**THE
INSTITUTION OF LOCOMOTIVE
ENGINEERS, LONDON.**

**BOILER SHOP EQUIPMENT AND
MANAGEMENT**

BY

**W. J. BENNETT,
MEMBER, BRIGHTON.**

With an abstract of the discussion upon the Paper

**FOURTH PAPER
(OF TRANSACTIONS)**

Session 1911.

**Read on Saturday, 30th December, 1911, at St. Bride Institute,
London.**

Presided over by Mr. Charles A. Suffield, Chairman of Council.

LONDON :

**Published by the Institution
1912.**

Price 1/6 net.

The Institution of Locomotive Engineers.

PAPER NO. 4.

BOILER SHOP EQUIPMENT AND MANAGEMENT.

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By way of introduction, I should like to bring to your notice this fact, that few articles manufactured from iron, steel or copper, should be made under conditions so systematic, as Locomotive Boilers, in fact, there are no workmen to whom it is more necessary that they should understand the laws of nature—as they effect their trade—than Boilermakers. It would be very hard to specify the number of boilers which wear out before their time in a most mysterious manner and also the number which explode from time to time—over which explosions much valuable time is spent in trying to solve the causes of them—yet, in some instances, if properly investigated, it might be attributed to want of knowledge, either on the part of the workman engaged on the particular work which has failed, or his supervisor. It will readily be seen that some, whom circumstances have enabled to become acquainted with the theoretical part of Boilermaking, have, for that same reason, been shut out from acquiring that practical knowledge of the business, which can only be obtained by years of hard work, and the closest of observation during time spent in the shops. Consequently, it may not always be possible to obtain that amalgamation of theory and practice which is most conducive to the best results. It appears, however, that the young man of to-day, has, by reason of the superior advantages of modern education, grasped this fact, and, whilst working hard during the day in his efforts to acquire the absolutely indispensable practical knowledge of his trade, manages to allow a certain proportion of his time to seeking after the theory of his profession, by which he may hope to become a master of it, both in theory and in practice.

The practical man putting down his tools and starting as Foreman or Supervisor finds himself absolutely removed from his previous experiences, and at once the power is required of him of being able to adapt himself to his altered circumstances which may require him to judge both men and methods from an altogether different standpoint to that which he probably hitherto has held. It may also happen that to obtain a position he desires, he will have to leave the place where he has been working at the tools, and take up a position where he is practically unknown and where the methods in vogue are strange to him. He might also find that he would be required to arrange for the equipment of his own shop as well as manage it. Therefore, first of all, I propose to deal with the machinery required.

PLATE ROLLS, commonly called Straightening Rolls, are most necessary, as the plates, except when specified to be dead level, are generally in a much buckled or wavy condition, and should not be marked off or drilled till they have first been rolled level. Some of these machines are provided with seven rollers, *see Fig. No. 1*, and will level plates of various widths and thicknesses. Machines of this type are supplied by Messrs. Rushworth & Co., of Sowerby Bridge, but a large set of rolls, which were capable of flattening steel plates 8ft. 0in. wide and 1½ins. in thickness, were made some years ago for the Fairfield Works by Messrs. Craig & Donald of Johnstone. This machine, however, had only five rolls instead of seven, but this same firm have, since that time, put on the market improved plate flattening rolls with only four rollers, capable of straightening plates up to 7ft. 0in. wide and 1½in. thick, the top bending roller being 13½in. in diameter and the top straightening roll 12in. in diameter, with two bottom rollers 13in. in diameter. These are very good machines. This firm have also, for some time now, had on the market an improved type of combined plate bending and flattening machine, with the top half of one of the cheeks to swing round so as to enable plates that have been bent into complete circles to be removed from the top rollers. *Fig. No 2* shows the machine with the top straightening roller run up into position, so that the machine may be used as a straightening machine only. The plates can be severely dealt with in this type of machine by pressing down the top bender roller over the plate to be straightened, so that when the plate passes through the rolls it gets a severe curve; and in running the plate back under the straightening roller—which has been set to bring the plate level—the curve which has been given to the plate is removed and all ordinary buckles, except in the thinner plates, are taken out with one running through of the plate. This machine is a most efficient straightening machine and it has also this advantage; the top bending roller is arranged to be raised or lowered at each end independently, so that when a

plate, with one side longer than its opposite side, has to be straightened, pressure can be put on the short side and in this way the plate is "drawn" or levelled on the one side only. Another advantage it has is, when the plate has been bent too sharp, it is not necessary to take the plate out of the machine to remove this—as is the usual practice with the ordinary bending rolls—because the straightening roller can be run into position, and, by running the plate back under the straightening roll, the plate may be flattened out and reset. This class of machine can be obtained capable of bending and straightening nickel steel plates up to 12ft. 0in. wide and 1½in. thick, the top bending roller being 22½in. in diameter, the top straightening roller 15in. in diameter, and the two bottom rollers 18in. in diameter, but a machine of the same pattern but lighter can be obtained, which will do all that is required to be done of this class of work for Locomotive Boilermaking, with a top roller 17½in. diameter, straightening roller 14½in. diameter and two bottom rollers 15½in. diameter, which will take a plate slightly over 12ft. 0in. wide. Such a machine is at the present time in use at the Brighton Works.

Next in order comes the VERTICAL PLATE BENDING ROLLS. *Fig. 3.* The introduction of this type of machine must be credited to Messrs. Pahuier's Shipbuilding Works at Jarrow-on-Tyne, this firm being manufacturers of marine boilers. The question of welds versus specially long plates came up for consideration and the difficulty of supporting long heavy plates in horizontal rolls suggested the employment of vertical rolls; and, but for this class of rolls having been designed, it is safe to assume that the construction of very large diameter boilers with so few cross seams would be impracticable. Very good machines of this type can be obtained from Messrs. Shanks & Co., of Johnstone, near Glasgow. The large centre roller being 16in. diameter and the two small rollers 11in. diameter, which will roll boiler plates 12ft. 0in. wide and 1in. in thickness if required. This is a very handy machine when fitted overhead with two swing jibs for lifting plates into the rolls and for steadying them during the operation of rolling, and also with a small centre jib crane for lifting the plates out of the machine after being rolled to a circle. This jib crane can be worked by specially constructed gear attached to, and worked by a lever on the side of the machine. A small jib crane of this class was recently fitted in the Brighton Works by Messrs. Craven Brothers of Manchester and is a most useful addition to the vertical rolls.

PLANING MACHINES also are very necessary tools in a Boiler Shop for the planing of the edges of the plates. This is always done for the best work, especially for boiler-work, not only because it makes for good and neat joints, but because it means safety. If the edge of a sheared plate is examined, it

will be seen to present an enormous number of cracks, due to the violent action of the shear blades in cutting, which under the strains of riveting, caulking and steam pressure would spread and become a source of danger by leading to rupture, whereas, when the edges of the plates are planed, all these tiny cracks are removed and the edges left quite sound; and it is also much easier to caulk a planed edge than an ordinary roughly sheared edge, the planing thereby doing away with a lot of work which would otherwise have to be done; in fact, no work should be put together with rough sheared edges when it can be avoided. The plate edge planing machine is one of the most common machine tools to be found in a Boiler Shop of any size. These machines are made in various sizes and lengths and can be obtained to plane work from 35 to 40ft. in length at one operation. Some machines are also fitted with a cross slide at one end for planing the ends of the plates simultaneously, and are also fitted with a revolving table for turning barrel angle rings or steel tubeplate flanges if required. Such a machine is to be found in use at the Great Northern Railway Works at Doncaster. A very massive planing machine, capable of planing 35 feet at a stretch, was made some years ago by Messrs. Craig & Donald to the order of Messrs. Thomson of Clydebank. It was fitted with an overhanging beam so that any length could be passed through it. The main screw had two improved carrying saddles. The chief peculiarity of the machine, however, was that it was fitted with hydraulic cramping-down rams, as well as with hand screw cramps, the rams being arranged to work at 800lbs. sq. in. either individually or simultaneously. Messrs. Craven Brothers of Manchester also supply some very valuable tools of this sort, adapted to plane in both directions with turn-over tools, or, when working in one direction only, with a very quick return motion, and arranged with an overhanging beam so that any length of plate can be planed by moving the plate forward through the machine, the same as in those of Messrs. Craig & Donald.

DRILLING MACHINES. The drilling machines used on boiler work are very numerous, and since the introduction of mild steels, the drilling machine has in many places slowly superseded the punching machine, owing to the fact that Engineers and Boilermakers do not like the crushing and distortion of the material—which takes place more or less—and the tendency to fracture, in punching the plates. The slowness of the process of drilling has led to the introduction of the multiple drilling machine in which several drills can be operated at the same time. In some shops the multiple driller is brought into use whilst the plates are in the flat, whilst in others, they roughly build up the work with a few bolts, and after marking off the outside plates for the holes required to be drilled, put the plates on the machines and drill through whilst the work is

in position, after which the work is taken apart, cleaned free of drillings, and then put up together again ready for riveting. Radial drills, *Fig. No 4*, are used, however, more extensively in Boiler Shops, and there are several manufacturers who put on the market some really first-class machines of this pattern. In some cases it is more beneficial to have a row of from three to four radial-armed machines than to have the multiple drilling machines, especially where work is required to be done without much moving, and also because, when long work has been completed, the smaller work can be placed upon these independent machines and got forward under much easier conditions than would be the case with one multiple drilling machine. There are also some very handy machines for drilling the holes for the tubes in the tubeplates, which were put on the market by Kendal & Gent of Manchester some years ago, *see Fig. 5*. On these machines two drilling heads are provided, the work being fastened on the bedplate of the machine. The two drilling heads are on a crossbeam and can be moved on same either inwards or outwards as desired, and, at the same time the crossbeam can be moved up and down the bedplate by gear, to enable the drills to be brought into any position desired without having to alter the set up of the work about to be drilled. These machines with the aid of properly designed drill jigs, enable the tubeholes of a boiler tubeplate to be drilled at a most moderate figure as regards cost, this being as low in some locomotive shops, owing to the tubeplates being drilled back to back, two at a time, as 1/9 per 100 holes.

COLD SAWING MACHINE. As it is a most wasteful job to cut up lengths of angle, tee and bar iron, except for very rough jobs, by angle shears, owing to the ends of the bars being distorted by the strain put on them—which necessitates them being cut again—most Boiler Shops have a cold sawing machine (of which class of machine Messrs. Hetheringtons, Cravens & Craig & Donald have supplied many to the engineering world) which soon pays for itself, for it not only cuts sections of these different types of material with practically no waste—only the thickness of the saw cut, which is generally from 3/16 in. to 1/2 in., being wasted—but the cut ends are as true and smooth as if they had been planed, and therefore no fitting of joints should be required if marked off and sawn properly; also the ends are cut at any bevel required by setting up in the desired position on this machine and sawn asunder. The 24 in. saws supplied for this class of machine by Messrs. Sandersons Brothers & Newbould of Sheffield are well worthy of mention.

For the **PUNCHING & SHEARING** of plates, many very good and useful machines are to be obtained of all the leading manufacturers. The machines of Messrs. Henry Pels for shearing any length and any width are amongst some of the best (Johns Patent Splitting Shears combined with Punching

Machine and Bar, Angle and Tee Cropper, *Fig. 6*). This machine will cut plates up to $\frac{3}{4}$ in. thick and bars 3ins. by 1in. at one stroke, and will punch $1\frac{1}{2}$ in. holes through $\frac{7}{8}$ in. plate. It will also crop round bars up to $1\frac{3}{4}$ in. diameter and $1\frac{1}{2}$ in. squares, will cut angles $4\frac{1}{2}$ in. by $4\frac{1}{2}$ in. by $\frac{3}{4}$ in., and tees $4\frac{1}{2}$ in. by $4\frac{1}{2}$ in. by $\frac{1}{2}$ in., and angles on bevel of 45 degs. $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{3}{8}$ in., the horse power required being $7\frac{1}{2}$; it works at 300 revolutions per minute, diameter of belt pulley 19in. and width of driving belt 4in., length of machine about 85in., width 43in., height 81in., and weight approximately 72 cwt. A rather larger machine can also be obtained, with a 30in. punching gap, weight about 80 cwt. These machines whilst built for strength and utility, have at the same time the advantage of not being ponderous, take up very little shop room—even the machines doing the heavier classes of work—and require very little expense to put them in their working position in the shop as regards foundations. Messrs. Becker & Co. of London have also some very good machines of a somewhat similar design on the market but whilst the frames of Pels' machines are made of mild steel plates, Messrs. Becker's are made of Siemens-Martin malleable cast steel which is considered to possess more than twice the strength of mild steel plate, and is considered to be so tough as to be almost unbreakable. Several other makers are also to be congratulated on the splendid classes of machines they offer to the engineering world for this class of work, Messrs. Craig & Donald having a massive combined punching and shearing machine with an angle and bar cutting arrangement. This machine is capable of punching $1\frac{1}{4}$ in. diameter holes through $1\frac{1}{4}$ in. plate and shearing $1\frac{1}{4}$ in. thickness of plate at a distance of 24in. from the edge and will punch holes 42in. from the edge of the plate, having what is termed a gap of 24in. for shearing and a punching gap of 42in.

HYDRAULIC PLATE FLANGING MACHINES. Of this class of machine there are also many makes and sizes on the market made by such firms as Messrs. Berry & Co., Fielding & Platt of Gloucester, and the Vauxall & West Hydraulic Company of London & Luton, one of the latter firm's presses having been installed in the Brighton Railway Works about November 1906, the working pressure of which is 1,500lbs. per square inch, the press being large enough to admit 10ft. 6in. between columns one way and 4ft. 6in. the other. It has a maximum clear daylight of 6ft. 0in. from the table to the head of the press, when the table is in its lowest position. The head of the machine has a 3ft. 0in. adjustment on the four columns. The four vice rams are capable of being moved to within 27in. of the centre of the table and have an adjustment on radial lines of 24in. The central holding-up ram is 7in. diameter and is contained in the main ram. The four holding up or vice rams are 7in. diameter and have a working power of 25 tons each.

The main ram is 20in. diameter and capable of developing a total load of 210 tons when working at 1,500 lbs. per square inch and it has a clear working stroke of 3ft. 0in. and the vice rams of 2ft. 6in. The water-saving cylinders have rams 4in. diameter, the two together capable of exerting a load of 16 tons, and they are so arranged that they can lift the lower die of the press until it is in contact with the work, before the pressure is admitted to the main ram. Suitable connections for the supply of low pressure water into the main cylinder when the water saving rams are in operation are provided. The maximum load the press is capable of exerting with both main ram and water-saving rams in action is 226 tons. Very good results have been obtained by this machine, but for flanging plates for the improved Belpaire type of boilers, I doubt if this press would be large enough between the columns. (*Fig No. 7*).

A PLATE FURNACE is necessary for heating the plates requiring to be flanged, also for the annealing of plates. There are several different patterns in use, some shops being fitted with gas furnaces, whilst others still retain the old side or end-fired type of furnace, built of firebrick which is well bound together on sides and ends by means of stout plates with stay-bolts running both lengthways and crossways of it, the uprights generally being made from old rails firmly bedded in the ground. The crown of the furnace is well arched and at the back is the bridge which separates the fire grate from the furnace bed, the roof over the fire grate being arched in such a manner as to throw the heat into the body of the furnace, where it is deflected on to the work lying on the furnace bed. At the front end the bed has several holes in it which lead down into the culvert and thence to the chimney, the draught from which induces the heat and flame to travel along the furnace.

HYDRAULIC RIVETING MACHINERY which was introduced by Mr. Tweddell as long as 45 or 46 years ago permitted a great improvement in methods of riveting to be made. *Fig. 8*. It is, of course, difficult to specify a complete plant, some shops having quite different types of machines to others, but generally the type of machine adapted for boiler barrel and shell riveting and for riveting foundation rings, fireboxes, etc. has a gap 17ft. 6in. long and is capable of exerting a crushing pressure on the rivet of 25, 50, 75 or 100 tons, according to the size of riveting to be done and the thickness of the plates; but very good work can be done working at 50 tons on seams of two-plate thickness, and at 75 tons pressure on butt-strapped joints of three thicknesses without distortion to the plates, whilst for copper box riveting 25 tons is ample, owing to the liability of the copper to distort if too much pressure is used. There are also the portable riveters of various types used for riveting firehole rings, tubeplates on barrel rings, etc., also the

scissors type of machine used for practically all classes of work. These are usually carried on light cranes of the jib type.

For obtaining the pressure required **ELECTRICALLY-DRIVEN PUMPS** are provided, and, as regards **ACCUMULATORS**, a weight-case accumulator in which the ram is fixed in the base plate casting and the cylinder is carried in the casing, which contains the punchings, pig iron, or heavy material required to give the desired pressure. Guide rails are fixed to the framework to act as a guide for the casing during its up and down motion. Wooden cushions are generally fitted at the base for the case to rest on when at its lowest point. An arrangement is also provided so that when the cylinder has nearly reached the top of its stroke, the lower valve is lifted permitting the water from the pumps to flow back to the suction tank, the upper valve retaining the pressure water in the cylinder.

ELECTRIC TRAVERSING CRANES for lifting the work should also be provided. These are generally arranged to travel the whole length of the shop in each bay, and are fitted with crabs which travel across the crane. These enable work to be shifted from one part of the shop to another most expeditiously.

JIB CRANES for lifting and holding work to be operated on at the different machines should also be provided.

AIR COMPRESSORS, for supplying the necessary power for working the pneumatic drilling, caulking and riveting machines which are required, also form a valuable part of Boiler Shop equipment, the "Sentinel" Air Compressors of Alley & Macrellan of the Sentinel Works, Glasgow, being very good. For air compressors a high grade of oil should be used in the cylinders with a high flash point and of a non-coking nature, that is to say, when the oil is placed on a shovel and held over the fire, there should be little or no carbon deposit left after the oil has been volatilised. Another point to be observed is to caution the attendant against using too much oil in the air cylinders, a drop every five minutes being sufficient in a cylinder of ordinary size. Soapsuds should be fed into the cylinders at least one day per week in order to wash away any deposits which may have accumulated through the use of oil which has been acted upon by highly heated air. The soapsuds may be fed through the regulator oil cup, but care should be taken not to let the machine remain idle with soapsuds in it, and, therefore, shortly before shutting down time, the feeding of soapsuds should be discontinued and oil feeding substituted. The discharge valves, air receiver, and any other places where any deposit is liable to accumulate should also be inspected and kept clean.

The Consolidated Pneumatic Tool Co., supply some very good machines for PNEUMATIC CHIPPING, CAULKING & DRILLING, their 4in. stroke "Boyer" hammers being very suitable for boiler chipping and caulking, and for light riveting. These can be obtained fitted with either round or hexagon chisel sleeves, the former being, however, generally preferred for caulking, whilst the latter are necessary for chipping. For heavy riveting the "Boyer" long-stroke hammers are also good, the Consolidated Pneumatic Tool Co's. No. 5 type for closing rivets up to $\frac{3}{4}$ in. diameter and No. 60 for $\frac{3}{8}$ in. rivets doing very creditable work, but to ensure the maximum of work from these machines, the pressure should not be less than 100 lbs. per square inch. There are also some other very good makes of this class of machine. Pneumatic drilling machines are most useful tools as are also the ELECTRIC DRILLING MACHINES, for operating upon work which it would be difficult to place under the ordinary radial drilling machine, these pneumatic and electric machines being specially made for getting at work in confined spaces such as the fireboxes and barrels of locomotive boilers, and for such work they are undoubtedly a great success. The best made are those by Messrs. Campbell & Isherwood of Bootle, near Liverpool and the Consolidated Co's. There has quite recently been put on the market an ACETYLENE CUTTING & WELDING PLANT, (Fig. 9) by Carbic Limited, London, by which old boilers when relegated to the scrap heap can easily and quickly be cut into pieces, for which it is quite possible there may be a great future. General tools, such as hammers, chisels, punches and dies and many other tools required, are generally made by a Toolsmith, employed in Boiler Shops for this purpose, the steel being bought for this purpose from first class manufacturers of steels such as Messrs. Sandersons Brothers & Newboulds and other makers in the market, whilst taps, drills, ratchets and reamers are also bought from the different makers of these classes of tools.

As regards the equipping of a modern Boiler Shop, it can readily be seen that with so many first class manufacturers of all the different kinds of tools needed for the making of boilers there should be no difficulty experienced in getting suitable machines adapted for the peculiar requirements of any individual shop by simply stating what is required and asking for quotations for same. Taking it for granted, that the shop has been equipped, the next thing to consider is the management of it. This often depends upon the originality or otherwise to the Supervisor concerned; no two Boiler Shops having the same methods of working. In the first place the Supervisor must know what men he requires and lay out each man's particular duties for him, also know what part of the work each man has been in the habit of performing previously. This is most

essential, owing to the men of a Boiler Shop being split up into so many sections of labour. Many Engineers have the idea that a Boilermaker can be put to do anything which can be legitimately called Boilermaker's work, but this is not so. Anglesmiths, Markers Off, Platers, Patchers, Riveters, Caulkers and Holders Up are not Boilermakers in the true sense of the word, but generally are only skilled in that particular branch of their trade in which they have specialized. The Boilermakers' Mates have also their own special branches of labour, as Furnacemen, Strikers, Drillers, Tappers, Stayers and Tubers, and there are lastly Labourers and Boilermakers' Apprentices, so that it requires a certain amount of care and study in laying out the men to see that each man is engaged upon the class of work he is most proficient to perform, it standing to reason that skilled men marshalled into their proper places will perform more and much better work than they would if their skill at any particular class of work should not have been taken into consideration.

The **ANGLESMITH** is considered an important man in a Boiler Shop, it being no easy matter to obtain good craftsmen, not many Boilermakers following this particular branch of the trade; a lot of troublesome work is involved in the bending and welding of the different sections of angles, tees and channels, this being the work done by the Anglesmith.

The **PLATER** works chiefly upon plates and he should know how to mark off work from a drawing for which a knowledge of geometry, projection and development of surfaces is necessary. Of course in many large Railway Shops, Platers are not called upon to mark off their own work, owing to these shops having generally a number of men, who are called **MARKERS OFF** or **TEMPLATE-MEN** whose place it is to mark off all work which is required from the drawings supplied them, thus leaving the Plater to do the rolling, levelling, setting up and bolting together of the plates ready for riveting.

The **RIVETER**, when the Plater has done this, takes the prepared work and as his name implies rivets it together which he often has to do in most awkward and constrained positions. There are four classes of riveting, viz:—machine, snap, countersunk and hammered. The real principle of good riveting is to see that the laps are kept thoroughly close and the holes "fair." For good sound work **HYDRAULIC RIVETING** is the best, hammered rivets being more expensive and through the amount of hammering required oftentimes become brittle. Countersunk rivets are generally tighter work than snapped ones because the hole being countersunk the rivet is really hammered solid into a faced joint, but as countersinking really weakens the plate, owing to it taking away a portion of the metal, it should only be resorted to when necessary. No drift should be used by Riveters and when holes are bad or

"unfair," the holes should be reamed till "fair" and round before the rivets are put in. The HOLDER-UP should also be watched to see that he is holding up the rivet properly and that he does not hold on the rivet whilst the Riveter is closing the hole or hold on the hole whilst the Riveter is finishing the rivet. The Rivet-heater also requires overlooking to see that he does not burn or overheat the rivets. Burnt rivets are always brittle and liable to break especially when they have been made too hot and then allowed to cool before being worked upon. On no account should any rivet which has been overheated be used.

The CAULKER chips and caulks all seams and rivets required, and generally sees to the testing of the work when necessary.

Having got his men started each at his particular class of work, the Supervisor should now turn his attention to the tools in use and abuse in his shop. I mention abuse for this reason, that it sometimes happens, that although the men know better, they will often use tools so wilfully as to seriously damage the work upon which they are engaged. The riveting hammer in particular is often put to wrong use. The ordinary size riveting hammers which should be used only for riveting over or clenching rivets are often used by Riveters when engaged at riveting over boiler stays. This should not be allowed, these hammers being far too heavy, but a much lighter hammer, called a stay-riveting hammer, should be used. The ordinary riveting hammer, being heavy, has the tendency when being used on stays, to bend the stays in the centre, instead of forming the head for which it is obviously being used. In the caulking of boilers much harm is sometimes done to the edge of the plates by allowing what is called split caulking to be done. This is done with a narrow seam tool and only wedges the work apart instead of making it solid. In the best caulking only a fuller wide enough to more than clear the full thickness of the plate should be used, and if the bevel on the edge on the plate is sufficient, this fuller should allow of the caulking being done in a proper workmanlike manner, without having recourse to seam tools of any other description, providing the plates have been properly closed before or during the process of riveting. The drift also is another tool which is abused. Although most necessary and useful—plates could not easily be drawn into position without it—it is often abused by being employed to stress and strain plates in order to pull holes into position, which have been either incorrectly pitched by the marker-off or worked out of line by the driller or punching press man.

Many instances of abuses of tools could be mentioned and a sharp look out on the part of the Supervisor is required to detect them, but when discovered they should be immediately abolished from the shop if a standard of good work is to be maintained,

The next items to be taken into consideration are the materials used in the manufacture of the Locomotive Boiler, namely, iron, steel and copper. The physical qualities and characteristics of these materials vary so much that the utmost precautions are necessary—as is evident by the elaborate specifications, minute inspection and exact tests by which Contractors supplying these materials are bound—and therefore the Shop Foreman should give great attention to the proper inspection of all material delivered to him to be used in the manufacture of Locomotive Boilers. Many years ago Dr. Siemens called wrought iron simply a sandwich of iron and dirt, and with all due allowance for prejudice in the mind of the inventor of the open-hearth steel, we are bound to admit that there is a large amount of truth in his definition. However careful the tests and inspections may have been before the material was delivered to the shop, no one can be altogether sure that out of a number of plates some may not be faulty by reason of the presence of lamination and blister in the interior, due to the presence of slag or dirt in the original bloom or pile. The surfaces and edges of the plates may appear good enough for any purpose, but there may be imperfect welds in the centre of the plate, which may lead to extensive corrosion or fracture. These troubles are never absolutely eliminated even by the best manufacturers. Frequently these faults are only discovered during the operation of bending, welding or flanging and sometimes even after the work is done. These defects are of serious moment in steam boilers especially when found to occur in plates exposed to the action of the flame or to the action of flame and currents of cold air combined, which causes sudden expansion and contraction of the material. Several methods are employed in the examination of iron and steel plates, one method being to mark the plate off into, say, about 1ft. 0in. squares with a chalk line—this being done to ensure that no part of the plate is missed as each square can be marked as examined—then to carefully hammer-test each square; if any lamination or blisters should be in the plate, the hammer will fall more springily on the laminated or blistered part than it will on the solid plate, and the solid plate will give out a more bell-like ring. Another way sometimes adopted is to place the plate horizontally supported at each corner on trestles and then to strew the face of the plate with fine sand; in tapping the plate from underneath notice is taken as to whether the sand is moved or not—if there is only a very slight movement of the sand, it is considered to denote the presence of lamination or a blister. Another way is to slightly warm the plate and the laminated or blistered portions will look black in comparison with the sound portion of the plate. When a faulty plate is discovered, under no consideration should it be used in a boiler, but it should be returned at once to the makers

with an explanation that a defect has been discovered, and, in the majority of instances, they will gladly change it. The peculiarity mentioned, however, is generally confined to best iron plates. Steel plates are almost free from lamination—in fact it so seldom occurs that it may be regarded as practically non-existent; and this is one great point in favour of steel as regards Boiler making. Steel is, however, very subject to corrosion on the face but in many cases protection can be given against this; in fact, in some shops the insides of boilers are cement-washed and allowed to dry before the boilers are tubed, as some protection from corrosion—this I consider is good practice. Oftimes in the manufacture of steel boilers, the material is badly misused by unskilful workmen in the heating and working of the plates into the required shapes. In some instances, the plates are allowed to become overheated and in many cases, even when the plates have been heated properly, they are hammered and worked when at too low a temperature, with the result that they become very brittle and are therefore very liable to fracture. It is always a good plan where possible after the work has been done on the plates in the way of drawing corners and setting, to have the plates put into a furnace and thoroughly annealed before building the work into boiler. Another very prevalent mistake made by Boilermakers, and oftimes accompanied by very disastrous results, is the plan of putting heaters or a gas jet on a part of the plate which is going to be operated upon—such as setting back a bulge or levelling one particular place—the heater only warming the plate and producing what is commonly known amongst Boilermakers as the “rotten blue heat.” At this heat plates are peculiarly subject to fracture when being worked, and no steel plate should have any hammering done to it at a low temperature. Either heat the plate properly before attempting to use a hammer upon it, or do not heat it at all. A simple test of this liability to fracture in a steel plate can easily be made in the following manner:—Take from a steel plate which is of boiler-plate quality a piece about 2in. wide and long enough for two tests to be made upon the one piece—this to ensure that you are putting under test exactly the same quality of material. Now take one end, put it in a fire and get it to a sufficient heat that oil will ignite when poured upon it in small quantities, and you have the heat termed “rotten blue.” At this heat attempt to flange it over an anvil or block, and it will generally show signs of fracture before it has been bent to approximately an angle of 30dgs., and the edges of the fracture when the grain is studied will appear like you would expect them to be in a piece of common iron. Now take the other end of the piece of plate and flange it without being heated at all, and you will find that in most instances it can be flanged over till the faces touch one another without any appearance of fracture.

Copper is also very susceptible to ill-treatment in working, especially to over-heating, which causes it to lose its ductility and become granular and brittle,—at 580dgs. F. it loses about 25 per cent of its normal strength. Copper can be worked either hot or cold—hammering makes it brittle, but annealing restores its softness. Both thin and thick sheets, if of good quality, can be worked cold, but for flanging to sharp curves or radii the plates should be heated to a blood red—a temperature which on no account must be exceeded or the copper will crumble and break to pieces under the hammer. A simple test of the good quality of copper can be obtained by bending it double when no sign of fracture should be seen. Good copper when fractured should appear silky and fibrous. Inferior copper has a coarse and blackened face, and will break easily when subjected to tests. If copper should be overheated by accident—as sometimes happens—on no account should any work be done upon it, but it should be allowed to cool down when it will regain all or nearly all of its original strength. The late Mr. W. Stroudley when ordering his copper for fireboxes, preferred it to have a slight admixture of tin, believing that it suffered less from the cutting influence of the blast than did the pure copper.

RIVETS. Both Iron and Steel Rivets should be subjected to various tests before being accepted in a Boiler Shop. As regards best iron rivets, generally used for riveting up fireboxes and for use in the most awkward and constrained places in the boiler, these should, if of good quality, admit of being bent cold around a bar the diameter of which is equal to the diameter of the rivet being tested. The head should also be heated and should bear hammering until it is flattened out to more than twice the diameter of the shank. These rivets should also stand being doubled when hot without fracture. Iron rivets have about 24 tons ultimate strength and should stand an elongation of about 25 per cent in ten inches. Steel rivets should admit of being bent double whilst cold. These have a tensile strength of from 25 to 30 tons and should be able to stand an elongation of from 25 per cent to 30 per cent in 10 in. However, extreme ductility is required in rivets more than high tensile strength owing to the enormous shrinking strain—due to cooling—which they have to stand, especially the long rivets like those used in riveting up the foundation rings of Locomotive Boilers. Rivets also are more subject to shear than to tensile stresses. There are some differences of opinions as regards the best type of rivets to use, some Boilermakers preferring to use the soft mild steel rivets whilst others stand out strongly for the best Lowmoor or Yorkshire iron rivets. This is, in many instances, purely a matter of opinion, but if cost is to be taken into consideration, that of the Lowmoor or Yorkshire iron rivet is very high when taken into comparison with that of steel rivets.

The Yorkshire iron rivet costs about £24 per ton as against about £9 per ton for steel.

There are of course many kinds of tests—by which a practised eye is able to judge the quality of the material used in Boilermaking—which are too numerous to mention. It sometimes happens that the Shop Foreman is called upon to order his own plates as far as the sizes and shapes of plates required from the manufacturer are concerned, and it is therefore essential to possess some knowledge of what sizes and weights are obtainable, because it is sometimes desirable to get the largest possible to save making more joints than necessary in the work on hand. Information of this kind can only be obtained from the price lists of the various iron, copper, and steel plate manufacturers. Also notice should be taken of the information so obtained of what are termed extras, any departure from the rectangular form such as plates tapered, ordered to be cut true to size, or to sketch, or to any irregular outlines, being invariably charged for as extras; also very large plates are charged more per ton, and sometimes to save the additional expense it is found cheaper to make an extra joint or so, even when the presence of the joint is to be deplored. Another peculiarity which it is well to take note of in ordering plates, is that the first size given is taken to be the length of the plate and the second size given the width. This is very important, especially when ordering iron plates, which to avoid fracture in rolling, must be ordered so that they can be rolled with the grain instead of across it. Thus, a plate required 4ft. 0in. long and 6ft. 6in. wide would be correctly ordered 4ft. 0in. by 6ft. 6in. as the grain always run the length-way of the plate. In steel plates this is not so necessary as there is little difference in the grain of the plate either lengthways or in width. In the ordering of angles, tees, bars, channels, bulb irons, etc., it must be remembered that the extreme sections are not obtainable from all manufacturers and generally a sketch is sent them of what is required and quotations asked for. Sometimes it will be found that the particular material ordered may be so small a quantity that the manufacturers, having no suitable rolls wherewith to roll the section, will not accept the order and you may have to endeavour to place the order elsewhere, where rolls for this particular section may be on hand. Again, with section iron, as with iron, steel and copper plates, extras will have to be taken into account, as in the purchase of this class of material, anyone can soon run into a lot of extra expense. Very large and also very small sections of angles, tees and channels are very expensive. Tees, bulb angles and Z bars will probably cost as much as 10/- per ton more than ordinary angles, whilst channels may cost as much as from 24/- to 28/- per ton more. But as a rule the extras are not so heavy on steel as on iron, because the difficulty of rolling sound sections

is not so great, from 5/- to 18/- generally covering the extra costs.

Estimating the cost of work is another detail of a Supervisor's work which is not so easy as it may appear to an unpractised man. Many details are apt to be forgotten or overlooked with awkward results. It is always best where possible to take sufficient time to go thoroughly into the most minute details before giving a decided opinion upon the real value of a piece of work about to be done. In some shops, work is paid for as regards plating by the ton, whilst in others so much is paid for each different job, Riveters generally being paid at the rate of so much per 100 rivets, or by the dozen or so much each. The prices in shops where piecework is in vogue have to be made to suit the condition prevailing, consequently, prices suitable to one shop might be totally inadequate in another, the prices being based upon the facilities for doing the work existing in each shop.

In dealing with the general management of a Boiler Shop, everything must go forward in a proper and systematic way, each particular class of work being put forward and done in proper rotation or it will soon be found that the Foreman has had too much of one class of work done, whilst other parts have been entirely neglected. As soon as instructions are given for the manufacture of a number of boilers, he should at once proceed to forward the manufacture of the foundation and firehole rings, barrel angle rings, dome rings, etc., and as soon as the boiler plates arrive, have them rolled, examined and marked off, the plates that required flanging sheared out and sent to the hydraulic flanging press, suitable blocks put in and this class of work at once proceeded with. Whilst this is in progress, the Marker Off should be busy getting the first barrel plates marked off—which as soon as done should be sent to the radial-armed drilling machine, and, five plates being placed on the machine, one on top of the other, drilled through at one time. The first five being drilled, the second five should be the next plates required to make the complete barrel, and, whilst these are being drilled the first five should be sheared and planed and handed over to the Plater for him to start rolling up, the second barrel plates following the first in order and so on with the casing wrappers, and copper box sheets. The copper tube and back plates should also by now have been flanged and marked off ready for drilling, and each different class of machine and men be getting busy. With proper care the work should now keep following on in order making each set of men busy, after the Plater coming the Riveter, Caulker, Stayer, Tuber and so on till the boiler is completed ready for the frame. If engines are required to be built, then frame plates, tenders or side tanks, bunkers, cabs, ashpans and all the necessary items required from

a Boiler Shop in the building of an engine, must be got in hand at the same time as the boilers, and also in a proper systematic manner to ensure that nothing is neglected to enable the engines to be completed without delay. Engines coming into shops for repairs should also be dealt with systematically; first the brick arch and firebars should be taken out and the firebox thoroughly cleaned down, the Boiler Examiner then proceeding to examine every accessible part most minutely and to make a proper report of all defects found. After this, it is settled whether the boiler has to be taken out of the frame for repairs or can be managed in the frame. Proper instructions should be given to the men as to the nature of the repairs to be done and proper supervision maintained to see that nothing is allowed to be forgotten to put the boiler into thorough repair before it is again sent out of the shops and a complete record of all such repairs done should be kept for future reference; also a complete record of the Boiler whilst under its Water Pressure and Steam tests should be taken.

In conclusion, I may say I have endeavoured to give some idea, as far as time would permit, of the machinery required in the equipping of Locomotive Boiler Shop and the management of same and trust I have, in some measure, been successful.

DISCUSSION.

The Chairman, **Mr. Suffield**, is opening the discussion, said that it was quite apparent that Mr. Bennett had kept himself fully acquainted with all the up-to-date machinery. Mr. Bennett had said, in regard to hand pneumatic tools, that the trouble was with the riveters. that it bent the rivet and, consequently, one got weeping. He (the Chairman) was privileged a few weeks ago to see the latest hand riveting tool. The ordinary riveter, of course, gave a straight direct blow. This new one, which was in use in the Works in the north of England, had three prongs. There was a centre prong and one on either side and the tool itself revolved very rapidly. The result was that you not only got a thicker section of head but you got it close down on to the plates.

Samples of the riveting done by this new tool having been handed round for inspection:—

The Chairman said that there were plenty of points in the paper that he was sure the members present would like to speak about and he asked some one else to continue the discussion..

Mr. Garratt said that he thought the Vulcan Foundry Co. had got a revolving stay riveter and also another firm in Lancashire. He thought there was a bit of history attached to these machines but he had not been able to follow the matter up. It might be of interest to the Meeting to know how they were going on. There were one or two patents taken out and he would like to know who was going to come out on top with the revolving stay riveter with a central pivot.

Mr. Menezes said he would like to know if the boiler plates in England were heated before they were put into the rolls. In India the plates were not heated as owing to the climate they were almost always warm. In England the climate was colder and he wondered if the plates would suffer if they were put into the rolls cold.

Mr. Nethercott said there was one point in the paper he wished to speak about and that point was that some Managers and Engineers seemed to have an idea that one Boilermaker was practically the same as another. It was absolutely the biggest mistake an Engineer could make. It was quite useless to think that you could take one man and put him on a particular job unless he had been brought up to that particular part of the work. You might just as well take a watchmaker and ask him to build an engine for you as to take a riveter and put him on to plating—it was practically the same. He had seen rather a large amount of this. A Manager would say “You have plenty of men; put them on to so and so.” but it would be completely useless. A boiler was a thing you could spoil and you could put one man on and spoil more work in one day than it would take you two months to put right.

With regard to general equipment, he thought Mr. Bennett had gone over the majority of the machinery, but to equip a Boiler Shop thoroughly, one would want to know the quantity of boilers to be turned out, also whether the shop was to be a general repair shop with tanks, tenders and so on included, because what suited one class of work would not suit another and the shop would have to be equipped for the quantity of output asked for. Unless the machinery was capable of keeping the men employed in rotation, one would do far better to have less men and less output. You must have the quantity of machinery—drilling, planing and punching, in proportion to what output was required.

About the rotating stay hammer, he did not know whether it was absolutely new. He thought not. Seven or eight years ago it was at work in Swindon Works on the G.W.R. and how these hammers finally stood the test perhaps Mr. Margetts would be better able to say than he was himself as since that time he had left Swindon.

Mr. Margetts said that the rotary hammer upon stay riveting had been abandoned at Swindon and hand work substituted.

Mr. Garratt said he had seen some experiments with this rotary hammer and it made a very pretty job but he had his doubts as to whether it made as good a job as ordinary hand riveting heading over, and he would like to know that his idea was borne out by experience. If they could bear him out he would be very glad; that it had been abandoned was pretty good proof that it was not perfection.

Mr. Bennett said, as regards the rotating hammer, that as far as his own experience at Doncaster went, they had very good results from stays. They worked the centre tool with the two outside prongs and the results obtained at that time were better than with the hand work. At the time of his leaving Doncaster they were still using rotating hammers.

Mr. Margetts said it all depended upon the pressure in the boiler. The rotary hammer gave very good results upon low pressure boilers, but with anything beyond 180 lbs. was not a success. The rotary hammer had a tendency to shake the stay and there was not blow enough to fill up the space in the thread. It made a very pretty job, but after extensive trials at Swindon, they gave it up altogether.

He noticed that **Mr. Bennett** said in the paper that there should be 75 tons upon triple riveting and 50 tons upon double riveting. He thought 75 tons was altogether too much upon butt straps because you must distress the work. The proof at Swindon was this, that with 880 lbs. pressure they had practically as good work as at 1,500 lbs. pressure. For several years they riveted up 225 lb. boilers with 28 tons upon the rivet. They then introduced 1,500 lbs. giving 48 tons upon the rivet. They certainly had better results than would be obtained by putting all the pressure (75 tons mentioned by **Mr. Bennett**) upon the strap as you would distress the work very much. He thought if you got 50 tons upon a $\frac{3}{4}$ in. rivet you had as much as ever you needed for 225 lbs. pressure.

He noticed also in the paper that **Mr. Bennett** said it was possible to stretch a plate one side in rolling. Now, he had never seen that done. He knew it was a pet theory of the makers of rolls, but according to his experience it was impracticable. He had seen plates pressed under a hydraulic press hot but it had no effect whatever upon the buckle. Even to warm the plates and to press them did not take the buckle out and he himself did not think it was possible to roll the plates cold to make one side which was short as long as the other. The buckle would be forced out sideways, but he did not think it was possible to stretch the plate in plate-levelling rolls.

He did not think there was very much to be gained by drilling plates in batches. High speed drills were very expensive and there was a tendency to wear off the clearance upon the drills. This was a very important matter in a Boiler Shop and his experience was that when drilling plates in batches you very soon wear out your drill, it becoming practically useless, especially in drilling tubeholes. The effect of copper upon the drill was worse than that of steel. Of course, you could do a good deal of drilling for the price of a high speed drill.

Mr. Bennett's paper was interesting and extensive. Of course a Boiler Shop at one time was reckoned nothing, now it took precedence over everything else.

Mr. Whitelegg, referring to what had been said about the rotating hammers said that some time ago his company had four locomotives made out at a Locomotive Company in the North of England—Stephenson's—and all the rivets in the copper box were done with the rotating hammers. He had had no trouble with these rivets since they came and the stays had stood better than their hand work stays, so he did not think there was any fault to be found with the rotating hammer. He did not know exactly what pattern Stephenson's used, but thought it was one of the latest kind. He knew it had a centre prong.

The Chairman said, referring to the riveting he saw done only a few weeks ago at a certain firm—he was not in a position to mention the name of the firm or the patentee—that this firm did the whole of their fireboxes, and under test they did not get any weeping. The section itself could be seen and it was far stronger than hand or any other machine riveting. He had heard numbers of locomotive engineers who considered it to be far better than hand riveting. The firm mentioned did it with either steel or copper and you should see by the sections that they were equally good.

Mr. Dearberg said that Mr. Bennett remarked in his paper it was advisable to do away with as many joints as possible and therefore to have the plates as long as possible. Perhaps it was interesting to know that Mr. Cooke had gone further than anyone else. For his new 4-6-2 tank locomotive he had a boiler with 11ft. 6in. barrel with no circumferential joints, it being made out of one plate.

Mr. Burt remarked that at the Brighton Works they had recently built some boilers, for re-building some of the 0-6-0 passenger tank engines, with barrels in one piece, the length 8ft., and the external diameter, 3ft. 6in.

Mr. Menezes asked what was the proportionate capacity of the steam dome in reference to the boilers.

Mr. Bennett replying to Mr. Menezes' question referring to the rolling of the plates cold, said that in most shops in England the general condition that rolling took place under was that after they were drilled the plates were annealed and then rolled when they were cold. He did not know of any Boilermaker practice where it was done hot except in the case of domes which were oftentimes rolled hot because they were so small. Mr. Bennett further added that if the plates were rolled at a low temperature, you would have practically the same thing taking place in the boiler plate as with the "rotten blue heat"—you would have fractures the same as in common iron plate.

Mr. Dearberg said he would like to ask Mr. Bennett to what extent caulking was done at Brighton. Some makers were very strict about this nowadays and it was done away with as much as possible and with very good work it was nearly always possible to do away with it.

Mr. Burt said that when some members of the Institution visited Swindon Works last September they were told there by one of the officials who showed them round the Works that caulking was not done at Swindon for the reason that it was thought that the men would make a better job in the first place if they thought the boilers were not going to be caulked after they were tested.

Mr. Margetts said he was afraid the official was not a Boiler-maker. They tried caulking without the seam tool—to use fullering only; but that was not such a success as seam tool caulking after fullering.

Mr. Bennett asked if Mr. Margetts meant to infer that after he had properly fullered his caulking he had to use a seam tool to finish.

Mr. Margetts replied: No, they did many boilers without seaming but the leakages in testing were more than in the case of those which were seam tooled.

Mr. Bennett said he should think, under the circumstances, the men had not made what he called solid caulking. They must have done flown caulking and where the plate was not close together they had simply flown the metal up to a close point and as soon as the steam got to that point it blew the piece out.

Mr. Margetts said, some years ago the Great Western bought some boilers from four firms, but they were retested when they got to Swindon and had a tremendous amount of leakage.

Mr. Nethercott said, as regards that, they had had some experience at Brighton for they bought a large number and they had not only done testing afterwards, but had taken rivets out and put new ones in, so it was not only a question of caulking. It was a question of riveting and all of these boilers *had* been tested.

Mr. Bennett said there was another little point he would like to ask Mr. Margetts about. When they were talking about the cost of flanging at one of the previous papers, there was a statement made about the cost, with reference to the Belpaire against the ordinary round crown type boilers. Of course, it was agreed that the Belpaire boiler was an expensive boiler to build and he thought he mentioned some prices at the time as regards the cost of the flanging of the throatplates. He said that for the ordinary type round crown boiler he could flange throatplates for 5/- each and he thought, if he had to do Belpaires, it would be £1 15s. 0d. or something like that. He thought perhaps Mr. Margetts would enlighten them as to the approximate cost of flanging Belpaire throatplates at Swindon.

Mr. Margetts said he was afraid he was not in a position to give an answer to that. Of course the Belpaire was very much more expensive than the round tops.

Mr. Carratt said he happened to be connected with a firm that made engines and they made Belpaire fireboxes and, including staying and all the rest of it, they came very much cheaper to build than round tops.

Mr. Dearberg said that, as he was the author of that paper, he thought he had the right to show another side of the question. His paper was not designed in regard to expense, but from the Engineer's—the designer's—point of view. It was the best firebox for steam generation and as for cost, it must be left a secondary matter, because superheater engines cost more and four-cylinder engines cost more and they earned more dividend, so with the Belpaire; what he meant to say was that it provided a better steam generator and that was the way that he regarded it as a dividend-gaining concern.

Mr. Bennett said he was not so much referring to Mr. Dearberg's paper as to a little argument he had had with Mr. Nethercott re the two types of boilers and he was asking for a little information that he should like to get.

Mr. Nethercott said that was quite right but you need not tie yourself to one type of Belpaire boiler. The one built at Swindon was conical but a square built parallel box would not cost nearly so much as one of those built on a cone.

Mr. Bennett said:—Yes, but he had not got the cost for one that was built on cone.

Mr. Grant, the London representative of the Carbic Co., then proceeded to give a demonstration with the Carbic Oxy-Acetylene Welding Plant and said that, without troubling the Meeting with technicalities, he wished to bring to their notice a recent development in the form of carbide, the "Carbic" cake, which was composed of the very best British carbide treated in its granulated form and compressed into blocks. The action

of the water dissembled small particles from the bulk and they dropped down into the tank, the gas coming from these small particles passing into the various chambers, through the purifier and on to the blow pipe. The great claim for the Plant was that the gas was only generated according to the consumption. The Plant would work a cutting blow-pipe and a welding pipe and whatever flow of gas you were using from the pipes the apparatus would generate sufficient to meet it. Mr. Grant explained portions of the apparatus to the Meeting and continued that the Plant was particularly made for breakdown work and was intended not so much for use as a welding plant. Sufficient welding gas could not be obtained to last a man for any lengthy job. Boiler work would want about $1\frac{1}{2}$ hours. Where, however, it was a question of breakdown or removing portions of engines or carriages in order to clear the permanent way, the plant was capable of dealing with the work.

After Mr. Grant's demonstration **the Chairman** closed the Meeting by saying that he had to thank Mr. Bennett very much indeed for his extremely interesting and able paper. It was very gratifying to them considering that Mr. Bennett was one of their latest members, that he should come forward and give them a paper at practically very short notice. It was rather a pity that they had not had more of a discussion but, of course, the subject was one which was rather difficult to discuss. He thought it would be better if they could have advance proofs of papers and the Council were arranging to do this and at any time, if a member would apply to the Secretary, he could be supplied with same. In proposing a vote of thanks to Mr. Bennett he would like to include Mr. Smith. Mr. Smith had been extremely good and right through Christmas had been busy preparing the lantern slides for illustrating the paper. At the same time they must include Mr. Burt who had been working very hard in the interests of the Institution. He, therefore, moved that a vote of thanks be passed to these three gentlemen.

This was seconded by **Mr. Anelay** and was carried unanimously.

The Chairman then said that as it was the last Meeting of the year, the Council individually and collectively would like to wish the Members a very happy and prosperous New Year.

Mr. Bennett said that he must thank them for their kindness in listening to the paper. At the same time he would have liked to have heard more discussion for the reason that he came there with the intention of trying to learn and the more discussion that arose the more opinions of other people he obtained. He knew what he himself thought but did not know what other people thought unless they argued, and if there had been more discussion it would have shown that there was more diversity of opinion.

Fig. 1.
Straightening Rolls.

Fig. 2.
Straightening Rolls.

Fig. 3.
Vertical Plate Rolls.

Fig. 4.
Radial Arm Drills.

Fig. 5.
Tube Plate Drilling Machine.

Fig. 6.
Punching and Shearing Machine.

Fig. 7.
Hydraulic Plate Flanging Machine.

Fig. 8.
Hydraulic Riveting Machine.

Fig. 9.

Acetylene Cutting and Welding Plant.

These plants are manufactured from 150 to 300 cub. ft.
gas capacity.

Boiler Machine Shop. N.E. Ry. Darlington.

Boiler Shop. N.E. Ry. Darlington.

Boiler Shop. N.E. Ry. Darlington.

Boiler Plate Shop. N.E. Ry. Darlington.