of the plant. That is quite apart from the money saved, of course.

Mr. McLaren : I had an experience in one case some years ago of cutting away a rudder post by the ordinary method, and in that case it was six weeks from the time the ship got alongside the dry dock until she was ready for sea again. I think it was mentioned that in a somewhat similar case where this process was used it was done in four hours.

Mr. Veness : I saw quite recently a case of a fractured rudder which but for this process might have been condemned. It was repaired in about twenty-four hours and the job was approved by the classification society.

Mr. Hulme : There is one thing which struck me when these demonstrations were being given. No doubt many of the members noticed the rapidity with which the plate was cut out. That feature is an essential in the manufacture of floats. In making the floats of a light material, they can be brazed together and completely finished by the same process. In welding or brazing under the ordinary conditions so much heat is generated in the surrounding parts that there is always that last little hole left ; but with this process that last bit can be put on and a perfect cylinder obtained, a float that will last a very long time. It is essentially a similar process that is used for making floats in copper work, and they obtain a sound job due to the rapidity with which they can close that last little hole.

It was decided that the discussion be adjourned till Monday, February 28.

A hearty vote of thanks was accorded to Mr. Fox on the proposal of Mr. Hulme, seconded by Mr. Howie.

The meeting closed with a vote of thanks to the Chairman.

ADJOURNED DISCUSSION

Monday, February 28, 1910

CHAIRMAN: MR. J. G. HAWTHORN (HON. MINUTE SEC.).

CHAIRMAN: To-night we continue the discussion on Mr. Fox's paper on "The Oxy-Acetylene Process of Welding." The interesting experiments which were carried out last week were valuable object lessons on the subject, and we derived a great deal of pleasure and information from seeing them; these will be added to this evening, and we will then continue the discussion. Mr. Fox may introduce the subject to us by a few words.

MR. FOX: I have not a great deal to add in relation to the subject of oxy-acetylene welding. We went fairly closely into the subject and I endeavoured to show you the class of repairs which could be successfully attempted by this means. The operator also endeavoured to show you how this work is conducted. Our intention is to repeat the practical demonstration we had last week and put you gentlemen in a position to take up the discussion.

CHAIRMAN: If any of the members present have any particulars of personal experiences of how this work has turned out, that is the class of information we want, and it would prove of very great value and interest; or should any visitors, whom we are glad to welcome to our meeting to-night, have any questions to ask or comments to make, they are quite at liberty to speak.

MR. G. L. FLORENCE: The company to which I belong some weeks ago had some repairs executed on a small boat, and I think two of the furnaces were welded up. The Board of Trade would not accept the oxy-acetylene system with regard to the furnaces, but as we had another job in view, our superintendent decided to approach the Board of Trade to ask them to consider the matter, with a view to accepting it on future occasions. The letter was written on the Friday night, and on Monday morning both the Board of Trade and Lloyd's sent a deputation of officials down to the works and examined the work being done by the oxy-acetylene process. They put it through a thorough test in the way of hammering it over the welding just as they would do on any other part of the boiler, and they were quite satisfied with the work. They saw it being done; and after it was done it was decided to put on the double water pressure test to suit the Board of Trade requirements, then have a steam test, and afterwards empty and examine the boiler. This was done, and everything turned out most satisfactory; there was no leakage whatever. They welded up two furnaces, the back plate and round about the back of the boiler, and filled up a piece 10 in. by $3\frac{1}{2}$ in. They actually cut a piece out and then filled it up around that plate. The next ship treated, the one we wanted the Board of Trade to agree to, was the *Hirondelle.* There were about thirty cracks in the furnace crowns. They examined that also. The cracks in the crowns were cut away and three different pieces were fitted into one crown and welded up round about. The trials are not complete yet, but they have put the job through the hammering test and it has proved most satisfactory. We have done a good many other jobs with the cargo boats in the company, and they also have been very satisfactory. One in particular I might mention. Right in the front plate between the two furnaces, a wing furnace and a lower furnace—a very narrow space—a crack developed 18 in. long. They cut out a piece 18 in. long and 3 in. wide and filled it up, and the test was absolutely correct. The ship has been running for the last four months and has not shown the least sign of "bleeding" at the part, and if one went to see it he would not know it from the rest of the plate. I do not want to go into the question at too great length in case you may think I have a mandate from the company, but I am pleased to open the discussion. With regard to the attitude of the Board of Trade, although I have no authority for saying it, I believe they are going to have a double water pressure test of all work done on crowns and back ends. The trials are not completed yet, but so far as they have gone they say they are thoroughly satisfied, and we have every hope that the Board of Trade will accept it, not only in this case, but in all future cases.

A cutting demonstration was then given, a piece of steel 9 in. wide and $\frac{3}{4}$ in. thick being cut through.

CHAIRMAN: There is one interesting point in connexion with that cutting demonstration which occurred to me, that is the absence of local heating. The temperature of the plate is raised to such a height in so short a space of time, there is such a sudden rise of temperature, that there is no time given for the metal in the vicinity of the cutting to become red hot. It is kept down to a blue heat of about 700°. That appears to me to be somewhat wonderful. One would naturally expect to see at each side of the flame a dull red at least, but as you have seen it is practically cold, and that can only be attributed to the fact that the rise of temperature is so sudden and so localized that there is no time for the surrounding metal to become heated and the flame cuts through like a knife.

A demonstration of the filling-in process was then given.

CHAIRMAN: Perhaps Mr. Fox would give us a description of the cylinders containing the acetylene.

Mr. FOX: The cylinders are autogenous welded and the gas they contain is compressed to a pressure of 10 atmospheres. They are tested to 600 lb. water pressure. As you are probably aware, acetylene is a gas that does not admit of being put under compression in ordinary circumstances. In order to overcome that difficulty advantage is taken of the dissolving property of acetone, which is capable of dissolving 25 times its own volume of acetylene for every atmosphere put upon it. That does not remove the danger, however. That is overcome by filling the cylinders with a porous material put in in the form of cement. The cylinders are filled from top to bottom with this cement, taken to an oven and "cooked," or baked to get off the moisture. A known quantity of acetone is then put in to allow us to get 100 volumes of acetylene at 10 atmospheres of pressure.

Mr. W. J. GUY: This is the first time I have been able to come from Sheffield to any of the meetings of the Institute, and I take the opportunity of contributing a few remarks to the discussion. I should like to ask the author, if, when a repair is being effected, any means are taken for annealing the furnace. It appears to me to be a rather important point, that of annealing the furnace, as the metal is apt to get brittle after a time.

Mr. FOX: In furnace work it is very often necessary to cast the rivets. In relation to annealing, this is always done by means of the blow-pipe after the operation and over a larger area than has been considered to be disturbed.

Mr. GUY: What I mean by annealing is that the material should be heated very gradually, and that is the only way in which annealing can be effectual. It appears that the heat from this process would be fierce.

Mr. FOX: It is only the little inner ring of the blow-pipe flame that has any fierce heat in it. The other is quite of a moderate temperature, so that you would be able to heat gradually for annealing.

Mr. JAS. TURNER: It seems to me that there is a commercial side to the use of this process in addition to its practical side, and I was wondering whether the author can give any figures to give us a comparative idea as to the cost compared with that or ordinary welding. I notice that two or three different kinds of burners are used, and it might be of interest to know the reason why different burners are used in different cases. Is it that the heat in one case is extremely local and more intense and a special burner must be used, while a different burner should be used where the heat is not so intense?

Mr. FOX: With reference to the change of blow-pipes, that is governed by the kind of metal one is working upon. One must gauge the blow-pipe where a less intense heat is required and to consume a less quantity of gas. With regard to cost, it seems to me that this is not a matter of very great importance. I refer to the intrinsic cost; the use of the system means a great saving in time. For instance, to repair a stern post of average dimensions it might cost £80 to £100 by this system, while to repair it by other methods might cost about ten times as much, £500 to £600 at any rate. Although the actual cost may seem large in proportion to what is done, it has to be compared with the saving that is effected in other directions.

Mr. TURNER: In order to focus the attention on something specific, may I ask if you could compare the cost of repairing a stern post by your process as compared with, say the Thermit system, and the difference in time. I do not know whether it is quite in order to bring forward such a definite comparison, but it would be of interest to practical men.

Mr. Guy: Is there any more difficulty in making the weld, or would it be as sound, if it were made overhead instead of on the bottom of the furnace? I should think the metal would tend to run, which possibly would make it rather awkward for the operator if he were making a weld, say on the crown of the furnace.

Mr. Fox: With reference to the first question in relation to the comparison between this system and the Thermit process, there was a gentleman here last Monday evening who said the saving in time between the two processes would cover the cost of the acetylene plant.

Mr. Turner: What was that comparison between?

Mr. Fox: Between this process and the ordinary method of welding. With reference to the second question, there is no difference in the result obtained in overhead work to that of work performed on the horizontal.

Mr. Guy: Is it just as sound a job?

Mr. Fox: Just as sound. The position has no bearing upon it, given a skilful workman, of course.

Mr. H. T. Bond: If there were a small crack in the furnace would it be necessary to cast the rivets all round the crack?

Mr. Fox: That depends upon the location entirely.

Mr. Bond: Assuming the crack to be in the crown, where it usually is.

Mr. Fox: Do you mean a surface crack? Mr. Bond: No, a crack right through the furnace.

Mr. Fox: About what length? Mr. Bond: Say about 7 in.

Mr. Fox: No, it would not be necessary to cast them all the way around. If it were anywhere near the back end it would be necessary to cast a few rivets in the neighbourhood.

Mr. Bond: I once saw a crack welded up, and apparently it was a good job, but when it had cooled down it cracked again.

Mr. Fox: Of course welding is not finished until the metal has cooled down; then we can say it is done, but not before.

Mr. Guy: Do the holes come quite fair? Mr. Fox: Yes, quite fair.

Mr. Guy: If there is unequal expansion I do not see how they can come back to the original position.

Mr. Fox: We have never had them sufficiently out to cause any trouble.

Mr. E. W. Whiteman: Supposing a plate about 6 ft. square is cracked to the extent of about 1 in. in the centre. Would there not be a possibility of further cracks developing after annealing? Would the plate be heated locally, or would it be treated over a fairly large area?

Mr. Fox: I presume you are referring to a flat surface?

Mr. Whiteman: Yes, a flat plate of a rather large size.

Mr. Fox: In that case you would be dealing with the most difficult class of work it would be possible to get hold of. The thickness would govern the conditions to a large extent. About what thickness would you assume?

Mr. Whiteman: The ordinary boiler plate, or a plate in a ship's side.

Mr. Fox: In a ship's side we would not attempt the work on a fixed plate, and we are dubious about getting success on any flat surface. The result, of course, would be buckling, or further cracks in an attempt to buckle.

Mr. Whiteman: Supposing you did attempt it, would you treat it locally?

Mr. Fox: No, we would try to cover a good area.

Mr. Whiteman: Would that not add to the difficulty on cooling down?

Mr. Fox: Not if it were a thick plate. If a thin plate is being treated, it would be treated more locally.

Mr. WHITEMAN : I suppose before filling the cracks you would chamfer the edges with a cutting blow-pipe.

Mr. FOX : Yes.

Mr. WHITEMAN : That would be better than cutting with a chisel, I suppose ? Mr. FOX : It would be equally as good.

Mr. T. M. BLOXAM : With regard to these blow-pipes Mr. Fox has shown us, I would like to ask if they can be used with the ordinary low pressure acetylene generator.

Mr. FOX : Blow-pipes are made for both systems.

Mr. BLOXAM : Could I use one of the blow-pipes shown with the low pressure system.

Mr. FOX : Yes for cutting, but not for welding. Of course for cutting it is not necessary to use acetylene. Oxygen and coal gas will give the same results, but the coal gas is not as satisfactory, and there is not any necessity to use it when the acetylene is at hand.

Mr. BLOXAM : I would like to ask another question with regard to a case I have in mind now, of a groove in the front end plate of a Lancashire boiler over the front end flange of the furnace. In filling in that groove I presume you would cut out the rivets in the neighbourhood of the groove. Would you go far beyond it ? The length of the groove is about 16 in.

Mr. FOX : Yes, you would go a good way round.

Mr. BLOXAM : It is about $\frac{3}{4}$ in. deep and $\frac{3}{8}$ in. wide.

Mr. FOX : You should cast the rivets a good way round the end, run them in and " V " it out.

Mr. BLOXAM : Would you apply any local heating beyond that of a Wells' light ?

Mr. FOX : Not on that thickness of plate.

Mr. BLOXAM : When the groove is filled up it would leave a sott of fillet on top of the flange. Would you allow that fillet ro remain ? Mr. FOX : Yes.

Mr. E. RUMSEY : Might I ask whether the action of the gas alters the microscopic structure of the steel ; does it alter its cutting qualities in any way ?

Mr. Fox : Not in the slightest.

Mr. Guy : That was in my mind when I put the question about annealing.

Mr. Fox : The gentleman who first spoke will bear me out from a hammer and chisel point of view.

Mr. Florence : I can vouch for that ; it was quite the same as the other part of the metal. That was the test one of the Board of Trade surveyors put on the work as soon as it was finished ; cutting it with a hammer and chisel.

Mr. H. T. Bond : Do you make up with steel or Swedish iron ? Mr. Fox : With Swedish iron.

Mr. Bond : In all cases ? Mr. Fox : I might say in all cases ; yes.

Mr. Bond : Is it possible to weld an alloy ? Mr. Fox : What alloy ?

Mr. Bond : Say gun-metal. Mr. Fox : No, gun-metal will not weld.

Mr. Bloxam : Can you weld cast iron ?

Mr. Fox : With a varying degree of success, and in small work.

Mr. Bloxam : Do you use cast iron bar ?

Mr. Fox : Yes, there are one or two motor-car cylinders here which have been repaired in that way.

A Member : Are the different pressures used for different thicknesses of metal ?

Mr. Fox : Of course there are two jets, the oxygen on a pressure of 50 to 60 lb. and the gas pressure, the heating agent, about 5 to 6 lb.

Chairman : The following is an extract from *The Marine Engineer* of April, 1909 :—

" Passing along the dock jetties of a continental port recently, we were attracted by a tent-like erection near one of the bridges. On approaching near with becoming caution we found evidences of work proceeding under cover of a sail. Closer inspection revealed a boiler which had evidently done duty in a tow boat for many years. The bottom shell plate, sludge door and surroundings were wasted by corrosion, and at first sight the only apparent method of reliable repair was a new bottom or a sale by auction. The owners' representative, however, had other intentions. The boiler was turned on its side and the man in charge was directing an expert armed with blow-pipe and auxiliaries with a view to build up the lacking material by the aid of the oxy-acetylene gas and Swedish iron. A day or two later, on examining the boiler, it was found to have been made up to the required thickness and the landings on the sludge door brought more into keeping with the requirements of a water-tight joint. The off-hand way in which the repairs were executed attracted one; in place of the boiler-makers' workshop and all its accessories, here we saw the enterprising engineer directing operations in a Bohemian fashion untrammelled by the ordinary usages of work-shop practice. The process of building up wasted places and welding cracks when they do not occur in a vital part, such as under great tension, appears to be greatly extending in use."

Mr. Bloxam: Can Mr. Fox tell us what the insurance companies and Lloyd's say to repairs by this process. I had the advantage of being here last Monday and hearing his lecture, and I understood him to say certain repairs had been done with the full knowledge and consent of the insurance companies and also Lloyd's. What is the particular objection of the Board of Trade; what do they base their objection upon? is it that the metal becomes brittle?

Mr. Fox: The Board of Trade are a most conservative body and the last to move; that is the only explanation I can give you. They have no particular objection; they are simply afraid to adopt it until it has been proved to be the correct thing, perhaps rightly so. It has been used with great success on the Continent for the last four or five years, and the Board of Trade are taking a decided interest in it, and perhaps within the next few months their objections will have vanished.

Mr. BLOXAM: Of course the question of economy does not mean so much to the Board of Trade as to some of the other classification societies. I did not know, however, whether there might be some definite point upon which they objected.

Mr. FOX: There is none whatever.

CHAIRMAN: In the *Marine Engineer* for October, 1908, is given an account of some repairs by this system on the s.s. *Indraghiri*, which had the sanction of Lloyd's.

Mr. JAS. HOWIE: What kind of repairs were they?

CHAIRMAN: Repairs to the boilers; the furnaces were made up, cracks welded in, and other repairs effected.

Mr. H. T. BOND: Not only were Lloyd's fully satisfied but they were most enthusiastic in the case of the *Indraghiri*.

CHAIRMAN: This class of information and experience is not only of value to us but is published afterwards in the Transactions and is sent all over the world, and when engineers come before us and give us the results of their practical experience that is the kind of information we welcome.

Mr. WHITEMAN: I would like to ask what is the best method of applying heat for the purpose of annealing other than oxy-acetylene. It would probably mean a saving in gas if some other source would do as well, say a Wells' light or a coke fire.

Mr. FOX: In boiler work a blow-pipe should be used on the other side of the plate, but in larger work, shaft work for instance, a coke fire might be used.

Mr. WHITEMAN: It is always an advantage to save the heating where one can.

Mr. FOX: Certainly, but in boiler work the spaces are too confined to use a Wells' light.

Mr. WHITEMAN: Do you ever apply the Wells' light.

Mr. FOX: It is done sometimes.

Mr. WHITEMAN: In the case of a thin plate we wanted to put a rim round it 2 ft. diameter and 1 in. thick. The rim was 6 in. deep. In almost every case the bottom plate buckled after the job was done. I should like to know whether Mr. Fox has had any similar experiences.

Mr. Fox: Obviously one would expect to get buckling in a case of that kind. The only treatment is levelling.

Mr. Guy: Could it not be prevented by having small holes in the centre through which the heat could flow?

Mr. Whiteman: The holes in the centre have been tried, but they did not prevent the buckling to any extent.

Mr. Bloxam: Referring again to the question I raised in connexion with the Lancashire boiler. Independent of what the Insurance company or Lloyd's would say, I suppose you would not hesitate to make that repair.

Mr. Fox: Certainly not; I would do it with the utmost confidence.

Mr. Bloxam: That is, provided the boiler sustained the hydraulic test, you would consider that a good job?

Mr. Fox: Undoubtedly I would.

Mr. Whiteman: I might quote an instance of the attitude of Lloyd's with regard to a tail shaft which was grooved just beyond the flange close to the coupling. It was about $\frac{3}{16}$ in. deep and the shaft was about 7 in. diameter. Lloyd's absolutely refused to have this treated with the oxy-acetylene process, although, personally, I believe we might have made a good job of it.

Mr. Fox: Is that some time ago? Mr. Whiteman: About six months ago.

Mr. Fox: As recently as that? Was it in London?

Mr. Whiteman: No, it was about 25 miles down the river, but it was under the London surveyors. The groove was just beyond the propeller, and was no doubt due to the galvanic action that would take place. I thought it was close to the coupling when I heard of it first, but I was wrong.

Chairman: I would like to call attention to the fact that this plate you see before you has been cut through by this process to get it out through the furnace. You will see how evenly it is cut—quite a finished job in fact. It is $\frac{15}{16}$ in. thick and is from the back of a combustion chamber. There is another feature in connexion with the job ; the rivets were driven out with the gas jet previous to cutting.

Mr. WHITEMAN : How would the cost of blowing out with the gas jet compare with the ordinary way of cutting out ?

Mr. FOX : There again the saving in time enters.

Mr. WHITEMAN : Leaving out the question of time, how would it compare ?

Mr. FOX : Very nearly on a par.

Mr. WHITEMAN : Supposing you had a cracked flange for a cylinder 2 ft. by 3 ft. in diameter ; would you attempt to repair it by this method ?

Mr. FOX : No, I would not attempt it.

CHAIRMAN : Time is money when the effecting of repairs detains the ship in port. Detention is a big item in connexion with repairs, and therefore when we wish to contrast the cost of different methds the element of time must enter very largely. In a case recently it took two men two days to do work that under other circumstances would have taken ten men seven days to do it ; and when we think of a saving in time like that, we can easily see that although the initial cost may be increased, it is more than counterbalanced in other directions.

Mr. W. J. GUY : It must be obvious to every one that this is a revolution as far as repairs are concerned, not only boiler repairs but ship repairs also, and the saving in time is bound to compensate for the initial expense.

Mr. FLORENCE : It may be of interest to know that a friend of mine has started cutting up an old boiler by this process with great success.

Mr. ADAMSON : It seems that if this process is generally adopted there will be no old boilers to cut up.

Mr. JOHN WEIR : Before the meeting is closed I would like to say how much I appreciate the remarks of the Chairman in which he welcomed the visitors here this evening. I have brought with me two friends from New Zealand, Mr. Howarth and Mr. Hosie, who may be said to represent the Australasian Institute this evening, and they have been much interested in the demonstrations and the discussion. That point with regard to cutting up old metal by this process is of great interest. Mr. Howarth was wondering whether Mr. Fox would advise, in the case of repairing a crack, chamfering the edges and filling in with Low Moor or Swedish iron, or cutting the cracked piece right out and fitting in a new piece. We were also in doubt as to how the boiler-maker regarded all this.

Mr. Fox: I am glad to say we have no trouble with the boiler-makers; they regard it as a new industry outside their department; it is a specialized trade which has sprung up alongside that of the boiler-makers. At its inception a little friction was caused, but that has now passed away. You ask, should we " V " out a crack or fill in a new piece. In some instances it is better to fill in, but in the majority of cases it is much better to cut out the whole area and weld on a new piece. The cost of a cutting and welding plant such as we have been using this evening is somewhere about £40 to £45.

A vote of thanks was accorded to Mr. Fox, on the proposal Mr. Guy, seconded by Mr E. W. Ross.

Mr. Jas. Adamson: We may congratulate ourselves on having not only a large meeting, but one composed of members and visitors who hail from places as far apart as China and New Zealand, and I hope that the good attendance will be maintained at our future meetings. Our objects are entirely educational, and we are exceedingly glad to see at our meetings any one who is particularly interested in the subject under discussion. I would again say that visitors are most heartily welcomed, not only to-night, but at all our meetings.

The meeting closed with a vote of thanks to the Chairman, on the proposal of Mr. Fox.