slings used during loading or unloading. It is necessary to make free use of packing bags as cushions, to prevent the pipes being rubbed, and in addition they should be wedged in position to prevent movement. The pipes on no account should be dragged along the ground as this has a very bad effect on the coating and wrapping. Pipes and specials are unloaded at destination either by hand or, if too heavy, by a crane or gantry, and it is usual to strike each cast iron pipe and special, a blow from a hammer when suspended in the sling, to ensure it " rings " soundly. This will enable cracks extending to the socket or spigot of the pipe to be detected, but if a pipe has cracked in the centre, due perhaps to a heavy blow, such defect may not cause any difference in the sound of the " ring," and it is only by very careful detailed inspection of each pipe and special that such damage can be detected.

Transport from the point of unloading by rail to the place of laying is carried out generally by bullock cart for steel pipes, up to say 18 inches diameter by 26 feet long or cast iron pipes up to about 21 inches diameter by 12 feet long. The pipes should be wedged into the carts with plenty of packing bags.

Above these sizes, the weight of individual pipes becomes excessive and it is desirable to use special trolleys or lorries. The pipes should be strung out along one side of the pipe trench, with sockets leading in the correct direction, *i.e.,* in the direction of laying, to avoid having to handle and turn the pipes round again, unnecessarily, later on. The exact laying length of pipes should be placed in each furlong section of the pipe track so as to avoid delay to pipelaying operations due to shortage of pipes in any section, while one spare pipe should also be placed in each section to make up for cuts, or pipes found defective.

Specials should be sorted out and each particular special should be unloaded as near as possible to the point it is intended to be used. Small pipes are lowered from the carts by hand and larger pipes are skidded off, so long as plenty of bags are placed on the ground to break their fall, They can also be rolled off on planks, or lifted off by a pair of shear legs. Suitable lowering and lifting gear is usually provided on special pipe trolleys.

During the hot weather months, in Northern India, where there is a great difference between the winter and summer temperatures, all pipes should be protected from the direct rays of the sun for a sufficient period to enable them to regain normal temperature, before they are laid, in order to obviate any exaggerated effects of temperature movements on the joints. For this purpose, it is a good thing to provide grass shelters which should be kept wet, over the pipes.

33. The pipe trench.

The writer has seen many pipelines which look, in common parlance, like a " dog's hind leg." There is no excuse for this, nor is there any reason why a pipeline should not be set out and constructed as carefully and accurately both in regard to line and level, as a railway, a road or canal. The pipeline should be set out perfectly accurately by line and marked with lime or chalk or by pegs. Usually it is convenient to use one side of the pipe trench as the basis of alignment for the excavation work.

In Great Britain, in normal subsoils and for the usual depths, the set out width of the trench which is paid for, is twelve inches plus the external diameter of the pipe-line, subject to a minimum of two feet, while joint holes are not paid for. If timbering or sheeting has to be employed, the thickness of the sheeting is usually added to the width given above. On many pipe-lines in India, the trench widths are far in excess of the above limits, (and entirely unnecessarily so) due largely to inaccurate setting out and negligent excavation work. Bends should be set out by using special templates forming the correct angles or a special jointed rule, on which is marked the standard angles of throw of the various types of bends employed may be used. For large mains where extreme accuracy is required, the bends should be set out by theodolite or circumferentor. Curves should be set out, either with the theodolite, or, by laying out the position of each pipe by off-sets.

The normal cover over the pipe-line should be from $2\frac{1}{4}$ to 4 feet, depending on the diameter. Small pipes from 3 inches in diameter to 6 inches in diameter may be laid with 2′3″ cover, pipes from 7 inches to 24 inches diameter should have not less than $2\frac{1}{2}$ feet cover, while larger pipes should have still greater cover. The cover is required to prevent damage to the pipes from loading due to traffic. It also helps to keep the water cool in summer and to prevent excessive temperature contraction and expansion movements in the pipe-line.

With large mains, the height of the spindles of sluice valves is greater than the normal cover. In such cases, unless embankments can be formed round the valve chambers, without disfiguration, the pipe-line should be laid deeper in the vicinity of the valves so that the valve spindle caps are about 6 inches below the surface. In very cold countries the depth of cover has to be increased in order to prevent the water of the pipe-line freezing in winter, but this does not arise under Indian conditions.

34. The bed of the trench.

The bed of the pipe trench in good subsoil should be excavated to the correct depth and gradient in order that when the pipes are laid, they may not require any filling underneath. Filling under the pipes being likely to cause settlement, no language is too strong in condemnation of such practice, which unfortunately still persists, particularly in India where supervision is not good.

With skilled pipe-laying labour in Great Britain, the levels of small pipe-lines in undulating country are set out as the work of pipe-laying proceeds, the pipe layer simply using a long straight edge laid along the invert of the last pipe to level off the bed for the succeeding pipe.

In India, however, with the usual classes of labour available, this course is certain to cause defective work and the best practice with moderate sizes of pipe-lines is to fix accurately with the level, pegs at intervals of 50 feet or so on the centre line of the pipe-line at the finished level of the bed of the trench before the trench is excavated to full depth. The bed is then excavated and trimmed off accurately to these levels, boning rods being used freely to check the same.

The joint holes are then cut. The holes should of sufficient size to allow plenty of room for the jointers to thoroughly caulk the joints, and should extend forward from about 6 inches behind the face of the socket for a length of about 2½ or 3 feet. Joint holes should not be made too large, as thereby the levelled off bed for each pipe will be shortened unnecessarily.

The spoil bank should be arranged on the opposite side of the trench to that along which the pipes are laid out.

The pipes should not be dropped into the trench until the bed of the trench is finished off exactly to the correct level and the joint holes formed. If this practice were universally followed, there would be no occasion for bad pipe-laying and settlement due to loose filling under the pipes.

35. The laying of the pipes.

Spigot and socket pipes and specials should be laid with sockets leading up-hill in all cases. If socketted pipes are laid in the opposite direction it is impossible to fill the joints with molten lead and there is tendency for the pipes to draw out, leaving a space between the end of the spigot and the back of the socket. For this reason, pipe-lines with all forms of joints should be laid up-hill not down-hill.

3 inches and 4 inches cast iron pipes are sometimes jointed in pairs or threes on the surface and lowered into the trench. This method however is not entirely satisfactory as unless the jointed lengths are carefully handled and balanced, the joints get distorted, or damaged.

Pipes should be lowered singly into the trench. Small pipes up to 9 inches diameter are usually lowered by hand and ropes, larger pipes are slung from 4 legged shear legs by chain or rope tackle (Fig. 67).

The pipes should be "rung," when supported in the sling and also carefully examined again to see that there are no defects.

Each pipe should be driven into the socket of the preceding pipe by swinging the pipe when still in the tackle so as to ensure that the spigot has gone home, the first coil of yarn being inserted at the same time. After a few lengths are lowered, they are straightened up by wooden levers and the joints are yarned, after which they are filled with melted lead and caulked.

It is best to leave the leading 3 or 4 pipe lengths without pouring the lead therein, in order to afford a chance of correcting slightly the alignment of the pipe-line as it is laid ahead.

During the hot weather months, care should be taken to see no pipes are exposed unnecessarily to the direct rays of the sun after laying, otherwise the tendency of the joints to "draw" due to temperature expansion and contraction will be unduly increased. For this reason the pipes should be covered with the filling as rapidly as possible.

36. Rock trenches.

When pipelines are laid in rock trenches, the trenches should be excavated to a depth of about 6 inches below the finished level of the invert of the pipeline and a layer of rammed broken stone ballast about 1/4″ to 1″ inches gauge should be laid and levelled off to form the foundation of the pipes.

If this is not done, the rock bed may be left slightly uneven, thereby not supporting the pipes evenly along their full lengths.

37. Bends, other specials and valves.

When laying out the position of bends and other specials, if due care is taken to select the correct position, it is frequently possible to avoid having to cut pipe lengths, and still maintain a good alignment.

Bends should be as gentle as possible, and the minimum size used in open country or in streets should be usually 22½°. When several sharp bends have to be used together, it is better to spread them out by separating them with straight pipe lengths, if it is possible to do this.

All important bends should be supported by solid blocks of concrete placed between the bends and the side of the trench, in order to take the thrust due to the water, while unimportant slight bends may be strutted by timber sections, left in permanently.

Sluice valves, air valves and hydrants should be erected with the valve spindle and door perfectly vertical, air valve tees should be placed at the summit points, with the top surface of the flanged branch horizontal and wash outs, which must have the branch invert at the same level as the main pipeline invert. (see Fig. No. 18), should be placed at the lowest points.

Pressure reducing valves and throttle valves and other appliances should also be properly levelled up when fixing, and all branches should be laid with their axes horizontal.

Typical examples of chambers for small sluice valves (Fig. 68), large sluice valves with byepasses (Fig. 69), single air valves (Fig. 70), double air valves (Fig. 71), fire hydrants (Fig. 72), reflux valves (Fig. 73), are shewn annexed. These chambers are of a simple design and of sufficient size to enable access to the valves to be obtained for operation. Covers of valve chambers for use in India should, preferably, be hinged and capable of being locked to obviate unauthorised interference.

All operating heads of spindles of valves should be within 12″ of the surface. Air valves and hydrants can be raised by the insertion of a suitable length of double flanged pipe between the tee on the pipeline and the base of the valve.

Sluice valves, which are laid at considerable depth, should have extension spindles of wrought iron or mild steel up to within about 6 inches of the surface, encased in a suitable cast iron protecting tube as shewn in Fig. No. 74.

Elaborate valve chambers are not necessary. If radical repair has to be carried out to a valve or other fitting, it generally happens that the valve chamber has to be dismantled in any case, so that it is best to provide as cheap and simple a valve chamber as possible.

38. Protective coating of the pipeline and its fittings.

After the pipeline is laid, great care should be taken to see that its external surface is fully protected as far as possible.

With cast iron pipes, specials, valves and fittings, all places where the coating has been damaged and also all chip marks on sockets should be touched up with a suitable bitumen or asphalte composition paint.

On steel and ingot iron pipes and specials, all places where the wrapping is torn or the coating otherwise damaged, should be repaired and patched and rendered equal in all respects to the original coating and wrapping. All exposed metal including all joints, socketted, flanged or victaulic, should be cleaned, painted, and wrapped with hessian impregnated in hot bitumen composition, so as to protect the whole of the pipeline against external corrosion. The life of the pipeline is dependent on the effectiveness of the coating and wrapping and every effort has to be made therefore to see the job is carried out thoroughly.

39. Crossings and other special works.

Rivers of considerable width are crossed by " inverted " siphons of flanged or rivetted pipes laid at a safe depth below the bed, in hard stiff subsoil or supported on piles, if laid in sand or quick sand or other yielding material. Sometimes pipelines with flexible joints are laid under bodies of water, on the bed. Narrower streams and rivers are crossed by arched or straight, self-supporting steel pipes, resting on masonry or concrete piers or abutments (Fig. 75), on girders carried by masonry concrete or steel work supports, or on bridges.

Light steel pipelines with flexible joints such as victaulic joints are carried across streams and valleys supported from suspension ropes. (Fig. No. 76) is an illustration, of such a crossing on a small pipeline in the Salt Range, Punjab.

Pipes laid underneath railways are generally of steel, either cased in concrete or carried through a masonry culvert. A good method for small pipelines is to thread the pipes through a larger casing pipe which is embedded in cement concrete (Fig. 77). The actual pipeline is thus free from any stresses set up by the railway, while, should a leakage occur, the pipes can be withdrawn from one end of the casing pipe.

Pipelines laid at steep gradients have to be properly anchored into the ground to prevent the pipes slipping away. The special conditions of each particular case has to be studied and the type of anchorage designed to suit.

As a rule, on pipelines for water, of modedate size, the anchorage consists of a special cast iron anchor casting with heavy base-plate, securely bolted down to a cement concrete block (Figs. 27 and 28). On steel pipelines, an expansion joint is provided on the lower side of each anchor so as to allow movement of the pipeline in sections between the anchorages.

40. Testing.

It is desirable to test the pipeline under hydraulic pressure in short lengths of say half a mile to a mile at a time as soon as possible after laying. The test head need not be as high as the proof test to which the pipes were submitted at place of manufacture, but should be in excess of the working pressure by the amount of hammer likely to be developed in ordinary operations. Under usual conditions for water-supply pipelines for working pressures of 200 to 500 feet vertical head of water, the provision of an additional 50 to 100 feet vertical head of water will suffice to cover the water hammer effects. The application of unduly severe pressure tests to a pipeline after it has been laid may do more harm than good, to the joints. The pipeline should be filled with water and the test pressure may be applied by a special test pump, fitted with a pressure gauge, similar to that employed for boiler testing purposes. For large pipes, the pressure head may be developed by suitable steam, oil engine driven or electrically operated ram or piston pumps, pumping direct into the pipeline.

The test should be applied for not less than about one hour without any appreciable fall in pressure being recorded.

In the case of a long pipeline the test pumping plant can be fixed at one end and the sections of the pipeline tested in short lengths from the pumping end, the test being applied in a cumulative manner to the first section, then to the first and second sections, then the first, second and third sections and so forth until the whole length is tested.

If practicable, the joints should be exposed for the test but the rest of the pipes should be covered. When pipelines are laid in traffic roads or populated areas, it is often too dangerous to keep the joints exposed. Under such circumstances, after the test pressure is applied, if the pressure gauge discloses the existence of leakages, they have to be searched for by driving a steel bar through the ground on to the joint of each pipe and detecting the leakage by its sound through a microphone receiver placed in contact with the bar.

Accurate records of the exact position of every joint in the pipeline are essential and without these it is impossible to know exactly where each joint lies and recourse has to be made to digging and exposing the joints. When leaks are discovered, no attempt should be made to tighten up or recaulk defective joints until the pressure has been released.

Before applying pressure tests the ends of the pipeline must be secured or strutted in the trench to counteract end thrust of the water on the blank ends and to prevent " pulling " or drawing at the joints of the end pipes.

The water for testing is usually introduced into the pipeline through a suitable temporary or permanent branch while the end of the pipeline is closed by a blank flange bolted on to form a flanged joint, or a suitable cap or plug is fitted with a caulked lead joint.

Sluice valves afford a convenient means of isolating various sections of the pipeline for testing, care being taken to ensure the doors of the valves when closed are perfectly watertight. For this purpose, the internal grooves should be cleaned of all dirt and sediment and the glands properly packed.

TABLE No. 1.

Particulars of poured lead caulked joints for British Standard spigot and socket pipes and specials Class B.

Internal diameter of pipe.	Finished depth of lead joint.	Estimated quantity of lead required per joint.	Approximate quantity of spun hemp yarn required per joint.
Inches.	Inches.	Lbs.	Lbs.
3 ..	1½	4·1	·25
4 ..	1½	5·2	·38
5 ..	1½	6·3	·44
6 ..	1⅝	7·9	·44
7 ..	1⅝	9·1	·50
8 ..	1¾	10·8	·63
9 ..	1¾	12·0	·69
10 ..	2	15·0	·75
12 ..	2	17·3	1·06
14 ..	2	20·0	1·38
15 ..	2	21·5	1·50
16 ..	2	22·6	1·63
18 ..	2¼	31·7	2·07
20 ..	2⅜	37·0	2·25
21 ..	2⅜	38·6	2·38
22 ..	2½	42·2	2·50
24 ..	2½	46·0	2·66

TABLE No. 2.

Shewing minimum radii of circles of curvature to which British Standard straight spigot and socket cast iron pipes with plain sockets, of various diameters should be laid.

Internal diameter of pipe.	Laying length.	Minimum radius of circle of curvature.
Inches.	Feet.	Feet.
3	9	216
4	9	216
4	12	288
5	9	252
5	12	336
6	9	252
6	12	336
7	9	290
7	12	387
8	9	329
8	12	438
9	9	367
9	12	490
10	9	406
0	12	540
12	9	490
12	12	653
14	12	755
15	12	804
16	12	857
18	12	958
20	12	1,059
21	12	1,110
22	12	1,160
24	12	1,260

Note:—The above figures are based on a maximum deflection, in each pipe length, which shall neither cause eccentricity of the lead joint ring greater than one sixteenth of an inch measured at the face of the joint, nor permit a space greater than about one-eighth of an inch between any part of the end of the spigot and the back of the socket of the joint.

PLATE I

SPECIAL CASTINGS FOR CAST IRON PIPE LINES

FIG Nº 1
S & S 90° BEND

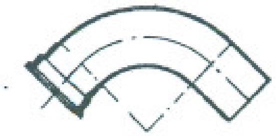


FIG Nº 2
S & S 45° BEND

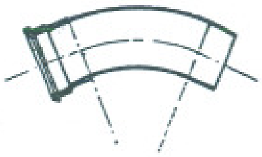


FIG Nº 3
S & S 22½° BEND

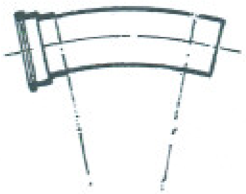


FIG Nº 4
S & S 11¼° BEND

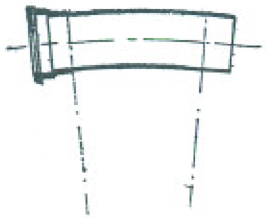


FIG Nº 5
S & S TEE

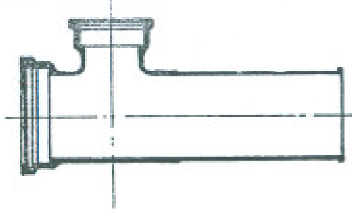


FIG Nº 6
S & S 45° BRANCH

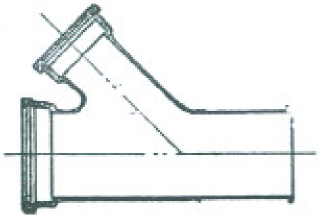


FIG Nº 7
S & S TAPER

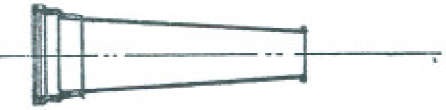


FIG Nº 8
S & S TAPER

FIG Nº 9
COLLAR

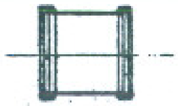


FIG Nº 10
CAP

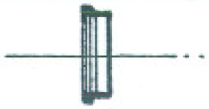


FIG Nº 11
PLUG

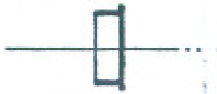


FIG Nº 12
S & S DUCKFOOT
BEND

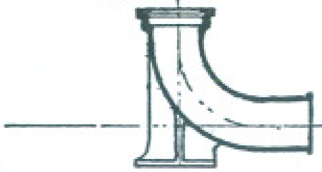


FIG Nº 13
FLANGED DUCKFOOT
BEND

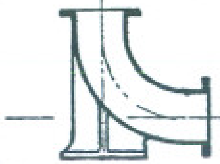


FIG Nº 14
FLANGED & SOCKET
PIECE

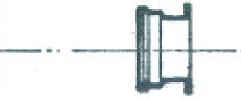
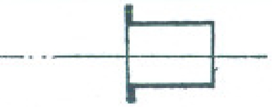


FIG Nº 15
FLANGED & SPIGOT
PIECE



Paper No. 143.

PLATE II

SPECIAL CASTINGS FOR CAST IRON PIPE LINES

FIG Nº 16
S & S TEE WITH FLANGED BRANCH

FIG Nº 17
BLANK FLANGE

FIG Nº 18
WASHOUT TEE

FIG Nº 19
FLANGED 90° BEND

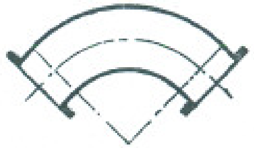


FIG Nº 20
FLANGED 45° BEND

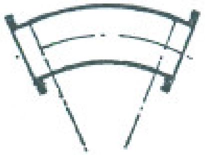


FIG Nº 21
FLANGED 22½° BEND

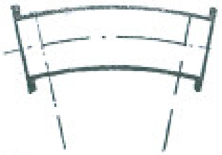


FIG Nº 22
FLANGED 11¼° BEND

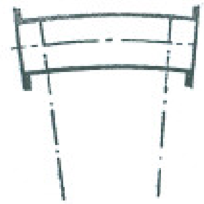


FIG Nº 23
FLANGED TEMPLATE BEND

FIG Nº 24
FLANGED TEE

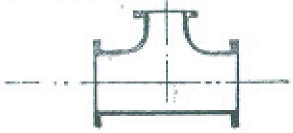


FIG Nº 25
FLANGED RADIAL JUNCTIONS

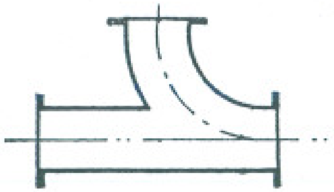


FIG Nº 26
FLANGED TAPER

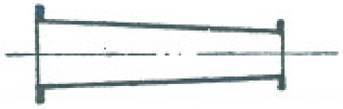


FIG Nº 27
FLANGED ANCHOR

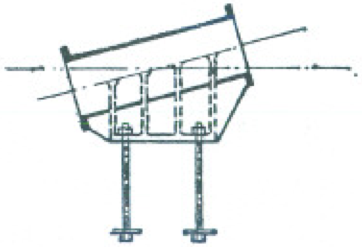
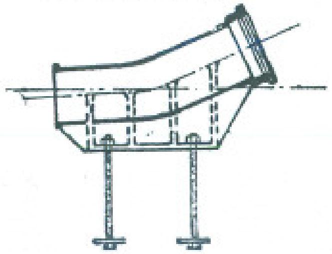


FIG Nº 28
S & S ANCHOR



Paper No. 143.

PLATE III

FIG No. 29
LOCK-BAR STEEL PIPE

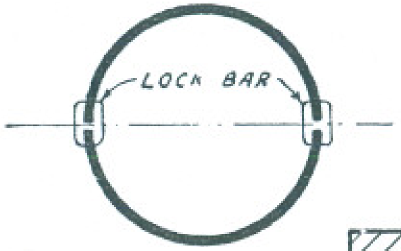


FIG No. 30
S&S STEEL TEE WITH
FLANGED BRANCH

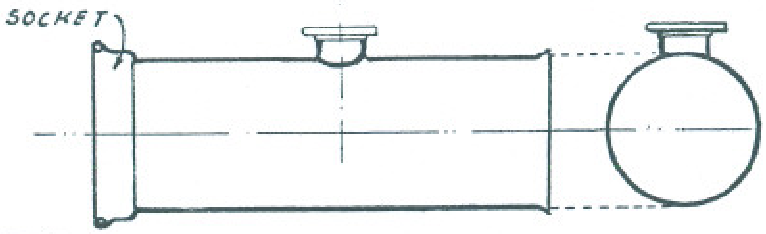


FIG No. 31
S&S STEEL BEND

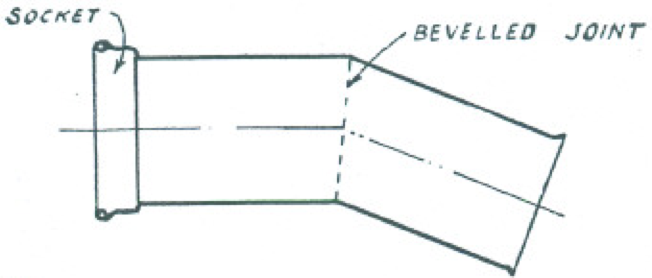


FIG No. 32
WELDED ON FLANGE
FOR STEEL PIPES

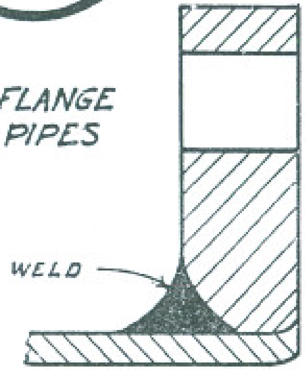


FIG No. 33
PLAIN SPIGOT AND SOCKET
JOINT FOR CAULKED LEAD

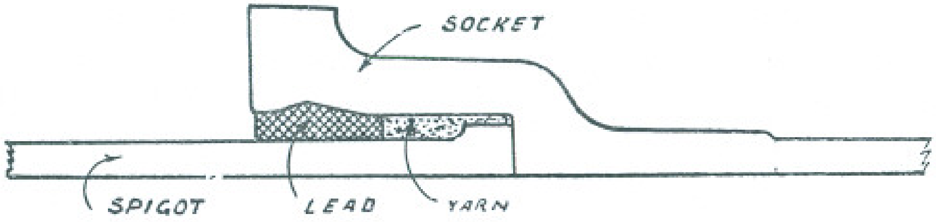


FIG No. 35
FLANGED JOINT

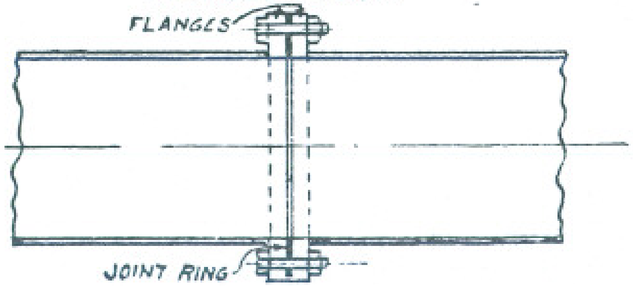


FIG No. 34
SPIGOT AND SOCKET
HALF TURNED & BORED JOINT

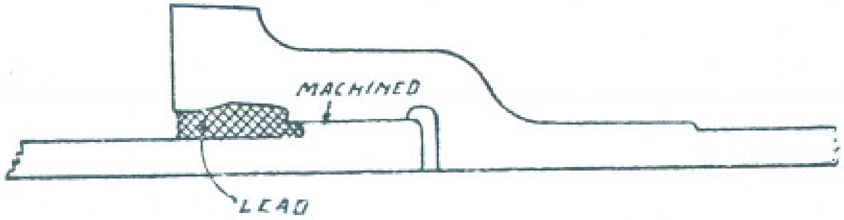


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PLATE IV

FIG Nº 36
STEEL YARNING TOOL

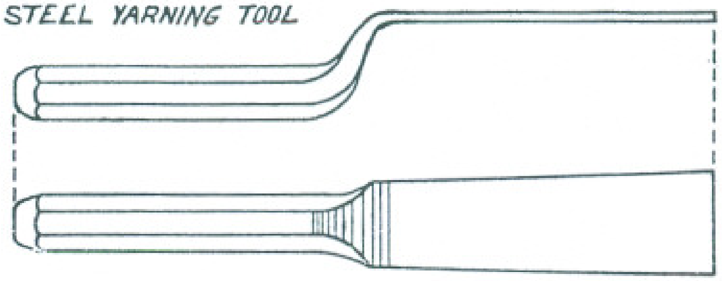

FIG Nº 37
LEAD DEVIL & POT

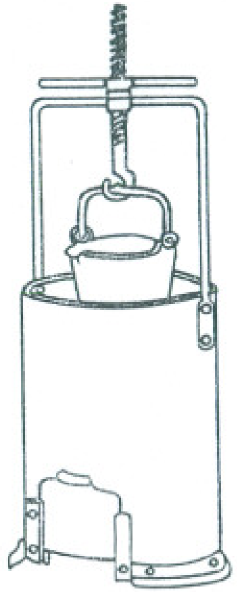

FIG Nº 38
JOINT CLIP

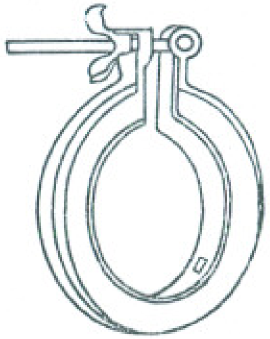

FIG Nº 39
SOCKETTED LEAD JOINT
BEFORE CAULKING

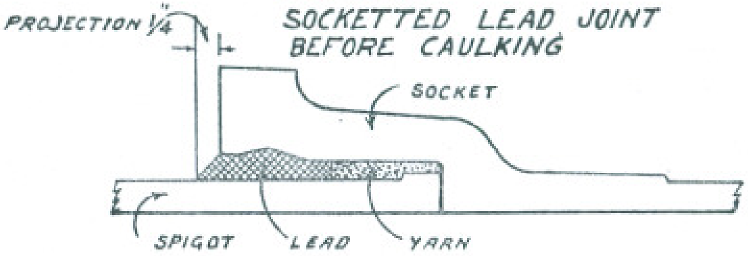

FIG Nº 40
STEEL CAULKING CHISELS

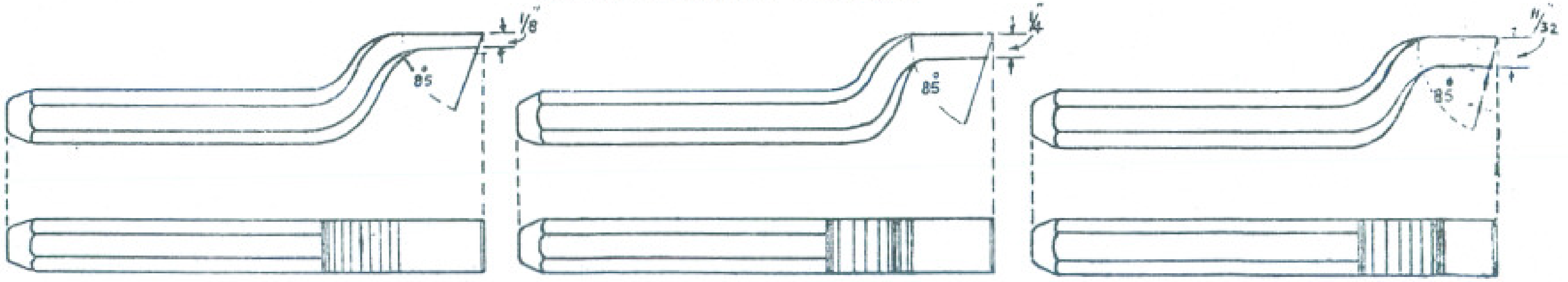

PLATE V

FIG Nº 41
METHOD OF CAULKING LEAD JOINTS

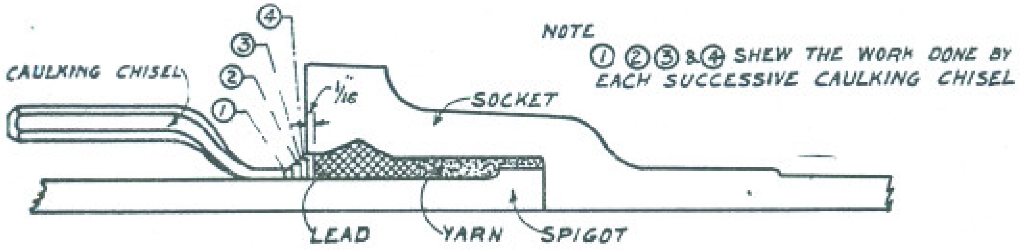

FIG Nº 42
SOCKET JOINT FOR STEEL PIPES

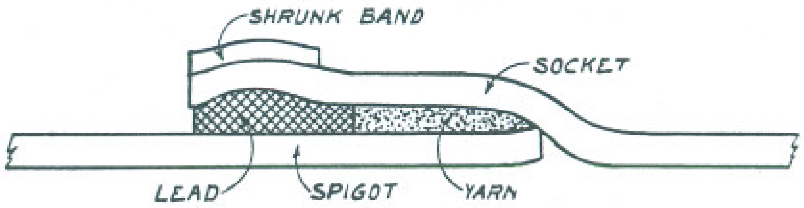

FIG Nº 43
TURNED BACK REINFORCED SOCKET & SPIGOT JOINT FOR STEEL PIPES (GUEST KEEN & PIGGOTTS LTD)

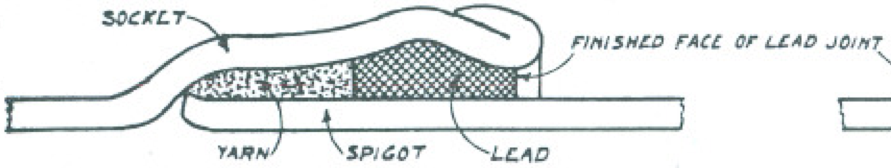

FIG Nº 44
PATENT INSERTED SOCKET JOINT FOR STEEL PIPES (STEWARTS AND LLOYDS)

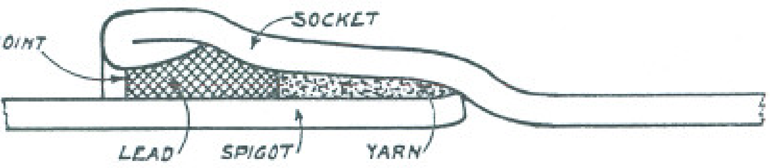

FIG Nº 45
SOCKET JOINT FOR STEEL PIPES (BRITISH MANNESMANN TUBE CO. LTD.)

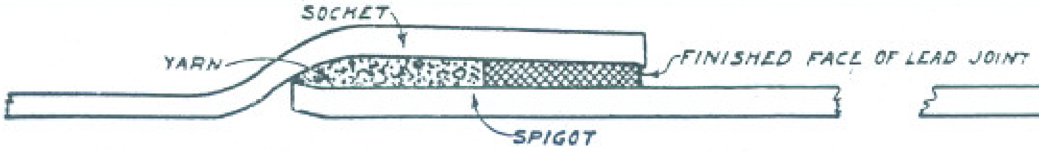

FIG Nº 46
REINFORCED SOCKET JOINT FOR STEEL PIPES (BRITISH MANNESMANN TUBE CO. LTD.)

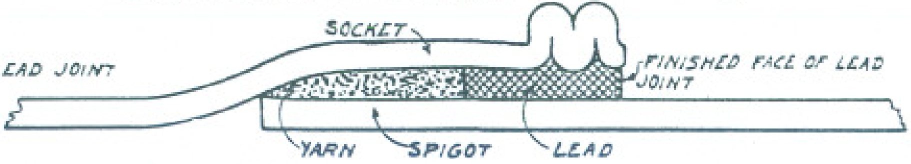

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PLATE VI

FIG Nº 47
HIGH PRESSURE SOCKET JOINT WITH GUARD RING

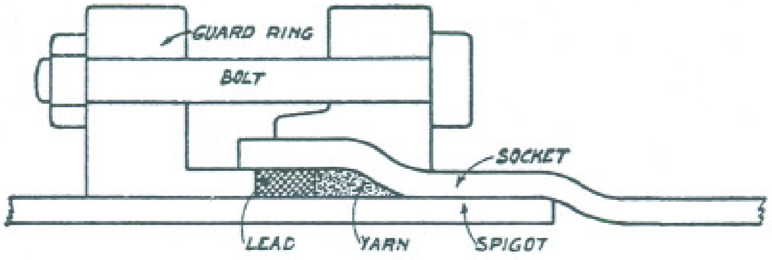


FIG Nº 48
RIGID SOCKETTED JOINT FOR STEEL PIPES
(GUEST KEEN & PIGGOTTS LTD)

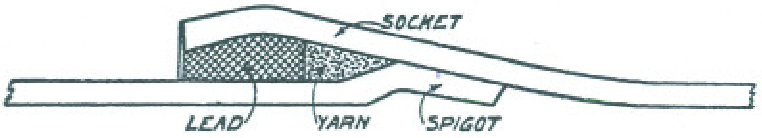


FIG Nº 49
RIGID SOCKETTED JOINT FOR STEEL PIPES
(STEWARTS AND LLOYDS)

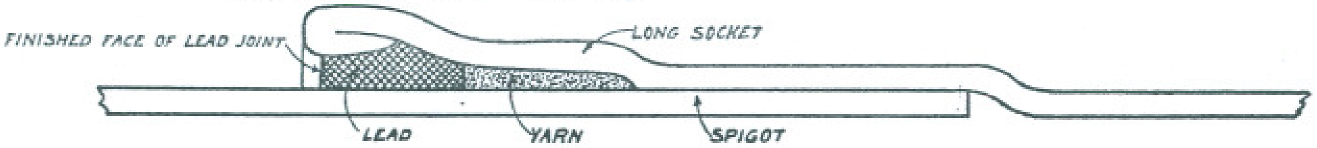


FIG Nº 50
TAYLOR CORRUGATED JOINT RING

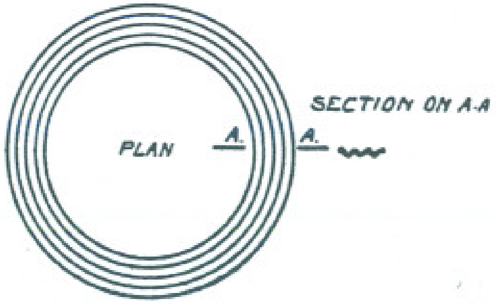


FIG Nº 51
HULBURD'S JOINT RING

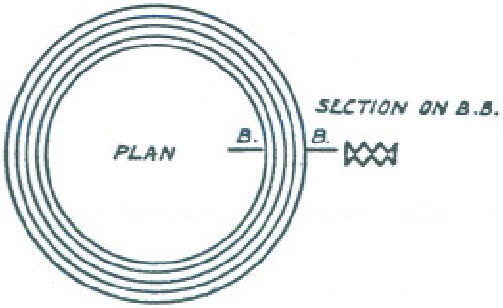


FIG Nº 52
HIGH PRESSURE FLANGED JOINT

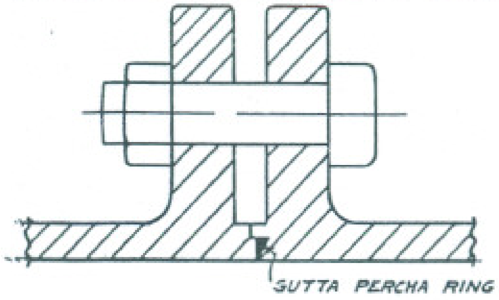


FIG Nº 53
MACHINED STRIP FLANGED JOINT

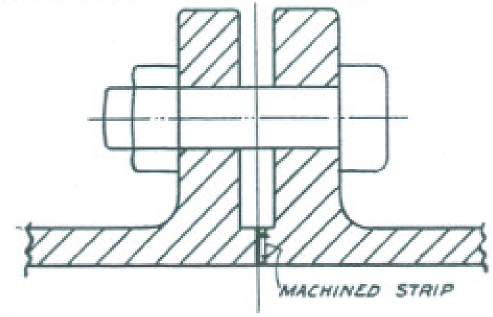


FIG Nº 54
VICTAULIC JOINT

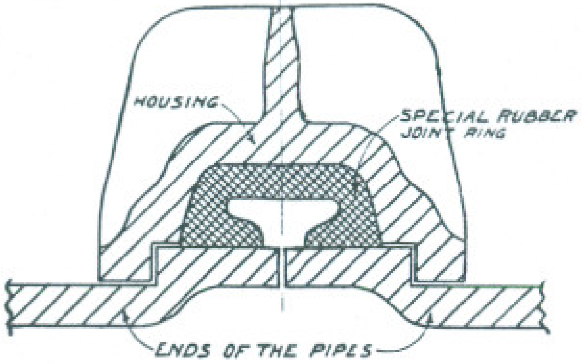


FIG Nº 55
SLUICE VALVE

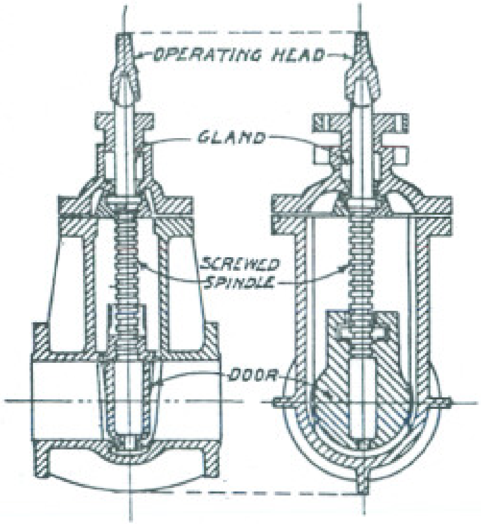


FIG Nº 56
SINGLE AIR VALVE

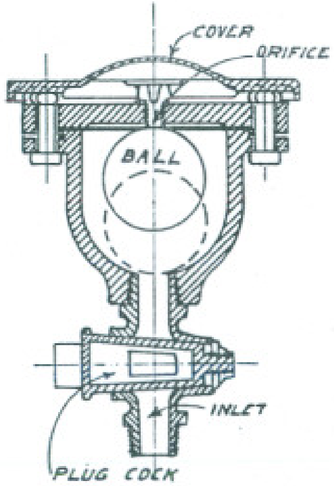


FIG Nº 57
DOUBLE AIR VALVE

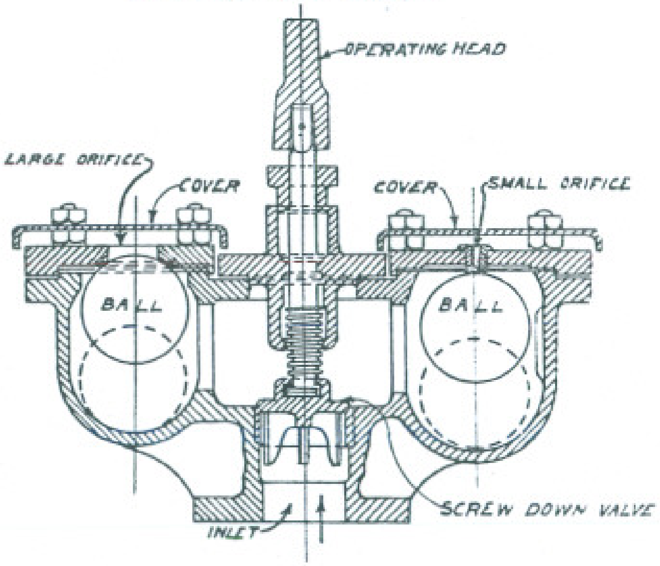


FIG Nº 58
BALL HYDRANT

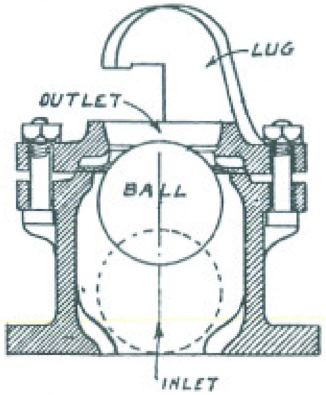


FIG Nº 59
SCREW DOWN HYDRANT

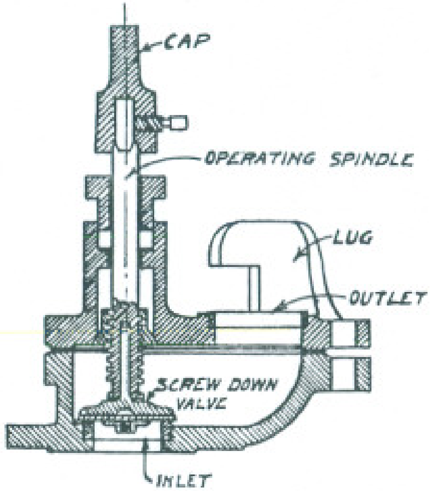


FIG Nº 60
SLUICE VALVE HYDRANT

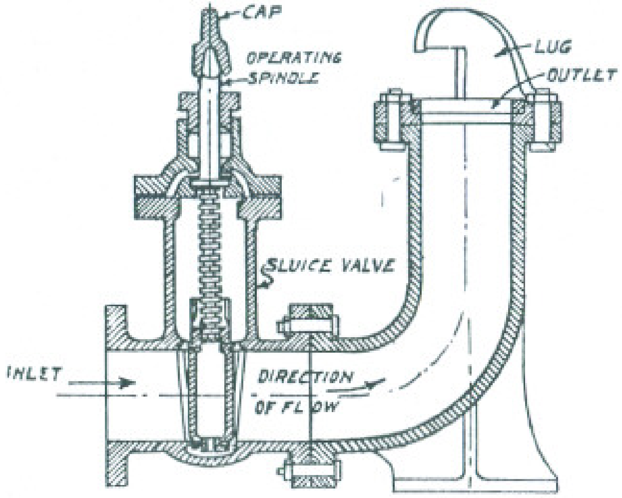


FIG Nº 61
REFLUX VALVE

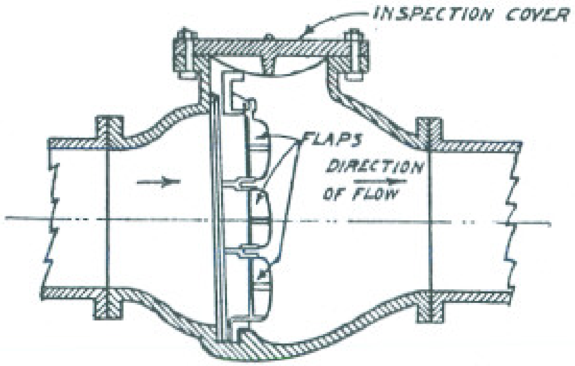


FIG Nº 62
FLAP VALVE

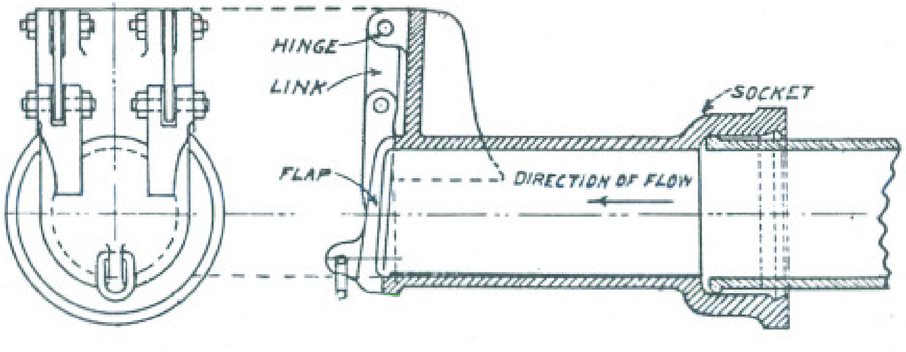


PLATE IX

FIG. Nº 63
PRESSURE REDUCING VALVE
DIAGRAMATIC SKETCH

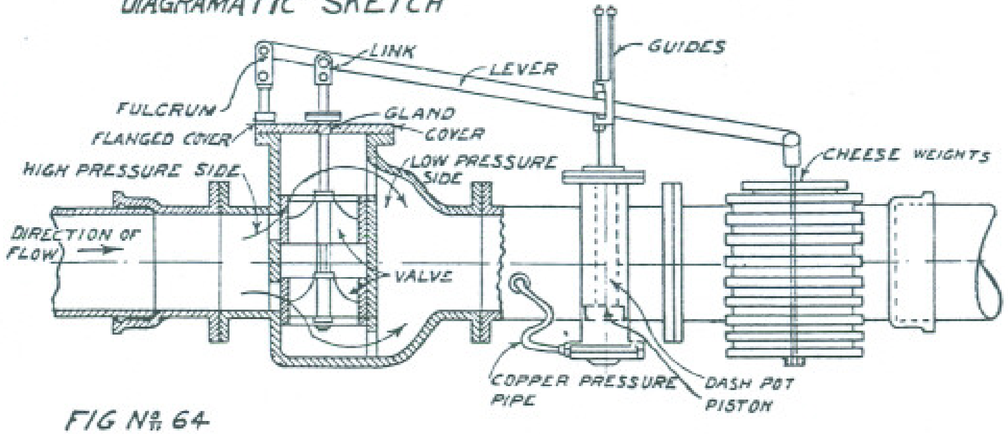


FIG Nº 64
AUTOMATIC THROTTLE VALVE

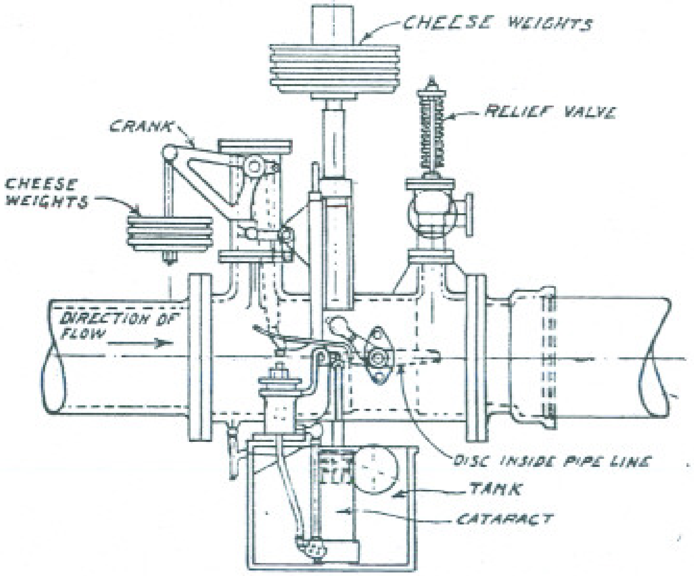


FIG Nº 66
EQUILIBRIUM VALVE ENCLOSED TYPE

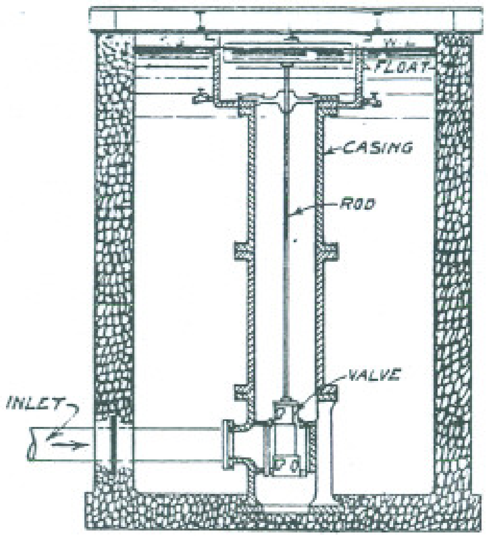
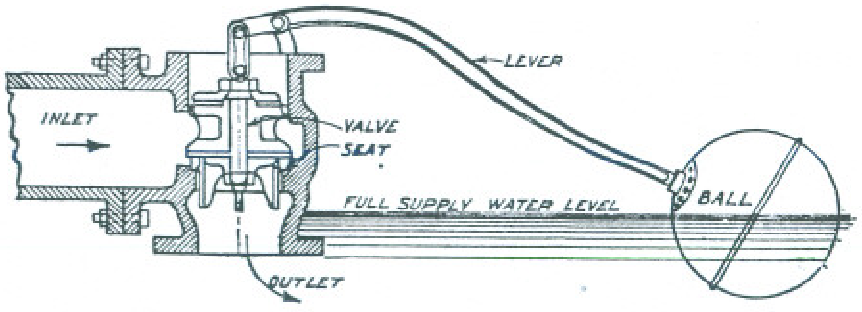


FIG Nº 65
EQUILIBRIUM BALL VALVE



VALVE CHAMBERS

PLATE X

FIG Nº 67
SHEAR LEGS FOR PIPE LAYING

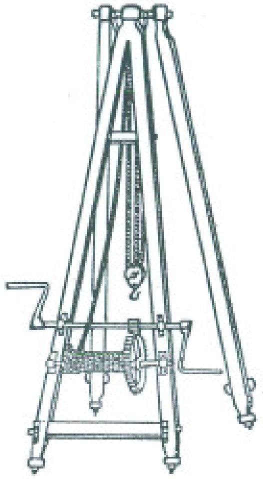


FIG Nº 68
CHAMBER FOR SMALL SLUICE VALVE

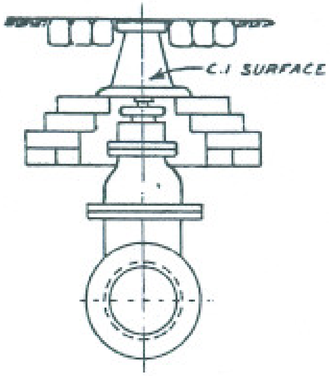
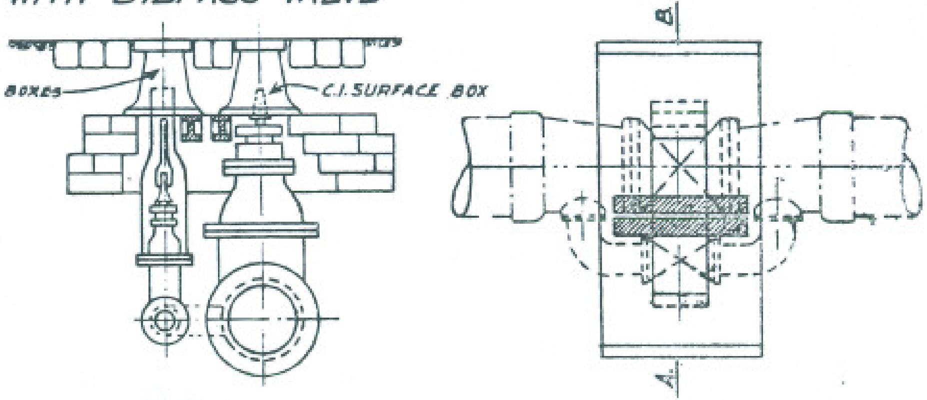


FIG Nº 69
CHAMBER FOR LARGE SLUICE VALVE WITH BYEPASS VALVE



SECTION ON A.B

PLAN

FIG Nº 70
CHAMBER FOR SINGLE AIR VALVE

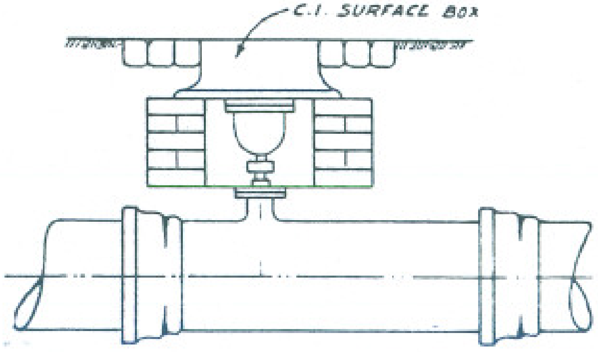


FIG Nº 71
CHAMBER FOR DOUBLE AIR VALVE

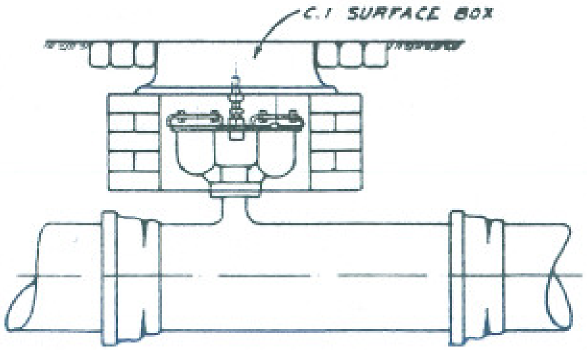


FIG Nº 72
CHAMBER FOR HYDRANT

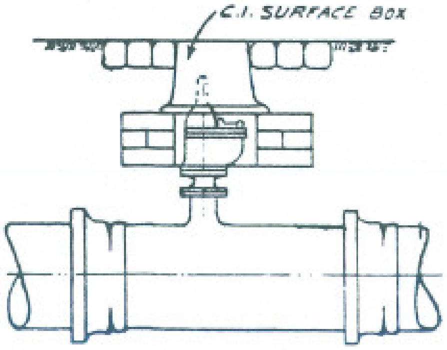


PLATE XI

FIG No. 73
REFLUX VALVE CHAMBER

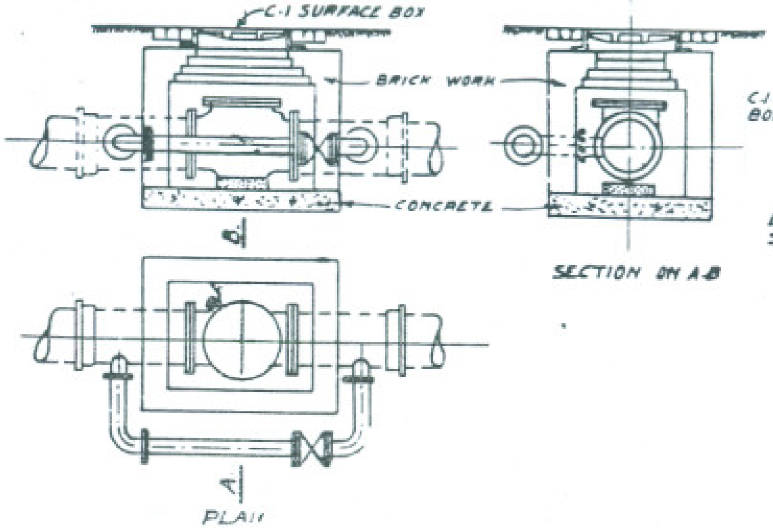


FIG No. 74
SLUICE VALVE WITH
EXTENSION SPINDLE

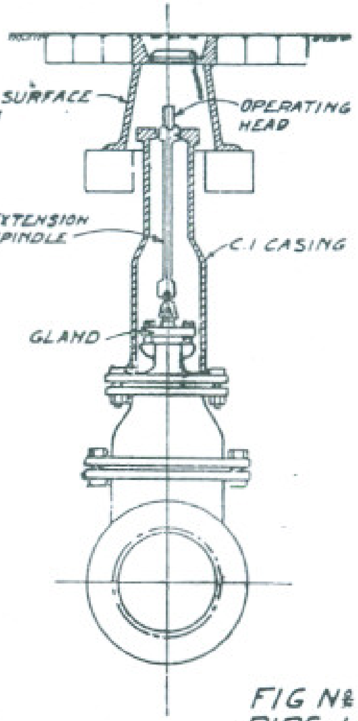


FIG No. 75
ARCHED RIVER CROSSING

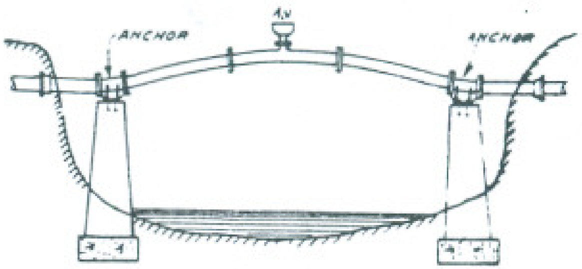
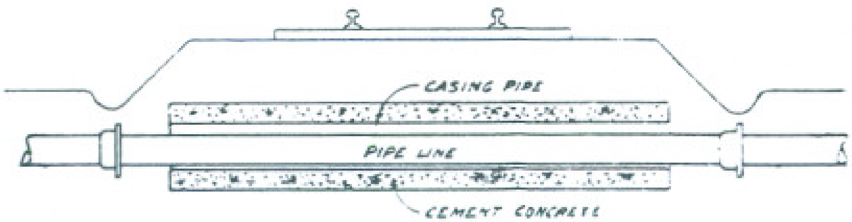


FIG No. 76
SUSPENSION CROSSING

FIG No. 77
PIPE LINE CROSSING UNDER RAILWAY
WITH CASING PIPE



DISCUSSION.

THE AUTHOR, introducing his paper, stated he had ventured to put forward a paper rather different from the usual type presented before the Congress, because, while most of such papers dealt with one particular work or perhaps one special aspect of a problem, his paper on Metal Pipelines was of a more comprehensive and general character, treating on the practice relating to manufacture and construction of various types of metal pipelines and fittings and their protection against deterioration. Usually much detailed information relating to manufacture and design of water-supply pipes and fittings was only available to the hydraulic engineer from the manufacturers and in India comparatively few engineers had acquaintance with the details of practical design and manufacture, as India did not manufacture steel pipes, nor were valves and similar fittings made here.

The information and particulars collected in the paper had not been culled from any text books or manufacturer's catalogues, but were based wholly on the personal experience and practice gained by the Author, who had tried to describe perfectly fairly the relative merits and demerits of cast iron and steel pipes and of the various types of joints employed in connection with the pipes. The Author hoped that the detailed practical information given in the paper would prove of assistance to hydraulic engineers, and particularly young engineers, who might in course of their work be called upon to deal with pipeline problems. He had tried to deal as fully as possible with all the various practical details of pipeline engineering which were met with in the course of construction and field-work.

There was one typographical error. On page 36 in the fourth line of paragraph 37, the word "minimum" should read "maximum" and what the Author really meant to state was that usually in open country and in roads and streets, the curvature of any bend should not exceed $22\frac{1}{2}°$ or one sixteenth of a circle.

MR. A. R. ASTBURY said that the paper covered one of the numerous branches of engineering knowledge included in Public Health engineerng, and was a very useful one. He drew attention to the Guma Water Works, Simla, which had been mentioned by the Author. In these works, water was pumped against 4,000 feet head to Mashobra in a single ift which was the greatest in the world, in connection with water-supply vorks.

He would have liked the Author to have given more information n his paper concerning the manufacture of pipes in India. Cast iron ipes were largely used throughout India and a description of the methods f manufacture of these pipes in India would have been of considerable alue. Referring to the oxide deposit found in the pipes of the Lahore Vater-works as mentioned on page 5 of the paper, the speaker said it vas of interest to note that the iron oxide was not formed from the metal of the pipes but was deposited by the water, which contained iron in solution. This oxide caused serious trouble to the pipelines and also to meters and other fittings, by blocking up the waterway. The Author had omitted to describe a very simple form of air valve which was in use on the Simla Water Works, which consisted of an open pipe carried up from the pipeline to above the hydraulic grade line.

R. B. DEWAN AMAR NATH NANDA said he congratulated the Author on the production of the paper which was a very useful one and he thought it would prove a practical landmark in the Public Health engineering literature of the Punjab. The subject matter had been very carefully and lucidly arranged and the whole had been got up in conformity with the latest engineering practice. He had read the paper very carefully but he was afraid he was not able to amplify it to any useful extent and he would therefore rest content by emphasizing a few points here and there. Firstly, he mentioned the question of "ingot" iron pipes, which were also called, "Armco" pipes. As remarked by the Author, they had actually made use of these pipes in the Punjab in the case of two Schemes—one carried out at Dalhousie and the other at Isakhel which was just nearing completion. The subsoil conditions at Isakhel were very bad and if the pipeline, which was laid in very corrosive subsoil in the 'Khadir' of the River Indus could survive the effects of those bad conditions, then the speaker would be prepared to certify all that was claimed by the manufacturers as to the superiority of "ingot" iron over steel in regard to resistance against corrosion. The next matter was the old controversial question of steel versus cast iron pipes, and he wished to draw special attention in this connection to the various numerous and serious cases of bursts of large pipelines in London during recent years, which had been reported in the press. These bursts had such serious consequences that the Metropolitan Water Board had been obliged to set up a special Committee to carry out investigations into the subject and quite recently the findings of that Committee had been placed before the Board and some of the engineering papers had commented on the report. The Committee in traversing the whole subject of its enquiry, had laid emphasis on a number of points which had important bearing on the matter. These included the depth of cover, the mode of construction of the roadways, the incidence and description of the traffic in the roadways and the vibrations set up thereby, the nature of the subsoil and its action on the pipes and lastly, faults in the manufacture of the pipes such as "sponginess," uneven thickness, "cold shuts" and various other defects. Speaking of "cold shuts" reminded him of a recent case at Jaipur Waterworks where he was shewn pipes manufactured in Southern India. These pipes were not up to the mark and compared unfavourably with pipes made by the Bengal Iron Company Limited. Reverting to the Committee which had enquired into the circumstances and conditions brought about by the bursts in London, it was of interest to note that the Committee had stated that for the future the choice of hydraulic engineers lay between the different classes of pipes mentioned by the Author in his paper. The particular characteristics of these varieties of pipes had been described by the Committee for the benefit of hydraulic engineers called upon to design watersupply schemes. Steel pipes should be used for trunk and high pressure, pumping, or gravity mains. He had a personal talk in 1928 with the Chief Engineer of the Berlin Waterworks on this subject and the latter was of opinion that only steel pipes should be used in highly populated and congested areas, because cast iron pipes were liable to cause serious catastrophes by bursting. As emphasised by the Author however, it was essential to protect steel pipes against corrosion, both internally and externally. The Author had mentioned on pages 5 and 14, the cement lining of pipes. The speaker had met a number of engineers in Great Britain who were in favour of this method of protection of steel pipes under certain conditions and of recent years the use of cement lined steel pipes had been greatly extended. The speaker had seen large diameter steel pipes with an internal lining of cement concrete one inch thick. Internal lining of cement concrete had a two-fold advantage as it prevented corrosion of the metal of the pipe when passing aggressive waters and in addition the strength of the pipe was increased. The speaker wished to emphasise on the discriminating use of steel pipes, because hitherto in the Punjab, in the case of various watersupply works carried out, such as in Amritsar, Ludhiana and other places, cast iron pipes had been employed not only for the distribution systems, where no doubt generally cast iron pipes possessed outstanding advantages, but also for long rising or pumping mains. For example, at the Ambala Waterworks built about 40 years ago, the headworks were situated at a distance of over 8 miles from the town and cast iron pipes had been used for the rising main. If, in those days, steel pipes, lined and protected against the effects of corrosion, had been available, it would have been preferable to use them. The Author had described in the paper, various varieties of joints for steel and cast iron pipes. In all the older waterworks schemes carried out in the Punjab, spigot and socket, half turned and bored joints had been used to a very great extent. This form of joint was very useful for river and railway crossings and the cost was very low and he would like the Author to say something about this type of joint in view of its extended use in the past.

MR. DONALD MACFARLANE described his personal experiences of the construction of the Port Sudan Waterworks, carried out under his supervision. The trunk pipeline, 8 inches in diameter, about 17 miles long, had to be laid in desert country and the only form of transport available was by camels. Cast iron pipes could not be used on account of their weight and after due consideration it was decided to lay steel pipes. The pipes which were screw jointed, were manufactured in suitable lengths so that two pipes could be transported by each camel, one pipe being slung on either side. Most watersupply works were operated on a commercial basis and the alternatives, steel versus cast iron pipelines, needed careful consideration in order to determine which was the best proposition. In connection with the Port Sudan

Waterworks, it was considered that the effective life of the steel pipes would be 5 or 6 years as against about 20 years for cast iron.

Steel pipes, on account of facility in transport, undoubtedly had a considerable advantage over cast iron pipes, for pipelines laid in difficult country, in spite of the fact that the life of cast iron pipes might be very much longer.

He would like to have the Author's views as to the comparative costs of steel pipes and cast iron pipes with ordinary Punjab conditions and what their relative life was.

In the case of the Port Sudan Waterworks, the pipleline was cleaned out by means of compressed air, which was forced into one end of the pipeline at a pressure of about 100 lbs. per square inch and the expansion of the air, when the other end of the pipeline was opened, drove out all sand, grit and even pebbles and gravel. He wondered if the Author had any experience of compressed air being used for a similar purpose, on other waterworks. The speaker had recently seen the manufacture of bitumen lined steel pipes in Great Britain and he considered that they were far superior to the coated and dipped steel pipes in regard to resistance against corrosion.

The Author had mentioned the use of rubber joint rings and the speaker asked if the Author had found the use of rubber entirely satisfactory under Indian conditions.

The speaker considered that it was very difficult if not impossible to estimate correctly the numbers of specials, such as bends, required for pipeline work, and had found it necessary to make large additional allowances to cover unforeseen contingencies and he would like to know the Author's views on the subject.

THE AUTHOR, replying to the discussion said that Mr. Astbury had mentioned that he would have liked a description of the manufacture of cast iron pipes in India to be included in the paper. The Author had not done so as the two concerns in India which manufactured cast iron pipes on a large scale, followed the same manufacturing processes as those of similar concerns in Europe—in fact the system of manufacture in India conformed to the conditions laid down in the British Standard Specification for cast iron pipes for water, gas and sewage as mentioned in the paper. The Author agreed with Mr. Astbury in regard to the source of the iron oxide deposits in the pipelines of the Lahore Waterworks ,which were derived from the water itself. The air exhaust arrangements in use in Simla consisted of air vents or pipes and were not air valves in the true sense. Such air vents were also used in the case of numerous low pressure water installations such as low pressure hot water central heating systems, and for domestic hot water supplies operated by hot water boilers or calorifiers. Such an arrangement however was not capable of general practical application to most waterworks systems, as the height of the hydraulic grade line obove the surface was too great in such cases.

Mr. Nanda had mentioned the recent cases of bursts in the water mains of the Metropolitan Water Board, London, and the Author agreed with him that large pipelines consisting of steel pipes were far more suitable for use in places where there was heavy traffic and in congested areas where bursts would be likely to produce serious devastating results. Under such conditions, the disadvantage of shorter life of steel pipes might very well be ignored, in view of the greater reliability of steel pipes to withstand shocks. As an example of the comparative immunity of steel pipes against liability of fracture and bursting, the Author described the case of a rising main consisting of steel, lap-welded spigot and socket pipes 17″ dia., 15 miles long, recently laid for the Jaipur Waterworks, Rajputana. The pipeline was tested to a hydrostatic pressure equal to 500 feet head of water on completion and only two small leaks occurred. In both cases these were caused by two very short lengths of split welds in the sockets of two pipes. The splits were very short and were hammered down cold and no further trouble had been experienced. It was impossible to conceive of a similar cast iron pipeline being tested without at least a few bursts occurring. In regard to turned and bored joints for cast iron pipes, these had been discussed in paragraph 20 of the paper. The disadvantages of turned and bored joints were:—

(*i*) Once the pipeline was laid, it was practically impossible to dismantle the pipes at a later date, as the joints could not be loosened.

(*ii*) The spigot and socket ends of the pipes had to be machined in a lathe. This increased the cost of manufacture.

(*iii*) The joints did not allow any play or movement in the pipeline to take up expansion and contraction due to temperature changes.

(*iv*) The joints were rigid and necessitated the pipes being laid absolutely true in alignment. It was thus impossible to lay pipelines on slow curves or sweeps such as could be done if open spigot and socket joints were used.

The Author considered that the cost of a cast iron pipeline with turned and bored joints would be at least as great as that of a similar pipeline provided with open spigot and socket caulked lead joints and bearing in mind the disadvantages, it was far better to employ open spigot and socket caulked lead joints every time. The Author was much interested to hear Mr. Macfarlane's experiences in connection with the Port Sudan Waterworks. He did not consider that screw jointed steel pipes 8 inches in diameter were as satisfactory as socketted steel pipes, for water-supply purposes. The comparative cost of cast iron and steel pipes depended upon the working pressure for which the pipes were required and the thickness of metal, cost of transport and many other factors. For pipelines for working pressures equal to 200 feet head of water and ranging from 3″ dia. up to about 24″ dia., the cost of cast iron pipes delivered by rail in the Central Punjab compared favourably with that of steel pipes and there was little, if any, advantage from the point of view of actual cost of the pipes themselves in using steel pipes. In difficult country, however, there was undoubtedly a saving in cost of handling and laying steel pipes as against cast iron and in very hilly country, it might be utterly impracticable to employ cast iron pipes. In the case of high pressure pipelines, where the working pressures were above the maximum limit of the British Standard Specification (400 feet head of water, working pressure), the Author, under normal conditions would prefer to use steel pipes.

It was very difficult to lay down a hard and fast rule as to the comparative life of cast iron and steel pipelines, but as a rough approximation, for good subsoil, in the Punjab, cast iron pipes would probably last 45 to 50 years against 25 to 30 years for steel pipes of reasonable thickness, in which due allowance had been made for a corrosion factor.

The Author had never heard of compressed air being used to clean out water-mains. As water was generally available, it was a simple matter to wash-out with water, all dirt, clay, pebbles, sand and other foreign matter deposited in pipelines, during construction. Wash-outs should always be provided in all pipelines at low points to facilitate this operation. Rubber joints or rather 3 or 4 ply rubber insertion joints were quite satisfactory for use in flanged joints under Indian conditions. After some time the rubber tended to perish, but this did not appreciably reduce the efficiency of the joint. Should a joint have to be broken however, it was necessary to use a fresh rubber insertion joint ring.

The Author had found no inherent difficulty in estimating specials. It was impossible to estimate the numbers of specials by simply examining small scale, general lay out plans and sections of pipelines and either large scale detailed drawings should be prepared or the alignment of the pipelines should be set out on the ground and the positions of bends and other specials accurately fixed beforehand. With reasonably careful work, the numbers of bends and other specials for any kind of pipeline could be estimated with a very high degree of accuracy, say within 2 or 3 per cent.

CORRESPONDENCE.

MR. T. SINCLAIR KENNEDY wrote as follows :—

Congratulations to the Author on a very interesting and practical paper. Couched in everyday language this paper puts forward information of value to Water Works Engineers—giving alternative views on matters contentious—and so stressing the value to practical Engineers deciding from their own experience which of several alternatives gives best results in practice in the particular locality.

I should like to make one or two comments :—

Para. 7. Incrustation (*page.* 5): From my experience of incrustation I should be inclined to agree with those Engineers who state that

Series B. With Spur or Bevel Gear.

6″ Valve is suitable for operation under an unbalanced pressure of 270 lbs. per square inch.

12″ Valve is suitable for operation under an unbalanced pressure of 68 lbs. per square inch.

24″ Valve is suitable for operation under an unbalanced pressure of 18 lbs. per square inch.

The third series marked below with higher pressures require a much stronger Gear of the Worm type:

Series C. With Worm Gear.

The 6″ Valve does not appear in this list.

12″ Valve is suitable for operation under an unbalanced pressure of 190 lbs. per square inch.

24″ Valve is suitable for operation under an unbalanced pressure of 42 lbs. per square inch.

Generally speaking, it is surprising under what a low unbalanced pressure in lbs. per square inch will a larger size of valve require gearing either spur or worm, and I think it is not commonly appreciated the tremendous forces exerted by these low pressures on the door (or wedge) of a Sluice Valve when closed. Thus in the case of a 36″ Valve it is difficult to open such without gearing when unbalanced pressure exceeds 3 lbs. per square inch.

For very high pressures special gear arrangements are needed involving machine cut gearing or an arrangement of external screw with ball bearing geared headstock. Alternatively, there are the special arrangements for operation by hydraulic pressure or electric power as mentioned by the Author. It can readily be understood that bye-passing arrangements do not overcome the difficulty of unbalanced heads in many cases which must be known to Engineers handling Water Works problems.

Para. 26. *Fire Hydrants* (*Page* 28). With the Author's remarks on the Ball Hydrants I find myself in agreement. Under intermittent water supplies this Hydrant is unpopular on account of the danger of contamination due to the ball dropping and leaving an open orifice. In some of the older Water Works a very large number of Ball Hydrants are in existence and in order to economise as far as possible a device called the "Ball Hydrant Conversion Element" has been evolved of which the attached illustration and description may be of interest. It is thus possible by using this simple device to convert a Ball Hydrant into what virtually amounts to a Screw Down Hydrant.

soft waters are the worst for causing incrustation. The removal of tubercles formed by such soft water is certainly much more troublesome. Incidentally, such tubercles are usually found in greater quantity near points where branches take off.

Para. 16. (*Pages.* 12-15): *Life of steel pipes.* The manner in which the 'pros' and 'cons' have been stated when considering Cast Iron versus Steel is a valuable contribution on this question. When read with Para. 17 a very accurate 'budget' should be possible and the most suitable pipes for any known conditions can be decided.

Para. 24. *Sluice Valves.* (*Pages.* 25-27). The last sentence of this para. states that Sluice Valves are usually made to open by rotating the spindle in a clockwise direction. This is different to the usual procedure with Steam Valves. The reason is not commonly known but is simply that a man can most conveniently turn a wheel or valve key thus—always provided he is not left-handed. The greatest effort is required in opening the valve against an unbalanced head as the sliding friction between door (or wedge) faces and faces on valve body has to be overcome.

The Author has touched on the question of gearing for Valves and it might be of interest to the Congress to have the results of recent studies on this question. It might, at first sight, appear that the head at any particular point in a pipe line is very small indeed, provided the pipe line is full, but, in cases of intermittent supply and where valve closure has to be done, say in case of a burst, the imporant question to decide is the actual unbalanced head on the valve when it is being opened. This point has been brought forcibly to my notice in practice.

On assumption that the valves are of the usual pattern with internal screw and are operated by a tee key, where it is possible to apply a simultaneous push and pull of 28 lbs. on each hand at a radius of 18″ on the key handle—*i.e.*, to put into the shaft an approximate torque of 1,000 lbs.—inches, we find that :—

Series A. 6″ Valve can be operated under 160 lbs. per square inch unbalanced pressure.

12″ Valve can be operated under 36 lbs. per square inch unbalanced pressure.

24″ Valve can be operated under an unbalanced pressure of only 8 lbs. per square inch.

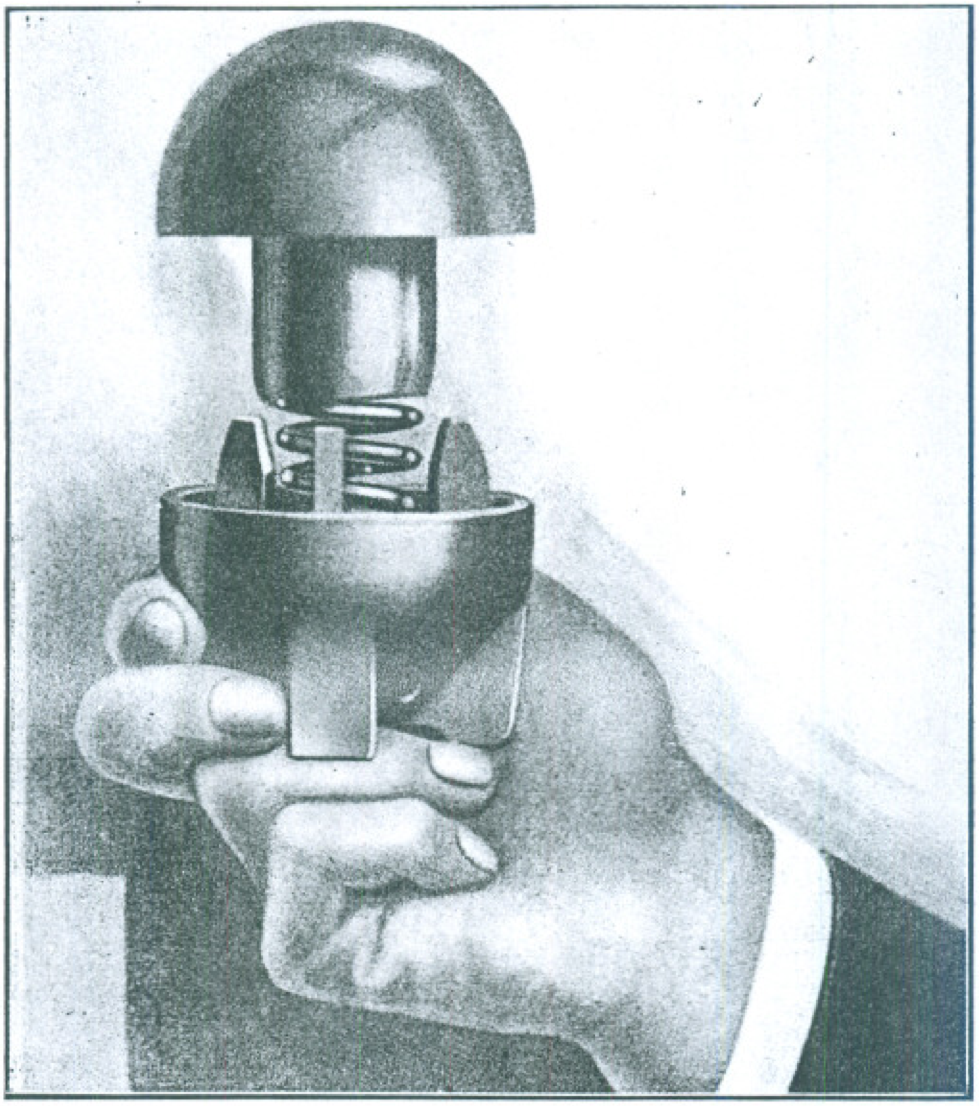
When the unbalanced pressure exceeds that given in above three examples it is necessary to use the simplest type of gear, *i.e.*, Spur gear or Bevel gear as this is suitable under the following conditions :—

Para. 31. *Piston Type Control Valve.* (*Page* 31): Reference is made by the Author to the Johnstone-Boving type of Piston Valve—commonly called Needle Valve. I think it will be admitted that the hydraulic control Needle Valve is not now so popular and the straight forward Needle Valve with a positive mechanical operation is preferred. The reason of the unpopularity of the former type is that after some years of operation it has been found difficult to avoid " creep " by virtue of slight wear on the hydraulic control section of whatever type. It may be of interest to the Congress to see photographs of a large Needle Valve constructed for the large Cauvery-Metur Project in South India. The photograph enclosed shows one of the Valves in the Makers' Works at the time of test.

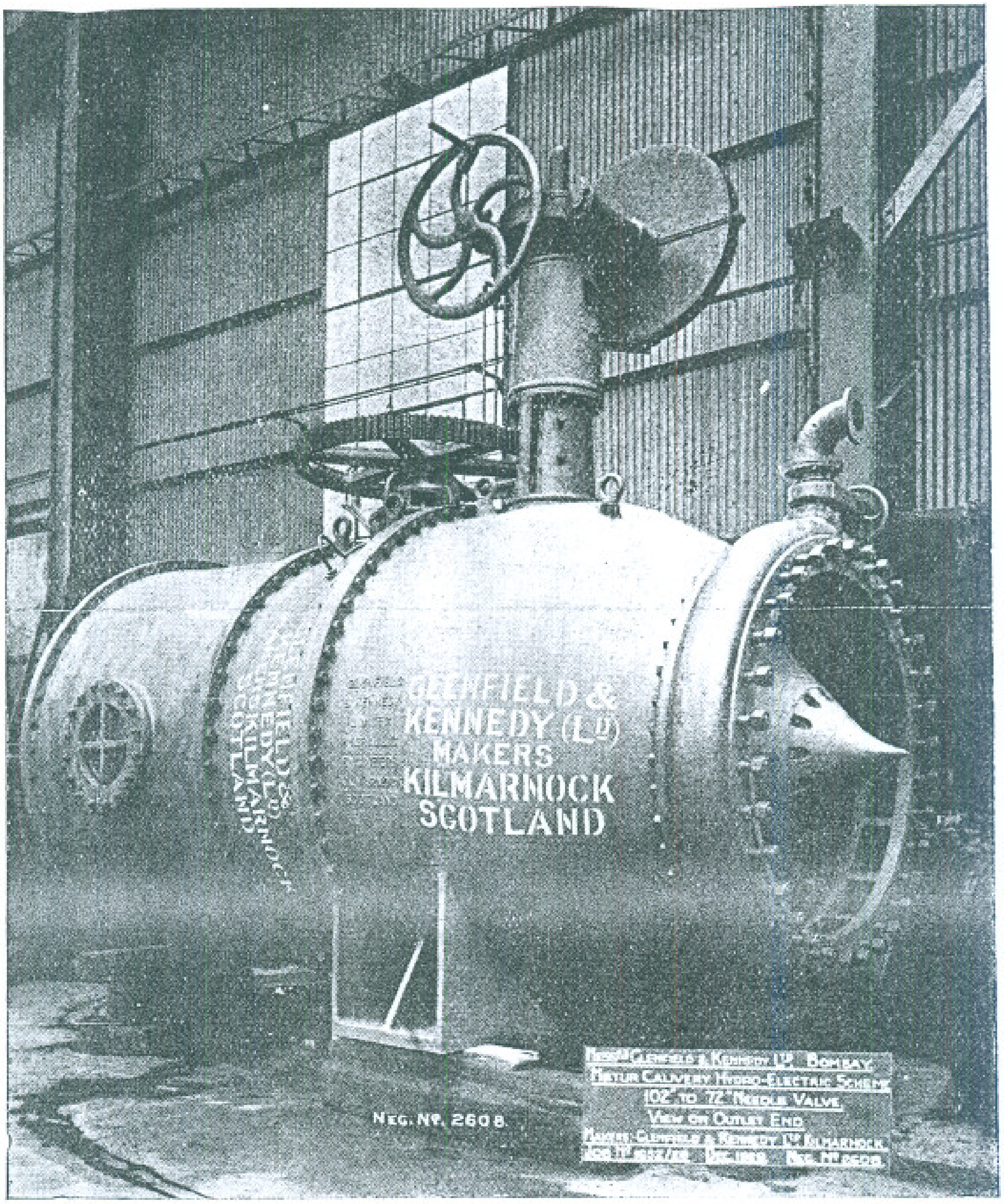
General.—I have read this paper throughout with very great interest and think that it can be used as a standard reference to all interested in the practical side of construction in Water Works. It is with very great regret that I am unable to be present to hear the discussion on this paper and I think the Author is to be congratulated.

"Glenfield"
Ball Hydrant Conversion Element

(PATENTS PENDING).



This is the Valve unit, which only has to be exchanged for the original Ball to convert existing Ball Hydrants into Valve Hydrants.


GLENFIELD & KENNEDY (LD)
MAKERS
KILMARNOCK
SCOTLAND
GLENFIELD & KENNEDY (LD) KILMARNOCK SCOTLAND
NEG. No 2608
Messrs Glenfield & Kennedy Ld Bombay
Mettur Cauvery Hydro-Electric Scheme
102" to 72" Needle Valve
View on Outlet End
Makers: Glenfield & Kennedy Ld Kilmarnock
Job No [illegible] Dec. [illegible] Neg. No 2608