Discussion.

The AUTHOR showed a number of lantern-slides in illustration of the Paper. The Author.

Mr. EDWARD SANDEMAN mentioned that he had had the advantage of watching the building of the Banagher dam, and had much pleasure in recording his appreciation of the ability and care displayed by the Author, who was the engineer also for the design and construction of that work. The dam was situated in the hilly country about 20 miles south-east of Londonderry, in a valley which was very difficult of access. Any engineer who saw the exposure of the rock would have been struck by the unusual shallowness of the trench and the massive jointless appearance of the granite schist which formed the bed of the valley. The site, however, had the drawback that the rock on the hillside sloped extremely steeply, and, although in places the rock was very good, in others it was poorer, and much care was necessary when digging the foundations. One big slide of rock occurred which fortunately did no harm, but he had always been very uneasy with regard to slips. The method adopted by the Author, namely, that of digging headings into the hillside one above the other, and filling them up as the work proceeded, was ingenious and had proved most effective. Mr. Sandeman.

The dam was curved, with two wings and with an overflow in the centre, and, as first designed, there were only two contraction-joints, one on each side of the overflow, which was 77 feet in width. After a time he came to the conclusion that more contraction-joints would be required, and two more were accordingly put in, in order to divide the wings. At a later stage the wings were again divided by contraction-joints, which commenced at a much higher level, so that eventually the contraction-joints were about 30 feet apart. The result had been very satisfactory, and there was very little sign of movement other than one or two hair-cracks, and they only occurred where the contraction-joints were situated; there was no crack at any other point. The use of displacers in the concrete might have helped in the bringing about of this result, although they were only used to the extent of about 18 per cent. That was a very small quantity, and the stones put in were not of large size. In building other masonry dams he had been able to put in as much as 33 per cent. when using granite and as much as 42 per cent. with gritstone, where the stones were naturally cubical in shape. There was much less tendency for cracking to occur where there was a large amount of stone in the concrete.

Mr. Sandeman. The cracking of concrete was sometimes due to the presence of too much water. In a Paper[1] describing thirteen dams built in Australia it was mentioned that five of them had cracked, and, when Mr. Sandeman wrote to the Author of that Paper about the matter, he mentioned in his reply that probably the amount of water used had a good deal to do with the cracking of the dams. On one occasion he had had two dams built at the same time and of the same section, both being about 1,100 feet in length. The foreman in charge of one was accustomed to the use of dry concrete, while in the other case the foreman was used to what might be termed "sloppy" concrete. The dam for which the drier concrete was used had no crack in it, but the dam made with the wetter concrete had a crack through the centre.

Mr. Davidson. Mr. J. R. DAVIDSON remarked that the Author was to be congratulated on having presented to The Institution a clear and concise account of a work which, while of no great magnitude, possessed several very interesting features. There were two minor points to which he would like to refer. In the section dealing with the pipe-line, the Author stated that the steel pipes were wrapped with hessian saturated with bitumen. He had found by experience that if the hessian were merely saturated with bitumen it did not provide a permanent protection to the outside of the pipes. For some reason the hessian seemed to possess the property of absorbing the bitumen, and after a few years it would be found that the bitumen had assumed a brown colour. It soon began to rot, leaving the pipes with very little protection. He thought that the explanation for the use of that form of protection was afforded by the Author's statement that the pipes were laid between 1927 and 1930, because it was only about that time that the improved form of protection began to be introduced. With the improved form the hessian or paper was merely used as a carrier, and was employed to wrap from $\frac{1}{4}$ to $\frac{3}{8}$-inch of bituminous mixture on to the outside of the pipe. The hessian then served a second useful purpose, in that it protected the bituminous composition during transport. Once the pipe was laid, however, the hessian was no longer of use, and it was immaterial if it disappeared, as the solid sheathing of bituminous compound was left intact. That sheathing ought to last indefinitely.

The Author referred to the bolting of the flanges with mild-steel bolts. He was of the opinion that, where there was sufficient section in the flanges, it was worth while using wrought-iron bolts, owing to their increased life as compared with steel bolts. In the present

[1] L. A. B. Wade, "Concrete and Masonry Dam-Construction in New South Wales," Minutes of Proceedings Inst. C.E., vol. clxxviii (1908–9, Part IV.), p. 1.

case, however, the Author had pointed out that the bolts were heavily galvanized after threading. **Mr. Davidson.**

The Paper showed very clearly that all the details in connection with the laying of the mains across the river Foyle had been carefully worked out, and in such an operation that was the only way in which success could be achieved. The chief difficulty experienced during the laying of the pipe appeared to have been that of keeping the dredged trench open long enough to lay the pipe at the proper depth. He thought it might be of interest to say something about a method of sinking a pipe-line across a river which was adopted some 45 years ago by the late Mr. G. F. Deacon, M. Inst. C.E., in connection with the Vyrnwy pipe-line bringing water from Vyrnwy to Liverpool.[1] That pipe-line, which was some 66 miles in length, crossed the river Mersey at Fiddler's Ferry, half-way between Runcorn and Warrington, where the river was tidal and was over 800 feet in width. Whilst it was true that at low spring tides it was possible to wade across the river in thigh-boots, at high tide there was a very considerable depth of water, and the stream flowed with a greater velocity than was found in the case of the river Foyle.

The Act which authorized the original scheme required that the pipes should be laid across the river Mersey at a depth which compelled the construction of a tunnel. That tunnel was, according to Mr. Deacon's account (which Mr. Davidson believed to be correct), the first tunnel ever constructed under a tidal or other river by means of a shield driven through entirely loose materials. The work was extremely difficult; the first firm of contractors had driven practically no heading at the end of 41 months, whilst the second firm of contractors spent another 21 months, and only a quarter of the length of the tunnel had then been completed. The work was then finished by direct labour, and it was completed in 4½ months. During the long period of construction, however, Liverpool was in dire need of water. The pipe-line had been completed throughout its entire length with the exception of the river-crossing, and, in order to provide an emergency supply, Mr. Deacon laid a temporary main in the bed of the river, coupled up on each side to the already-constructed main pipe-line. The temporary pipe which was laid was about 15 inches in diameter.

Mr. Deacon floated the pipe across the river as a whole, and sank it in the sand and silt of the river-bottom by means of hydraulic jets. Mr. Davidson thought that the report which Mr. Deacon made on that work was of interest. It was quite a brief document,

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[1] "The Vyrnwy Works for the Water-Supply of Liverpool," Minutes of Proceedings Inst. C.E., vol. cxxvi (1895–96, Part IV.), p. 24.

Mr. Davidson. but it showed the great attention that Mr. Deacon paid to matters of detail. The report was dated 2nd June, 1891, and was as follows :—

"I beg to report that the launching of the steel tubes, intended for temporary use pending the completion of the Aqueduct Tunnel under the Mersey, was successfully performed on the evening of the 31st May ultimo.

"The peculiarities which distinguish the case under consideration from any others in which, so far as I know, water mains have been laid are as follows :—

"1. The working pressure in the Vyrnwy Main at this point is about 140 lb. per sq. inch.

"2. The width of the river at the point of crossing is about 800 feet.

"3. The low-water channel of the river (generally about 250 feet in width) travels from side to side for nearly the whole 800 feet of width, and occasionally moves in a single tide from one side to the other.

"4. The bottom of this channel is from 5 to 10 feet below the banks intermediate between the two shores, and about 16 feet below certain portions of the banks liable to be washed away near the shores.

"5. This channel is, moreover, 16 feet below the high water of Spring tides.

"6. Except just during the turn of the tide the velocity of the current, even under the most favourable conditions—that is to say during neap tides—would be at least 3 to 4 ft. per second past the pipes during the process of launching, and before they were sunk beneath the bed of the river.

"Under these circumstances, it will be well understood that extraordinary precautions were necessary to ensure success; but these precautions having been taken, I have never doubted the success of the undertaking.

"The tubes with their flexible joints were put together zig-zag upon cradles resting on launching ways, laid at right angles to the river on Cuerdley Marsh, Lancashire."

Mr. Davidson thought that the idea of putting the tubes zig-zag was to provide for the extra length when the pipes settled down into the curves of the river-bed, so as to avoid putting any tension on the pipes.

"The zig-zag form was maintained during the launching by means of four steel wire ropes, the lower pair connecting all the cradles and the upper pair connecting horizontal booms of timber lashed to the tubes at every joint. These booms were destined to maintain the zig-zag in a horizontal position upon the water, and to prevent the tubes from overturning.

"Thirty feet higher up the river than the intended pipes there were moored fore and aft, with their sterns downstream, eight 23-ft. river boats, and across the sterns of these boats was tightly stretched from shore to shore a 30-ton steel wire guide cable. A second 30-ton steel cable for hauling was passed across the river in the intended line of the pipes to a powerful steam winch on the Cheshire shore; this cable was connected with the ends of the four wire ropes holding the tubes in position.

"A tail rope of steel was used to control the motion, and horses with double-purchase tackle were used to assist in starting, making up the total horse-power for hauling purposes to twenty-two. Mr. Davidson.

"One of the chief precautions necessary was to counteract the great lateral pressure upon the tubes due to the velocity of the water past them during the process of launching and that of sinking. For this purpose the boom across every alternate joint was connected by a steel guy rope to a block, the sheave of which ran upon the 30-ton guide rope held by the sterns of the boats.

"It was decided that upon the whole the safest time for the launch to begin would be at high water of a neap tide. Several suitable tides occurred before and after the end of May, and that of the afternoon of Sunday, the 31st ultimo, being the first tide after the necessary preparations had been made was selected for the operation.

"A preliminary trial having shown that all was free, the launch was begun without difficulty on the turn of the tide at 6.35 p.m.

"Twenty-seven and a half minutes later the Cheshire end of the tubes had been brought to its intended position. In about fifteen minutes more, a temporary connection having been made on the Cheshire side, the water was turned on and the tubes sank into their required positions. In less than an hour from the commencement of the launch, Lake Vyrnwy water was being discharged on the Lancashire shore.

"On the following morning the pipes were found to be below the bottom of the channel, and so flexible are the joints that the wash of the current is quite sufficient to keep them below, whatever may be the course taken by the channel.

"The hydraulic jets have been brought into play where the banks are dry at low water, and have completely buried the pipes.

"I apprehend no danger whatever to navigation. No traffic was stopped by the operation."

The sentence about the hydraulic jets required explanation. In the bottom of the pipe, at intervals of about 2 feet 6 inches, there were orifices closed by loaded valves. To the top of each valve was attached a length of piano-wire which passed through a watertight gland in the top of the pipe, the wire thus passing across the vertical diameter of the pipes. Outside the pipe a float was attached to the end of the wire. The result was that when the wire was pulled a jet of water under a pressure of 120 pounds per square inch rushed out of the orifice and scoured a hole, and the succession of those holes joined up into a trench and the pipe went down. Unfortunately, it was found that particles of sand and small gravel got between the valves and their seatings, with the result that there was a very considerable leakage from the main during the whole of the time that it was in use. However, it served its purpose, and it continued to work until the tunnel was completed.

In 1921, Mr. Davidson was engaged on the plans for the crossing of the same place by the third and fourth pipe-lines, and, as the existing tunnel was full with only two mains, he proposed to lay the

Mr. Davidson. new pipes in the bed of the river, and to sink them by means of hydraulic jets. Instead of using the main pipe itself for the supply of water to the jets, he proposed to attach on each side of it a 6-inch pipe which would be fastened below the horizontal diameter by clips. From those supply-pipes connections were to have been taken to nozzles attached to the bottom of the main pipe. Each connection between the supply-pipes and the nozzles was to have been controlled by a cock with a rigid spindle carried up above the water-level. He had had a model made of this, and he believed that some of the members present that evening had actually seen that model at work. It was made on a practical scale, and was at first so arranged that the jets discharged in both directions; as might be expected, however, he discovered that that method would not work, because two opposing jets counteracted each other, and the result was a series of holes near the jets, with heaps of sand in between. As soon, however, as the jets were all made to discharge in the same direction, namely, along the line of the pipe, there was no trouble in scouring a trench, and it was possible to put a pipe down so quickly that it could be seen gradually sinking into the sand. There was no reason to believe that it could not have been sunk to any depth required in that material, up to about 10 feet of cover. The river authorities did not agree to the proposal to lay the pipes in the bed of the river, however, and they compelled the construction of a second tunnel. That work had just been started by Mr. Frank Hibbert, M.C., M. Inst. C.E., with Dr. W. L. Lowe-Brown, M. Inst. C.E., as consultant.

Mr. Hill. Mr. H. P. Hill said that the absence of any mishap during the work described was notable, and showed the foresight and care that had been exercised in the preliminary stages and during the construction. The work carried out was somewhat unusual, and was in a tideway where various contingencies could not always be anticipated. He thought that the Author exhibited a great deal of courage in choosing the method adopted for crossing the river in preference to utilizing the bridge, and he congratulated him on the excellence of the work in getting the main "drop-tight." It was often necessary to carry pipes, either for drainage or water-supply, across navigable waterways. He had come across one case, on the river Nile at Mansura, where the pipe was taken across the river to supply water to the other side; no one had had the courage to put the pipe under the bed of the river, and it was carried on the railway bridge. The bridge had to be moved every time a boat passed, and the result was that the pipe had to be severed each time—a somewhat lengthy proceeding. A longitudinal section of the type of joint used at Londonderry would be of interest. There were many different commercial designs of ball-and-socket joint; he wondered whether the Author had adopted the "Carlton" joint. Mr. Hill.

Mr. Davidson had described the adventures of Mr. G. F. Deacon in laying a pipe across the river Mersey in 1891; the Paper showed the advance which had been made in the technique of such work since that date. The methods adopted by the Author had proved so satisfactory that they did not call for any criticism.

Mr. G. M. C. TAYLOR remarked that he would like a little more information on one or two points, especially with regard to the laying of the pipe-line across the river, as he anticipated that he might have to deal with a very similar problem. Mr. Taylor.

The Author mentioned that reinforced spun-concrete pipes were used for a non-pressure length of pipe-line. He had recently carried out some drainage work in Northern Ireland, and had found that he was able to get concrete pipes of excellent quality, both circular and egg-shaped. Where there was no internal pressure he would prefer the pipes to be without reinforcement. He noted that each section of the pipe-line was floated out on barrels, and he assumed that the barrels were necessary in order to get the joint entirely above water-level, so that it could be made in the dry. He would like to ask whether the section itself would float without any barrels, or whether the joint at the end would be too heavy, as he imagined that a sealed 12-inch steel tube would float. The Author stated that in the case of the 100-foot sections temporary support in the centre was given during the process of laying. It would be interesting to know how that temporary support was given.

The only other comment which he desired to make was on the way in which the pipe was duplicated under the river. The object of duplication was to reduce the possibility of an accident from cutting off the complete supply. The chief dangers to be anticipated were from the anchor of a ship catching hold of the pipe-line and damaging it, and from a barge or ship sinking and lying on top of the pipe. It seemed to him that with the two pipes situated so close together, and cross-braced, the object aimed at would not be achieved, and that for true duplication it was necessary to have them very much farther apart. He thought that it would have been better either to have laid a single pipe or to have laid duplicate pipes so far apart that both were not likely to be damaged by dragging anchors or sunken ships.

Mr. H. W. S. HUSBANDS remarked that about 32 years ago, he had been connected with the sinking of an 18-inch steel pipe across the river Avon at Bath. The river at that point was only about 100 feet in width, and the interesting point about the work was that it was proposed at first to employ divers either to get the pipe Mr. Husbands.

Mr. Husbands. down or to join the sections under water. The contractor's engineer suggested another method, however, which was accepted, although some people had such doubts as to whether it would be successful that a wager was laid on the result. The engineer won the wager. He believed that the tide went up as far as Bath, but the river was not navigable to any extent at that point. The method adopted was to put a gantry across the river, and to grab out a trench, the whole length of pipe being lowered together by screw-jacks. He could not remember whether the bends were attached beforehand or whether a cofferdam was afterwards laid around each end of the pipe to finish off the work. The difficulty which was expected was that the pipe would be strained by the jacks not working evenly, but by means of signals it was found possible to keep the jacks turning equally, and no difficulty occurred.

The Author referred to the calculations adopted for the purpose of seeing that the pipes were not over-stressed, and on p. 197 of the Paper he said, " Allowance was also made for the vertical component of the stress caused by the hydrostatic pressure of the water under working conditions ; this amounted to a maximum of 0·8 ton for any joint." He would like to ask what the Author meant by that statement, as it was not very clear to him. It seemed to him that in the case of a pipe of the type used the only external water-effect which would be obtained on the pipe would arise from the buoyancy of the river itself. If the Author was referring to what was generally known as the " uplift," it was true that it had been stated that with a pressure-pipe there would be some uplift from it, and that consequently if it were put under the ground it would have to be taken to a certain depth to avoid the effects of uplift. A Paper [1] had been read before The Institution in which a similar calculation had been made, and he had pointed out on that occasion that in the case of a tube the hydraulic head resolved itself into either pressure or velocity, and there was no external effect since the pressure was acting entirely within the tube. If that was not what the Author had in mind, he would ask him to explain what he meant.

He did not know whether or not ball-and-socket joints were so finely machined nowadays that they worked without any packing, and perhaps the Author would inform him as to whether any packing was used. The Author stated that packing was used in the case of the ordinary joints, but had given no corresponding information with regard to the ball-and-socket joints. It would also be interesting to know whether the Author had considered using some such

[1] G. Haskins, " The Construction, Testing, and Strengthening of a Pressure Tunnel for the Water-Supply of Sydney, N.S.W.," Minutes of Proceedings Inst. C.E., vol. 234 (1931–32), p. 25.

joint as the "Victaulic." That joint allowed a certain degree of flexibility, but perhaps not sufficient for work of the kind in question. Mr. Husbands.

Mr. Taylor had asked whether the pipes would not have floated without the aid of barrels had they been full of air and with their ends sealed. Had they been able to do so, however, it would appear that they would not have sunk when necessary, and weights would therefore have been required to sink them.

In conclusion, he would like to congratulate the Author on the conciseness of his Paper, on the very interesting nature of the work described, and on its successful accomplishment.

Mr. W. J. E. BINNIE congratulated the Author on the clear way in which the Paper was written. The work that it described was of great interest. The Author referred to the reasons for rejecting the proposal to lay the pipe-line on the surface of the river-bed, and gave as the first objection the danger of damage from anchors. There were many instances of pipes being laid on the bottom of a river where the bed was not liable to scour. A pipe had been laid from the island of Hong-Kong to the mainland, although in that situation the pipe was liable to be broken by ships dragging their anchors; the pipe was weighted down at intervals with large blocks, however, so that if one portion of the pipe happened to be broken by an anchor the damage would be localized. Mr. Binnie.

During the War his partner, Mr. Martin Deacon, M. Inst. C.E., had had to get a supply of water across a channel in connection with an aerodrome near Dymchurch, with as little delay as possible, and he had used an armoured hosepipe; before doing so he had made inquiries at Fleetwood, where ordinary armoured hosepipes had been used, one 12 inches in diameter and several smaller ones. Some of them had been in use for 30 years and were still in good condition. If a pipe had to be laid very quickly, or if there was no objection to its being laid above the bed, that method was very simple when a small pipe was used.

With regard to the velocity of the current, the great difficulty of keeping the trench open with a strong current was emphasized in the Paper. At Vancouver it had been necessary to lay pipes across the Narrows, about 1,300 feet in width; there was an $8\frac{1}{2}$-knot tide, and it was impossible to open a trench. Each pipe was therefore dragged right across by means of a capstan situated on the farther bank. He believed that there were eleven pipes altogether, the older ones being 12 inches in diameter and the others 18 inches in diameter. In recent years some of the old pipes had been taken up after having been in position for more than 25 years; they were 12-inch pipes and were originally about 1 inch thick, and when they were removed it was found that at certain places the tops had been

Mr. Binnie. reduced to about ½ inch, and even ⅜ inch, by the scouring of the current.

The Author. The AUTHOR, in reply, expressed his appreciation of the kind remarks which the speakers had made about the Paper and about the work itself.

With regard to the external wrapping of the pipes, he agreed with Mr. Davidson that, were the work being done to-day, instead of hessian-wrapped pipes the more modern bitumen-sheathed type would be used. At the time when the pipes were purchased, however, hessian wrapping was the latest method, as Mr. Davidson had suggested. With regard to the hessian wrapping one curious thing had happened which was unique in his experience. He found one morning that a great deal of this wrapping had disappeared entirely from the pipes, and no trace of it could be found. A watch was therefore kept, and it was found that cows were allowed in the field where the pipes lay. The cows had a great liking for the hessian wrapping, and stripped it off by the yard.

A considerable quantity of Low Moor iron was used on the scheme in preference to steel, especially under water, but the flange-bolts, to which reference had been made, were very well protected against corrosion. They were not only galvanized, but were coated thickly with bitumen, in addition to the wrapping, and it was felt that, as neither water nor air could get to them, they were not likely to deteriorate in the course of time.

The methods of carrying a pipe-line across a river were almost unlimited in their variety, and the problem of the engineer was to originate or to adapt that method which best conformed with the local conditions. Apart from the actual physical conditions, there were other points which had to be considered, such as, for example, the effect which would be caused by any interruption of the supply. In the case described in the Paper, the pipe-line was the main channel for the water-supply of a city, and it was considered undesirable to run any more risk of interruption than was unavoidable. In some cases, however, the taking of certain risks might be justified, and a very much cheaper method could then be used.

In all probability the cheapest and quickest method of carrying a pipe-line across a river was to use steel pipes with welded joints, the pipes being assembled on the bank at right angles to the river. The pipes could be assembled either on free-running rollers or, in the case of a long pipe-line, on flat bogies running on a temporary light railway. Cables would then be attached to the leading end and taken across the river to winches on the opposite bank. During a period of slack water and absence of wind, the pipe-line would be hauled across and allowed to sink to the bed of the river. That

The Author.

method pre-supposed a combination of favourable conditions which were not often met with on one site. If the pipes were sunk by allowing water to enter them, great care was necessary, as the water tended to concentrate at the lowest point and might cause a sharp angle to form in the pipes, with consequent fracture. The method was not suitable for permanent work, where an interruption of the supply would have serious results. In one case in the United States a 22-inch gas-main had to be laid under the river Mississippi where the latter was 3,000 feet in width and 125 feet in depth, and it was divided into six smaller pipes on reaching the river-bank, so that some of them at least would remain in service in case of accident.

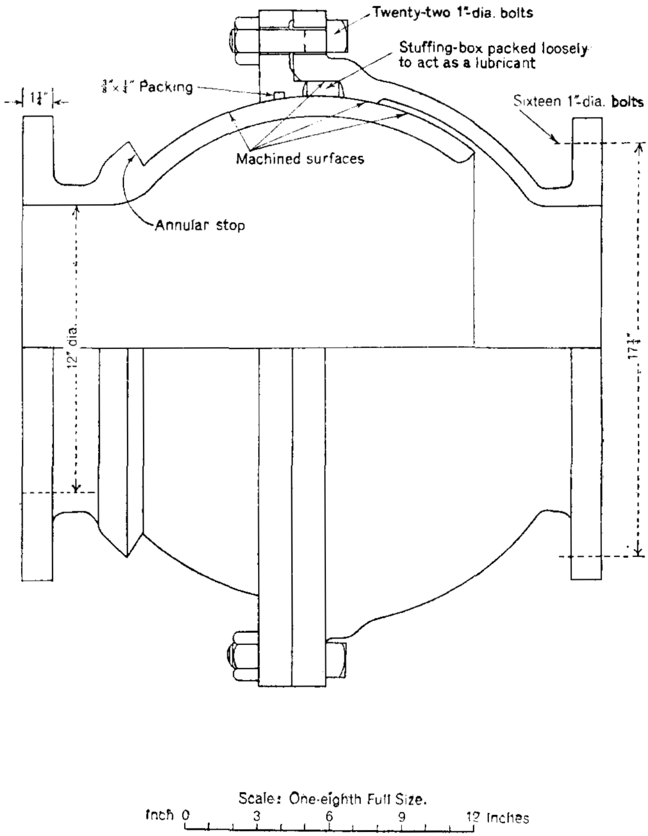
With regard to the method used for crossing the river Foyle, the Author had put various alternative proposals before the contractor, although he considered that the one actually used gave the greatest certainty of success in laying and of permanency in use. One alternative which was considered was to attach below the invert of each of the pipe-lines a 3-inch or 4-inch steel tube, fitted with nozzles, all pointing in the same direction, at intervals along the underside, through which it was intended to pump high-pressure water. It was considered that if the pipes were first lowered to the bed of the river and the nozzles then brought into operation, the sand would be washed away and the pipe-line would gradually sink to any desired depth The reason why that proposal was abandoned was that, especially on the north-west side of the river, the bed contained a number of large boulders, which would not have been removed by the jets. He was interested to know that a somewhat similar method had actually been used at an earlier date.

Both the "Victaulic" and the "Carlton" joints had been considered for providing the necessary flexibility in the pipe-line. He had often used the "Victaulic" joint, which was suitable for pipe-lines where only a small movement was anticipated. During the actual process of laying the submerged pipes at Londonderry, however, the movement required was as much as 25 degrees, and that could not be obtained with the "Victaulic" joint. The "Carlton" joint was a light and economical type of ball-and-socket joint with a considerable range of movement, but the type actually used (*Fig. 8*, p. 214) was adopted as its great strength enabled it to resist successfully the considerable stresses met with during the process of laying.

The concrete pipes used were centrifugally spun and were manufactured in England. The reinforcement assisted them to withstand the severe handling of the railway and shipping companies, but in spite of that reinforcement a large proportion of the pipes arrived in a damaged condition. The reinforcement was also required for the

The Author.

Fig. 8.



LONGITUDINAL SECTION OF CAST-STEEL BALL-AND-SOCKET JOINT.

pipes in the peat bog, which were carried on piles driven at 6 feet intervals, as described on p. 192. The Author.

The point had not been raised in the discussion, but a disadvantage of concrete pipes, as compared with iron or steel pipes, was that the inner surface " coated up " much more rapidly and, in consequence, the pipes had to be brushed out more frequently. This coating, or slime, if not regularly removed, tended to retain colour which, under certain conditions, such as excessive alkalinity of the water, might be released and thereby affect the supply. In comparing the cost of concrete and metal pipes for water-supply this question of brushing-out had to be taken into consideration.

Reference had been made to the weight of the pipe-line. The unusual thickness of the metal, together with the weight of the inner and outer coatings, caused the pipes to sink readily, even with the interior kept free from water. The temporary support given to the 100-feet lengths was not shown on Figs. 7, Plate 1; it was given only occasionally when there happened to be an unusually rapid current, and it was merely a temporary tie from the stern of one of the pontoons to the centre of the pipe-section.

The question of laying the second pipe-line in a separate trench had been given careful consideration. The labour-costs of laying two entirely separate lines would, however have been nearly double that of laying a twin pipe-line in a single trench. He thought that, in view of the depth at which the pipe-lines were laid, and the thickness of the mattress which was added, the danger from anchors was really very slight, and the strength of the pipes themselves was such that a fracture was unlikely. At the time, it was thought that the principal risk consisted in the possibility of a joint blowing out, and if that happened, the second pipe-line, although only four feet away, would not be seriously affected.

With regard to the concrete weight-blocks placed on the external bends, although bends of large radius under low pressure and with fixed joints might not require weighting, having regard to the comparatively high internal pressure of the Foyle pipes and also to the use of freely-moving ball-and-socket joints, the Author considered these weight-blocks to be essential. In the case of water-power schemes employing heads of up to 1,000 feet or more, steel anchor-rods and heavy concrete blocks were used at all bends, whether vertical or horizontal, to prevent any possible movement.

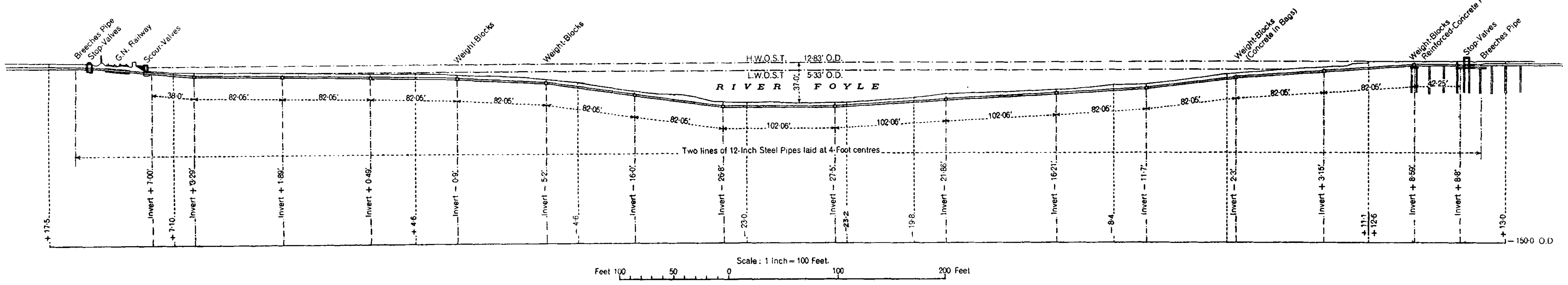
Although the surfaces of the ball and socket were very accurately machined and polished he did not think it advisable to rely on " contact " for watertightness, as under a head of 426 feet the

The Author. smallest jet would rapidly wear away the metal. The surfaces were provided with an annular groove filled with grease packing measuring $\frac{3}{8}$ inch by $\frac{1}{4}$ inch, and also with an annular stuffing-box packed loosely to act as a lubricant, as shown in *Fig. 8*.

*** The Correspondence will be published later.—Sec. Inst. C.E.

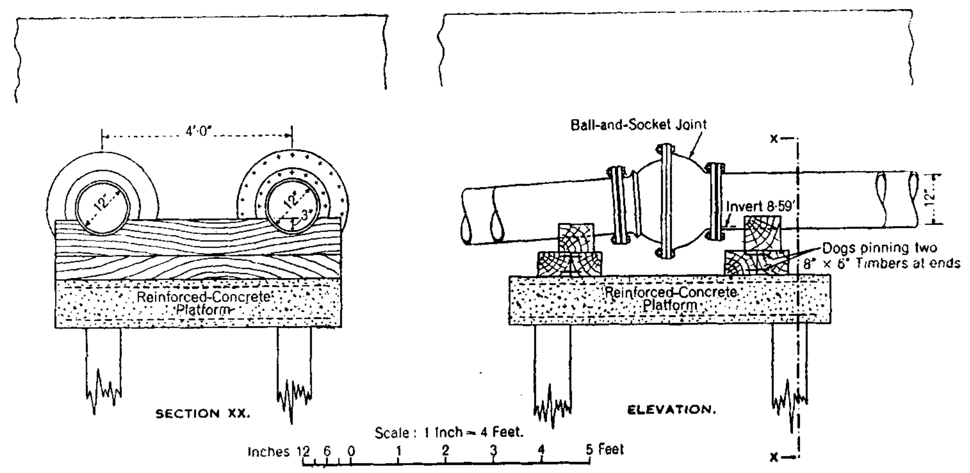
THE RIVER FOYLE CROSSING, (LONDONDERRY WATERWORKS).

FIG.: 3.



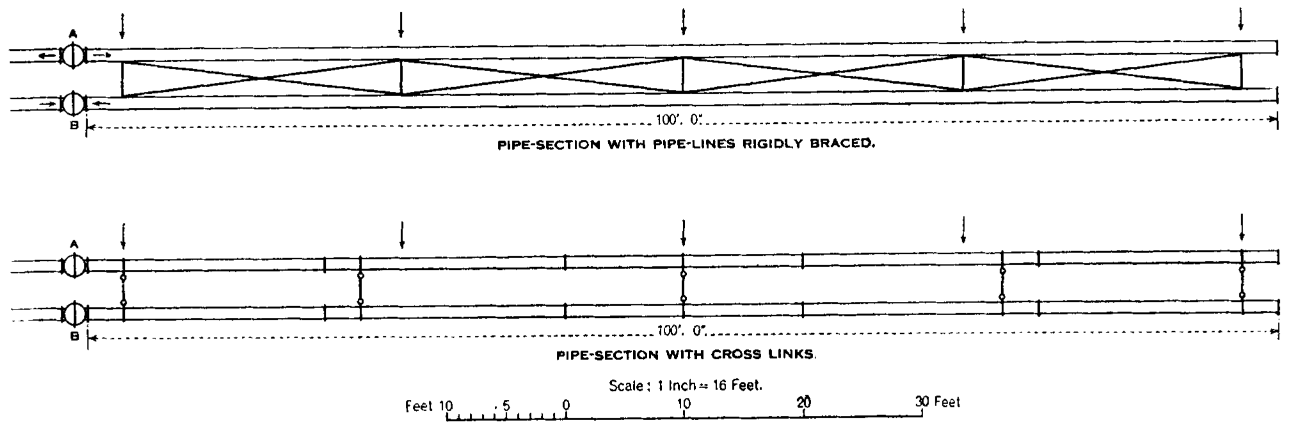
SECTION OF RIVER AT SITE OF CROSSING.

FIGS: 4.



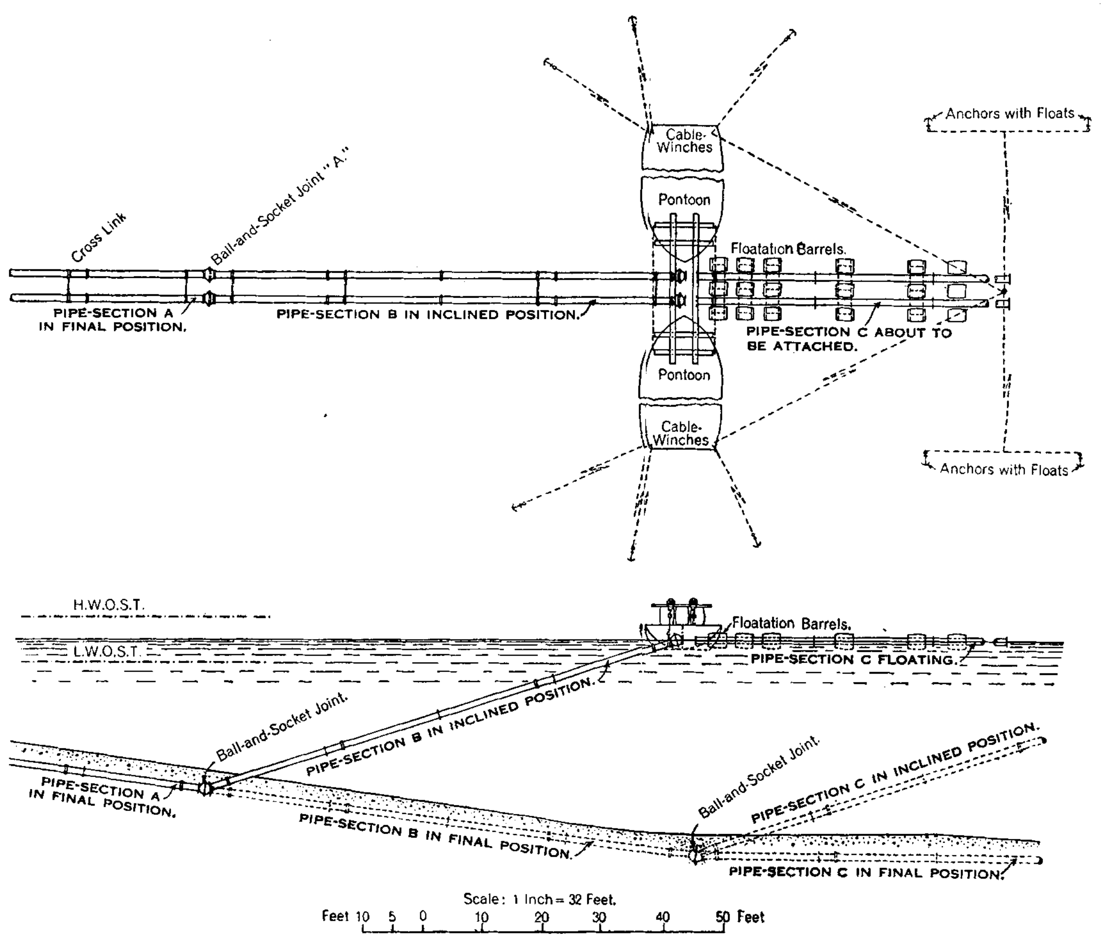
BALL-AND-SOCKET JOINTS, WITH SUPPORTS USED ON RIGHT BANK.

FIGS: 5.



METHODS OF CROSS-CONNECTING PIPE-SECTIONS.

FIGS: 7.



METHOD OF LOWERING PIPE-SECTIONS INTO POSITION.

W. CRISWELL.

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