I will, with your permission, give you a general description of the pipe to be used in the Coolgardie Water Scheme in Western Australia, from a makers' point of view, and also give you such a description of the present mode of manufacture and of the difficulties yet to be overcome as will enable you, in the event of similar pipes being used here, to avoid some of the worst elements in the present pipes of which I have personally supervised the construction of some 16,000 or 17,000.

The particular pipe being used is that known as a "Rivetless" "Locking Bar," or "Secret Joint Pipe," so named because the edges of the plate or plates of which the pipe is made, are united by means of a longitudinal bar so shaped as to allow the plate edges to be inserted therein, and there retained by having the edges of the said bar closed over the edges of the plate, the edges of which had been thickened or upset. And when the pipe so constructed is made faithfully it can stand a very high test, far higher, indeed, than either welded or rivetted pipes; but, as I will explain later, is very uncertain both as to its tensile or hydraulic value.

This particular kind of joint was patented some 15 years ago by a man named Quadling, it was revived a year or so ago by Mephan Fergusson, and has been somewhat erroneously called after him.

No use was made of the first patent because none of the steel mills could turn out plates of sufficient length to make it payable.

The Coolgardie water pipes are 28ft. long, 30in. diameter, and are formed of two plates, each 28ft. x 3ft. 11½in. x ⅛in., and two locking bars 28ft. long.

The steel, both of locking bars and plates, has a tensile strength of from 25 to 29 tons per square inch, with an elastic limit of 20 per cent. in 10 inches, and a contraction of not less than 45 per cent.

The locking bars for the ⅛in. plates weighed 6½ lbs. to the foot.

Manufacture.

The method of making a pipe is as follows:—A plate is passed through a set of flattening mills and thence on to a truck or moving bench, so arranged on rails or slides as to allow of it with
the plate being passed between two pair of wheels, or disk cutters, which being fixed a distance apart equal to the length of the pipe to be made, accurately cuts the plate to the exact length required.

The plate is then fed on to a planing machine, 45ft long and about 10ft. wide, constructed so as to contain the plate on a central bed 28ft. long by the width of the plate, and upon which the plate can be firmly held by means of two longitudinal girders united at each end, and connected to two hydraulic rams. On each side of the plate bed is a machined guide bed intended to support a heavy saddle or tool holder, into which on each side is fitted adjustable cutters, made of the best muschet steel, 1½in. x ½in., ground with a cutting edge of not more than 30°. These cutters are so arranged as to allow of their being advanced one before the other, thus dividing between them the labour of cutting off any surplus metal on the plates. I have seen one, the leading cutter, take off as much as 1 inch at a cut, but it is better to divide the work into a number of cuts, each about ½in.

In the same saddle, and immediately following the set of cutters, is a series of rollers, upon vertical axes, so fitted as to be, like the cutters, adjustable.

The object of the rollers is—that immediately after the cutters have brought the plate to its proper width, to upset, or buff up, or thicken the edge of the plate, and the rollers, five in number, are so advanced one in front of the other, that the labor of setting back the plate edge is equally distributed between them.

These rollers are made of the smallest diameter, capable of withstanding the pressure, and two or more in each series are grooved so as to overlap the plate edge, and at the same time are indented within the groove so as to slightly split the plate, or a better term would be to set back the center of the plate, at the same time slightly overturning the edges. The next roller being parallel would further set back the overturned edges, and, at the same time, put a perfect finish on the plate edge. Lastly, the plate is made to pass through two rollers so placed as to form a gauge as to the thickness of a plate edge, and if same has been upset too much, to reduce it to its proper thickness.

The saddle or tool holder is made in two pieces held together with five 5in. screws and nuts. It was found by actual experiment that nothing less than five screws of 5in. diameter would withstand the tremendous outward thrust, consequent upon the pressure applied through the upsetting rollers.

The saddle was moved from end to end of the machine by means of two leading screws, one on each side of the bed, and placed in a channel or recess so that a corresponding threaded nut within the saddle could be thrown in or out of gear.

When the saddle had made its journey and was thrown out of gear, it was returned by means of a steam windlass. The two leading screws were inter-geared so as to always run together.
The plate now having been trued up and its edges upset, it is taken and passed through a set of horizontal rollers, in which the upper one has the ends turned convex, to the radius of the pipe, and the lower roller has its ends turned concave to the same radius + the thickness of the plate. The object of these rollers is to bend the plate for about 9 inches from its two edges, to a radius equal to the R of the pipe, because, owing to the plate having had its edges upset or thickened, it was found impossible to curve the plate at that spot in the ordinary curving rollers.

The plate having passed the last operation is swung into a set of longitudinal rollers to be curved. These rollers are 30ft. long, and the plate when curved should have a radius one inch longer than the radius of the pipe. (For the reason that these pipes always have a tendency to flatten in the closing machine).

The next operation is the building up of a pipe, and this is done by dropping one plate into a cradle and placing a locking bar on each edge, and then dropping a second plate into the upturned edges of the locking bars. The two plates and bars forming a complete pipe being then firmly bound together by means of half round clips joined with two pins and cotters.

The pipe as now appearing is then lifted on to a travelling trunk, made to run on rails, or better still in V shape slides, so that it can be moved into the closing machine or as we called it the squeezer, which I will now describe to you.

The squeezer as in use at the Messrs. G. and C. Hoskin's factory is far more simple than the style at use at Mr. Fergusson's.

G. and C. Hoskin's squeezer consists of a heavy casting with an opening about 12in. larger than the pipe to be squeezed. At the top of this opening is fixed a die or anvil, 6in. x 6in. x 10in., with a longitudinal groove cut to the shape of a finished joint. At the lower end of the casting is a hydraulic cylinder and ram, upon which is fixed a second anvil or die, similar in shape and size to the first mentioned. Now, in order that the pressure of the lower ram should not be lost it was necessary to have a mandril or prop within the pipe to be squeezed. There are two types of mandril in use, and I feel bound to describe both. That in use at Mr. Fergusson's is composed practically of an upper and lower die or anvil, similar to those already described and placed base to base, but divided by a stepped wedge which could be withdrawn or inserted by the action of a small hydraulic cylinder and ram. The object of the wedge is to cause the upper and lower dies to expand against the upper and lower locking bars of the pipe, and then to transmit the pressure received from the hydraulic ram through the lower bar to the upper one. This mandril nose is suspended at the end of a girder 28ft. long so that it can be operated at any part of the pipe.

To the above mandril there were found many objections, one being a danger that in the hurry of working the hydraulic levers,
it might happen that pressure was applied to the lower ram before the wedge had expanded the mandril, in which case the lower and upper dies would probably cut right through the pipe, to its utter ruin.

Another objection is that there is during the life of the dies on the mandril an ever increasing tendency to rock, thereby causing a greater strain to be put upon one side of the bars to the other, with the probability that the pipe will leak.

The great advantage claimed for this form of expanding mandril was that it could be freely moved along the pipe when the wedge is withdrawn, and also after the pipe was squeezed the mandril could be easily withdrawn.

I may here tell you that pipes, when made up or built, are always built with a longer diameter across the locking bars than elsewhere. This being necessary because it was found that the process of squeezing tended to flatten the pipes between the locking bars.

The Messrs. G. and C. Hoskins, after using the expanding mandril for some time discarded it and in lieu had a solid one, and by experiment found the best vertical diameter for the mandril, so that the pipe built oval would be squeezed round. It was found that the solid mandril gave much better results than the telescopic one. The pipe having been successfully squeezed would be rounded up and tested to 400 lbs per square inch, then heated to 300 or 400° F. and dipped into a mixture of bitumen and coal tar.

The pressure required to squeeze a pipe was found to be as follows:—

- Weight on accumulator = 2,400 lbs.
- Accumulator piston = 6 in. diameter = 28.2744 square inch.
- Squeezer ram = 18 in. diameter = 254.469 square inch.
- Total pressure on ram = 276 tons.
- Effective length of die 4½ inches.
- Pressure per square inch of 4 bars = 30 tons.

Hydraulic tests.—The test under the contract was 400 lbs. per square inch, but owing to the bursting of nearly all pipes made it was reduced to 350.

If you look at the sketch, Fig. 2, you will see I have divided part of a locking bar into five parts, each being equal to the distance that one of the lips has to travel before coming in contact with the plate.

Now in the operation of squeezing a pipe the die would come into first contact with the bar at the point "5," thereby excluding the part below "5" from expansion. And from examination of many hundreds of complete pipes I found that the bar exhibited
no reduction in width across the web; so that in the operation of squeezing a pipe the locking bar between the points 1 and 5 had to expand sufficient to allow the "lip" to come to the plate.

I have already told you that the elastic limit of the steel was 20 per cent., whereas by my argument the locking bars were subject to at least 25 per cent. And this argument is borne out by the results of after examination and test, for all the pipes which burst under the test and which had no visible defect, fractured the bar at a place between 1 and 2; and from microscopical examination I found that hundreds of pipes having passed the test, nevertheless, had their bars fractured, and some of them had the appearance of a bunch of horse hair. There is no doubt, in my mind, that the steel was too hard and the locking bars badly formed.

I will draw your attention to the sketch which shows an ideal plate edge, Fig. 1 B, and of a style as nearly always formed at G. and C. Hoskin's work, but if you look at the joint which I have here you will note that the edge, instead being as in the sketch, is reduced to a wedge at such angle as to form the best possible device for bursting open the bar.

You will also easily note the impossibility of a locking bar formed as this one is (Fig. 1), being pressed into the hollow behind the upset edge as in Fig. 1 B.

A pipe made up with plates upset, as per sketch on board, may or may not be a tight pipe under pressure, because the extreme edge of the edge does not offer sufficient resistance to the movement of the locking bar. But a pipe so made will stand the highest tensile strain.

While a pipe made with plate edges like would be absolutely dry under the test of 400 lbs., but would at all times be liable to burst owing to the bar having been bent over the angle ×. This fact was shown to me by reason of a number of burst pipes having fractured from × to a point between 1 and 2.
COOLGARDIE WATER SUPPLY PIPES.

It was the custom to have one test piece 2in. wide cut from a pipe once a week, and submitted to a tensile strain. I had some 60 so cut and tested, and the average strain supported was 22.5 tons, while the highest was 28.75, and the lowest 11.5 tons. Yet out of the pipe of which the test piece had failed at 11.5 tons, I took two other pieces, and they took 18.9 and 22.75 tons respectively. All of which goes to show that this particular secret joint is very unreliable.

Of course the result of the tensile test of one piece a week, when we were making as many as 400 pipes in a week, is not a fair sample of work done. It is only 1/10 of the week's work. And yet as a fact only 1.5% of pipes tested failed.

I think, now having put you in the way of understanding the general position of the work, I shall serve you best by detailing particulars of the more important errors or difficulties which were met, and putting against each my view of the reason, and what in my experience is the best method of overcoming same.

1. Locking bars wrong shape. Should be far rounder, and have lips 1/4 inch longer; and should also be set out radially and have straight jaws.

Reason.—By making the bar round like a far greater pressure tending to compress the jaw could be given, and still give more metal in line of present fractures. The bar being set out radially would avoid the strain which must now come upon the upper edge of the plate when being squeezed, and would enable some of the metal at present in the bar inside the pipe being transferred to the outside.

The bar should also have straight jaws, instead of at present. By this means the movement now necessary to bring the bar into contact with the pipe would almost disappear.

2. The tensile value of the steel should not be over 22 tons per square inch, and the deficiency in strength (if any) should be made up by adding metal.

Plate Edges.—The thickness of the upset edges is too great in comparison with the thickness of the plate = 100% nearly. My reason for coming to this conclusion is that pipes on which the locking bar had not been squeezed on to the plate but had nevertheless well overlapped the edge, stood the hydraulic test and were tight, and also stood a fair tensile strain of 18 tons, while the same pipe sent back to be resqueezed was at even chances liable to burst.

That the upset plate edges should be formed at a radius of not more than 1/8in., and should finish in a neat and thin edge capable of fitting well home in the locking bar. That the edge of the plate and the inside of the bars should be prepared with red lead or the like.
COOLGARDIE WATER SUPPLY PIPES. 27

Reasons.—Under the present method and contract, an absolutely dry pipe was demanded (a qualification never expected or demanded of any other form of built pipes), and I know of my own knowledge that to acquire this perfect dryness, hundreds of pipes must have had the lips of the locking bar driven into the surface of the plates, a defect almost impossible to detect except by cutting.

The object of the red lead and oil, etc., is first, to preserve the surfaces, and second, to present opposition to the ingress of water. Any surplus lead or oil, etc., would be ejected at once by squeezing.

At present also, owing to the demand for a perfectly dry pipe, the contractors would make the plate edge full thickness and depth, and would employ considerable force to drive the plates into the bars, with the result that tight pipes would result. At the same time it generally happened that the plates were not home in the bars. This fact was not objected to by the Government, but in my opinion the value of the joint was materially impaired in order to have the dryness.

Another reason for having the thin edge and the red lead, etc., is that if the edges are too thick and not home in the bar, there is a liability of the edge being crushed, and this was exhibited when, for other visible faults, the bars were cut off.

There are other errors that you would have to combat, but they are mistakes in machinery, and I have no desire to enumerate them, but there are one or two that I think you ought to know.

As it is really impossible to roll the plates absolutely to the required radius, so it will follow that one plate will frequently be wider than the other, and though the pipe will not present any great difficulty in building, yet in the squeezer as the pipe is being squeezed, there is a continued effort of the narrow plates to tilt the bars; and if a bar is squeezed when so tilted or canted, then the next squeeze will tilt the bar a little more, so that by the time half the pipe is squeezed, the lip of the bar will be almost thrust through the plate, while the other side will not be within $\frac{1}{2}$ in. of the plate.

The best remedy is to lift the pipe and reverse it, but even that is not very satisfactory.

As I have already said, I consider secret joints objectionable where heavy pressures are to be overcome. The greatest pressure likely to exist in these pipes is 240 lbs. per square inch, without any allowance for shock. And as I have already pointed out, notwithstanding the test of the pipe to a higher value, there is a strong likelihood of its bursting with a much smaller load. And it is in this aspect that I compare them, as regards utility, with a rivetted pipe. In the latter, allowing a careful inspection of work
in making and honest material, the hydraulic value of the pipe can easily be calculated, and within a very small margin, relied upon. While in the locking bar pipe, no inspection of the work during construction will enable you, even with fair accuracy, to estimate what pressure it will stand. And when it does fail it fails for the whole length of the pipe.

In my opinion the value of the locking bar pipe would be increased 50 or 100 per cent. if the locking bar were heavier and of the section I have suggested. The lengthening of the lips would allow of the bar being bent into the upset edge and not bent over it as at present. Then the edge is too thick, and this was proved by the construction of a pipe (afterwards condemned for lamination) which had an upset edge of a \( \frac{\frac{1}{2}}{\frac{1}{2}} \) in. on each side, and in order to split the bar so as to the more easily get the pipe to pieces, we tried to burst the pipe but could not at 500lbs. per square inch.

Before finishing I think I ought to tell you that the G. and C. Hoskins have introduced a new method of upsetting plate edges, and that is by taking them from the planer where they are trimmed only, and drawing them through a series of rollers placed as follows:—one pair horizontal and one pair vertical. The vertical rollers are placed between the axes of the horizontal rollers so as to actually form a parallelogram, so that, when a plate is drawn through, it is held firmly by the horizontal rollers, and the vertical ones upset the edges. There is no doubt as to the superiority of the machine and its work.
COOLGARDIE WATER SUPPLY PIPES.

Discussion.

Mr. J. T. N. ANDERSON (the President) said there had not been many papers read before Engineering Societies on this question. A paper had been read before the Institute of Civil Engineers by the late Dr. Percy Frankland on the general subject of bacterial growths in water supplies. A great desideratum was to have a water that contained very little nourishment for the bacterial growths. Efficiently filtered water would never subsequently carry a large quantity of bacteria. Climatic conditions were very different in England to Coolgardie, as the temperature variations in the latter case would be some 30° more than in the former.

Dr. JAS. JAMIESON, M.D. (who was present by invitation of the Council) mentioned that from the terms of the notice paper the discussion must be a very general one. The subject would have to be considered from two different standpoints. First, the comparative advantages of the use of enclosed pipes instead of open channels; secondly, any special circumstances there might be in Western Australia. Water running along an open channel, introducing itself to the air, was aerated and oxygenated, and the water would be positively benefited, and generally speaking open channels would be preferable to pipes. In closed pipes something might be added to the water and there would not be the same chance of anything being removed from it. In Western Australia the conditions were peculiar. For years now it was recognised that there was a great prevalence of typhoid fever there, especially in the mining towns. Generally typhoid was spread by means of contaminated water and contaminated milk; but in most of the goldfields condensed water was used which was pure; also condensed milk, which was subjected to a considerable heat before being tinned, and would be free from contamination until the tin was opened. These two sources of typhoid were therefore not applicable to Western Australia. The special circumstances were that there were no sanitary arrangements and all kinds of foul matters got to the surface, and, as in the Victorian goldfields in the early days, they contaminated everything. Unless the water was conveyed through practically safe localities where there was no risk of contamination, pipes would be better than open channels. He did not see that there would be any great harm in conveying the water a long distance in iron pipes. Taking into account the whole of the circumstances the benefits of conveying water in closed channels in Western Australia outweighed the disadvantages in carrying it in open channels. If the water was fairly free from germ organism and organic matter at the source and the temperature did not exceed 60° or 70°, they would not multiply very rapidly. Everything depended on the local conditions.
Mr. FOSTER SMITH mentioned that the intermediate stations would each hold about two days' supply and the amount of water passing through would disturb that already there. The reservoir at Coolgardie was five miles from the town itself, and this was the only one near any habitation. The pipes passed through a desert and he did not think it possible to have open channels on account of the immense deposits of shifting sand and the tremendous evaporation which had taken place. The pipes were laid about 2 ft. 6 in. below the surface where the temperature was practically uniform, being about 62°, except for a short distance across the salt lakes where they were carried on tressels. The pipes were coated with bitumen. The first reservoir was in virgin country with a catchment area of 800 square miles not heavily timbered and there would probably be little organic matter in the water.

Mr. Fyvie considered that from an engineering point of view there would be very little danger from contamination in the scheme before them. He considered there was a great deal of harm caused by the dead ends in the reticulation system of Melbourne. Recently there was a stoppage in their 8 inch meter and after removing the cover they discovered three dead eels, 3 feet 9 inches, 2 feet 6 inches, and 2 feet 2 inches long, in it, and this was not at a dead end. Some very interesting features had been mentioned in the paper and he hoped the discussion would be continued at the next meeting.

By Correspondence,

Mr. A. N. PEARSON regretted that owing to a previous engagement in the country he would be unable to be present at the meeting, to discuss the probable effects on the Coolgardie water supply of conveying the water long distance in closed pipes exposed to the weather in a warm climate; and the time at his disposal before the meeting was too short to admit of his giving any special thought to the question. Speaking generally however, and at short notice, he was inclined to think there would be little or no injury. Judged by the ordinary chemical standards there might be an improvement. There might, owing to the warmth of the water in the pipes, be an increase in the number of bacteria which grow in the dark in the absence of a full supply of air; but these would afterwards be mostly removed by insolation and sedimentation in the storage reservoir at Coolgardie if it were large enough to allow of long standing. He was inclined to think that the disadvantages of transmitting through closed pipes—notwithstanding the somewhat higher temperature that would be attained by the water in the absence of evaporation—would not be so great as the disadvantages of possible contamination in open channels. In any case he regarded efficient domestic filtration as a necessity in the case of all surface waters in this country.

By Correspondence.

MR. G. HIGGINS, in connection with Mr. Foster Smith's Paper on the Coolgardie Water Supply pipes, wished to call attention to an important aspect of this scheme for water supply. Referring to the effect on the purity of the water of its prolonged confinement in closed
pipes. Some of our members may be able to give us the benefit of their experience in similar cases; but he had reason for fearing that the water, when it reaches its destination; will be impure and unwholesome unless it is given an opportunity of purifying itself by aeration. Some years ago a series of experiments were made by Mr. L. J. Le Coute, C.E., on various systems of water supply in California. Analysis, both chemical and bacteriological, were made of the water at various points in the aqueduct and pipe-lines. It was invariably found that water, after having flowed freely through a length of open aqueduct, was much purer than when it entered it. On the contrary, water, which was fairly pure on entering a closed pipe, was found to be very far from pure on emerging from the pipe a mile or two away; a rapid growth of fungus had taken place, and an unpleasant odour and taste were noticeable. Two processes for purifying the water were adopted with success: First, canvas screens were employed to intercept the vegetable and other floating impurities; secondly, the water was broken up into small portions by means of some artificial cataracts. He thought it would be found desirable to introduce air into the water for Coolgardie at the pumping stations. The best way to introduce air, in a finely divided state, into a liquid, is by means of numerous small jets which carry the air well into the body of the liquid.

Mr. Fyvie presumed that the average breaking strain of the test pieces given as 22.5 tons, highest 28.75 tons, lowest 11.5 tons, is per square inch, and not the actual stress necessary to rupture the piece. If this is so, the highest test only comes up to about the average of the original strength of locking bar and plate, and considering the very severe treatment the locking bars were subjected to in the squeezer, he would agree with the author, that the material should have been more ductile, say 20 to 25 tons tensile, and elongation not less than 25%; contraction of area not less than 50%. The edges of plates seem also to be rather severely treated, it would be interesting to know if many failures occurred at this point. He understood that 276 tons was the total available pressure for closing the joint; was the full pressure used every time, and for how long was it kept on? Was the pressure suddenly applied, or slowly? If suddenly applied, the pressure or blow might be considerably in excess of the above, due to the momentum of the loaded accumulator. He presumed in closing the joints they started at one end and finished at the other; has the bar not a tendency to elongate while undergoing the closing process? The test pressure of 400 lbs. per square inch would only equal a stress of about 10.74 tons per square inch of plate section; which is not by any means a severe test for the plate, and yet this seemed too great for the joints, which had to be reduced to 35 lbs. (see hydraulic tests), and he understood the static head or pressure would amount to 230 lbs. (without allowing for shock). This would give a factor of safety of only about 1.45, which appears to be cutting it rather fine (considering the uncertain nature of the joint). He would consider a test pressure of nearly 500 lbs. not too much for a single rivetted joint of the same material (56% joint), factor of safety = 2.2. Double
rivetted (70% joint), 600lbs. = 2.6. With rivetted work and good materials one can come quite close to the calculated strength with very little uncertainty about the matter. It would appear to him that unless the locking bar joint can be made much stronger (as suggested by the author), much of the material in the plates is thrown away, and no matter how cheaply those pipes can be produced, this could hardly compensate for the extra material used, and the uncertain nature of the joint. It would be interesting to know the relative cost of the production, as compared with rivetted pipes, after making due allowance for the capital cost of the expensive gear necessary. What type of joint is used to connect the sections together when laid down. It is hardly reasonable to expect the material to stand much of a test after being strained beyond its elastic limit; no doubt the suggestion made by the author would do much to improve the joint; but the treatment in closing the joint by this series of sudden nips is bad in the extreme. If the closing could be done gradually by a series of rollers, passing the pipe three or four times through, would close the joint with much less permanent injury to the material. But the joint is new and much may yet be expected from it, with greater experience. He was sure that one and all would agree that great credit is due to those who have brought it to its present state, and admire the pluck and energy, together with the ingenuity displayed in the construction of machinery for its production, and the solution of the many difficulties overcome so far, the credit of which he understood is mostly, if not wholly, due to Australia.

Mr. Arthur Foster Smith in reply to Mr. Fyvie's questions:—
"Re test pieces, the average breaking strain is given as 22.5 tons, highest 28.75 tons, and lowest 11.5 tons. Was this per square inch and not the actual stress necessary to rupture the piece?" replied that the stress was always calculated as per square inch of metal. In answer to the question, "having regard to the rather severe treatment of the upset plate edges, he should like to know if many failures occurred at this point?" his reply was that no instance occurred of the upset edge being sheared, and he thought only one example of the plate being withdrawn without fracturing the bar. Respecting the question as to whether the pressure was applied suddenly or slowly the author had some difficulty in replying to the question, because what the querist may think quick or sudden another might think slow. The supply pipe was 3/8 in. into the cylinder of the "closer," and the movement of the ram was not rapid. And the ram upon coming into contact with the lower bar had first to overcome the weight of the pipe, and then before the full weight of the static head took effect, there were four locking bar jams to be squeezed, and he took it that inasmuch as the operation of squeezing was easier at one part than another he might say the operation was not suddenly done but slowly. It was possible to stop the machine before the joint was quite closed. He thought, however, there may have been some slight theoretical difference due to the speed of the downfall of the accumulator at the moment of the bars being
finally squeezed upon the plate. In answer to the question "I presume in closing the joints they started at one end and finished at the other. Has not the bar a tendency to elongate while undergoing the closing process?" He replied: Yes there is a tendency to elongate. When they began the works the elongation was \( \frac{1}{4} \) in., but the die or anvil used caused a considerable wave to flow in front, but as the die or anvil was lengthened and graduated the tendency really disappeared so far as could be observed. In regard to this paragraph of Mr. Fyvie's remarks, he trusted he was not indiscreet in pointing out that the matter can hardly be deemed to come within the scope of his paper. Mr. Fyvie gives us his opinion and he is quite right, but the paper was written purposely avoiding any opinion on the merits of the scheme but only upon the pipe, and further, the paragraph does not easily lend itself to being termed into a question on the original paper. At the same time, he was glad to state that the stress of 103\% tons or rather 107\% tons per square inch of plate section is correct, and it did prove too much for the "joint." The greatest head to which the pipes would be subject in the scheme is 600 ft., equivalent to 240 lbs. per square inch, but in those heads it has been arranged to have pipes with plates \( \frac{3}{8} \) inch thick, and the bars have been revised and are 83\% lbs. per ft. instead of 6\% as in the pipes out of \( \frac{3}{8} \) in. plates. The bars are also made with a different section. There are no results to give you, as when the author left West Australia none had been made. In the matter of comparing the locking bar joint with a rivetted joint, the author found some difficulty. For instance, a 30 in. pipe made with a single rivetted joint should stand a stress of 33\%75 tons per foot of joint, that being the ultimate strength, while taking the average value of the joints under consideration, we find it will stand 67\%5 tons, or nearly 3 times as much as a rivetted joint; but the extreme difference between the highest and lowest tests indicates such a magnificent uncertainty that we can hardly be expected to place much reliance on the locking bar joint as described, but with an improved locking bar, he saw no reason why the "joint" should not be thoroughly reliable at a stress far exceeding that of any rivetted joint. Mr. Fyvie suggests that it would be interesting to know the relative cost of production of the locking bar pipe compared with rivetted joints, after making allowance for the capital cost of the expensive gear required. Although the matter is, he thought, not such as should form part of our proceedings, he had no objection to give his experience. A plant, such as was employed in making the Coolgardie pipes, would cost £25,000, and would only make pipes of one size. To make a plant suitable for various sizes would cost a very great deal more, probably £3,000. While a plant to make rivetted pipes of any size he did not think would cost more than £3,000 or £4,000; but with the best plant for making rivetted pipes, he did not think more than one pipe per day could be turned out finished, while with a plant costing £28,000 for making locking bar joint pipes, you could certainly turn out from 30 to 40 in a day, and the relative values per 1 pipe per day is £3,000 to 1, and £7,000 to 1, but on making 1,000 rivetted pipes you would be employed say 1,000 days, while with the locking bar pipes you would be
employed only 25 days. The joint rings used on the above described locking bar pipes is a ring recessed to take head on both sides, and indented to cover the bars. Mr. Fyvie suggests that perhaps rollers could be better employed in closing the bars than the present methods. The author hardly thought such would be an improvement. He thought the friction on the working parts (of rollers) would be enormous, and hydraulic power would still have to be employed to keep the machines up to their work. He did not see how you could hold the two plates and bars together while you rolled them. In the present method they are held together by rings. He thought that by rolling there would be a considerable tendency to elongate the bar. The joint, as he had stated, was invented by a man named Quadling, and was patented some 16 years ago in England. He also patented a method of closing the bars with rollers. While the author agreed with Mr. Fyvie as to the credit due to the inventor, who, by-the-bye, was an Englishman, he thought the Government who used the pipe in the face of the combined adverse opinion of a Board composed of the most celebrated engineers, deserves more.
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