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(OF TRANSACTIONS).

STEAM PIPES:

THEIR MATERIAL, WORKMANSHIP AND ARRANGEMENT.

BY

MR. W. J. NOWERS BRETT

(ASSOCIATE MEMBER).

Read in the Premises of the Institute on Monday, 14th November, 1892.

Discussion Continued Monday, 28th November, 1892.

PREFACE.

58, Romford Road,

Stratford, Essex.

November 14th, 1892.

A meeting of the Institute of Marine Engineers was held here this evening, presided over by Mr. W. J. Craig, when a Paper on "Steam Pipes, their Material, Workmanship and Arrangement," was read by Mr. W. J. Nowers Brett (Associate Member).

The Blocks for the illustrations have been kindly executed and presented to the Institute by the Editor of *The Marine Engineer*. This opportunity is taken of acknowledging our indebtedness to him.

The subject of the Paper was partly discussed this evening, and some valuable remarks were made. It was resolved that the reply of Mr. Brett to the various points dwelt upon, should be taken first at the adjourned meeting, to be held on Monday, November 28th, when other considerations might be suggested to the author as worthy of place in the discussion.

JAS. ADAMSON,

Honorary Secretary.

STEAM PIPES:

THEIR MATERIAL, WORKMANSHIP AND ARRANGEMENT.

BY

MR. W. J. NOWERS BRETT

(ASSOCIATE MEMBER).

Read at the Institute, 58, Romford Road, Stratford, E., Monday, November 14th, 1892, at 7.30 p.m.

The subject of steam pipes, which I have the honour to bring before you, has during recent years assumed great importance in the engineering world, and looking at it in the light of some recent experience in explosions and fractures, I think it well worth your earnest consideration and discussion, and hope that ideas will be evolved, which, when carried into practice, will give greatly increased confidence to all employed in the marine engine-room. Official investigations following accidents to steam pipes have done much to show the defects and the weakness of brazed pipes, and I think I may be excused a digression to point out the great benefit that would accrue if greater prominence was given to these reports in all our technical journals, and in the following pâper I propose to quote fully from some, to illustrate and emphasize where defects are most likely to occur.

The higher pressures of the present development of the marine engine have caused a certain amount of suspicion to rest upon the brazed worked copper pipe, and accidents, attended in some cases with lamentable loss of life and injury, seem to confirm engineers in their opinions as to the uncertainty of the ability of these pipes to stand the more severe test now imposed upon them. In the old-fashioned two-cylinder compound engines the brazed copper pipe did its work very well, and taking into consideration the peculiarities of the marine engine-room—vibration, movements of engines and boilers during heavy weather, alterations in the shape of the vessel's hull and the desire not to increase the number of expansion glands—copper seems to be the favourite material, and there is no reason why it should not be used for very high pressures with perfect safety.

Although brazed main steam pipes are looked upon with distrust, the seam of a good copper pipe properly made is as strong as the rest of the material; and for many reasons these pipes are almost exclusively used in marine practice, and consequently this method of manufacturing pipes claims our primary, and I might also add, our earnest attention, because it is likely to be generally used for some time. The greatest danger attending the brazing of a seam is the liability to burn any part of the material, causing the formation of a flaw or crack where it was originally sound, or to partly burn the bevelled edges and so make the seam unsafe, and therefore this operation requires all the care of a skilful and trustworthy man. The damage to a pipe by burning is well illustrated in the following report:—"The pipe in question formed one of the branch bends of the main steam pipes of a new Atlantic steamer; its internal diameter was 8 inches, its thickness ·272 of an inch, or No. 2 W.G., and it was made by one of the most eminent firms of coppersmiths in the kingdom, with a brazed joint in the usual manner. Before being placed in the ship this pipe was tested by hydraulic pressure to 320 lbs. per square inch, or twice the working pressure, on three occasions, with satisfactory results. Nevertheless, when bolted in its place, and while being subjected to a hydraulic test, for the purpose of proving that all the joints were tight, it gave way at a pressure of 310 lbs. per square inch, and tore for a length of 20 inches near to the brazing, the material at the point of fracture presenting the appearance of having been partially *cracked during the operation of brazing*. From tensile tests cut from the pipe in the vicinity of the fracture, and also away from the injured part, it was ascertained that the material had a tenacity of 33,000 lbs., showing that the copper was of good quality, and taking the dimensions of the pipe into consideration it should have been capable of resisting a pressure of about 2,200 lbs. per square inch before giving way; the fact of it failing at a pressure of 310 lbs. per square inch is of so alarming a character that . . . it is right to suggest that it is deserving of . . . serious consideration."* This report emphasizes the necessity of great care on the part of the workman, and also shows how easily copper of good quality loses its virtue.

A great deal depends upon the way the edges are bevelled. It is customary in some places in the interest of cheapness to bevel the outside edge and not the inside edge of the seam. It is almost unnecessary for me to say that this method should be deprecated, because it is clear that the thick edge will work into the part overlapping it, and so

* "Lloyd's Circular."

render the pipe liable to tear or crack in a line parallel with the seam. Both edges should be bevelled, but if made long and thin they are more liable to burn; the bevels of medium length always make the most satisfactory seam. If the bevels are made by hammering, great care should be exercised to prevent the parts adjacent to the seam being reduced in thickness, and furthermore, they should be made to properly overlap one another, and the combined thickness should on no account be less than the uniform thickness of the pipe; but an increased thickness of 25 per cent. or more, can be advantageously given as an additional factor of safety. In the best practice the bevels for straight lengths of pipe should be formed on the edges by machine planing, and then, and only then, are true and equal surfaces obtained, and I believe this method is really the cheaper of the two. The fact that properly bevelled edges are of the first importance for the soundness of a brazed pipe is shown in this report—"The pipe was 7 feet long by 7½ inches diameter, and was made of sheet copper ·284 inch thick. The copper was rolled, and the edges bevelled and brazed in the usual manner. It appears that the pipe when first inspected and tested was found unsatisfactory along the line of brazing, the overlapping or joint in some places being open, so that the surveyor could insert his tester about half an inch. The joint was re-brazed at these open places, and the hydraulic test again applied to 320lbs., which was the test pressure required by the rules (viz.—twice the working pressure, which is 160lbs.). The pipe withstood this pressure, but as the surveyor did not feel quite satisfied with the general appearance of the re-brazed parts, he recommended that the pressure be put higher. While this was being done, one of the re-brazed parts commenced at once to show symptoms of weakness, and at 500lbs. pressure per square inch (which is 340lbs. above the steam pressure) the pipe gave way at that place and opened out for a length of 7 inches. Three samples were cut from the pipe, near to the place where it gave out; one longitudinally, one transverse and one across the brazed joint. The tensile tests of the two former were 15 tons each, and the latter 12 tons per square inch. The results of these tests show that the copper was of good quality, and had the brazed joint been perfectly made throughout, the bursting pressure of it would be over 2,000lbs. per square inch instead of 500lbs. The bevelled edges of the copper plate, where the pipe gave way, *were bevelled too far back and not sufficiently overlapped, thereby considerably reducing the thickness of the copper at that part, which was torn through the solid metal and not the brazing.*"* The

* "Lloyd's Circular."

italics are mine, and the words they emphasize point to the necessity for careful workmanship. As with the proverbial strong chain so with the worked and brazed copper pipe, its strength is that of its weakest place.

The operation of brazing is sometimes a difficult one. The part to be brazed, owing to the shape of the pipe, may be some considerable distance above the fire, and if ordinary solder is used, there is great danger in over-heating. In a case of this description, the only remedy is to improvise a solder that will flux without damaging the lower portion of the pipe, but this cannot be done at present without sacrificing one of the most essential properties of this metallic cement. Ordinary soft brass solder is usually composed of copper, tin and spelter (zinc) in certain proportional parts, and is a material with nearly the same ductility as copper to allow for a certain amount of working under the hammer, but requiring a high temperature to make it run. To lower this running temperature the coppersmith must mix a certain amount of additional tin, but a seam brazed in this manner cannot be worked afterwards, because the requisite ductility of the solder is destroyed. A curious characteristic of new solder is worth mentioning, and may be of service to a marine engineer, if, by force of circumstances, he is compelled to try his "'prentice hand" at brazing. If we attempt to flux new, dry solder with borax, we find it will run something like water upon hot metal, and that it is most difficult to secure contact. Solder before use should be kept in a solution of borax and water, as the solder, being highly porous, absorbs the borax, and the longer it is kept in the solution the easier it will run and unite when used.

Speaking generally, the material for steam pipes of triple expansion engines is not so good as that from which the steam pipes of the old compound engines were, without exception, made from. The impurities found in adulterated copper are principally iron and spelter (zinc), and these foreign substances help to destroy its special properties.

Working the bevelled edge on sheet copper often determines its quality, and I think it necessary to say that copper is used which after annealing will not stand even that very mild test. Material of this description may possess a comparatively high tensile strength, but it is unsatisfactory to work. As the edge is thinned down by the hammer, it has a tendency to crack, and probably to form lamination flaws. The cracks in the overlapping parts of the seam are nullified to a certain extent by the brazing solder, but flaws in the parts adjacent to the seam, although, perhaps, invisible during the test, or closed by planishing the pipe, will develop in use by the vibration of the engines to an extent approaching rupture, and then, under exceptionally unfavourable circumstances, a complete fracture of serious dimensions is the result. This remark, of course, applies to original flaws in sheet copper, due principally to the presence of impurities or blow holes; and another fact necessary for me to mention is, that main steam pipes for high pressures should not be worked out of sheet copper made from old material which has lost its virtue. I might say it is almost necessary to have a special reliable brand, which would be in the interest of the copper manufacturers as well, because it is imperative that copper as pure as possible should be used, otherwise its attributes as a material for marine engine steam pipes are gone.

The following particulars from a report* on a steam pipe explosion, which took place on the s.s. *City of Lincoln*, will serve to show the development of flaws in a copper pipe, and furthermore, they will supply useful information, culled from experience. This instance belongs to the category of which the steam pipe of the *Elbe* was a prominent illustration, and includes a number of others more fortunate in the matter of loss of life. The failure on the *City of Lincoln* was in the form of a crack through the solid copper for a length of 8 inches along the edge of the brazed seam. The pipe was $6\frac{1}{2}$ inches internal diameter, by about $\frac{1}{4}$ inch in thickness, with a scarph $\frac{5}{8}$ inch in breadth, and was subjected to a working pressure of 160 lbs. of steam. The failure, according to the report, was partly due to the presence of water, *but mainly to the fact that the pipe was dangerously weak by reason of old flaws*. The machinery of the vessel was built under the inspection of the surveyors of Lloyd's Registry, and a machinery certificate was granted by that body about nine months before the failure. To ascertain the tensile strength, elongation, &c., of the material forming the pipe, several strips were cut out, and carefully prepared for testing; those that were curved were straightened by steady pressure. When pulled in the testing machine only one out of four pieces gave anything like satisfactory results, and even this was deficient in both elongation and contraction of area, while not one of the strips presented the *silky and salmon-pink coloured appearance at the fracture which is obtained from sheet copper of good quality*. The bending tests were also unsatisfactory. The results of the tensile tests, with remarks upon the appearance of fracture, are given in the following table :—

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* Board of Trade.

Test No.	Dimensions of Test Piece. Thickness. Inch.	Br'dth Inch.	Area. Sq. In	Ultimate Stress. Actu'l Tons.	Per Sq. In. Tons.	Per Sq. In. Lbs.	Elongation in 5 inches. L'ng'h Inch.	Elongation in 5 inches. Per Cent.	Dimensions at Fracture. Inch.	Contraction of Area. Per Cent.	Remarks, Appearance of Fracture, &c.
1	·255	1·0	·255	2·8	10 98	24595	·25	5·0	·945 X ·23	14 9	Coarse and granular.
2	·28	1·0	·28	3·7	13·21	29590	·62	12·4	·91 X ·245	20·7	Slightly coarse and granular.
3	·285	1·0	·285	3·4	11·93	26723	·32	6·4	·95 X ·245	18·6	Coarse and slightly granular.
4	·26	1·0	·26	3·75	14·42	32300	1·50	30·0	·84 X ·20	35·3	Slightly coarse.
5	·26	1·0	·26	1·98	7·61	17046	Inappreciable.	..	.. ..	Inappreciable.	Broke through solid copper at outer edge of scarph. Fracture, for $\frac{2}{3}$ thickness outside of deep purple colour, remaining $\frac{1}{3}$ of light pink.
6	·25	1·0	·25	2·29	9.16	20518	·13	2 6	.. ..	Inappreciable.	Broke through solid copper at outer edge of scarph. Fracture, for $\frac{1}{2}$ thickness from outside, of dark brown colour, remaining $\frac{1}{2}$ of light pink.
7	·266	1·0	·265	2·64	9·96	22310	·13	2·6	·96 X ·25	9·4	Coarse.
8	·278	1·0	·27	2·96	10·96	24550	·35	7·0	·95 X ·245	14·0	Crystalline and slightly granular.

All tensile tests made with strips in normal condition—i.e., cold and not annealed.

The pipe was patched and when tested to a pressure of 140lbs. per square inch the seam began to leak towards the flange (see plate 1), and when 200lbs. was reached it leaked freely. On examination the seam was found defective for about two-thirds of its length, and the pipe was replaced by one of solid drawn copper. The Engineer Surveyor-in-Chief of the Board of Trade drew a parallel between this pipe and the condition of the exploded steam pipe on the s.s. *Elbe* and in his opinion "the purple appearance of the metal where the defects were located indicated that the cracks either existed in the original sheet of copper or were produced while the pipe was being made." It is also necessary to lay stress upon the evidence of a member of the firm of coppersmiths who bent the pipe to the required shape but did not braze it. He was of opinion, after examining the pipe, that the defective seam and the discolouration through the solid copper was due to a too free use of borax.

It is quite possible that the exploded pipe of the *City of Lincoln* was not properly tested and examined when new,* because the pipe was in such a state that if a hydraulic pressure of double the working steam pressure had been applied the defective condition of the pipe would probably have been made known. This is, I think, a fair and proper test for a copper pipe, and I am of opinion that if the test is carried much above this, it is stressing the pipe to an unnecessary degree. Perhaps the most thorough test for a brazed pipe is the customary one of that eminent shipbuilding firm, Messrs. Denny and Co., viz.—the pipes are tested at the coppersmith's to double the working pressure, the brazed seams are examined by hammering along the whole length of the seam and by using a magnifying glass to detect any flaws that may have occurred; and further, the pipes, when jointed up in their places, are again tested, from engine stop valve to boiler stop valve to double the working pressure. This is a very substantial test, and should be adopted by all engine builders for new work.

When finishing a brazed-worked pipe it is usual to well planish the seam, a process which does the material no harm if the pipe is properly annealed afterwards; but sometimes the pipe is subjected to the hammer afterwards, when the planishing can be carried to such an extent that the virtue of the material will be damaged by causing it to become hard and brittle—a dangerous quality in a copper steam pipe.

In a number of cases where brazed pipes have failed they

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* There was no special record that this pipe was tested when new, and a member of the firm of Messrs. Doxford & Son—the builders of the machinery but not the makers of the pipe—stated in evidence that the pipe was not tested by his firm.

have been replaced by those of solid drawn copper, and in new work they are more than occasionally used. Their manufacture has lately received considerable attention, and by the introduction of the rotative mandril only a fraction of the power formerly applied is now used, and the material is subjected to considerably less stress. In the best system in practice at Birmingham the copper ingot is pierced with a small hole by a special machine, and the new rotative steel mandril is then forced through by hydraulic pressure—the other end of the mandril forming a ram working in a water cylinder, the whole being turned by suitable mechanism. The 2-feet ingot with a small hole has now become a "shell" 4 feet long with a 3 to 5 inch bore. It is then passed through the tube-drawing mills, also upon a rotative mandril and completed.* Solid-drawn copper pipes have, so far, been very successful in marine engine practice, but they are not always free from defects. I have repeatedly seen them cracked or split longitudinally—in some instances for a very considerable distance; varying in sectional thickness to the extent of $\frac{1}{16}$ inch in $\frac{1}{4}$ inch, being below gauge thickness on one side, and exceeding it on the opposite side, thus lacking in uniformity; and the inside of the pipe covered by a multitude of small cracks in all directions and of considerable proportional depth, due probably to overheating during annealing, and I have also detected lamination flaws when the material of the pipe has been experimentally torn through, although at present only in pipes of small diameter, but supposed to be of the best quality. In the solid-drawn pipe there is often less chance of detecting a flaw than in the brazed-worked pipe, because by working sheet copper we are generally able to find its faults. A small blow-hole in the ingot of copper will develop into a long and serious flaw —and very often a hidden one, either completely contained in the material or appearing on the surface inside the pipe, where, if it is some distance from the end, it is impossible to see it. These defects show, that though the solid-drawn pipe is a very great advance towards the perfect steam pipe, there is yet further room for improvement in quality and greater care in their manufacture.

In my own opinion the solid-drawn pipe has been excelled by the copper depositing process invented by the Messrs. Elmore. I have seen specimens of their manufacture that appear to be the ideal of copper steam pipes realized. In section they are perfectly true, and of uniform thickness all round, and can be manufactured to any diameter required in

* "Machinery for Tube Making," &c., by Mr. W. H. Baraclough, M.I.M.E., read before the Mason College Engineering Society. *Vide* "Engineer," p. 338, Vol. lxxii.

practice. They are guaranteed to reach a tensile breaking load of 20 tons per square inch, with proportional elongation, either lengthways or circumferentially. In considering the merits of these pipes it will, perhaps, be better to briefly state the process of manufacture. The tank is made of wood, lined inside with a bituminous composition, and at the bottom of the tank is fixed a perforated copper plate covered with granulated copper. The mandril (of cast iron, with a thin coating of copper deposited by the ordinary cyanide process) revolves in a solution of sulphate of copper, and between, but not touching, two copper plates to equalise the resistance of the electrolyte, and on completing the connections of the electric current, the granulated copper forms the anode[1] and the mandril the cathode[2]. The pipe is deposited upon the mandril from the solution, but does not adhere to the original copper lining upon the cast iron, because the copper being exposed to the air for a short time, produces a coating of oxide, which effectually prevents adherence, and in this way one tube can be deposited over another. The chief feature in this process is the use of a burnisher—a piece of agate—which travels from one end of the pipe to the other, and the pressure of which is varied, together with a difference in the solution, to produce different qualities. The whole process is very slow, as shown by the fact that it takes 168 hours to deposit $\frac{1}{8}$ inch thickness of copper upon a mandril 6 inches in diameter. When the pipe has been deposited to the required thickness, the mandril carrying it is passed through rollers under pressure, which slightly expands the pipe, and allows it to be drawn off the mandril.* The products of this process leave very little room for criticism from a technical point of view, and the only suggestion I can make is—considering the fact that oxide effectually separates the deposited layers—that unless the manufacture is kept up to its proper standard of excellence, if due care and supervision is not exercised, it seems possible that pipes of a scaly nature may be produced. I suppose all engineers have taken a great interest in this most ingenious invention, because it is the means of producing a reliable seamless pipe of first-class quality—a pipe of higher tensile strength than that hitherto obtained from the best sheet copper, and one in which it is impossible to find the ordinary flaws. From a financial aspect the copper deposited pipe bears, apparently, a very favourable comparison with its rivals, its market price being the same as the solid drawn pipe. But judging from the fact that it takes a very long time to form the deposit, I am

1 The positive pole :—The way the current enters the substance through which it passes.

The negative pole :—The way the current leaves.

* *Vide* "Engineer," page 178, vol. lxxi.

inclined to think that if the patents are to be profitably worked, the selling price must be raised.

The bending of copper pipes and the working of copper tee-pieces and pieces with a multeity of branches may be profitably discussed. The easy bends can be dismissed without notice, but where sharp bends are required (and they should not be used if it is at all possible to do without them) they should be made in short lengths of pipe, and if of seamless pipe, of greater thickness than the straight length, so that the "back" may not be weaker than the uniform thickness of the straight length. This will make the "saddle" extremely thick in proportion, but it is a defect on the safe side, and will—as the "back" is the smallest arc of the bend, and therefore more stressed by movement—allow the bend to easily withstand the working—if not excessive—of the whole range of piping, and therefore it is a source of ample strength when a bend is used to take up the expansion instead of using a gland and stuffing box, although it is an unsatisfactory practice at any time. A brazed worked-bend can be made very uniform in thickness throughout by rolling the sheet metal to suit the ultimate shape. A strong pipe can be made by "cramping" the seam as shown in Fig. 1, which, however, takes longer and requires more care than if scarphed only one way. Tee-pieces or three-way pipes, if made of copper, are worked as shown in Figs. 2, 3, and 4; in the two former, seamless pipe can be used to advantage; the latter is composed of several parts worked out of sheet copper and brazed together. The former are undoubtedly the more reliable; Fig. 4 shewing a weakness in the centre piece. Fig. 2 is the ordinary way branches are made to a pipe, and it and Fig. 3 are the best methods of making copper pieces of three or more ways. But if any doubt is entertained of any copper piece, a gun metal casting can be substituted, and I should strongly recommend that all branched pieces having weak places, if made of copper, should be made of cast gun metal of ample thickness throughout, and with webs to give the necessary degree of stiffness. It should be much easier to get satisfactory brazing in bends and worked branch-pieces than in long straight lengths of pipe, principally because they are more easily fitted together and manipulated over the fire for brazing.

To save the trouble and expense of flanges the socket joint is sometimes used. The socket should not be worked on a seamed pipe, but a seamless sleeve-piece may be used instead. When working a socket-end, great care should be taken to keep the stepped part as stout as possible, and it is almost better to reduce one end to fit the other, instead of the reverse. In any case particular attention must be paid to the running of the brass solder, as it rarely runs the depth of the socket ; no joint of this description should be used in the vicinity of a bend.

The brazed flange has been almost as troublesome as the brazed seam, and has contributed its quota to the number of defective steam pipes. The ordinary method of fixing the flange by bevelling the end of the pipe into the countersunk side of the flange and then brazing—is sufficient if the flange is a very stout one ; but very often the flange is thin, often without a bevel and having very little bearing. Making the flange with a boss gives a good bearing surface for brazing ; but there is a medium between having too much and too little. If the boss is a deep one the brazing is more often defective than otherwise, because the brass solder is seldom run completely through, and for this reason it is questionable if the flange with the deep boss is always as strong as its appearance seems to convey. When a sharp bend occurs near a flange the strength of the brazing of a bossed flange may be advantageously supplemented by a few copper rivets.

The only method differing from the ordinary practice that has made much headway in marine work, is the flange patented by Mr. Pope and shown in Figs. 5, 6 and 7. The ends of the pipes are belled out to form the jointing faces. If seamless pipes are used the flanges can be formed as shown in Fig. 5, but—and I beg to differ—Mr. Pope prefers the form shown in Fig. 6, in which the copper flange-pieces are worked separately and then brazed on the ends of the pipe. The jointing rings XX can be made of cast steel or iron, or malleable steel or iron, but cast steel is preferable. When the rings are made in one piece, they have to be strung on to the copper pipe before both ends are flanged out, but they can be made in halves, half checked at the meeting ends. I have seen this method of flanging and jointing used with a working pressure of 250lbs. per square inch in marine practice.

The idea patented by Mr. de Ferranti was the outcome of the explosion at Deptford, and although ingenious and applicable to stationary engines with a good foundation, is not, in my humble opinion, quite suitable in its present form for marine use. I have been informed that it has given complete satisfaction where applied to the boilers and engines of the Electric Supply Corporation, but if applied to steamships it will necessitate a greater safeguard owing to the movements of the structure. The flanges are secured to the pipe by corrugations as shown in Fig. 8—but for marine fitting I would suggest that it be slightly altered, as shown in Fig. 9—the grooves made much deeper probably continue to have their defects and flaws, even if the steel and iron pipes be made many times the thickness of the present copper ones.

Some time ago an interesting paper dealing with the use of iron main steam pipes was read before a kindred Institution.* The author advocated their use in lieu of copper ones, and in the course of his paper mentioned his experience of an iron lap-welded pipe fitted on board the s.s. *Claremont.* The pipe was five inches external diameter, and fitted with screwed and brazed flanges, and the steam speed was low, the pipe being large in comparison with ordinary practice. The original thickness of the pipe was ·375 of an inch, and after $8\frac{1}{2}$ years continuous service the thickness was practically the same as when new. The interior showed no signs of pitting or corrosion. It was covered with a thin coat of black oxide nowhere exceeding $\frac{1}{32}$ inch in thickness, and where the deposit was thickest it was curiously striated by the action of the steam. On the scale being removed, the original bloom on the surface of the metal was exposed and externally, the pipe, which was not covered, suffered slightly from corrosion. The pipe, it must be admitted, possessed the qualifications expected, but I cannot help thinking the conditions under which it was tried must have been very favourable.

The priming of the boilers would have a severe excoriating action upon the internal portion of iron steam pipes, and in exceptional cases the severe scouring would quickly shorten their lives, for even the great resistance of copper to this action is slowly overcome by it.

The general arrangement of main steam pipes claims attention. An ordinary range of piping should be supported at certain distances throughout its length, and must not be rigidly fixed in any way, as in the case of a water-tight bulkhead, but should be left free to take up the movements of engines and boilers. An interesting lesson may be found in the failure of a brazed copper pipe on board the s.s. *Ragusa.* This pipe connected the two stop valves on the main boilers. It was 6 inches internal diameter, about $\frac{1}{8}$ inch in thickness and had a brazed seam running along each side of the pipe, the ends being flanged in the usual manner. It had always given trouble, and during heavy weather the pipe burst and the fracture opened and closed with the rolling of the ship (see plate 2). Mr. Traill, the Engineer Surveyor-in-Chief of the Board of Trade, in his observation, says:—"The pipe . . . . . . was obviously too rigid, and being the only connection between

* North-east Coast Institution of Engineers and Shipbuilders.

the upper parts of the boilers, it is not surprising that it has given so much trouble. It is well known that boilers on board ship frequently move considerably during heavy weather, and it is the duty of those who are responsible for the fitting of the steam pipes to see that they take no part in controlling that movement." The arrangement for taking up the movements and expansions of pipes are important, and as such deserve due consideration. In all cases where the design of the pipe is made to allow for its movements, I think the material under this condition and the action of vibration and temperature is unduly stressed and liable to rapidly deteriorate in quality, and probably to crack; but if the safest form of gland and socket expansion joint with safety collar to prevent drawing out is properly placed and fitted, the resulting evil of this triple action is very small.

Sharp bends must be avoided if at all possible and other arrangements substituted, and in the general design as few ordinary bends as possible introduced. All ranges of piping must be efficiently drained, and drain pipes fitted wherever condensed steam or water from priming is likely to collect. Water in a steam pipe acts like a hammer, and all pipes are subject to its stress more or less. It has been the primary cause of several explosions—some quite recently. The steam pipe of the s.s. *Rohilla* exploded "owing to the stresses brought on it by the moving water within," and the internal surface of this pipe must have been frequently subjected to the scouring action of water. Water hammer action is a grave danger and might be the cause of a perfectly sound pipe failing. As an instance of the force exerted by a water hammer blow, it may be mentioned that the main engine stop valve cover—a very strong one—was severely cracked in a radial direction by the above explosion. At the enquiry into this accident a surveyor suggested that special fittings should be provided so that the drained water could be seen, and thus the amount of water formed and the efficiency of the drain ascertained.

In the fitting of steam pipes, I must strongly denounce the practice of drawing pipes up to their places with bolts, if they do not fit. Where this practice is followed I should be inclined to think that the fixing of the engines and boilers themselves were not satisfactory, and the resulting vibration acting upon a pipe or pipes held in a strained position is sufficient to damage even the best brazed seam or flange. More attention should be paid to the fixing of engines and boilers, and to the balancing of the working parts of engines, and I am glad to see the attention of one eminent experimentalist at least diverted in this direction. Vibration is not only a source of discomfort but a danger, a deteriorating action upon the whole structure, so we cannot expect steam pipes to remain unaffected by it.

An important point in favour of copper as a material for steam pipes is that it can, from its nature, take up the greatest number of small unknown strains that must occur in ranges of pipes, better than any other material, and thereby give less trouble with the joints. Its most serious defect is its loss of strength with every increment of temperature, but the day is distant when we shall have to increase the margin of safety for compensation. So far, copper pipes have rarely, if ever, burst in the material apart from the seam or flange, but I would suggest a greater margin of safety than that now generally used, and this is becoming more recognised in new work. Regarding brazing, I reiterate the remark, that if properly done, it will be equal to the strength of the copper itself, and as it is likely to be used, although so often denounced, I hope, as a safeguard, to see the introduction of a workable brass solder of great strength and comparatively low running temperature. By this means we could get a more reliable brazed pipe, because the possibility of burning the material would be more remote. Testing by hydraulic pressure is an unfair test by itself, and should not be carried above twice the working pressure ; but the seam should, in every case, be tested by the light use of a hammer and the magnifying glass while under this pressure, which I mentioned before as being used by Messrs. Denny, and in addition to this the inside could be examined afterwards by a specially arranged light and reflector. The fire over which the pipe is brazed should be freed from impurities, and by this precaution a better contact with the solder would be obtained, and the discolouration of the joint avoided. The rules of the Board of Trade, that surveyors may test copper steam pipes in their places at any time they consider necessary, should, in my opinion, be carried further. They should be taken down once in a given period, and annealed and tested by hydraulic pressure, and as previously described. If they remain in their places for some years without annealing, they become brittle, probably from the vibration of the engines, and they are then in a dangerous condition ; and further, the passage of old copper pipes through the fire would cleanse them, and would, if there were any open flaws or cracks, open them out and make them visible. This is, although a more expensive method, the only way to efficiently examine and test old copper steam pipes.

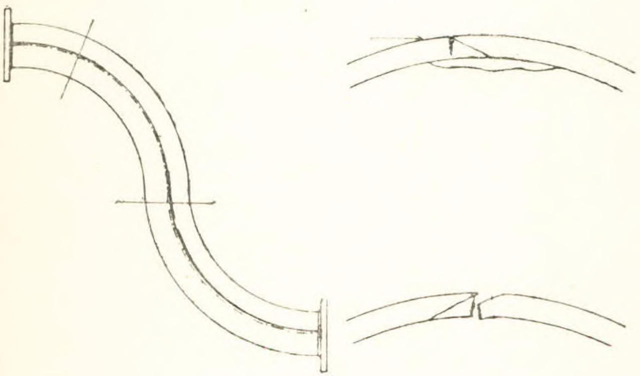


Plate I.

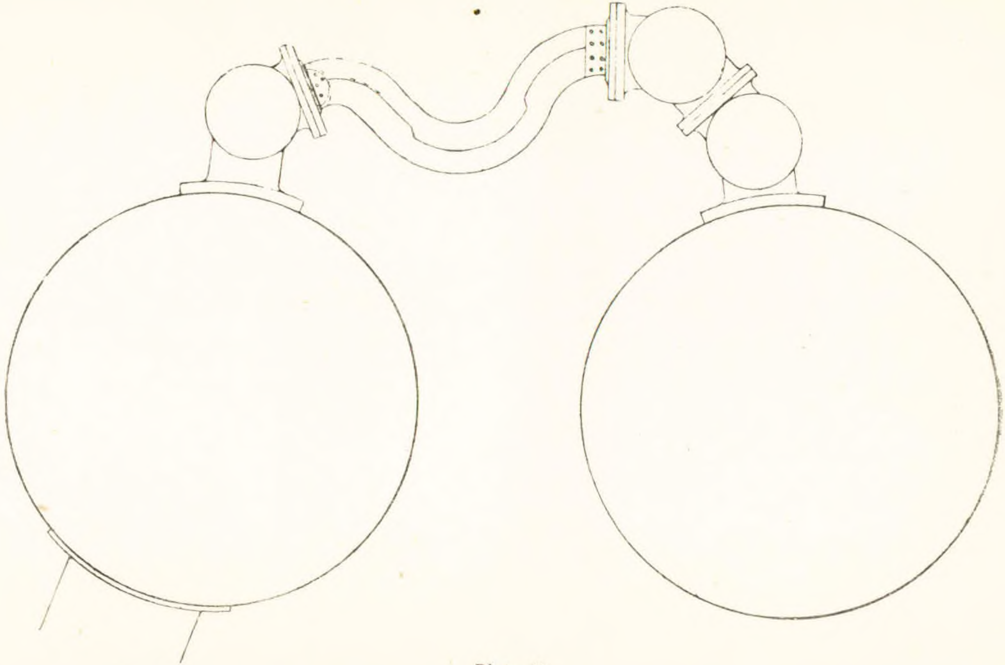


Plate II.

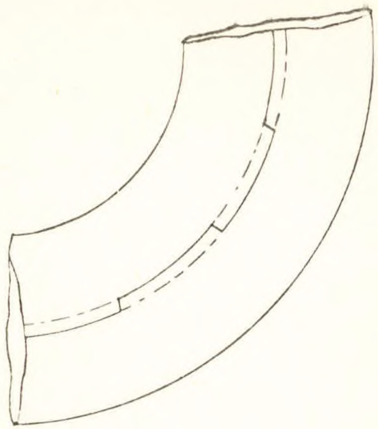


Fig 1.

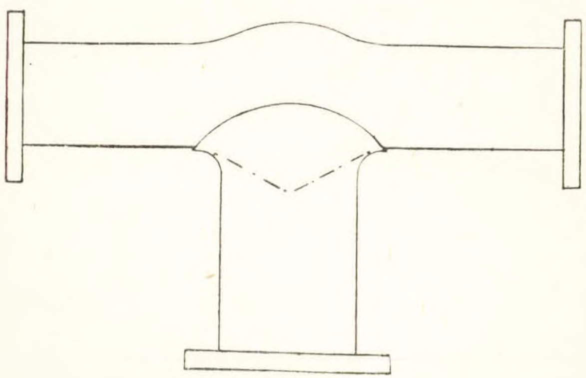


Fig 2

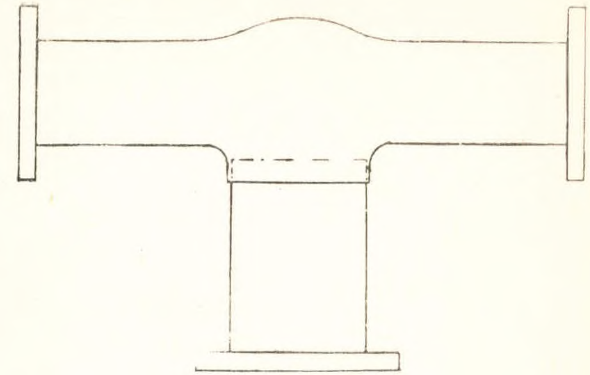


Fig 3.

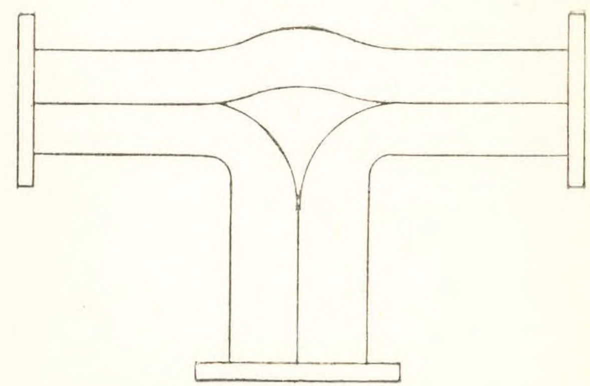


Fig 4

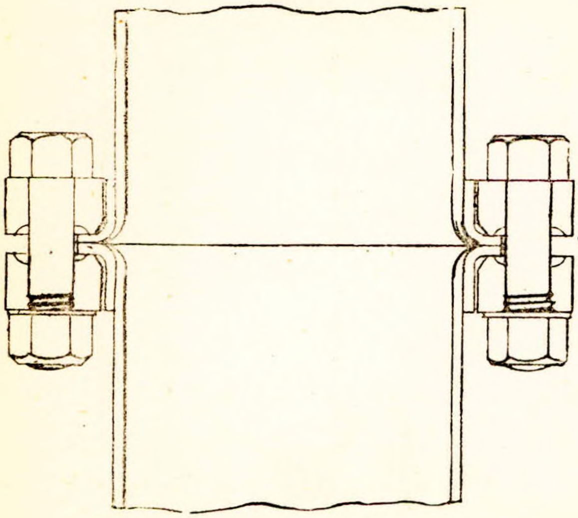


Fig. 6

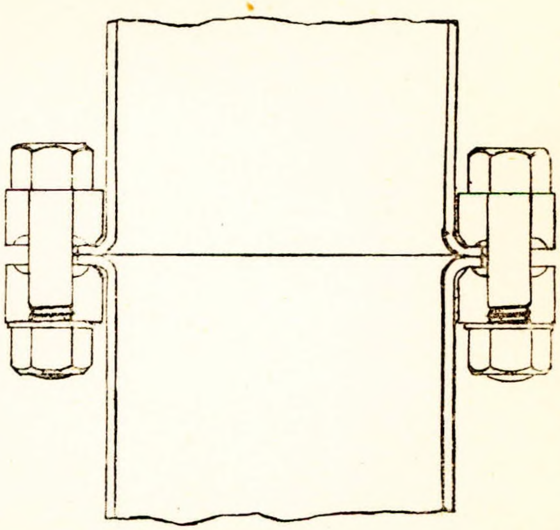
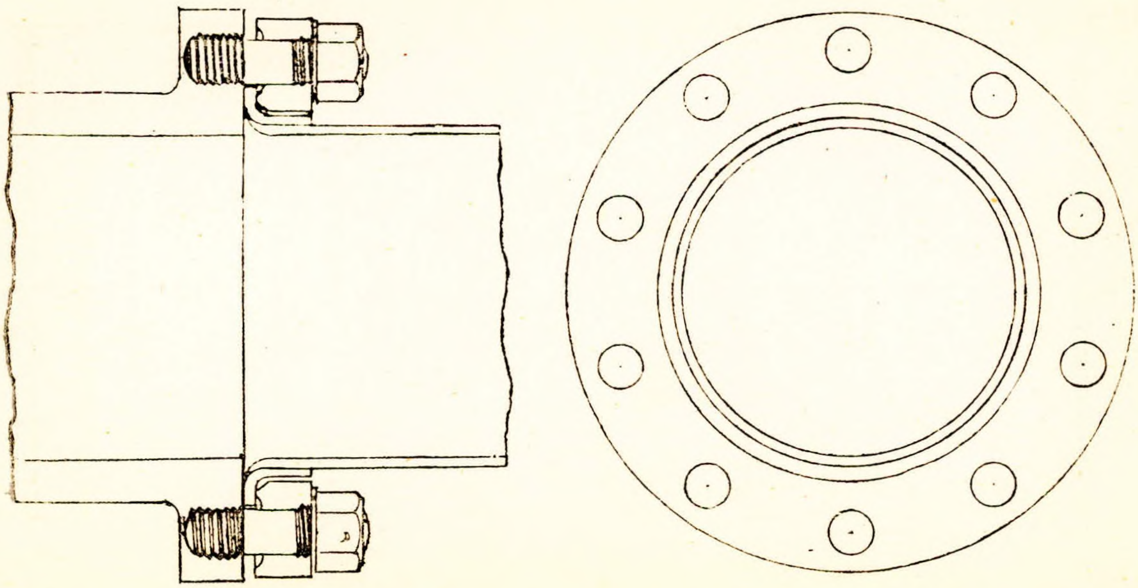


Fig. 5

Fig. 7


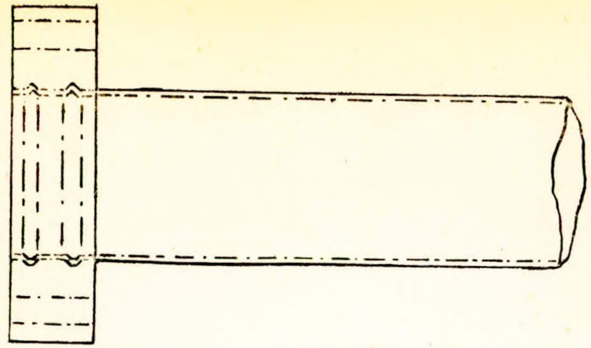


Fig. 8.

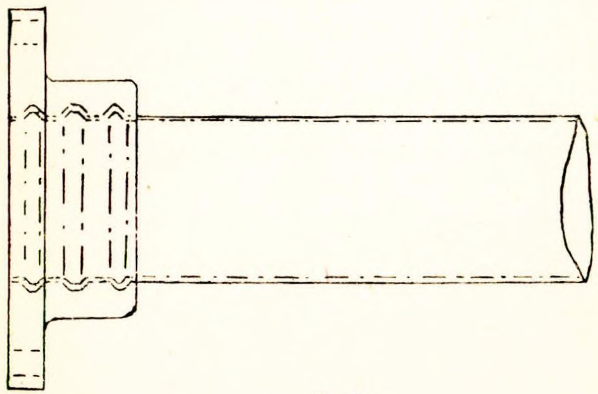


Fig. 9.

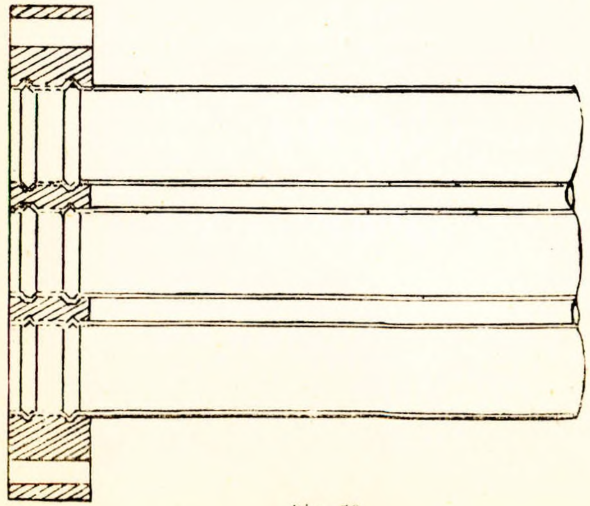


Fig. 10.

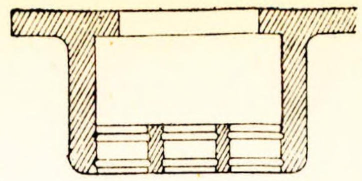


Fig 11

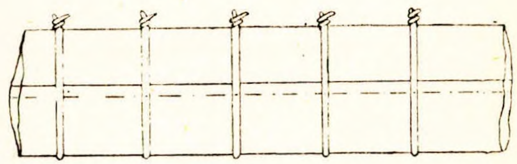


Fig 12

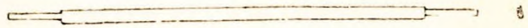


Fig. 13.

Fig 14

INSTITUTE OF MARINE ENGINEERS.

(INCORPORATED.)

SESSION, 1892-3.

PRESIDENT:

LORD KELVIN.

VOL. IV.

DISCUSSION

ON

THE FORTIETH PAPER (OF TRANSACTIONS),

STEAM PIPES,

THEIR MATERIAL, WORKMANSHIP AND ARRANGEMENT,

BY

MR. W. J. NOWERS BRETT,

(ASSOCIATE MEMBER,)

READ AT

58, ROMFORD ROAD, STRATFORD,

ON MONDAY, NOVEMBER 14TH, 1892.

DISCUSSION (CONTINUED), 58, ROMFORD ROAD,

ON MONDAY, NOVEMBER 28TH, 1892.

READ ALSO AT

THE UNIVERSITY COLLEGE, CARDIFF,

ON WEDNESDAY, JANUARY 25TH, 1893.

PREFACE.

58, Romford Road,

Stratford,

November 28th, 1892.

A meeting of the Institute of Marine Engineers was held here this evening, when the Discussion on a Paper, by Mr. W. J. N. Brett (Associate Member), entitled "Steam Pipes, their Material, Workmanship and Arrangement," was resumed.

The Paper was read at a meeting held on Monday, November 14th, and was then partly discussed, further consideration on the subject being adjourned till this evening.

Mr. W. J. Craig (Member of Council) presided at both meetings.

The Paper was also read and discussed before the Members at the Bristol Channel Centre, in the University College, Cardiff, on Wednesday, January 25th, 1893, when Professor A. C. Elliot, D.Sc., presided.

JAS. ADAMSON,

Honorary Secretary.

SESSION, 1892-3

LORD KELVIN, President.

"STEAM PIPES: THEIR MATERIAL, WORKMANSHIP & ARRANGEMENT,"

BY

MR. W. J. N. BRETT.

(*Associate Member.*)

DISCUSSION

AT

58, ROMFORD ROAD, STRATFORD,

ON

Monday, November 14th, 1892.

THE CHAIRMAN.

(Mr. W. J. CRAIG, *Member of Council.*)

We have all heard this paper read with much interest, and I have no doubt you have all followed it very carefully. It reflects very great credit on Mr. Brett for the care and trouble he has taken in going through the whole of the points of such an important and comprehensive subject. I have noted a few of the points to which he has called attention, and I do not think he has omitted any that are very material. In the first place he has called our attention to a brazed pipe that failed through improper brazing—improper workmanship; 2nd. To a brazed pipe that failed in the solid metal and not at the brazing—failure of material caused by improper workmanship; 3rd. He deals with the quality of the material of copper pipes ; 4th. Instances of flaws in material, and the improper use of materials for brazing ; 5th. The testing of copper pipes and the different methods of same ; 6th. Solid drawn pipes and the method of manufacturing them, and the defects they are liable to ; 7th. Bends and T pieces of copper, and ways of making these *versus* gun-metal bends, &c. ; 8th. Ordinary flanges and ways of connecting them to pipes ; 9th. Patented pipes, flanges and specialities, and arrangement of same ; 10th. The effects of vibration and straining of a vessel on pipe arrangements generally ; 11th. Devices for strengthening pipes and so preventing failure and explosion ; 12th. Iron pipes as a substitute for copper ; 13th. General arrangements of pipe installations under the headings of allowance for straining, expansion, sharp bends, confined water and the draining of same ; and 14th. Brittleness on account of age. Now, there is a great field here for those who are members of this Institute, who are makers of pipes, or who have been employed about the making of pipes, and also for those who have the using and working of steam pipes at sea. Engineers at sea are able to take note of the services of these pipes, and, knowing what is required of them and what they have to undergo, will be able to tell us their experiences. I would, however, like to put it to those who may take part in the discussion, that it would be as well if their remarks were kept as far as possible under the separate headings that I have enumerated. It will make the matter much clearer when the discussion comes to be recorded in our " Transactions." Any Member reading what took place would then clearly understand to what any particular speaker was referring. I think we may now proceed with the discussion. The paper is a very valuable one and it relates to a matter which, especially in these days of high pressure steam, is of great importance in marine engineering.

Mr. F. W. SHOREY.

(*Member of Council.*)

The subject of the paper that has just been read is certainly a most interesting and important one, and great credit is due to the author for the way in which he has brought it before us. He has gone very fully into the whole matter, and has certainly given us some of the causes of the accidents that have occurred. There are still, however. some further points in regard to which I should have liked to have heard his views, although no paper of the kind could deal with every point that might be raised. I should like, for instance, to have heard him give us some opinion as to what are the best styles of expansion joints. He said that some of the causes of accidents and explosions are due to bad workmanship. Well, we are all painfully aware of that fact, but what is the best method of preventing some of this poor brazing? We have now come to times of very high pressures, and it is most important that steam pipes should be as sound and as perfect as they can be made, because when one of these pipes splits up on board ship it is impossible for those below to get out of the way quick enough. I believe the time will soon come when we shall have to give more attention to steam pipes than has hitherto been bestowed upon them. There is one method of preventing accidents which has been tried with very satisfactory results, and I think it a very good plan. It may not be any information to some of those present, but I know it to have been tried with excellent effect. The method is this. As soon as the fires are set away, open the stop valves to the steam pipes, but keep the engine-room stop valves closed, so that as the temperature rises in the boilers the temperature rises in the steam pipes also, and you thus get a gentle, steady expansion right through. I believe that many steam pipes burst through water hammering and through too sudden expansion. But by keeping the stop valves open in the way I have described, and letting the steam work gently through, the pressure on the pipes as well as the pressure in the boilers is increased gradually. Now about the scarphing. We, as sea-going engineers, have not much to do with that, because we are not makers of pipes, and the accidents arising from bad joints are due to bad workmanship. I believe you can braze a pipe and make it much stronger at the joint than at the other parts of the pipe. I have seen it done in the way the author has described, but the scarphs must be properly made. A great fault often found is in not having one scarph put on level with the other, so that a kind of gutter is formed and a weak place is at once created. Many a pipe has gone from that cause. There is also a danger in making the scarph too long. If you make a long scarph and the edges become too thin they are apt to curl up, and there is another weak spot. I think that if engineers who have to look after new engines would see to things of this kind a lot of trouble would be avoided. The author of the paper also speaks of machine planing, but the planing of these scarphs right along the pipes would hardly be practicable. A good coppersmith can make these joints quite as well by hammering them out as by planing. The paper then refers to Elmore's patent tubes. I have seen that process, and there is a firm here in London—Messrs. Blundell—which was the first to use Elmore's tubes, and they found them to answer fairly well. I have seen a piece of pipe made by this process cut through and put in the fire, when we found that it had large blisters both inside and outside. I believe that these tubes are not now going along so successfully as was at first anticipated. Mr. Brett says that these copper deposited pipes compare favourably in price with solid drawn copper pipes. As a matter of fact I believe Elmore's pipes are a farthing a pound cheaper. Mr. Brett also said that by this process you get a perfect pipe, but we found in one instance that the pipe was not parallel. We wrote to Elmore about it, and he replied that the mandrel did not happen to be correct. Regarding the hoops, I do not know exactly what Mr. Denny's idea is in having hoops round steam pipes, but I do not think they would strengthen the pipe much. They might prevent a slit from going up the pipe. I see, from an article in the *Mechanical World*, that the Naval Engineer Officers at the New York Navy yard have been testing copper pipes, and I will read you what their ideas are of hoops round steam pipes. The article says: "A comparison of the results obtained show nothing in favour of banded pipes; on the contrary it appears possible that under the conditions of test the bands may have exerted a detrimental influence on the final strength of the pipe. Placed just at the edge of the soft metal at the ends, they probably accentuate the irregular strains which occur at this point and cause the pipe to give way at lower pressure than it would, had they not been used. In any case it is shown that the bands, when spaced as they were, offer very little support to the intermediate metal if it is soft. It would be like putting a new piece of cloth in an old coat." I can only repeat that I should have liked to have heard the opinion of the author of the paper as to the best form of expansion joint, for I think that a great deal of the harm is done through not having pipes that will yield by expansion to the pressures to which they are subjected.

Mr. R. LESLIE.

(*Honorary Treasurer.*)

I fully agree with the Chairman and Mr. Shorey that Mr. Brett is entitled to great credit for the paper he has brought before us. It deals with a subject which at the present time is engaging a great deal of the attention of engineers, and it is a matter that cannot be too deeply gone into, especially in connection with an Institute of this character. Mr. Brett, to my mind at any rate, has treated the subject very fully and ably, and it speaks very well for our Institute that one of our associate members should have read such a paper. As far as my experience of copper pipes has gone—and I have been in twenty different ships—I must say he has treated it very fairly throughout, and the points set forth are to my mind as nearly right as possible. There are many points connected with the manufacture of copper pipes that need explanation, but really the two principal points, and the two which I look upon as being the only important ones, are, in the first place, the quality of the material, and, secondly, the workmanship. If these two are good I think the superintending engineer can look after the rest, but if you want a good pipe the quality of the metal must be good and it must be properly worked. I agree with Mr. Shorey as to the evil of turning steam of 300 or 350 degrees on to the cold pipes, which of course is just as bad as throwing anybody into a bucket of ice. There can be no doubt that the pipe gets a shock which certainly does not tend to improve it, and if there is a weak point in a pipe these shocks are just the things to find it out. When I went to sea I went even a little further than Mr. Shorey. I had all the stop valves opened, including those to the engines, and I used to heat up the engines at the same time that the boilers and the steam pipes were heated up. I think engineers on board ship cannot be too careful in the way they treat steam pipes when turning the steam on. If there is time to do it—and it is safer to take time—boilers, steam pipes and engines should all be gradually heated up together. I believe in doing things in a slow, determined way, and I think that the treatment of steam pipes at sea needs more care than possibly any other part of the machinery. I have seen pipes made of different qualities of copper. A sheet of copper may look to be perfectly good, but still, on the surface, if you examine it carefully, there are indications of slight cracks, and when you come to test it you find it is not good. It will not stand the strain that a better quality of copper will stand. With regard to the making of joints, there is a great deal in what Mr. Brett says in his paper. With a good coppersmith you may pretty well depend on the pipe, but in other instances, where men are not careful and where they are rushed or hurried through a job, I do not wonder that some pipes turn out badly. They may look all right on the outside, but very little trouble is taken about the inside, and it is in the inside where the evil arises. If you get good copper and good workmanship, there is not much to fear from copper pipes if they are well treated afterwards. There seems to be any amount of strength allowed, and with good material and good workmanship it only requires careful treatment to keep them running for any number of years. If you allow water-hammer action to go on in the pipes, you may just as well put them under the steam hammer at once, because nothing will stand it. It is well called "water-hammer" action. I saw one case where part of a main stop valve went up the engine room hatchway and was never seen again; and that once stood a pressure of 500 lbs. per square inch.

Mr. W. WHITE.

(*Member of Council.*)

I have listened with great pleasure and interest to Mr. Brett's paper, and would urge the importance of avoiding vibration, as far as possible, in connection with steam pipes. Make the pipes the proper size, give them the proper bend and the proper length, joint and build them up thoroughly, and do away with the vibration, and copper pipes will give perfect satisfaction.

Mr. BAKER.

(*Coppersmith.*)

I will on your invitation say a few words on this subject, and illustrate my remarks by sketches on the blackboard dealing with several details of copper pipe construction, and may explain what, in my view, are the causes of some of the defects complained of. Mr. Brett referred to a pipe the overlapping or joint of which was left open in some places, so that the surveyor could insert his tester about half-an-inch. If the joint of a pipe was left open in this way over-night, the workman could not make it sound the next morning; it is impossible. In another part of the paper the author said: "When finishing a brazed worked pipe it is usual to well planish the seam, a process which does the material no harm if the pipe is properly annealed afterwards;

but sometimes the pipe is subjected to the hammer afterwards, when the planishing can be carried to such an extent that the virtue of the material will be damaged by causing it to become hard and brittle—a dangerous quality in a copper steam pipe." But there is another source of trouble in a joint which the author has not referred to. They might well hammer a seam down, but as they had brass in the joint, when the pipe got under steam and the pipe expanded and contracted, the result sometimes was that they could put a knife underneath the edge of the bevelled copper at the joint, and the seam failed. The cause was that the brass did not expand in the same way as the copper, but this trouble could be overcome by covering over the seam with brass after the joint had been completed. Referring to Elmore's patent, I may say it is a copper depositing process and the surface of pipes constructed on this system is a series of waves throughout. If they bent a straight pipe made on this plan would it stand? So far as I know it has never yet been tried.

A MEMBER. Why not, if it is a homogeneous substance?

Mr. BAKER. Well, I ask the question. It has never been tried yet that I can learn.

A MEMBER. Could not the deposit be made on the bent pipe?

Mr. BAKER. That I do not know.

THE CHAIRMAN. Have you any doubt yourself about a pipe standing under the circumstances you have stated?

Mr. BAKER.

Yes, I have, but we have had no experience as yet. It is a new thing. Engineers grumble a good deal about upright joints, but it is because, as a rule, they are not properly fitted. If an upright joint is properly bedded and brazed, there is no better joint in the world. I complain that copper pipes are greatly handicapped and because they do not *always* stand the strain that is put upon them the poor copper pipe is blamed for everything.

Mr. GREER,
(*Member.*)

Referring to a complaint that in jointing a copper pipe the solder did not get in underneath the brazing, I would suggest that this difficulty might be obviated by having a flange with four or more lugs on it. I will illustrate my suggestion by the use of the blackboard.

Mr. C. McEACHRAN.

(*Member.*)

The author of the paper has dealt with the subject so fully that he has not left much to be said. I think, however, he said something about putting drain pipes on steam pipes. I think it quite unnecessary to do anything of the kind. My experience of drain pipes is that they are carried away and cause more trouble than they are worth. I think, as Mr. Shorey and Mr. Leslie have said, that if steam is got up in the boilers, steam pipes and engines at the same time, there is no necessity for drain pipes ; that is to say, if the steam pipe is above the level of the boilers. If a steam pipe has a bend in it in which water can lodge, you must have a drain to let the water escape, but it is very seldom that steam pipes are constructed like that now. I object to any arrangement by which a steam pipe is constructed in a trap form, with a part of the pipe so bent that water can lodge there. You must not drive the water into the engines or the result will be a breakdown. We ought to have a bend in all steam pipes, even if you can run them straight. If you have them straight you are bound to have a breakage of some sort, very often at the neck of the flange. They generally make the bend very easy, so that no water can accumulate in the pipe. It does not matter, however, if there is water in the pipe so long as the steam can pass over it. As Mr. Leslie remarked, you should get up steam in the engines at the same time that you get up steam in the boilers, because it is just as necessary to heat the engines quietly as it is to heat the boilers quietly.

Mr. SHOREY. Mr. Leslie has misunderstood me on this point.

Mr. McEACHRAN.

If you are standing in port for a long time there is no reason why you should not close the stop valves in your engine room when the engines have been sufficiently heated. But what is the use of drain pipes on the steam pipes ? There is one thing much more necessary on a steam pipe than a drain and that is a safety valve. I think that a safety valve on a steam pipe is perhaps quite as necessary as it is on a boiler, and I am of opinion that some of the explosions which have occurred may have been due to higher pressures than were believed to have been on the boilers. Now that steam pressures have been carried to 160 and

180 lbs. per square inch, there ought to be safety valves on the steam pipes n the same way as there are on the feed pipes.

Mr. Shorey. Where would you place the safety valve on the steam pipe ?

Mr. McEachran. Nearest the engine room.

Mr. Shorey. You think that when this water-hammer action comes on the safety valve would relieve it ?

Mr. Baker. With the rebound, yes.

Mr. Shorey. I doubt it.

Mr. McEACHRAN.

I think that there should be safety valves on all steam pipes, and that they are as necessary there as on feed pipes. No water rebounds in a steam pipe that is properly heated while steam is being got up. If an engineer has plenty of time in which to get steam up—and he ought not to get up steam without plenty of time—this water hammer action will never take place. The whole trouble arises through neglect or carelessness in not starting to get up steam early enough and in starting by opening the steam on to a cold pipe. It is unreasonable to expect that a cold pipe will stand the shock of the temperature of steam at a pressure of 100 lbs. per square inch. I consider that copper T pieces should be a thing of the past because there is so much work about them that it is very difficult for any coppersmith to avoid over-heating at some part, and then weakness arises. I consider that all T pieces should be cast.

The CHAIRMAN.

The discussion will now stand adjourned until Monday, November 28 ; the lateness of the hour calls for a close of the present discussion.

SESSION, 1892-3

"STEAM PIPES."

ADJOURNED DISCUSSION

HELD AT

58, ROMFORD ROAD, STRATFORD,

ON

Monday, November 28th, 1892.

THE CHAIRMAN.

(Mr. W. J. CRAIG, *Member of Council.*)

This is a meeting for resuming the Adjourned Discussion on Mr. Brett's paper, on the very important subject of "Steam Pipes." Those of you who were here on the last occasion will remember that we had a well sustained discussion, right up to the moment of closing. In fact, the discussion had to be closed rather abruptly. I see that in the *Engineer* of last week the remarks of those who spoke on the last occasion are given in a somewhat condensed form, and I would suggest that it would be a very good plan to re-open the subject by reading the report. I would, therefore, ask Mr. Adamson to read those remarks on the paper in the *Engineer*, and it may prevent any of the ground that was covered at the last meeting being gone over again.

* * * *

The Honorary Secretary here read the Report of the discussion.

* * * *

The CHAIRMAN.

That is a synopsis of the discussion when the paper was read. I believe that before we go any further Mr. Brett has something to say with regard to some of the remarks that were made at the last meeting. You will remember that I noted a few of the points that were raised in the course of the paper. I do not know whether Mr. Brett, in what he is going to read, will deal with those points seriatim, but it may be convenient that I should run over them again. * * * * You will see that they open up a very wide field for discussion, and after we have heard what Mr. Brett has to say further, we shall be very pleased to hear the remarks of other gentlemen present.

Mr. BRETT.

I think we are very much indebted to Mr. Craig for enumerating the divisions into which we can divide this interesting and important subject. It simplifies it very much and so facilitates discussion.

In reply to Mr. Shorey's remarks concerning expansion joints I must refer him to the paper. I said, "the arrangements for taking up the movements and expansion of pipes are important, and as such deserve due consideration. In all cases where the design of the pipe is made to allow for its movements, I think the material under this condition and the action of vibration and temperature is unduly stressed and liable to rapidly deteriorate in quality and probably to crack; but if the safest form of gland and socket expansion joint, with safety collar to prevent drawing out, is properly placed and fitted the resulting evil of this triple action is very small." Mr. Shorey will now see that I am not in favour of working the material into such a shape as to take up a known movement in a range of piping. Mr. Shorey asks "What is the best method of preventing poor brazing?" The paper is, if anything, rather strong on this point, because it deals with workmanship, burning of material, a too free use of borax, impurities in the fire, the introduction of a brass solder of great strength and comparatively low running temperature, &c.; but although the list is very complete, I would like to add the necessity for absolute cleanliness of the surfaces that have to take the solder. I cannot agree with Mr. Shorey when he says marine engineers have little to do with the scarphing of a seam. They should look after the making and repairs of copper pipes very much more than they do at present, and not leave the matter almost entirely in the hands of the coppersmith. With regard to binding pipes, I think Mr. Shorey will see that I am of his opinion when attempting to strengthen copper pipes with iron bands; but I firmly believe that binding a pipe by hoops, with the modifications I state in the paper, by wire-binding, or as I suggest, by a flat strip wound spirally round the pipe, will prevent a fracture from extending to a dangerous length. None of these measures should profess to strengthen a pipe and should not be used with that idea unless like materials are employed, when a certain amount of support will be given to the pipe. If binding is resorted to, copper should be the binding material for a copper pipe.

I entirely agree with Mr. Shorey and Mr. Leslie in the method of warming steam pipes before the full pressure is admitted. In fact Mr. Leslie's simile about throwing somebody into a bucket of ice, is a happy one, even if it is not a practical one. In my opinion the opening of the stop valve was an important factor in a recent and disastrous steam pipe explosion.

Mr. White will see that I lay great stress upon vibration, but I am under the impression that his remarks point to the vibration of the pipes themselves, due to their own defects. The passage in the paper reads ; "In the fitting of steam pipes, I must strongly denounce the practice of drawing pipes up to their places with bolts if they do not fit. Where this practice is followed, I should be inclined to think that the fixing of the engines and boilers themselves was not satisfactory, and the resulting vibration, acting upon a pipe or pipes, held in a strained position, is sufficient to damage even the best brazed seam or flange. More attention should be paid to the fixing of engines and boilers, and to the balancing of the working parts of engines, and I am glad to see the attention of one eminent experimentalist at least diverted in this direction. Vibration is not only a source of discomfort but a danger, a deteriorating action upon the whole structure, so we cannot expect steam pipes to remain unaffected by it." Mr. White will not remedy this state of things by making, fitting and fixing the pipes properly ; something more is wanted, and that something is to balance the working parts of the engines and to properly bed and secure the engines in the ship, and only this will reduce vibration to its minimum.

I was glad to hear Mr. Baker. He prefaced his remarks by saying he was a coppersmith, and I think his comments agreed with the details of the paper very well.

I am decidedly against Mr. McEachran's idea of doing away with drain pipes and I will go further and say that they should be more frequently fitted. If they are often carried away it is surely not impossible to prevent it. Drain pipes can be fixed and used without causing any trouble and, moreover, they should be used and not kept as ornaments.

With regard to the idea of fixing safety valves to steam pipes, I should like to ask the question, is the resulting force of water-hammer action exerted simultaneously all round the internal circumference of the pipe? I think not. Water-hammer action is a bubble of steam in water which, by its lower temperature, condenses the steam in the bubble and the water under the influence of the full boiler pressure fills the space occupied, first by the steam and afterwards by the partial vacuum—the instantaneous collapse of which produces the noise that accompanies this conflict of steam and water. My opinion is that these bubbles are formed locally—if I might use such an expression—*i.e.*, at different places, either in the midst of the water or directly on the internal surface of the pipe and that the sum of the force of the blows is not exerted in increasing the total internal pressure; consequently a safety valve, fixed next the engine stop valve as suggested by Mr. McEachran, would be useless. Water-hammer is more dangerous in the crown of a bend than anywhere else, because the bubble rises in water and the sides of the crown are the weakest parts.

The CHAIRMAN.

Mr. Brett has gone over the remarks of most of those who made observations on the last occasion. Of course they were only general and spontaneous observations, not studied, but Mr. Brett has taken them up and studied them out. If any other Member would now like to make any remarks on the subject we shall be pleased to hear him.

Mr. A. LAWRIE.

(*Member.*)

I have no remarks to make except that I have been many years at sea, but never saw a bad steam-pipe yet.

Mr. G. CLEGHORN.
(*Member.*)

I have really very few remarks to make on this paper, Mr. Brett having already dealt with the subject so thoroughly. He has given us a great deal of information about the material and the workmanship, and about the method of treating the pipes while they are being made. He has also given us some suggestions which are very valuable, and I agree with him in everything in that respect. If you have copper of good quality, and the pipe is made by a workman who knows his work, and he is not hurried over the job, I think the result will be a reliable pipe. It is all a question of price. There is no doubt that if a shipowner or anybody else who requires a pipe is prepared to pay for it, he will get a pipe that he can rely on for any pressures we are using at the present time. With regard to the suggested method of strengthening pipes, Mr. Shorey has cited authority to show that bands are detrimental. I do not see how that can be. You all know very well that putting a ring round a furnace strengthens it, and I have no doubt that by putting rings round a steam pipe, you practically reduce the length of the pipe and so strengthen it. Mr. Brett has suggested applying bands with an oval or a flat section in connection with the pipe instead of a round section. I quite agree with that, but I think the best thing you can have is a spiral strip of copper round the pipe. Take a strip of copper, say twenty feet long, and wind it spirally round the pipe. I do not think you can have any better method than that.

THE CHAIRMAN. Would you solder it to the pipe?

Mr. CLEGHORN.

Yes, I would. Then Mr. Brett says in his paper that he would advocate the use of a brazing material of a high melting temperature.

Mr. BRETT. No; a comparatively low temperature.

Mr. CLEGHORN.

Oh! Then I misunderstood you. I was going to point out that if you put the temperature too high it would melt the pipe. I think the method proposed by the coppersmith who spoke on the last occasion, of running a stream of metal into the joint and entirely covering up the seam, a very good idea. With regard to the proposed introduction of a relief valve into the steam pipe, I do not see how it can be done. I do not think there is anything to beat a drain pipe, and there should be a good many drain pipes. Some years ago I thought about putting a relief valve into a pipe to do away with the danger from water, but I could not think of any form of valve that would be suitable. The valve would have to be made to lift at or above the working pressure. I have seen three main steam pipes go, and in neither case had we anything like the working pressure on. The cause of the pipes going was this water-hammer action, and the highest pressure in either of the three cases was a pressure of 22 lbs. The accidents were due to water in the pipes.

THE CHAIRMAN. What sizes were these pipes ?

Mr. CLEGHORN.

One of them was a ten-inch pipe. Steam had been got up, the engines had all been heated and tried, and then everything had been shut up. If there had been any relief valve on that pipe, and it would not have been made to rise at less than the working pressure, it would not have lifted unless the valve had been at the very spot where the pipe went. I agree with Mr. Brett that this water-hammer action is entirely local.

Mr. M. B. TYLER
(*Member.*)

I agree with the greater part of Mr. Brett's paper, but there is one part to which I take exception. I refer to that portion where the author expresses his aversion to steel steam pipes. I see nothing to prevent steel steam pipes being used, and I believe that, if not to-day, we shall in the near future be able to obtain solid drawn steel pipes of sufficient diameter for the present high pressures. Some five years ago I saw a steel pipe which had been in use for nearly three years in connection with a high pressure job on board one of Messrs. Fisher, Renwick & Co.'s boats, and there was nothing apparently amiss with the pipe, either internally or externally.

I do not see any reason whatever why steel steam pipes should not be used, and I think that in the near future they will be the pipes of the day, not only on the score of expense, but also on the ground of suitability. I agree with Mr. Brett very heartily in his remarks about water hammer action. I think that when a pipe bursts it is due to action that is entirely local, and I think the cause of pipes going arises a great deal from unequal expansion.

If there is water in a part of the pipe, that part cannot be heated so quickly as the other parts, and there is consequently a portion of the pipe where the strain becomes so great that the pipe will not stand it. Mr. McEachran suggests that there should be safety valves on steam pipes, but the valves must be made to lift at not less than the working pressure, and if that is so, will they accomplish the object in view ? I think not, because I contend that explosions are due, not to excessive pressure of steam, but to entirely local action, arising in most cases from extreme expansion or contraction at one particular place. I know of one case where a steam pipe burst with one end open. One gentleman—I think it was Mr. White—compared the escape valve on a feed pump to a valve on a steam pipe ; but the two things are for entirely distinct purposes. The valve on a feed pump is to meet a case of neglect in opening some of the valves, and not because the pressure will ever become abnormal from any other cause. One other matter as to which I wish to say a word is in regard to the flanging of steam pipes. I believe you can have a pipe too stiff in the flange. Often when you examine an old pipe you will find the copper behind the flange thinner than the other part of the pipe, and that is really the most dangerous part of the pipe.

Mr. Brett. You referred, Mr. Tyler, to a steel pipe that had been in use for some time. Do you allude to the pipe of the "Claremont ?"

Mr. Tyler. I cannot give you the name, but it was at Newcastle, and the pipe when I saw it was practically as good as new.

Mr. Brett. I dare say it was the same. I have gone fully into the pipe of the "Claremont." It was a good test for an iron steam pipe.

The Chairman. With regard, Mr. Tyler, to that incident of a pipe bursting or rending with one end open, were you speaking of that as a matter of fact ?

Mr. Tyler. It was a fact within my own personal knowledge. It was a four inch pipe. The steam was turned on by accident and the pipe burst. The burst was three inches long and close to the brazing. I do not believe that pressure has anything to do with the bursting when you turn on the steam suddenly. The action is entirely local.

Mr. KIRKWOOD.
(*Member.*)

I cannot see that there is any objection to a valve on a main steam pipe. There is one fitted in the ship on which

I am now engaged, and when we have to stop the engine suddenly the valve on the steam pipe is the first to blow. I consider drains on steam pipes very necessary, but I think that automatic steam traps would be even more desirable.

THE CHAIRMAN. At what part of the steam pipe, Mr. Kirkwood would you advocate fixing the safety valve ?

MR. KIRKWOOD. The top.

THE CHAIRMAN. The top of the bend ?

MR. KIRKWOOD. Yes.

THE CHAIRMAN. The highest part of the pipe.

MR. KRIKWOOD. I know that in the ship I am in, that is the valve which always blows first.

THE CHAIRMAN. Presuming you have a trapped shaped steam pipe, with the trap before coming to the highest point of the pipe where you put your valve. In that case would you still fix a safety valve ?

MR. KIRKWOOD. Yes. It is when you are running at full speed and have to stop suddenly that they come in most handy. I recommend them, not as a relief for water hammer action, but as being most useful when the engines have to be stopped suddenly.

Mr. W. W. WILSON.
(*Member of Council.*)

Except for the purpose of eliciting some further information regarding the Elmore process of manufacturing copper pipes, I did not intend taking part in this discussion. That information I obtained from the remarks which were made at last meeting without necessitating me asking the questions, and it seemed to confirm my belief that there was but little advantage gained by this method. The course which the discussion took, however, causes me to think that something further ought to be said regarding some of the points referred to in the paper.

In the first place, therefore, it appeared to me that Mr. McEachran sounded a somewhat discordant note in the discussion, judging from the interruptions which occurred while he was explaining his views, interruptions which I was very sorry to hear. In my opinion, the position which he took up regarding draining of main steam pipes was correct, and that there is no necessity for drains where these pipes have a fall from the engines back into the boilers, though where they are led in such a way as to form a well, I do consider that it is imperative a drain should be fitted at that part.

Reference has been made in the paper to the testing of main steam pipes by hydraulic pressure to double the working steam pressure. No doubt when pipes are new this is a very wise precaution, but why it should be insisted on in the case of old pipes in their places on board ship, I confess I cannot understand. No one ever thinks of testing an old boiler to double pressure (and I think the feeling now-a-days is that even new boilers should not be so tested). Why then should we be required to do so in the case of steam pipes? Even the very parties who demand that copper pipes shall be tested to double pressure seem to recognise that it is not quite the right thing to do, for in their own instructions to their surveyors they say that in applying the hydraulic test, "Care is to be taken in the case of old boilers not to overstrain them, but the test must always exceed the working pressure." Why, then, should not "care be taken" in the case of old steam pipes also? No one would object to testing a little over the working pressure, but if it is necessary not to "overstrain" old boilers, is it not as much necessary not to "overstrain" old pipes? In my own opinion considerable damage is done by this testing, and it is a very doubtful means of decreasing the cases of burst steam pipes, which presumably is the object in view. I am aware of three cases (and I daresay there are many more were we to inquire closely) in which steam pipes have burst very shortly after the double pressure test had been applied, and though I cannot definitely say so, still I am inclined to think that that same test had a good deal to do with the accidents. I say that all the tests that we like to impose will not prevent these accidents taking place, for so long as care is not excercised by those in charge and steam is carelessly raised and stop valves carelessly opened, we must expect to have burst pipes. Mr. Leslie and Mr. Shorey both drew our attention to the troubles arising from these causes at last meeting, and I am only too glad now to be able to support their remarks by saying that care and common sense on the part of the marine engineer will do more towards diminishing the number of steam pipe explosions than all the legislation in the world, of course always granting that material and workmanship are satisfactory, which ought to be ascertained when the pipes are new.

Annealing of pipes is, I think, a good suggestion, and might be carried out when at any time they are taken down for repairs, but to have them taken down for this purpose specially, would, I agree with Mr. Brett, be a somewhat expensive proceeding, and would, no doubt, be much objected to by the shipowner.

For the purpose of reducing the possibility of opening stop valves too suddenly, I have seen in a number of instances a very good idea applied. This consists of a small connection betwixt the top and bottom of the stop valve, so that when the stop valve is shut this can be opened, and the empty pipe gradually filled until the pressure on each side of the valve is in the equilibrium, when the large valve can be opened easily without any risk or trouble. I consider this a very good plan, and it certainly would be a very serviceable fitting to all stop valves.

With regard to the proposition made by Mr. McEachran, of having a safety valve fitted on all steam pipes, I do not think it is practicable, for, with Mr. Brett, I think that the water-hammer action is purely local, and would not at all times be relieved even were a valve fitted. Mr. Kirkwood tells us that in the ship in which he is at present serving there is a safety valve fitted for this purpose, but I am afraid that Mr. Kirkwood has misunderstood the object. To the best of my knowledge (and I think I am speaking correctly), the valve so fitted has been placed there more as a sentinel than for any other purpose, and being so it is usually set to blow off about two pounds less than the boiler safety valves. Mr. Kirkwood, however, makes a very good suggestion, which I think might be more utilized than it is at present. I refer to the use of steam traps. Recently I have seen one of these applied for draining the jackets of the main engines, and I am assured by the chief engineer that under certain conditions it has given exceedingly good results. The patentee, however, having made some improvements in the construction, asked to be allowed to substitute one of these improved ones instead of the old one, so it was removed, and I cannot say how the new one has worked, though I should judge from what I saw of it that it would be quite as effective as the old one.

At our last meeting Mr. Tyler drew our attention to the general complaint arising from the fracture of pipes round the brazing at the back of the flange. I think we are all agreed that some improvement is wanted for the purpose of removing this drawback, and it was with this object in view that the flange described by Mr. Greer was designed. I am informed that this flange has served its purpose very well, and I was assured recently, by the manager of a large engineering firm who hold a license for its manufacture, that, although they use it somewhat extensively now, they have not found it to fail in any instance. I hope to be able to judge for myself on this subject shortly, as I have just seen one fitted on a main feed pipe.

Mr. T. W. FISH.

(*Vice-President.*)

The presence of high-pressure boilers in our modern steamships demands the employment of safe and reliable steam pipes. These have, in many recent instances, been made of iron and proved to be both strong and reliable under extreme pressure.

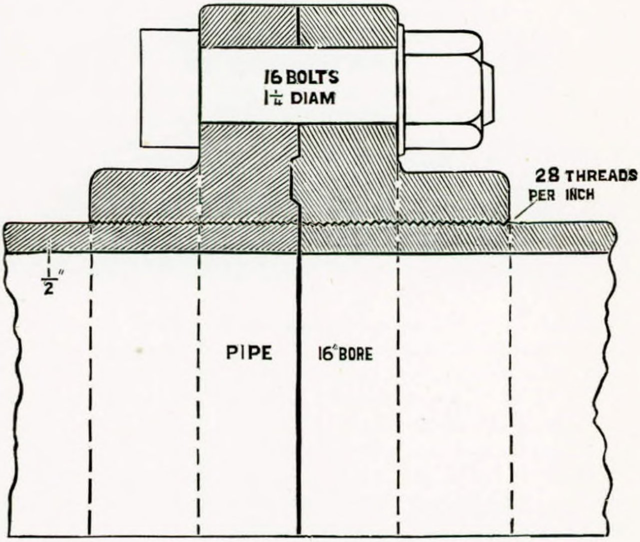
Copper pipes have been preferred to iron pipes on account of their superiority in some respects, for they are not liable to corrosion from water or moisture, and, owing to their higher elasticity, they adapt themselves more readily to straining incidental to the working of a vessel in a sea-way.

On the other hand, while the tensile strength of copper is injuriously affected by a high temperature, that of iron is not thereby influenced to any appreciable extent, and the heating of the former for brazing at the seam may result in occult damage to the pipe, by seriously diminishing its strength.

Lap-welded iron steam pipes have been and are being adopted in many of the largest and most powerful steamships. If iron pipes to withstand high steam pressures be carefully manufactured in straight lengths (or nearly so), satisfactorily tested, and when fitted in place care be taken to provide a sufficiency of expansion joints (preferably made of gun metal and of the stuffing box and gland type), their use will result in greater increased safety over copper pipes.

Lap-welded iron pipes 20 in. bore and $\frac{9}{16}$ in. thick for a working pressure of 165 lbs. per square inch, have been satisfactorily tested and fitted aboard ship. A mode of procedure in manufacturing reliable iron steam pipes, and a description showing a method of fixing the flange to the body of the pipe, may prove of some little interest to some of our members and are herewith simply detailed:—

The plate is rolled from a well-hammered billet and, before being formed into a tube of the required bore, its edges are prepared for lap-welding by being dressed and bevelled. The welding is accomplished in the ordinary way by a suitable heat from a coke fire and hammering from a small machine, as is practised in the welding of a plain furnace for a marine boiler. The tensile strength of test pieces, with the weld across, taken from pipes made in this manner, differed so slightly from that of the solid plate as to be practically of no account as affecting the strength of the tube. The ends of the pipe are prepared for receiving the flanges (also of malleable iron) by being cut with a fine thread in a lathe. The flanges being screwed on are further secured in position by expanding the ends of the pipe while yet in the lathe.



Mr. JAS. ADAMSON.
(*Honorary Secretary.*)

I thought it would be of interest in connection with our discussion to-night to give the results, with a few remarks thereon, upon a test which was conducted with a view to ascertain how much a certain steam pipe would stand before actually bursting. The tests were conducted very carefully, and the results noted in detail. It would be weariness to the flesh to give the whole of the figures, but I will give you the main points. The pipe was originally 6 ft. 5¼ in. long, and there was a flange at each end. There were thirteen bolts in each flange. The pipe while being tested was connected on to the force pump, and the circumferences taken at the several pressures.

Prior to these tests being made the pipe was tested on board the ship up to 320 lbs., which was double the working pressure, and it stood the test all right. With regard to the subsequent tests it should first be stated that the dimensions of the pipe taken before testing were as follows :—At A, $22\frac{7}{32}$ in. ; at B, $20\frac{1}{16}$ in. ; at C 20 in.; and at D, $20\frac{2}{32}$ in. The results of the tests showed that at 300 lbs. and 500 lbs. pressure there was no alteration in the circumferences. When 600 lbs. pressure was reached a very slight change took place. There was a slight fullness at C, where the circumference had increased to a shade over 20 in., the other dimensions being the same as before. At 700 lbs. pressure there was a slight fullness at the end of the pipe marked D, about 6 in. from the socket part of the flange. At 800 lbs. pressure the dimensions had increased, at B to $20\frac{5}{32}$ in. and at D to $20\frac{1}{8}$ in. At 1,100 lbs. pressure the joint gave out at the flange, where the brazing was also started and leaking, and when the pressure was removed there was found to be a permanent set to the following dimensions :—A, $22\frac{9}{16}$ in. ; B, $20\frac{15}{32}$ in. ; C, $20\frac{1}{16}$ in. ; and D, $20\frac{3}{8}$ in. After the joint had been re-made the pressure was increased to 1,200 lbs., when the pipe burst at the bend. It split exactly at the lap, and of course the copper there is very much thinned down. The burst is exactly opposite the edge of the inside lap. This pipe had been in the ship for $4\frac{1}{2}$ years, and there was some little doubt as to whether it had been tested originally to double the working pressure. That was the reason why it was tested to destruction to see what it would actually stand.

A MEMBER. Had the pipe been made in two halves ?

Mr. ADAMSON. There is a seam on both sides. It is a straight seam right through, not laced. I have here a description of how the pipe was made, and I will read it to you. "The method by which the bend was made is stated to be as follows :— The sheets were first cut to the required size for the two portions of the bend, and their longitudinal edges were thinned down to form the laps, and then 'rounded off' to prevent them from cracking, the intended width of lap being in this case from $\frac{3}{4}$ in. to $\frac{7}{8}$ in. The positions of the extreme points of the bend were then marked off and the two parts were worked to the shape required. During the latter operation each portion was probably placed in the fire about half-a-dozen times for the purpose of softening the material after it had been hammered. The two portions were then put together ready for brazing, a length of about 6 in. being brazed at one time, the operation being, however, continuous—that is, the pipe was not taken off the fire until the brazing was completed. After this the pipe was thoroughly cleaned and scoured, and subsequently it was planished with a view of toughening the copper. The most suitable end was then 'worked out' to receive the straight portion of the pipe to which it was brazed, and the flanges were afterwards put on in the positions required. The mean length of the bend measured along the seams from the face of the flange was 2 ft. $4\frac{3}{8}$ in.; its mean external diameter was 7 in. very nearly, and the radius at the throat of the bend was also about 7 in. The flange, which had been secured to the stop-valve chest by twelve 1 in. bolts, was 14 in. in diameter, and $2\frac{1}{16}$ in. thick, the central collar being 1 in. deep." This pipe actually gave out at a pressure of 7·5 times the working pressure. I think the general practice is to make them with a margin of from 9 to 10, so that the actual margin of safety in this case was rather less than usual. But there is no mistake that this pipe gave out owing to the thinning down of the copper, and it gave out at the place where they usually give out, viz., where the inside lap joins the outer lap to make the joint. One of the speakers in the course of the discussion referred to the bursting of a pipe which I think it was said gave out when there was only 10 lbs. pressure on the boilers. That may have been due to peculiar circumstances.

I think we shall all agree with what has been said about drawing up steam pipes to bolt the flanges together. With reference to the practice of hooping pipes mentioned by Mr. Brett, as patented by Mr. Peter Denny, I believe the reason why Messrs. Denny put hoops or bands round steam pipes was to minimize the danger to life and limb, if any pipe did burst, and they hold that the banding of pipes by their process certainly strengthens them. This is not borne out apparently by the tests made by the naval engineers of the United States, but Messrs. Denny & Co. have carried out a great number of tests and they are thoroughly satisfied that the banding of steam pipes on their plan is certainly a very great addition to the strength of the pipes. The testing of old steam pipes up to double the working pressure is, I know, a sore point with many of us, but I cannot say that my experience has been exactly the same as Mr. Wilson's. I have never seen a pipe give out immediately after the tests. I understood it was the general practice that whenever a steam pipe was repaired it should be tested up to double its working pressure, no matter how old it was. Mr. Thomson showed me a pipe some few months ago which was certainly one of the most peculiar I ever saw. It was a pipe about 14 inches in diameter, and was grooved in a most remarkable way, as if it had been scooped out. It happened at the bend and I do not know what the action could have been to bring the copper of that pipe to the state it was in when I saw it. With regard to Elmore's process, I remember that about a year ago I tried to get a quotation from them for steam pipes of ordinary dimensions. They could not, however, supply me with quotations, and I was somewhat surprised to learn recently that they had not only quoted prices but had actually made pipes. I am inclined to think with Mr. Wilson that there is not very much in Elmore's process. Messrs. Brown Brothers, of Edinburgh, deposit copper on the rams which they supply for hydraulic machinery by much the same process, and when I was in Edinburgh last summer, I saw some rams undergoing the process. It occupies a long time. I think they take two days to deposit the copper upon a 2 in. ram, so I should be inclined to think that copper pipes made by the Elmore process would be much more expensive than the solid drawn copper pipes.

The CHAIRMAN.

We have had another evening's prolonged and profitable discussion on the very important subject of steam pipes, and I daresay we all have a clearer knowledge of the various points connected with the subject than before the paper was read. Judging from the nature of the discussion, or rather from the form of many of the contributions thereto, which were much more of an interrogatory or enquiring nature than is usual in this Institute, it would appear that an interchange of views, supported as they were by the results of experience and actual experience in practice, was necessary for the confirmation of opinions on some points that were previously rather obscure. This, of course, is generally the *raison d'etre* of a paper, though it seldom applies to papers read at this Institute, which are mostly on subjects the whole details of which are every-day practice and the life experience of the members. The address on "Steam Pipes," which has led to this discussion, thus justifies its importance as a paper and Mr. Brett's selection of it as a subject, and for several reasons, one of which is the fact, which was admitted throughout the discussion to-night, that manufacture has much to do with the efficiency of steam pipes. Most of us have not enjoyed the advantage of a coppersmith's training, but those who have had that advantage have made the methods and the matter clear to us, and I think we should be so well pleased with their assertion of unbounded faith in a well-made and well-brazed pipe that we should forgive their trade reference to an unappreciative world that "won't pay for good work and good material." The high pressures now obtaining have recently brought steam pipes into such disastrous prominence that it is no wonder that such a subject should receive serious consideration, not only from us, but also from all concerned in the use of steam pipes and their manufacture. I feel sure, therefore, you will endorse my sentiments with regard to the importance of this contribution to the transactions of our Institute, coming as it does at a time when so much attention is being given to the matter by all interested, and my view is more than fully borne out by your own earnest discussion of all the points connected with it. These points have all been so fully dealt with that there is little left for me to say further than that there are several minor points which have just occurred to me when looking over the report of the last meeting. These I will indicate more as a matter of policy than anything else, because the transactions of our Institute seem to be of some considerable importance to others besides ourselves, and though we are not bound to recognise interpellations of our own private literature otherwise than by our own members as expressed in course of actual attendance, still, on some points, such as those I am going to mention, it would be as well that the report of these proceedings should be fairly clear, even for the sake of our own members who have not been present, if not for those outside who might consider they could interpret our reports unfavourably, and do so, seeing that we cannot very well restrict their perusal, unless, perhaps, we make them less interesting. However, I notice that Mr. Brett in the course of his paper alludes to the cost of the different kinds of steam pipes, and indicates those made on Elmore's patent process for consideration. The point has been taken up by several members during the discussion, but I think it should be made clear that this patent process can include the taking of the copper direct from the ore and depositing it in the form of a pipe or rod casing, as well as from the manufactured ingot, thus saving all the intermediate and costly processes of handling, smelting, refining and manufacturing up to the ingot stage. I shall be very pleased to explain this process fully to any one interested, a specimen having been specially prepared for the company I represent in view of their negotiating for the coating of their hydraulic rams, which you know, I dare say, are of rather exceptional dimensions, being 28 feet in length. This process is peculiarly well adapted for such purposes, as in this instance the great pressure—5,000 lbs. per square inch—will not admit of any butts, laps, or even brazed junctions of any kind, but must be a casing or a single piece, enclosing the whole piston like a stocking. Some of these rams are at present fitted with a copper casing drawn on the full length. These are of course not covered over the top end section, although they are covered at the bottom end and all round their circumference to the top end, where it is not necessary, being always outside of the pressure area. This explanation may serve to satisfy those, concerned or otherwise, to whom our transactions are interesting that a better understanding of many minor points and details can be attained by attendance at our meetings than can possibly be gathered from the reports, even if it were expedient from a publishing point of view to record everything in print.

Mr. WILSON. I was not aware until to-night that in Elmore's process the pipes were made from the ore. I thought it was only the crude copper and not the ore that Elmore dealt with. I thought he dealt with the copper after it was smelted.

THE CHAIRMAN. No, the ore.

Mr. WILSON. It seems an incredibly long time to make a pipe on this process—168 hours. That must run up the expense terribly, I should say, even if you do make it from the crude ore.

THE CHAIRMAN. It is all automatic, without much labour.

Mr. ADAMSON. Before closing the discussion on the subject matter of this Paper, it will be of interest to call attention to the following notice in reference to Main Steam Pipes of iron and steel for high-pressure marine and other boilers, issued by the firm of Messrs. A. & J. Stewart, Limited.

"A few months ago we sent you detailed results of tests made on Wrought Iron Lap-welded Main Steam Pipes manufactured by us, intended to take the place of Copper Pipes hitherto used on board steamships. Since that period we have completed several extensive Installations of Main Steam Pipes, diameters ranging from 20 in. to 6 in. inside. These pipes were made under the most stringent conditions, and have now been at work for some time, fulfilling the requirements of the specification in the most complete sense.

"In the issue of *Engineering* dated 21st April, 1893, a descriptive notice of the new Cunarder, 'Campania,' appears, from which we take the following extract relating to one of the Installations in question :—

> 'It is an easy transition from the feed arrangements of the boilers to the steam pipe connection with the engines. The whole of the main steam pipes in the two ships are of wrought iron, with lap-welded joints. These are the first Atlantic vessels fitted with these pipes, and the departure from copper has been determined upon after very careful tests carried out by Mr. Laing, which tests satisfied him that the wrought iron pipes used gave greater security against mishaps.
>
> 'We published the results of these tests in a previous volume (see *Engineering*, volume 52, page 519), but it may be here stated that a pipe of $11\frac{1}{4}$ in. bore, with metal of $\frac{13}{32}$ in. thickness, was subjected to hydraulic pressure up to 800 lb. to the square inch without showing any effect, and it did not burst until the pressure reached 3,100 lb. to the square inch. A much smaller pipe, of 8 in. bore, and of metal $\frac{5}{16}$ in. thick, showed no movement nor leakage at 1,600 lb. pressure, and only burst at 2,800 lb. The compression and tensile tests gave results equally satisfactory.
>
> 'The pipes used in the Cunard Steamers were all supplied by Messrs. A. & J. Stewart & Clydesdale, Ltd., Glasgow. The largest pipes are of 20 in. bore, and the thickness of metal is $\frac{9}{16}$ in.'

"We will be glad to quote prices for your requirements in Main Steam Pipes of any diameter from 24 in. to 3 in., either in Iron or Steel, on receipt of specification or detailed drawings, showing the Installation complete."

BRISTOL CHANNEL CENTRE.

PRESIDENT:

PROFESSOR A. C. ELLIOTT, D.Sc

DISCUSSION

HELD IN

THE UNIVERSITY COLLEGE, CARDIFF,

On Wednesday, January 25th, 1893.

Mr. FIELD.
(*Member.*)

I have found that the best plan of making pipes of large diameter is by thinning the edges to be brazed uniformly, scarphing these edges zig-zag, and brazing the joint from inside of pipe ; by this means the brazing metal should be run completely through the joint.

In making quick bends or branches, a good plan is to build them up and braze the parts together ; by this method you should retain a greater uniformity of thickness in the metal throughout the bend or branch.

A good way of testing is to plug or blank flange one end of the pipe, set it on end and fill with water, and test the brazed parts by tapping the joints smartly with a small hammer.

Mr. J. McCALLUM.
(*Member.*)

My impression on reading Mr. Brett's paper was one of disappointment that he had not treated the matter more completely. Possibly the absence of diagrams and illustrations has something to do with this, but I take it for granted that we are met this evening to discuss more particularly the copper steam pipe, and the cause of its failures, rather than the cast iron steam pipe and its behaviour on shipboard. I think we all agree that the former metal has qualities which the latter does not possess, such as a high tenacity and elasticity, and that it is the favourite material for steam pipes and is eminently fitted for the work it has to do.

No one will dispute Mr. Brett's assertion that the solid drawn pipe is superior to the brazed one, but with this disadvantage, that we have not got machinery to bend it to the necessary form when the pipes are above 9 in. or 10 in. diameter, so in large diameters we have to fall back on the worked and brazed bend, and before we discard it, it would be as well to analyze some of its defects and failures, and its adaptability even for straight lengths.

We have no occasion for alarm at these failures. They teach us a lesson: defective machinery and boilers before this have given out with equally disastrous results.

Criticising Mr. Brett's paper, I do not agree with the decisions arrived at by the experts as to the real cause of failure, namely, that the copper was burnt in the operation of brazing.

Now, in the first place, when a piece of copper is burnt the fact is so evident that it requires no magnifying glass to detect the flaw, and if we are to believe the pipe mentioned was really burnt, then the one who passed it is the one responsible; but I think you will agree with me when I explain what is, in my opinion, the cause of those flaws and where to look for them.

Take for example the manufacture of a 10 in. main steam pipe bend. The workman, after selecting a suitable sheet, works the throat and back of the bend out of it, thins or bevels the edges, and puts the seam together, either in the ordinary straight way or by cramping it, afterwards brazing and planishing it to take out all the indentation.

Now in all cases when edges have to be thinned or bevelled down, it is not true they have a tendency to crack if the metal be treated in the proper manner—namely, the edge of copper plate is trimmed and rounded over with a file and worked to the bevel by hammering uniformly along its length and by steps as it were to the edge; if the edge is not treated in this way and the thinning down to the edge done in stages less than 4 in. long, cracks will sometimes appear.

Planing of the bevel edge, suggested by Mr. Brett, would certainly obviate this, but the work of planing the thin copper would be so difficult and tedious that few firms would care to undertake it, as no other advantage would be gained by this expensive treatment.

Any engineer in making a spliced boiler joint of ordinary packing would fit the bevel ends neatly together to ensure a reliable joint, and the same exactness is required in the fitting together of the bevelled edges forming the seam of the copper pipe, especially in fitting the back and throat of a bend together, where the seams are apt to overlap each other irregularly, if treated unskilfully.

This bad fitting of the bevels is mentioned in the fourth clause of Mr. Brett's paper.

When brazing the joint, the solder is best applied in the inside of the pipe, where it floats with the heat and insinuates itself between the edges, often bagging the lap with its weight and running through to the fire. The skilful workman at this point presses the bagged copper into its place again, and in so doing leaves the least possible amount of solder between the copper sufficient to make the joint reliable, the blast at this moment being shut off and the brazing done in lengths of about 4 inches.

If any of our Members will take the trouble to examine the inside of any defective main steam pipe which comes under their notice and which has developed a crack, otherwise than at the flange, he will invariably find the flaw in the vicinity of the seam, and in the records of pipe explosions the evil has been located there ; he will also observe the inside edge of the lap distinctly defined and prominent, the edge being in wake of the crack showing outside.

I may mention that for some time past I have taken particular notice of this feature in the many steam pipes which come under my observation for repair, and the defects have appeared as I have described. My conclusions were that this did not originate in a burnt seam, but was the result of too much hammering, the distinct sharp edge of the inside lap starting the mischief, which the working of the pipe afterwards aggravated till it developed into a crack visible on the outside. This, in my opinion, is the origin of the cracks, and not burning of the seam, and it can be tested any day with a piece of ordinary copper.

To obviate this evil, and after planishing the pipe, the seam outside should be clayed and another lot of solder floated inside, at the same time turning the pipe a little, to permit the objectionable edge of seam inside being covered. (*See specimens.*) This is a sure cure, and there is no steam pipe made but what can be treated in this way.

I would also draw your attention to the fact that all the failures of main steam pipes have occurred in first-class steamers, engined by first-class firms, whilst the much-abused tramp, with the same high pressures and under worse conditions, has steered through these misfortunes without any mishap.

I can only account for this by stating that, in my opinion, the less a seam is hammered the better will be its behaviour afterwards, and the less care, attention and work in this direction bestowed on the pipes for the tramp class of steamer has proved their salvation.

All main steam pipes should be annealed every six months, as their working tends to harden them.

I do not agree with Mr. Brett in his remarks about the socket joint, for it is a most reliable one and easily brazed, and it is rarely it gives out, but instead of reducing the one end of the pipe to fit into the other, which reduces the bore, it is preferable to hammer and stretch a socket to fit over the other, forming a lip to receive the solder when brazing; although the socket piece is reduced in thickness, it is, when fitted and brazed on the other portion, much thicker and stronger than at any other section of the pipe.

Any sharp or square bend is always to be avoided in the lead of pipes, and it is surprising the amount of distortion and straining pipes will stand if they have nice easy open bends.

The expansion and contraction and work of steam pipes, especially in long lengths, demands such contrivances as expansion glands, loops, bends and boxes, any of which, when judiciously fitted, work most efficiently, but when expansion glands are fitted, as I have seen them, on the main stop valve of the engines, at right angles to the long lead of piping, and close to a bend, it is not surprising that such steam pipes are always giving trouble ; a corrugated piece about fifteen inches long is a good fitting, as also is a loop of a **U** shape, and in long lengths of winch steam piping nothing beats a circle formed with the piping, about 18 in. diameter and which can lie horizontally or vertically.

In the selection of flanges, care must be exercised in not having the flange too deep, and it is not always an advantage to have a deep collared flange fitted, unless it is rivetted and sweated with tin, for if brazed it is only with great care the end of the pipe and face of the flange are preserved from burning before the intense heat reaches the solder to melt it. Mr. Pope's idea, in reference to the securing of the flange to the pipe, is an old style. He may have improved it a little, but it is quite a common fitting in France and in French steamers.

Mr. De Ferranti's system of securing the pipe to the flange, by means of corrugations, was commonly practised in Canada, to my knowledge, fifteen years ago, and although suitable for low pressures is scarcely the fitting for the modern steam pipe.

In conclusion, I would state that the steel steam pipe will never, in my opinion, entirely supersede the copper one ; it may so do in straight lengths, but, presuming large diameters could be bent in steel, I should be pleased to learn how, in the case of a failure in a steel pipe bend, it could be repaired —certainly not so easily or economically as with a copper one.

Mr. David Gibson (*Member*). To prevent the escape of steam in case of fracture, I believe an automatic shut-off valve could be designed and used with advantage on main steam pipes.

The Chairman (Prof. Elliott). Iron and steel will probably supersede copper in the manufacture of steam pipes. I have recently seen some very good steel bends of large diameter.

Mr. BRETT'S REPLY.

I agree with Mr. Cleghorn that it is a great mistake to hurry a coppersmith with his work. He is also right in saying a good copper pipe is a question of price, and I would add a question of careful supervision.

The strengthening of a furnace with an iron ring and of a pipe similarly treated, hardly afford a fair comparison, because the materials are different. You can tighten an iron ring upon a copper pipe too much, and then the pipe will not be free to expand where it is bound. Rings or bands of copper would be more suitable. Mr. Cleghorn has spoken upon the utility of a copper strip wound spirally round the pipe, and he agrees with me in the details of this arrangement, which seems perfectly practicable. This method would not only prevent a serious rent but would also materially strengthen the pipe. My view, that water-hammer action is entirely local and that a relief or safety valve is useless, is borne out by the experience of more than one speaker.

Mr. Tyler is under the impression that I am hostile to iron or steel steam pipes. I am not: I firmly believe that they will eventually supersede copper pipes. I have gone more fully into the subject of copper pipes because they are so widely used and because they have, unfortunately, forced themselves so much upon our attention. At the same time, anticipating a more general use of iron or steel pipes in the future, I have endeavoured to point out their probable defects and peculiar qualities. I agree that the rapid expansion, if it is not uniformly distributed, is a dangerous action in a brazed copper pipe. When flanging the end the pipe is sometimes reduced in thickness, but it is entirely a question of workmanship and there is no excuse for it.

I think Mr. Wilson is right in suggesting the reason for fixing the safety valve mentioned by Mr. Kirkwood. The safety valve blows because—and it is the only reason I can give—the velocity of the steam in the pipe is suddenly arrested and naturally the pressure is momentarily increased, but the steam is so elastic that a pressure a little higher than the pressure of the boilers could not be sustained for more than a moment, and the equilibrium of the pressure would be as quickly restored. The factor of safety of steam pipes is so high—as shown by the pipe referred to by Mr. Adamson—that, in my opinion, the slightly increased pressure would in no way affect the pipe.

The suggestion to fix automatic steam traps is a good one, but, if proper care is exercised in opening stop-valves and drain cocks, their usefulnesss will only be appreciated where a great deal of priming is going on.

I cannot understand the comparison between old copper steam pipes and old boilers, made by Mr. Wilson. In testing old boilers some limitation to the double working pressure rule is necessary. Boilers are sometimes in a very bad condition due to corrosion, and the straining resulting from a cold water double pressure test might be absolutely dangerous to their working safety. With copper steam pipes no such apprehension need be felt. If, after a number of years' service, a pipe be taken down and properly annealed, the properties of the material will be nearly, if not quite, as good as when the test pressure was applied to the new pipe. It is really a question of cost, and I can quite understand some opposition to this necessary safeguard. Mr. Wilson believes that testing old copper pipes has led indirectly to the ultimate failure of some of them. This view I cannot endorse, but I am entirely against testing a copper pipe unless it has been annealed. Care and common sense should be the engineer's equivalent for the good material and good workmanship of the coppersmith. The equilibrium pipe mentioned by Mr. Wilson is a very good arrangement and should be more generally used.

We are much indebted to Mr. Adamson for the interesting tests, and notes on the results of these tests, on a steam pipe, and for the details of its manufacture. It affords another illustration of unsatisfactory workmanship when working the bevelled edge and when fitting the halves together. The "grooving" in the pipe mentioned by Mr. Adamson might have been caused by the action of water.

The difficulty experienced in bending Elmore pipes has been overcome. At first the material after this operation was unsatisfactory, but experience has enabled the manufacturers to remedy this defect. They do not favour the use of the ordinary hydraulic ram, where the motion is intermittent, but recommend machines such as the "Fowler" or "Watson Laidlaw," so that when bending pipes of large diameter a steady flow of the material is secured.

I cordially agree with Mr. McCallum that copper as a material for marine steam pipes possesses qualities that iron or steel does not. I should like to answer his remarks in detail and, before I proceed further, I will say that his assurance that there is no occasion for alarm at these failures would come better from the coppersmith than the engineer. They certainly teach us lessons, but they are dangerous ones, and who is going to pay the price—if not with life, with terrible injuries! Mr. McCallum's suggestion that the Board of Trade officials were mistaken in their opinions, when they arrived at the conclusion that the pipe mentioned in the paper was burnt during the operation of brazing, is not fair criticism unless he actually saw the pipe. I will admit that when a piece of copper is burnt the fact is evident to the workman, but it is possible by the same means to damage the virtue of the metal and pass the pipe out as sound. Mr. McCallum gives a graphic description of the method of bevelling a sheet of copper, even to the most minute detail, but he has not followed my paper closely. He says "it is not true they have a tendency to crack if the metal be treated in the proper manner." What I said was: "Working the bevelled edge on sheet copper often determines its quality, and I think it necessary to say that copper is used which after annealing will not stand even that very mild test," &c. I still maintain that view. If the material is bad—and it often is—no matter how carefully the edge is worked, it will crack. Mr. McCallum repeats what I have said about the inner edge grooving the lap above it, but, if the inner bevel is properly tapered down this will not take place. I advocated an increase of as much as 25 per cent. in the thickness of the seam, and of course the additional thickness can only be obtained by floating in solder. This would make good any reduction in the thickness of the pipe when hammering the bevel. Mr. McCallum confuses "grooving" with "burning," but there is no analogy between the two, and it is impossible to mistake one for the other. Planishing the seam can be carried too far, but a little light hammering will show whether the seam is sound or not, and that should be the whole of its utility. Mr. McCallum says only first-class steamers have been the delinquents, and that the much-abused "tramps" have escaped the crime of a defective steam pipe. There never was a greater fallacy for two reasons :—(1) the "tramps" have contributed their quota, and (2) some of our much-vaunted first-class steamers have not too much money spent upon their construction or repair—in fact, many of our passenger steamers are as cheaply attended to as the much-abused "tramp." I now come to a very peculiar statement, viz., that "all main steam pipes should be annealed every six months." If that were compulsory, the marine coppersmiths' would be a most lucrative business. When I made the suggestion in the paper "that copper pipes should be annealed and tested periodically," I purposely refrained from naming a period, but I will now say that, in my opinion, they should be annealed and tested once in three years, and that should be the minimum. With regard to the socket joint, Mr. McCallum prefers the present method to my suggestion. He prefers to socket one end to fit the other so as to form a lip to receive the solder. I should like to ask, how often in his experience he has seen the solder run the whole length of the socket? The remark that the socket joint is stronger than any other section of the pipe I cannot follow. The stepped part is invariably weak, and if the pipe is not carefully worked it may become a source of danger, hence my suggestion that a seamless sleeve piece should be used, or that one end should be thinned and reduced to fit the other, which may be slightly increased in diameter. The reduction, if any, of the bore of the pipe would be, I think, a matter of hardly any consequence, because pipes are usually made larger than is actually required. I do not like the idea of using a corrugated length of pipe to take up the expansion or contraction of the range. In the first place I am not in favour of working and stressing the material, because in many instances it eventually produces cracks. It would be a difficult and expensive thing to make, and we have no guarantee that the copper would not be unduly stretched and thinned while the corrugations were being made. If Mr. McCallum will read my paper he will find that the Ferranti steam pipe is perhaps more suitable for high than for low pressures. Then, as I understand it, we have the assertion that steel steam pipes will never entirely supersede copper ; I am afraid they eventually will but I don't think it is possible to get a more suitable material than good copper for reasons which I have already given. With regard to the question, "How can a failure in a steel pipe bend be repaired ?" it will be necessary to make bent steel pipes in such a way that it will be possible to rivet a patch over the defective place—not a very difficult matter I am sure. Mr. Gibson suggests the use of an automatic valve to shut off the steam in case of a fracture occurring in a pipe. I thought this idea out myself some time back, and I came to the conclusion that it was not practicable—it could not be relied upon to do its work. In the bending of steel pipes of large diameter, Professor Elliott clears up what appeared to me a great, although not insuperable difficulty, and I only wish he had given us some details. As it is no easy matter with large copper pipes, I think you will agree with me when I say that a really good steel pipe bend is a triumph of mechanical art.