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PIPES AND FITTINGS USED IN WATER SERVICES TO BUILDINGS.

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At the Punjab Engineering Congress in 1931 a paper was presented by Mr. D. A. Howell which dealt with the materials and construction of Trunk and Distribution pipe-lines for Water Supply using metal pipes. That paper described the mains and fittings connected with them which bring the water from the headworks of any waterworks undertaking to the consumers' premises.

The present paper is a continuation of that presented in 1931 and deals with pipes of smaller sizes used in the service connections from the distribution mains to consumers' buildings and in the buildings themselves. Reference is also made to the fittings used with such pipes and to public stand posts.

Pressures in service connections seldom exceed 250 feet and in hilly districts are kept within this figure by dividing the area of supply into pressure zones. In India, even 100 feet is seldom reached as service connections are not, as a rule, given to storeys higher than the first floor. In Bombay and Calcutta, where offices and blocks of flats several storeys high are in existence, the pressure in the water mains is insufficient to make the water reach the highest storey and such buildings have their own booster pumping plants which give the necessary additional pressure to take the water to the highest point in the building.

Pipes for service connections may be of lead, copper or wrought iron. Lead pipes are extensively used in Great Britain and, on account of their resistance to corrosion, long life, and ease with which, in the hands of skilled plumbers, they can be laid in difficult corners, have many advantages over the less flexible pipe of wrought iron. Copper pipes are rapidly coming into favour in England especially for exposed work in hotels and institutions where appearance is also a consideration, and for use with waters which have a solvent action on lead.

Partly on account of cost, partly due to lack of skilled labour, and largely on account of the pilfering which would occur, lead and copper pipes have not been used extensively in India, and here the wrought iron pipe is almost universally employed. Where wrought iron service pipes are laid, however, lead piping is used, in good practice, when connecting up the former with sanitary fittings, a short lead connecting piece being fitted between the comparatively brittle sanitary fitting and the rigid iron pipe, in order to give flexibility. This pipe should be laid on a bend, as shown in Fig. 24 in order to admit of slight movement without damage, of the cistern, lavatory basin, or other fittings to which connections run.

Lead pipes.

Lead pipes for water service aremade by the solid drawn process in which the molten lead is forced through dies under hydraulic pressure. As the finished pipe is passed out of the hydraulic press it is wound on drums into coils of suitable length in which form it is commercially stocked.

The lead used is virgin soft pig and old lead should not be used. The pipes should, if possible, be marked at frequent intervals with their weight in pounds per lineal yard.

Lead pipes of commerce for waterworks purposes are made in three qualities, " light," " medium," and " heavy," and in the table below the weights for pipes in these qualities as laid down by the British Waterworks Association, are given. Many waterworks undertakings in Great Britain, however, insist on heavier pipes being used. Figures for typical undertakings are also given in the table. Up to 110 feet head the light quality is suitable while for pressure between 110 feet and 250 feet the medium quality may be used, but these figures are subject to the statutory rules of the waterworks authority of any particular district.

Quality of Locality.		*Weight per yard of lead pipe in pounds. Internal diameter in inches.*					
		½"	¾"	1"	1¼"	1½"	2"
British Waterworks Association Specification.	Light ..	5	8	11	14	18	24
	Medium ..	7	12	16	21	27	33
	Heavy ..	9	16	21	28	36	48
LONDON ..	..	6	9	12	16		
NEWCASTLE ..	..	7	11	16	22½		
BRIGHTON ..	..	5·6	7·8	12·4	15		

Lead pipes, lighter than any given in the above tables, are on the Indian market, but they are intended for use as soil pipes and are not suitable for water-supply work. Great care is necessary in checking deliveries of lead piping as unscrupulous dealers will try to pass off, as of heavy quality, pipes lighter than given in the above table for light pipes.

A lead pipe, once laid, is practically everlasting and in many Roman remains, as, for example, those at Pompeii, portions of the original lead pipes, in an excellent state of preservation still exist.

As has already been mentioned, one of the greatest merits of the lead pipe is its adaptability and the ease with which it can be bent. Small pipes up to say, 1 inch in diameter are easily bent and, provided the bend is sufficiently rounded, bulging will not occur.

When bending pipes of larger diameter and up to 2 inches (larger sizes are seldom used in water-supply work) some kind of filling is necessary inside the pipe at the point to be bent in order to prevent bulging of the pipe and restriction in diameter. A common form of filling is sand, well rammed into that part of the pipe which has to be bent. With such filling little damage occurs to the pipe and after bending the sand core can be easily washed out.

Joints in lead pipes.

Joints in lead pipes are usually " wiped." The wiped joint, universally used in England, is seldom seen in India and merits description as, in the highest class work even where wrought iron pipes are used, wiped lead joints are used on the short lead connecting pipes between the wrought iron pipes and sanitary fittings.

The method of making " wiped " joints is shown in Fig. 1. The ends of the two pipes to be jointed are opened out, one somewhat larger than the other and the ends are filed to a feather edge. The ends are then scraped clean so as to leave the pure metal exposed and are then rubbed with tallow. When now joined they should form a close fitting union with a clear waterway through as shown in the diagram. Solder, composed of two parts of lead and one of tin is now melted and heated to suitable temperature, (the correct temperature is that which will just char a piece of wood dipped into the molten mixture). The solder is poured by the plumber from a ladle held in his right hand while a large wiping cloth is held in his left hand below the joint to be wiped, as shown in the diagram. The solder, on pouring from the ladle, adheres partly to the pipe, the excess running off on to the wiping cloth. This surplus is brought round on to the top of the joint and the process is repeated until the joint is sufficiently heated and tinned. Surplus cold metal is then removed and the cloth passed quickly round the joint in one direction only, leaving a perfectly smooth convex ring of solder round the joint. Modifications of this process are employed to form branches and also in joining pipe laid vertically or at any angle.

Brass fittings such as taps, valves and connections to sanitary ware, which have to be joined to lead piping have plain ends, as shown in Figs. 10 and 11 (*b*), to which the lead pipe is joined. Where fittings have screwed connections a union nut fitted with a piece of plain brass pipe is used for connecting up with the lead pipe. In joining lead and brass pipes or lead pipes with brass fittings the brass or the plain end of the fitting must first be thoroughly cleaned and tinned with fine solder, resin being used as a flux. To fix the brass into the lead pipe, the end of the latter is swelled out, while near the end of the former a groove is

filed all round the fitting into which the edge of the lead pipe is hammered to prevent movement while the joint is being wiped. The joint is finshed in the same way as a lead wiped joint but care must be taken to bring both metals to the same heat and to wipe the metal away from and not towards the brass as, owing to greater conductivity the solder cools more rapidly and unequally on the brass than on a lead to lead joint.

The joining of lead to iron by a wiped joint never gives satisfactory results as solder does not readily tin to iron nor, when tinned, is it reliable. Where a lead and iron pipe have to be joined two methods are used. In the first a brass union piece is joined to the lead with a wiped joint as described above and the screwed end of this union is coupled with the screwed end of the iron pipe. In the second method the end of the lead pipe, having been passed through a special union, is enlarged and is forced home on to a washer between the two pipes by screwing up the union nut. These two couplings are illustrated in Figs. 2 (*a*) and 2 (*b*).

The latter joint does not give satisfactory service as lead, being a partially fluid as opposed to a springy metal, it flows under the pressure of the union nut of the joint and so working loose, ceases to be watertight. The British Waterworks Association, whose rules represent the best waterworks practice, allows only jointing of the union type.

Waters containing more than about 7 parts of calcium carbonate per 100,000 have no appreciable solvent action on lead and such waters may be passed through lead pipes without danger. "Soft" waters (*i. e.*, those with a small calcium carbonate content) are unsuitable for passing through lead pipes on account of their slight solvent action on lead. Furthermore, upland surface waters such as run from peat-covered moorlands which are a common source of supply in Great Britain contain certain organic acids which assist the solvent action of the water on lead and these should not be passed through lead pipes.

The effect of a minute quantity of lead on the human system is negligible, but the lead tends to accumulate in the body and the long continued use of water contaminated with lead may result in serious lead poisoning.

Where soft or moorland waters occur it is necessary to replace the lead by another material or to thoroughly protect the lead from the solvent action of the waters. Lead pipes washed internally with tin or with a solid tin lining have been used on such occasions. The former type are unreliable as the tin flakes off and where a joint is made the heat of the jointing process causes the tin to fall from the lead.

For making a tin lined pipe the same type of apparatus is used as for a lead pipe, but the cylinder from which the pipe is pressed consists of two metals the outer portion being lead with an inner core of tin. This gives a more permanent job, but here again exposure of the lead at joints, due to melting of the tin, occurs.

For the same reason that acid-bearing waters should not be passed through them, lead pipes should not be laid in soils containing acids with a solvent action on lead. Lead pipes should not be laid in walls constructed with cement mortar as the gypsum in the cement attacks the lead. A limestone mortar does not attack lead but the presence of gypsum in the mortar will cause corrosion of the lead. In such cases the lead pipe should be passed through an iron guide pipe previously built into the wall.

Some waterworks undertakings using a soft moorland water; Birmingham which draws its supplies from the mountains of Central Wales, may be cited as an example; give the water an artificial hardness by introducing a definite proportion of calcium carbonate into the water and so rendering its action on lead service pipes neutral.

Copper pipes.

Copper pipes or solid drawn tubes have come much to the fore in recent years for use with soft or other waters having a solvent action on lead and also on account of their appearance being neater than that of lead. The solid drawn copper tube has the same flexibility as the lead pipe, but its high cost deterred its rapid introduction, although, on account of the simple joints used, its fixing costs are less than in the case of lead.

The Manchester Royal Infirmary may be cited as a typical modern institution fitted throughout with copper water service pipes, and a few remarks about the copper piping used there may be of interest. The tubes on the main lines are of solid drawn copper, the thicknesses being as follows :—

Dia.	*Thickness.*
2″, 1½″	9 w. g.
1¼″, 1″	10 w. g.

The thicknesses of screwed copper tubes laid down by the British Waterworks Association are given below and, on comparison, will be seen to be of lighter section than given above.

BRITISH WATERWORKS ASSOCIATIONS STANDARD THREADED COPPER TUBES.

Internal dia. of pipe.	*Thickness of metal.*	*Threads per inch.* [These threads are smaller than, and do not fit with those on, wrought iron tubes.]
1/2″	16 w. g.	20
3/4″	15 w. g.	20
1″	14 w. g.	20
1½″	14 w. g.	20

On these thicknesses the ordinary screw and socket joint is used. For internal service connections, however, tubes of very much lighter section (19 w. g. on tubes up to 1 inch and 18 w. g. on $1\frac{1}{4}$ and $1\frac{1}{2}$ inch) can be employed which still retain an ample margin of safety for all normal working pressures. No extra thickness to combat corrosion from within or without is necessary. In the Manchester Royal Infirmary D. D. copper pipe fittings manufactured by Messrs. Fyffe and Coy. of Dundee are used. With these fittings no screwing of the pipe is necessary and Fig. 3 shows clearly how the joint between the two copper pipes is made. The only tools required are a die or forming block and two expanding tools to form the end of the tube into a cup-shaped seating to receive the gunmetal nipple of the union, the two being forced into water-tight contact by the union coupling nuts. The only point requiring special attention in jointing light copper tube is that, after cutting the pipe as square as possible the end should be carefully smoothed with a smooth file to remove ragged edges and saw marks. No red lead or other packing should be used in a copper tube joint. The D. D. fitting is made of gunmetal and is sold in many forms. For example, in one form it is screwed for joining with an iron pipe at one end while the other is formed for receiving a copper tube.

A simpler form of this joint known as a cone joint is shown in Fig. 4. No special tools are required, all that is necessary being to enlarge the copper tube to fit over the cone. With this type of joint, however, trouble may arise due to the tubes working loose.

Another form of the joint, used for coupling copper tubing with brass or gunmetal fittings is, the "Instanter joint" and is shown in Fig. 5.

In this joint the copper tube having been pressed home to the distance stop A, as the union nut B is tightened on to its seating C the specially shaped compression ring D buckles and forms the corrugations on the copper tube as shown, thus holding the latter firmly in position as shown in Fig. 5 (*d*). In this figure the corrugations which prevent slip are shown exaggerated. In practice the pipe corrugation is negligible and forms no obstruction to flow. With this type of joint soft or annealed tube should not be used.

Light copper tubes of good quality can be very easily and quickly bent in the $\frac{1}{2}$ inch and $\frac{3}{4}$ inch sizes. The $\frac{1}{2}$ inch size can be bent without even annealing. The $\frac{3}{4}$" size should, however, be annealed to get the best results. Annealing is done by heating to a dull red heat on the part to be bent and manipulation when cold. Sizes of 1 inch and over should be annealed and filled. Dry sand well rammed into the pipe as already described for lead pipes, gives a satisfactory filling. If filling is not used the pipe will become dented and cause an obstruction to the flow of water.

Copper pipes can thus be bent as easily or more easily than lead while a highly skilled plumber is not required for making the joints. Where labour costs are high, as in Europe or America, their low fixing

costs are an important factor in favour of copper pipes while the risk of lead poisoning is, of course, removed. With the fall in the price of copper their introduction into India for the highest class work is worthy of consideration.

Wrought iron pipes.

In India, service connections are almost always made of wrought iron pipes. Wrought iron pipes are made by bending iron strip and closing with a lap welded joint, but solid drawn tubes are also on the market. In the smaller sizes used in service connections wrought iron pipes are referred to as tubes. The length of service of an iron tube depends largely on the quality of strip used in its manufacture. Tubes made from pure ingot iron are on the Indian market, but are about 20% more expensive than tubes made from standard British iron of repute. The cheap tubes on sale in the bazar are made from Belgian or other Continental strip of inferior quality with many impurities, and the life of such tubes is short.

In their commonest commercial form wrought iron tubes are "galvanized." Wrought iron tubes which are to be galvanized must first be cleaned in an acid bath after which they are dipped in a bath of molten zinc or spelter, oxidation being prevented by covering the zinc with ammonium chloride. Electro galvanizing is not used for wrought iron tubes.

The thin zinc coating which adheres to the tube, acts as a protection against rust and corrosion. For use inside buildings plain wrought iron tubes may be used with only a coat of paint. In buildings with several independent pipe systems such as hospitals where hot water, cold water and steam services may be given, the painting of pipes in different colours is useful for distinguishing the pipes of different services and thus facilitating repairs and renewals. The quality of the galvanizing varies much ; on the cheap brands sold in the bazar the zinc coating is very often put on without previous treatment of the pipe in an acid bath and flakes off in handling before the pipe is laid. The exposed iron, where the galvanizing has flaked off, rapidly rusts, and the rust extends along the surface of the iron under the zinc, causing the eventual failure of the tube. Tubes made by makers of repute, although costing more than the cheaper varieties, may be relied upon to be made of sound strip of correct weight and to have had proper treatment at the time of galvanizing. Such tubes, in sizes $\frac{1}{2}$ inch and upwards always have the maker's name rolled as a raised brand on the surface of the metal. The tubes manufactured by Stewarts and Lloyds (brand S. & L) or the Scottish Tube Coy. (brand S. T. C.) are examples of products of repute.

Occasions arise where soils are so corrosive that the protection afforded by galvanizing is insufficient. The author has had recent experience of a case of this nature at Multan where service connections of galvanized tubes to public standposts corroded and became perforated

after about four years. Tubes used for replacements and new service lines in this area, in addition to their original galvanizing, are dipped in a hot bitumen bath and are wrapped in hessian also dipped in bitumen before laying. Time alone will show the effectiveness of this treatment.

Wrought iron tubes are made in three qualities : "gas," "water" and "steam." The materials used for each quality by any given maker are the same, the "quality" being dependent on the thickness of metal in the tube. Gas tubes by makers of repute are tested to 250 lbs. per square inch while steam tubes are tested to 500 to 1,000 lbs. per square inch. Below is given a table showing the thickness and weights of wrought iron tubes adopted by the British Tube Makers Association. After galvanizing, the weights of course become heavier and the amount of galvanizing varies. The columns of weights after galvanizing represent good modern practice.

Nominal Internal bore.	*Nominal thickness of tube. Wire-gauge No.*			*Weight per running foot in lbs.* Black.			Galvanized (approximate weights).		
	Gas.	Water.	Steam.	Gas.	Water.	Steam.	Gas.	Water.	Steam.
$\frac{3}{8}''$	13	12	11	·582	·644	·703	·628	·695	·759
$\frac{1}{2}''$	12	11	10	·818	·896	·973	·883	·967	1·080
$\frac{3}{4}''$	11	10	9	1·165	1·268	1·403	1·234	1·344	1·487
1″	10	9	8	1·653	1·833	2·008	1·752	1·942	2·128
$1\frac{1}{4}''$	9	8	7	2·367	2·598	2·827	2·485	2·727	2·968
$1\frac{1}{2}''$	8	7	6	2·978	3·237	3·500	3·121	3·398	3·675
2″	8	7	6	3·786	4·128	4·473	3·937	4·293	4·651

For water service connections, pipes of "water" quality should always be specified. When calling for quotations from suppliers the weight of the tubes should always be demanded and checked as unscrupulous dealers will try to palm off cheap quality "gas" tubes as tubes of "water's" quality. As practically no bazar dealers carry tubes of "water" quality, the checking of weights after purchase is essential.

A further point worthy of note is that British makers manufacture wrought iron tubes in lengths of 16 to 20 feet, while continental makers supply in lengths up to 24 feet or over. If, therefore, the pipe lengths in any consignment average much over 18 feet it is fairly certain that continental pipes are being supplied. In Great Britain, the Ministry of Health model bye-laws now lay down that wrought iron water service pipes should be of "steam" quality, but questions of cost preclude the use of the heaviest quality pipes in India for water-supply works. The running contracts of the Indian Stores Department provide for the sale of all three qualities of wrought iron galvanized tubes by makers of repute.

Wrought iron tubes are almost invariably coupled by screwed and socketted joints with the general form of which every engineer is familiar. The pipes have a thread cut on them at either end and are joined by screwing into internally threaded sockets. Screwed and socketted wrought iron tubes are sold with a socket screwed on at one end of every tube and, in the larger sizes, with a protecting ring on the thread at the other end. The usual trade practice is to measure the tubes for payment over the socket with the latter screwed fully home ; that is with the tube halfway into the socket, and the price of the tube thus measured includes the price of the socket. When tubes are sold at a rate per " effective foot " the measurement is made over the pipe only and the price of the socket is not included, unless specially mentioned.

Fittings for wrought iron tubes.

Unlike the lead pipe or copper tube the wrought iron tube cannot be bent to fit into awkward corners and so a variety of fittings are standardised for using with wrought iron pipes. These comprise, in addition to sockets already mentioned, bends, reducing sockets to enable one sized tube to be joined to another of a different size, nipples for joining two socketted fittings, tees both equal and unequal for joining one pipe-line with another, elbows which are in reality sharp bends, flanges, plugs and others of a more special nature. A number of these are shown in Fig. 6. Where fittings are ordered from a priced catalogue it should be remembered that fittings with outlets of unequal diameters are charged according to the price of the largest diameter. In the case of fittings which require a socket at one end, as, for example, bends of longscrews, the price of the fitting includes the cost of one socket.

In addition to fittings of wrought iron, malleable and soft cast iron fittings for wrought iron pipes are made and are now available on the Indian market. These fittings are very neat in appearance and are of ample strength for water service. For additional strength they can be obtained banded as shown in Fig. 7.

The gas thread cut on the outside of the tube ends is a tapered thread while that on internally threaded fittings may be either a parallel thread or a tapered thread. The most usual form of joint is a tapered male thread on the pipe and a parallel female thread on the socket. A section of the joint thus formed is shown at Fig. 8 from which it will be seen that the watertightness and strength of the joint depends on the action of one or two threads and on the metal of the socketted fitting being sufficiently malleable to adjust itself to the tapered male thread.

The tapered thread socketted fitting is, however, now coming to the fore and is an improvement which was embodied in the Reports of the British Engineering Standards Association of 1922. British standard taper thread fittings are now on the Indian market and mark a definite advance in waterworks practice. Where a hard malleable iron fitting is employed, their use is essential as the "give" in the metal

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of such fitting would not be sufficient to ensure watertightness if a parallel thread were used. A portion of a joint using the British Standard taper thread is shown in Fig. 9 from which it will be seen that all the threads of the joint are bearing equally. The British Standard threads are of the same size as the old pipe threads for tubes up to 2¼" bore and so this class of fitting can be used with all the sizes of tubes used in ordinary service pipe-lines. The threads are so arranged that the coupler, be it a socket or any other fitting, can be screwed by hand on to the tube leaving about four threads exposed. The joint is completed by two or three turns with the pipe wrench. A light coating of paint on the pipe is all that is necessary for ensuring a watertight joint. No heavy application of white lead is necessary and no hemp is required. Fittings complying with British Standards always carry the British Standards mark branded or rolled on to them and, in addition, such fittings carry the maker's mark. They can thus always be distinguished. Such fittings are somewhat more expensive than the ordinary patterns commonly sold by bazar dealers but, in view of the more permanent and effective job they give, are cheaper in the end. A further outstanding feature of the British Standard Fitting is that all regular fittings for the same diameter pipe have the same centre to face dimensions, thus greatly facilitating drawing office work in preparing elaborate pipe layouts.

The threaded portion of a tube is a cause of weakness in the tube and the length so threaded remaining outside the socket should be kept to a minimum. Where "British Standard" fittings are used this is possible as the amount of engagement of the pipe and socket is known. Below are given figures showing the amount of this engagement for tubes of different sizes :—

Nominal diameter of tube	½"	¾"	1"	1¼"	1½"	2"
Engagement or overlap	13/32"	17/32"	19/32"	23/32"	23/32"	27/32"

In this way connecting pipes in complicated layouts can be cut with accuracy and subsequent waste and creation of random lengths can be avoided.

Where tubes are joined by the ordinary screwed and socket method and whatever type of screwed fitting is used, the operation must be carried out from one end, and consequently when a joint requires repair or a junction has to be inserted, a portion of the work, often a considerable length, must be dismantled. By fixing "connectors" or "long screws" (*see* Fig. 6) at intervals, this difficulty is overcome. A thread is cut at one end of the connector of sufficient length to allow the whole of the coupler or socket together with a backnut to be screwed on to it while a thread of the ordinary type is cut on the other end. When the tubes are in position the collar is screwed over the joint and this holds the pipes together. The socket being screwed over the tapered thread of the pipe end gives a tight fit while watertightness on the connector is ensured by tightening up the backnut.

Flanges, screwed on to the tube ends can also be used for the same purpose, but with such joints very exact fitting is necessary if a proper junction is to be effected.

There is a growing practice in wrought iron pipe work to use the union type joint B, already described in connection with lead and copper pipes instead of the long screw or connector. Such connections are more rapidly and more easily made than are the long screws.

The unions for wrought iron pipes may be of malleable iron but may have a gunmetal or brass seat as shown in Fig. 6 (*a*). If no gunmetal or brass seat is provided then either a gasket between the two pipes will be required or properly fitted "faces" must be made on the pipe ends. Such a joint is shown in Fig. 6 (*b*). It will be noted that the male thread on one half of the union projects from and is not cut into the metal of this half of the fitting.

Before leaving the question of joining wrought iron tubes a few points on the practice of laying may be noted.

Pipe-fitters should be provided with a proper set of tools which for wrought iron tube work should include a working bench complete with pipe vice at one end, a set of drills, stocks, taps and dies for all sizes of threads on which the fitter will have to work, files, pipe-cutters, hacksaw (with a supply of spare blades), at least two pipe wrenches and spanners for hexagonal nuts or shanks. Examples of tools are shown in Fig. 30.

When tubes have to be threaded the die should be so adjusted that the cuts are made gradually, the layers of metal taken off at each successive cut being comparatively thin. In this way a smoothly finished thread will result.

Dies, and pipe cutting tools should be efficiently lubricated. While for lubrication of wearing parts of tools and machinery, a mineral oil has been found to give the best results, for lubricating the actual cutting tool when in the metal, a vegetable oil gives easier working and better finished results. In cold weather, when vegetable oils tend to congeal, an addition to them of a small proportion of mineral oil will make the mixture flow more freely.

Where screwed joints are made the threads should be lightly covered with white lead ground in oil. Only a small quantity of white lead is necessary and an excessive amount results in its being deposited inside the tube, where it causes an obstruction to the flow of water in the tube. Small particles also may work loose and pass down the pipe where they may interfere with the working of meters and other fittings. Hemp is sometimes wrapped on the threads to assist in making a watertight joint, but where the latter are properly cut, this is unnecessary. Mistries should be discouraged against using hemp while the use of cotton waste instead of hemp should never be permitted.

Where " faced " metal surfaces have to be joined, the smearing of such surfaces with white lead or shellac varnish will ensure watertightness. The insertion of hemp rope or cotton waste into such joints definitely reduces their efficiency.

The pipe wrenches provided in the pipe-fitter's equipment should only be used on cylindrical surfaces such as pipes or sockets. Where work has to be done on fittings provided with hexagonal bodies or shanks such as unions or taps, proper standard wrenches should be used.

For use after cutting pipes a burring reamer should be provided. This tool removes the small burrs formed by pipe cutting on the inside of the tube and thus enables a full bore to be maintained.

Joining service connections with cast iron distribution mains.

Where a wrought iron service connection is a continuation of a cast iron main the two are joined using flanges, the cast iron main, if necessary, having a taper special to bring it to the same diameter as the service connection.

Where service connections take off cast iron distribution mains the junction between the two is formed by a ferrule of brass or gunmetal of which examples are shown in Fig. 10. The main to be threaded is first drilled to the required size and the hole so formed is tapped to receive the thread of the brass ferrule which is then screwed firmly home on to the cast iron main. The other end of the ferrule may be screwed to couple direct to a wrought iron tube or brass union or may have a plain end for forming a wiped joint with a lead service pipe.

The screwing of wrought iron tubes direct into cast iron mains does not give a satisfactory watertight joint. The cast iron, being brittle, will chip off if a pipe of iron is forced on to it. On the other hand, the soft metal of a brass or gunmetal fitting yields and fits the threads in the cast iron when the fitting is forced home and thus watertightness and permanency are ensured.

It is undesirable to tap any main for a connection greater than a third of its diameter. Where the main is small and a connection of a larger size than this is required, it is usual to make a small connection and enlarge up to the required size by means of a reducing socket. The reduction in flow in a pipe caused by a temporary restriction of the waterway is small ; it is the diameter of the comparatively long service pipe and hence the friction therein which is the determining factor governing the quantity of water which will be delivered. This point is stressed here as in the majority of Punjab towns the charges for private unmetered connections from the water mains are made according to the size of the ferrule irrespective of what size the connecting pipe to the building may be. As such charges are supposed to bear some relation to the quantity of water taken, they should be based on the size of the service pipe, irrespective of the size of the ferrule used.

The majority of British waterworks authorities insist that a screw-down plug shall be incorporated into the ferrule so that the service connection may be completely isolated from the main in case of a burst or other emergency. Two typical ferrules complying with this requirement are shown in Fig. 11 (*a*) and 11 (*b*).

The Morris Swivel ferrule, shown at Fig. 11 (*a*) is simple and inexpensive while the outlet connection, swivelling round the portion which is screwed into the main, enables connections to be taken off at any angle after the ferrule is screwed fully into the main. The ferrule is not intended for regular opening and closing but for isolating the service connection in cases of breakdown and after fixing the cap over the screw-down valve the earth covering over the main is refilled. No surface box for access is provided.

When the plug valve has to be operated, as for instance, when the service connection requires repairs, this valve which is fitted with a packing ring is, at all stages of opening, watertight. The valve spindle is operated by any strong screwdriver inserted through the opening in the cover.

This ferrule should, however, be always kept fully open or fully closed as, in these positions, permanent watertightness is ensured. If the valve is left partially open water may, in course of time, leak past the packing ring and, passing out into the subsoil, cause damage to adjacent buildings. The plug valve is operated by a suitable key, or a strong screwdriver may be used.

The Glenfield screw-down ferrule, illustrated in Fig. 11 (*b*) is meant to be used in conjunction with a surface box at ground level and serves as a regulating stopcock for the building connection which is always accessible. It may, however, be protected by the cover as shown after which the surrounding earth is filled in. It should be noted that in this ferrule the valve itself is separate from the operating spindle and should the pressure in the mains drop the valve falls on to its seat and prevents a back flow of water from the service connection. This is a particularly useful feature in towns with intermittent supplies as it prevents foul water or gases being drawn back into the mains. Wherever surface boxes are used in connection with ferrules or valves they should be of the hinged cover pattern. Surface box covers retained by chains get lost through theft in practice, the chains being easily breakable.

Where service connections have to be given to mains already in use it is desirable to be able to fix the connecting ferrule with the main running under pressure and various appliances for this work are manufactured. The Morris apparatus, used in conjunction with the Morris ferrule, is one of the best of these appliances and has been adopted as standard for use in the Public Health Circle, Punjab.

The apparatus is illustrated in Fig. 12 and the method of operation is as follows :—

The packing piece "A" is placed on the main to be tapped, the joint between the packing piece and the main being made with sheet rubber cut to shape. The apparatus is then placed over the packing piece and is drawn tightly into position by screwing the nuts on the eye bolts "RR" on to the lugs "J" of the saddle piece.

The key "B" is removed and the cap "C" given a one-third turn which enables the centre spindle to be withdrawn. A combined drill and tap of required size is then inserted, care being taken to see that the slide valve "D" is fully open. The drill is now brought into operation by the handle "G" and as the drill commences to cut the feed screw "E" is brought into operation through the friction washer "W". After the hole is drilled and tapped the drill and spindle "E" are withdrawn and the slide "D" is closed by turning the screw "H". The ferrule "N" is then screwed into the adapter "M" and the spindle is replaced as before. The slide "D" is now withdrawn and the ferrule is screwed tightly into the main by the handle "G". The apparatus is now dismantled leaving the adapter attached to the ferrule. The adapter is then disconnected from the ferrule and the upper part of the ferrule (*see* Fig. 11), is screwed home after which the service pipe is connected. The plug valve inside the ferrule may now be unscrewed by means of a key in order to turn on the water.

Fixing service connections with steel distribution mains.

Where the metal of the main pipe is thin, as in the case of steel mains, there would not be sufficient threads in the joint between the main and the ferrule to give a permanent and water tight joint. In such cases an expanding nipple is used. Various types of expanding nipples are on the market and the Woodall-Parkinson patent nipple, illustrated in Fig. 13 is typical.

This connection consists of a short length of steel tube A, screwed externally at each end similar to an ordinary barrel nipple. At the end entering the main there is an internal annular projection B. For fixing this nipple, a special tapered mandrel C is provided, fitted at one end with a screwed stem D, nut E and lengthening sleeve F, the larger end of the tapered mandrel being of such diameter as to just clear the bore of the nipple without the internal projection.

For fixing the connection the main is drilled and tapped in the ordinary way. The nipple, nut and lengthening sleeve are then put together and screwed into the main with a pipe wrench engaging on the unthreaded portion of the nipple, the lower screw of which is tapered to admit of screwing tightly home. A suitable spanner is then applied to the nut and the mandrel is thereby drawn through the end of the nipple, transferring the projection from the inside to the outside of it, and thus securely rivetting the nipple to the main. After the removal

of the lengthening sleeve, a saddle joint is made of a gutta-percha ring and cast saddle piece, followed by the coupling socket to which the branch service pipe is subsequently connected. The socket is drawn up tight, forcing the gutta-percha joint home between the main, the saddle and the branch service-pipe.

As this type of connection has not a plug incorporated in it, a stop-cock will have to be placed on the branch service-pipe as near as possible to the connection.

Steel mains may also be tapped under pressure using this type of connection in conjunction with the apparatus already described for tapping cast iron mains under pressure. The apparatus is fixed and the hole in the main is drilled and tapped as before, the drill and spindle being subsequently withdrawn from the apparatus.

The drill is now replaced by the screwed connector with the mandrel in position and these are fixed into position using the spindle of the apparatus as before. As the screwed connector is lowered the slide, which was moved to close the opening when the drill was removed, is withdrawn. The chains are now released and the apparatus removed, escape of water being now prevented by the mandrel fixed into the connector as shown in Fig. 14 (*a*).

The saddle piece is now lifted off and the temporary packing replaced by the gutta-percha ring and the whole is made tight, after replacing the saddle, by screwing on a Morris ferrule as already described, or a ferrule of similar type. The ball valve attachment is then screwed on to the ferrule branch and a lengthening piece is fixed to the ferrule body to give a bearing for the collar on the mandrel spindle when the mandrel is withdrawn [*see* Fig. 14 (*b*)].

The mandrel is now withdrawn [*see* Fig. 14 (*c*)] as already described and with its attachments is removed from the brass valve. Escape of water is now prevented by the ball valve as shown in Fig. 14 (*d*). The whole job is then completed by screwing in the actual valve, at the same time pushing the ball valve to the position shown in Fig. 14 (*e*), after which the ball valve and its attachment are removed. The service connection can now be laid after which the valve is opened, its cover fixed and the whole left as in Fig. 14 (*f*).

Fittings on Service mains.

Fittings used in connection with service pipe-lines comprise valves of different types and forms, cisterns, and taps to sanitary and other fittings. All types of fittings for service pipe-lines are marketed with either screwed connections for coupling to wrought iron mains and unions or with plain tapered connecting pieces for attaching to lead pipes. Certain fittings are also made with flanged ends for connecting with flanges on wrought iron pipes while other fittings are also available for use with copper tubes. Fittings on service mains are usually of brass

or gunmetal, the latter being used for the best quality work and with the highest pressures. Even in brass fittings, the parts subject to wear such as spindles of valves, are made of gunmetal.

For special services fittings are sometimes made with white metal or cast iron bodies but these are the exception rather than the rule.

For use at a certain religious fair the author obtained a special consignment of white metal taps as the losses of brass taps due to theft was extremely heavy.

A fitting of good manufacture will have the maker's name stamped on it. Cheap inferior articles of Continental, Japanese and also British manufacture are on the Indian market but such fittings can always be distinguished as they carry no maker's name. " Made in England," " Tested " and similar statements stamped on waterworks fittings are, in themselves, no guarantee of quality.

Valves and taps are required on service pipe lines for isolating sanitary fittings or for controlling the supply to branch pipes and to cisterns. They may be hand operated or automatic in action and will be considered under these heads. Valves for working pressures up to 100 lbs. per square inch are classed as " light," for working pressures up to 150 lbs. as "standard" while "extra heavy" valves are used for high pressures up to 300 lbs. per square inch. " Standard " quality valves should be used on all water service connections on account of the longer service they give as compared with valves of " light " quality.

All valves, spindles, and other internal parts should be of a corrosion-resisting alloy. If the shank of the fitting be screwed it should have a British standard pipe thread. All unions should be of the ground in or shouldered washer type. In the former the two faces to come into contact are ground to give a perfect fit while in the latter type one part of the union fits over the other and contact is made with a shoulder on the latter to which a washer is fixed.

Hand operated valves may be classed as plug cocks, gate, globe and check valves while taps are classed as stop, bib, pillar and globe depending on their various forms. Plug or ground cocks consist of a tapered plug, through which an opening, the size of the pipe waterway, has been drilled, and this plug has a ground in fit in a body with an internal taper of the same shape. The body is drilled to the required waterway size and the flow of water is regulated between full and nil by a quarter turn of the plug. The body may be threaded at the ends for screwing on the wrought iron pipe or may be flanged. The tightness of the fit and adjustments for taking up of wear are effected by means of the small nut working on a collar on the underside of the cock body. Plug cocks are unsatisfactory in situations where frequent operation is necessary as their large working surfaces rapidly wear and excessive leakage at the cock results. Examples of plug cocks are shown in

Fig. 15. Plug cocks are usually made of cast iron but for high class work or where high pressures are met are made of gunmetal with packed glands which are adjustable for water tightness.

A Globe valve is shown at Fig. 16 and a Gate valve at Fig. 17. Both are sometimes referred to as Peet valves. These are usually wheel operated as shown and have packed glands which are adjustable for watertightness. For high pressure work the globe valve gives a greater certainty of watertightness while for low pressures owing to its full direct waterway, the gate valve offers a minimum loss of head due to friction. Globe and Gate valves are opened by turning the operating wheel in an anti-clockwise direction.

Stop taps serve the same purpose as Gate and Globe valves but their action is similar to that of a bib tap, in other words they close automatically against any back flow. Every private connection from the mains of a water supply undertaking should have fitted on it a stop tap in a position readily accessible to the consumer or to the officials of the supply undertaking. Such a tap enables any private premises to be cut off in case of burst or should repairs have to be effected.

In good practice a stop tap should also be fitted on ths supply pipe to flushing cisterns or other sanitary fittings. A stop tap in such a position is shown in Fig. 24.

Stop taps should always be used on water service connection in preference to gate or globe valves. The latter are usually installed in India but do not give such good service as stop taps. Moreover, a good stop tap costs about 30 % less than a good Peet valve.

The common bib cock or tap, in one or more of its various forms is known universally. Such taps may be of the ground plug type or of the screw down type, the latter operating in a manner similar to the globe valves already described. Plug taps costing a few annas each are on sale in the bazaars all over the country. This type of tap, even when of good quality material and manufacture rapidly wears out and causes waste of water far in excess of any saving in first cost effected. Its flow, moreover, is difficult to control and it cannot be operated with reason by the illiterate population of India.

The waste which occurs with ground taps may be seen at any railway station with water supply facilities where, on the departure of a passenger train, all taps are left running full bore.

The screw-down tap is far more satisfactory but here again a word of warning against the so-called cheap taps of this pattern is necessary. A specification for sound and inexpensive screw-down bib, pillar and globe taps has been prepared by the Incorporated Joint Committee on Water Regulations formed by the Waterworks Association of Great Britain and taps complying with this specification are available on the

Indian Market. Such taps bear the stamp J.C.S.W.R. on the cover, and in addition the maker's name. Such taps are on sale in the Indian market at prices very little in excess of the cost of the so-called cheap tap.

The taps shown in Fig. 19 comply with this specification, the principal points in which are :—

(1) Shanks screwed for iron or copper shall comply with the standard specifications for screwed threads for such pipes. All threads shall be right-handed.

(2) All fittings shall be made to pass a test pressure of 300 lbs. per square inch.

(3) Valve seatings shall be raised $\frac{3}{32}$ inch and shall be of a minimum width across the flats of $\frac{1}{8}$ inch.

(4) All fittings, including stop taps with union ends, shall have full water-way throughout.

(5) The word " inlet " must be cast or stamped on the inlet side of all stop taps, or a direction arrow must be cast on the body of such taps.

(6) All valves and spindles shall be of non-corrodible metal while valves for hot water fittings shall be pegged so as to rotate freely and lift with the spindle.

In the taps illustrated the valve is not pegged to the spindle and is free to drop should the pressure in the supply pipe fall.

(7) The lift of the valve shall not be less than two and a half complete turns of the screw on the tap spindle.

(8) Washers of cold water fittings shall be of specially prepared leather or other approved material while those of hot water fittings shall be of good quality fibre.

(9) The name or registered trade mark of the maker shall be stamped on all fittings. The word " Best " must not be used.

The minimum weights of taps complying with the J. C. S. W. R. Specification are as follows. These weights should be checked when bazaar purchases are being made.

Bib taps.

	$\frac{3}{8}$"	$\frac{1}{2}$"	$\frac{3}{4}$"	1"	$1\frac{1}{4}$"
	oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Bib tap with plain tail for lead, weight complete.	$12\frac{1}{4}$	1-0$\frac{3}{8}$	1-12$\frac{3}{4}$	2-12$\frac{3}{4}$	5-0
Bib tap screwed for iron threads.	$12\frac{3}{4}$	1-0$\frac{7}{8}$	1-12$\frac{3}{4}$	2-13$\frac{3}{4}$	5-1

Stop Taps.

	$\frac{3}{8}$"	$\frac{1}{2}$"	$\frac{3}{4}$"	1"	1$\frac{1}{4}$"
	oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
With plain ends of lead ..	12$\frac{1}{2}$	1-0$\frac{7}{8}$	1-12$\frac{3}{4}$	2-13$\frac{3}{4}$	5-1
Screwed for iron, male ..	13$\frac{1}{4}$	1-1$\frac{7}{8}$	1-13$\frac{3}{4}$	2-14$\frac{3}{4}$	5-3
Screwed for iron, female ..	14$\frac{1}{4}$	1-2$\frac{7}{8}$	1-15$\frac{1}{4}$	3-0$\frac{3}{4}$	5-7

Pillar and Globe Taps.

	$\frac{3}{8}$"	$\frac{1}{2}$"	$\frac{3}{4}$"	1"
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Pillar tap weight ..	1-1$\frac{1}{2}$	1-7$\frac{1}{8}$	2-9$\frac{1}{2}$	3-13$\frac{1}{4}$
Globe ..			2-4$\frac{3}{4}$	3-13$\frac{1}{4}$

The specifications of the British Ministry of Health are similar to the above but provide for a slightly lighter construction.

Taps are made in either gunmetal, hard brass or white metal. "Gunmetal" for this purpose means an alloy containing not less than 88 per cent. by weight copper, not less than 8 per cent. of tin and the balance of 4 per cent. made up of zinc, lead or spelter and having a tensile strength of not less than 14 tons per square inch of sectional area. "Hard Brass" means a composition of copper and zinc with or without lead or tin, not less than 62 per cent. by weight of the composition being copper, and having a tensile strength of not less than 12·9 tons per square inch of sectional area. "White Metal" means a non-corrodible alloy having a tensile strength of not less than 12·9 tons per square inch of sectional area. Hard brass is the commonest material, and taps of such material are made to a polished finish. Gunmetal fittings cost about 10% more than those of brass. The brass may be nickel or chromium plated, the latter finish being particularly suitable for high class bathroom and lavatory work and can be kept bright by merely wiping over with a damp cloth.

A modern improvement in the design of bib taps and lavatory equipment has been the introduction of the "Easy Clean" fitting. In such fittings sharp corners are rounded off while in the case of bib taps a rounded cover encloses the upper portions of the standard tap. Examples of "Easy Clean" fittings are shown in Fig. 31. Such fittings are unusually supplied with a nickel or chromium plated finish. Their cost is of course high but where domestic labour is difficult or costly to obtain they enable the fittings of a house or building to be kept bright at a minimum of expense or trouble.

Brass fittings to be chromium plated should first be nickel plated and then receive the chromium plate.

Brass fittings are also made with a white porcelain enamel finish which is very suitable for hospital and similar work. The Kings College Hospital, London is fitted throughout with such taps.

Bath and lavatory fittings.

The following points in connection with water fittings to baths and lavatories should be noted :—

(1) Every bath and lavatory supplied directly from the mains should have an inlet distinct from and unconnected with the outlet. The combined inlet and waste outlet for such fittings is now obsolete, as it is open to several objections. A certain amount of dirty water gets washed back into this type of bath each time the supply is turned on. Also water authorities object to it as secret waste can occur.

(2) The overflow should be below the inlet. This prevents the possible fouling of the inlet pipe.

(3) Bath taps for hot water should not be less than $\frac{5}{8}$" bore and for lavatories not less than $\frac{3}{8}$" bore.

For fixing brass fittings, pipe fitters should be provided with proper spanners to fit the hexagonal portions of the shanks and covers. Fittings are damaged and their appearance is spoiled when pipe or other wrenches with serrated jaws are used on the flat surfaces of the hexagonal portions of such fittings.

For special places, such as public standposts or in schools or institutions, taps of the self-closing variety are used and two typical self-closing taps are Tylors " Waste Not " (Fig. 20) and the Glenfield " Non-Concussive " (Fig 21).

The " Waste Not " tap is opened by moving the handle which causes the gunmetal lever inside the tap to raise the gun-metal spindle against the pressure of the brass spring, taking with it the loose plunger which is fitted inside a socket formed on the lower portion of the spindle and which is forced upwards by the water pressure on its underside. When the handle is released the spring forces down the spindle and plunger thereby closing the tap.

Should the handle be held open however, the tap closes automatically, the loose plunger, descending by its own weight on to its face and stopping the flow after a predetermined quantity of water has been drawn.

The action of the Glenfield tap is as follows :—On pressing the top button the small valve in the centre of the piston opens, thus releasing the pressure from the underside of the piston. The pressure on top of the piston then forces the same down and opens the main valve. On releasing the button the spring closes the small pilot valve and the water gradually passing between the piston and the casing increases the pressure behind the piston and gradually closes the main

valve. The spring underneath the pilot valve is simply to carry the weight of same and to overcome the friction of the spindle.

Another type of self-closing tap is used for the flushing of water closets instead of the usual flush cistern (to be referred to later). An example of such a valve manufactured by Crane-Bennett is shown in Fig. 21 (*a*). The action is as follows :—

The operating handle opens the auxiliary valve "A" relieving pressure in the dashpot chamber "B". The area of the dashpot chamber being greater than the area through the main valve, the water to the main valve "D" forces the latter upward thus opening the valve. When the handle is released the auxiliary valve "A" closes, water from the supply enters the chamber "B" under pressure and this closes the valve D. The rate of flow can be varied by the valve "H".

The closing action is non-concussive while the flow, reducing slowly, breaks the siphonic action of the outlet to the vessel being flushed, thus allowing the refilling of the bowl of this vessel.

Water undertakings in Great Britain do not permit the use of this type of valve for flushing purposes on account of the possibility of tying it open and thus allowing waste, which, with the flush cistern, cannot occur. In buildings with a private water supply and in ships, where the headroom is insufficient for a flushing cistern, this type of valve finds considerable use. The Savoy Hotel and Bush House, London are two large buildings where this type of valve is in use.

Automatic valves on water service connections comprise check valves and ball taps and an example of the former is given in Fig. 18. Check valves are used to prevent a back flow in a pipe line. Their action is clear from the figure. Check valves offer a definite obstruction to flow and where a minimum loss of head is required should be of a larger size than the service pipe with which they are connected.

A typical ball tap is shown in Fig. 22. Ball taps are used for the automatic control of the water level in cisterns. The hollow metal float rises with the water and at a pre-determined level the valve, operated by the arm attached to the float, closes. The cheap pattern ball valves sold in the bazaar have very restricted water-ways, and if anything approaching a full flow from the service connection is required the ball valve should be of a larger nominal size than the pipe with which it is connected. The example of which a drawing is given complies with the British Waterworks Association standards in which the restrictions to flow are comparatively small. The valve shown in Fig. 23 is of the equilibrium type and is suitable for use with high pressures as the water pressure acts in both directions on the specially shaped plunger.

Ball taps, of necessity, are fixed high up in tanks and cisterns and so when the latter are being filled the water falling from the valve makes considerable noise. This noise, in certain cases, such as the flush cisterns of water closets in residential buildings, causes a considerable nuisance and may be obviated by carrying a vertical connection from the

valve downwards to the base of the cistern. This silencing pipe should have three or four small holes drilled near the top to prevent the siphonage of water back into the supply pipe. The valve shown in the drawing is screwed to take such a pipe.

Points to look for in a properly constructed ball valve in the smaller sizes are :—

(1) The washer should be of good quality rubber or other suitable material and not less than 1/8" thick and should be enclosed in an internally flanged cap screwed to the piston.

(2) The diameter of the cotter pin should not be less than 3/16".

(3) In the piston type of ball tap the length of the piston bearing should be (*a*) for the horizontal type, not less than $1\frac{1}{2}$ times the diameter of the piston and (*b*) for the vertical type, not less than $1\frac{1}{8}$ times the diameter of the piston and the range of action of the piston should be such that the tap will close when the washer is reduced in thickness by $\frac{1}{8}$".

(4) The material used for the lever should be a corrosion-resisting alloy, or copper, and of such quality and section that it can be bent but will show no permanent set under working loads. This is essential as after fixing the tap, the position of the ball will require adjusting so that the valve will close at a predetermined level.

(5) The float should be a copper ball not less than $4\frac{1}{2}$" diameter and, when finished bright should have a thickness of not less than 26 I. S. W. G. where the ball does not exceed $6\frac{1}{4}$ inches and not less than 24 I. S. W. G. in cases where the external diameter is greater than $6\frac{1}{2}$". The jointing of the float should be by means of an efficiently burnished, lapped and soldered seam.

The following table shows the dimensions and minimum weights for all taps laid down by the British Waterworks Association :—

Bore of shank ..	$\frac{3}{8}$"	$\frac{1}{2}$"	$\frac{3}{4}$"	1"	$1\frac{1}{4}$"	$1\frac{1}{2}$"	2"
Dia. of waterway through seating.							
Low pressure ..	$\frac{3}{8}$"	$\frac{1}{2}$"	$\frac{1}{4}$"	$\frac{3}{4}$"	$\frac{1}{2}$"	$\frac{3}{4}$"	1"
High pressure ..	$\frac{3}{8}$"	$\frac{3}{8}$"	$\frac{1}{1}\frac{1}{6}$"	$\frac{7}{8}$"	$1\frac{1}{4}$"	$1\frac{1}{2}$"	2"
Lever of drawn copper.	$\frac{1}{4}$"x$\frac{1}{4}$"	$\frac{3}{8}$"x$\frac{1}{4}$"	$\frac{3}{8}$"x$\frac{3}{8}$"	$\frac{3}{8}$"x$\frac{1}{2}$"	$\frac{3}{8}$"x$\frac{1}{2}$"	$\frac{3}{8}$"x$\frac{3}{8}$"	$\frac{3}{8}$"x1"
Minimum length of leverage from fulcrum to centre of float.	$13\frac{3}{4}$"	$13\frac{3}{4}$"	17"	22"	26"	30"	35"
Length of leverage from fulcrum to centre of piston.	$\frac{1}{2}$"	$\frac{5}{8}$"	$\frac{3}{4}$"	$\frac{7}{8}$"	$1\frac{1}{8}$"	$1\frac{1}{4}$"	$1\frac{1}{2}$"
Dia. of piston ..	$\frac{5}{8}$"	$\frac{1}{1}\frac{3}{6}$"	$\frac{7}{8}$"	$1\frac{1}{8}$"	$1\frac{3}{8}$"	$1\frac{5}{8}$"	2"
Dia. of cotter pin	$\frac{3}{1}\frac{}{6}$"	$\frac{3}{1}\frac{}{6}$"	$\frac{1}{4}$"	$\frac{1}{4}$"	$\frac{5}{1}\frac{}{6}$"	$\frac{5}{1}\frac{}{6}$"	$\frac{3}{6}\frac{}{4}$"
Dia. of ball ..	4"	$4\frac{1}{2}$"	6"	$6\frac{1}{2}$"	8"	10"	12"
Length of tail pipe.	$2\frac{1}{4}$"	$2\frac{1}{4}$"	$2\frac{1}{2}$"	$2\frac{1}{2}$"	3"	3"	$3\frac{1}{2}$"
Weight of valve, body and piston only.	$6\frac{1}{2}$ oz.	$9\frac{1}{2}$ oz.	14 oz.	1 lb.	11 oz	2 lbs.	6 oz.	3 lb.	5 oz.	6 lb.	0 oz.

Balls may be tested for watertightness by immersion in hot water. If there are any leaks the air warming inside the ball will expand and issue from the leaks, when it will be visible.

Cisterns.

Even where a continuous supply of water is given, breakdowns in the supply occur while there are certain domestic fittings such as hot water boilers and water closets to which a continuous supply is essential. It is a common practice therefore to have a reservoir in all buildings even where continuous service has to be given ; such a reservoir is known as a cistern. A cistern is placed at the highest point in a service so that once filled, water can gravitate from it to all points to be supplied. House service cisterns are usually made of wrought iron or steel sheets and are seldom deeper than three to four feet. Cold water house service cisterns may, however, be made of slate, lead, copper, or wood lined with lead or copper or of any corrosion resisting alloy.

The plates used in wrought iron or steel cisterns should be either welded or rivetted together, and cisterns should be galvanized or otherwise protected against corrosion after the cistern is constructed. The top of the cistern should be properly strengthened either by angles or tie bars and the plates, before galvanizing or being otherwise protected against corrosion should have the following minimum thicknesses :—

Nominal capacity of cistern.	*Thickness of side and bottom plates.*
Not exceeding 40 gallons.	16 I. S. W. G.
Over 40 gallons but not exceeding 100 gallons.	14 I. S. W. G.
Over 100 gallons but not exceeding 200 gallons.	12 I. S. W. G.
Over 200 gallons but not exceeding 500 gallons.	$\frac{1}{8}$ inch.

I. S. W. G. means Imperial Standard Wire Gauge.

For cisterns of wood, lined with lead or copper, the wood should be well seasoned and free from sap and should be finished not less than one inch thick. The lead should not weigh less than 5 lbs. per square foot while if copper is used it should not be less than 22 I. S. W. G. The joints in a lead lined cistern should be burned or wiped soldered, while the joints in a copper lined cistern should be welted and brazed.

The metal lining, whether lead or copper should be turned over the top edge of the cistern. This prevents water passing between the lining and the wood frame and so lessens the chance of damage by rot to the latter.

The capacity of cisterns depends on the size of the building in which they are placed, and on the purpose for which they are to be used. Cisterns are usually covered by wood boarding which can be easily removed for cleaning purposes. The covering of the cistern is necessary in order to prevent the entry of light which would cause the formation of vegetable matter on the water surface. Cisterns should, however, be ventilated and the boarding roof allows of this. Such boarding does not, however, give a mosquito proof cover and in India the cover should be rivetted on as part of the tank and be fitted with an access manhole for cleaning. Where cisterns are completely closed in this manner they should be adequately ventilated. A vent pipe similar to that used on sewers would serve this purpose.

Every cistern should be provided with a ball tap, fixed above the water line and this tap should be supported independently of the supply pipe and should be in such a position that it cannot become submerged. If a ball tap is fixed to any cistern by a nut through a side of the cistern it should be secured with a backnut.

All cold water cisterns should be provided with a warning pipe and should have no other overflow pipe. The internal diameter of this pipe should not be less than $\frac{3}{4}$ inch and in no case less than the diameter of the supply pipe. It should be so fixed that its invert is 1 inch above the full supply level of the cistern and not less than $1\frac{1}{2}$ inches below the top of the cistern. This warning pipe should discharge at a point outside the building so situated that its coming into action is clearly visible.

In addition to the ball tap on the inlet a suitable stop tap should be provided on every outlet pipe (excepting the warning pipe) and such tap should be as near the cistern as possible. This stop valve should be pegged to lift with its spindle and the water pressure (which may be only a few inches if the cistern is nearly empty) should not (as in standard fittings) be relied upon for lifting the valve.

The drinking water supply in a house should be taken direct from the main and not from the cistern, where it is open to contamination. In England it is good practice to provide three taps in kitchen sinks, one for the hot water supply, one for the cold, both of these being fed from the cistern, with a third for drinking water coming direct from the main.

For water closets, small cisterns are employed to give the momentary large flush required in such fittings. The usual sizes are three and two gallons, the latter, for waste-preventing reasons, being specified by most British water authorities. Sanitarians, however, claim that a 3 gallon flush is essential and where the water authority will permit the larger cistern should be provided. For Indian conditions the 3 gallon cistern is essential. Such cisterns are made of cast iron and may be painted or enamelled to agree with the interior decorations of the room in which they are fixed. The author, on his last leave in 1930, visited

a factory in Hungary where flushing cisterns (and other fittings such as baths) were being made from pressed steel which was subsequently stove enamelled to prevent corrosion. Such fittings should sell at a competitive price in India, as, owing to their lighter weight and less liability to damage, their costs of transportation to inland towns must be less than in the case of fittings of cast iron.

The cover of the ordinary flushing cistern is of the same material as the cistern itself but is not mosquito proof, as a slot has to be left in it for the operating handle. Mosquito proof flushing cisterns are however made by the important firms in this line of business such as Doultons or Shanks and are available in the Indian market.

Flushing cisterns work by siphonic action which is brought into play by the operating handle. The appliance must be provided with an efficient waste-preventing apparatus of the valveless type. Such apparatus is necessary for breaking the siphonic action of the outlet pipe and this prevents the cistern discharging continuously.

The requirements of the Ministry of Health, Great Britain, for a flushing cistern (*see* Fig. 24) are as follows :—

(1) The cistern should be longer and wider at the top than at the bottom, and, in the case of cast or moulded cisterns, the corners should be rounded inside and outside.

(2) The underside of the bend in the siphon pipe (or in the dome pattern, the top of the straight discharge pipe) should not be less than $\frac{1}{8}$" above top of the cistern.

(3) The siphon (or dome and discharge pipe as the case may be) should either be of corrosion-resisting materials, or be efficiently protected against corrosion.

(4) The water line should be plainly indicated on the inside of the cistern one inch below the invert of the warming pipe at its inlet end.

(5) The ball tap should be of such design as to allow the cistern to fill rapidly, and should close when the water rises to the water line.

(6) The cistern should be provided with a suitable tail pipe of corrosion-resisting alloy, with a cap and backnut screwed to fit the outlet nipple.

(7) If the cistern be of a capacity of not less than 2 gallons, the outlet nipple, the tail pipe, and the flush pipe should not be less than $1\frac{1}{4}$ inches in internal diameter.

(8) The siphonic apparatus should be capable of being rapidly brought into action when the water is at the water line, and should be so constructed that water cannot flow down the flush pipe except whilst a flush is being properly delivered, nor any siphonic discharge take place until the cistern has filled up to at least 75 per cent. of its nominal capacity.

(9) The cistern should be capable of discharging at the rate of 2 gallons in 5 seconds when attached to the flush pipe.

Hot Water Supply Fittings.

The question of hot water supply to buildings is so closely connected with the subject matter of this paper that no apology need be made for making a reference to it. In all better class houses in Great Britain a hot water installation forms part of the standard equipment while, with the growing demand in India for the amenities of life the installation of hot water supplies to buildings in this country is becoming more and more common.

It is not proposed to refer here to the calculations necessary in designing a hot water system but some reference to the usual layout of such an installation is desirable.

The hot water equipment to a house consists of a low pressure boiler and hot water cylinder interconnected by a primary flow pipe circuit together with a secondary flow pipe circuit or circuits serving all the taps in the building. The general arrangement of such an installation in a house is shown in Fig. 29.

Water is heated in the boiler, which may be independent, or, as is often the case in England, may be incorporated in the kitchen range. As the water warms, it expands and rises in the uptake pipe of the primary flow circuit, being displaced by cold water from the cylinder. Eventually all the water in the cylinder becomes heated and forms a reserve to meet sudden demands from the various points of draw off.

In order that the boiler may be kept within reasonable proportions hot water cylinders are usually designed with a capacity of one hour's flow at maximum demand. For retaining their heat, cylinders in exposed places should be covered with lagging but where fixed inside buildings, cylinders are frequently placed in linen cupboards where the heat radiated from them will serve a useful purpose in airing the articles in the cupboard.

From the top or hottest portion of the hot water cylinder the secondary flow uptake pipe rises by as even a grade as possible to the highest off-take and again falls by even grades to a lower point in the cylinder where it is again warmed up. Such movement is known as thermo-siphonic action and the movement of the water in the flow pipes is continuous and automatic.

The flow being continuous, hot water is drawn immediately any tap on the system is opened. In large buildings the thermo-siphonic action may be insufficient to force the water round a long circuit and in such cases a small circulating pump, operated by electricity or other means is used to accelerate the flow.

For cheapness the secondary flow system is sometimes omitted and a single pipe is provided running from the cylinder to the various taps. Such an arrangement never gives satisfactory service as, on opening a

tap, the contents of the pipe, which are probably cold, have to be run off before hot water from the cylinder is obtained. The hot water system is connected with the high level cistern of the building concerned whence the necessary pressure for operation is obtained.

Points for note in the diagram are :—

(1) The position of the safety valve on the primary circuit. This is necessary in case the water in the circuit commences to boil.

(2) The use of an expansion pipe on the secondary flow to prevent any undue pressure beyond that due to the head from the cistern.

(3) The cold feed to the system enters below the cold end of the secondary system. This prevents the undue cooling of the reserve hot water in the cylinder. The cold feed should never be connected direct to the primary return pipe. If this is done undue temperature stresses may occur on the boiler while if a large draw off of hot water is taken the temperature in the primary flow pipe will drop to such an extent as to cool the water in the upper part of the storage cylinder.

The following points regarding the component parts of a correctly designed hot water supply are worth noting :—

The boiler should be of cast iron and the water space should completely enclose the furnace. Sufficient access doors to admit of the cleaning of scale from within the water space should be provided. Screwed bosses should be provided on the body for the primary circuit connections.

A drain cock should be provided at the lowest part in the circuit to admit of the whole system being emptied.

The hot water cylinder should be of galvanized iron or copper and should be capable of withstanding a pressure of at least 20 lbs. per square inch. In high buildings this pressure will, of course, have to be increased. Thicknesses of 14 I. S. W. G. for sizes up to 40 gallons and 12 to 10 I. S. W. G. for sizes up to 100 gallons in iron represent standard practice.

Cylinders may be either double seamed, lap jointed or (if of copper) brazed and rivetted and should be provided with screwed bosses for the feed, expansion and primary flow and return pipes. Cylinders and pipes in exposed places should be lagged in order to reduce heat losses.

Lagging material should be a good non-conductor of heat and asbestos is one of the commonest materials used.

A stop-cock should be fitted on the cold water supply pipe so that this supply can be cut off to enable repairs to the system being carried out.

The primary flow and return pipes should be at least 1 inch diameter and the expansion pipe and feed pipe from the cold water reservoir

FIG.1

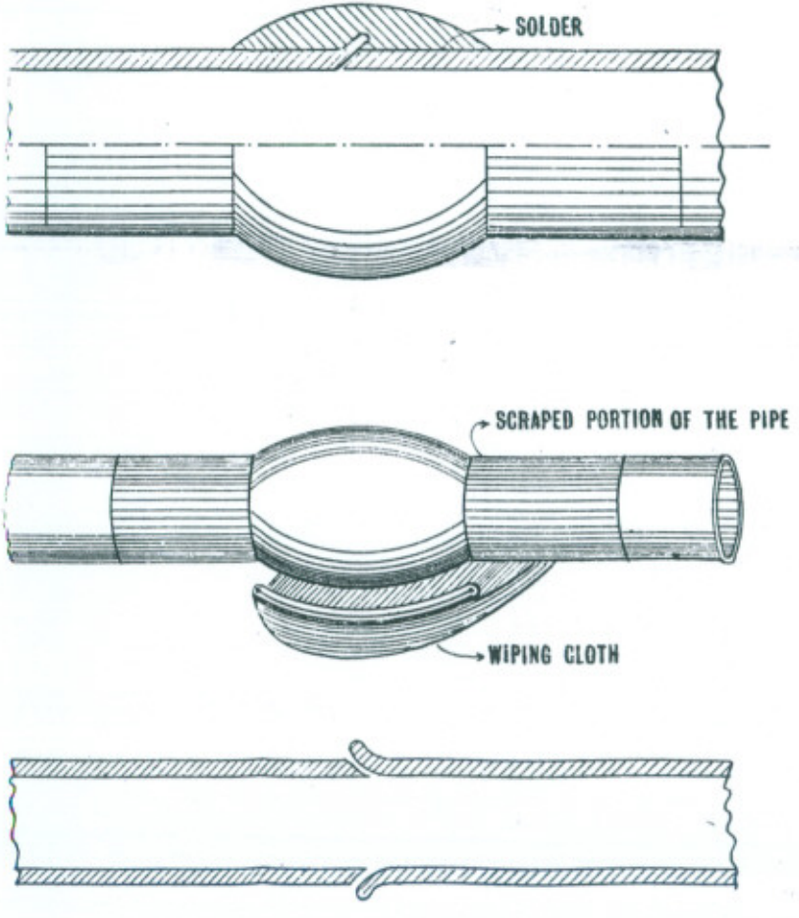


FIG.2
LEAD TO IRON JOINT

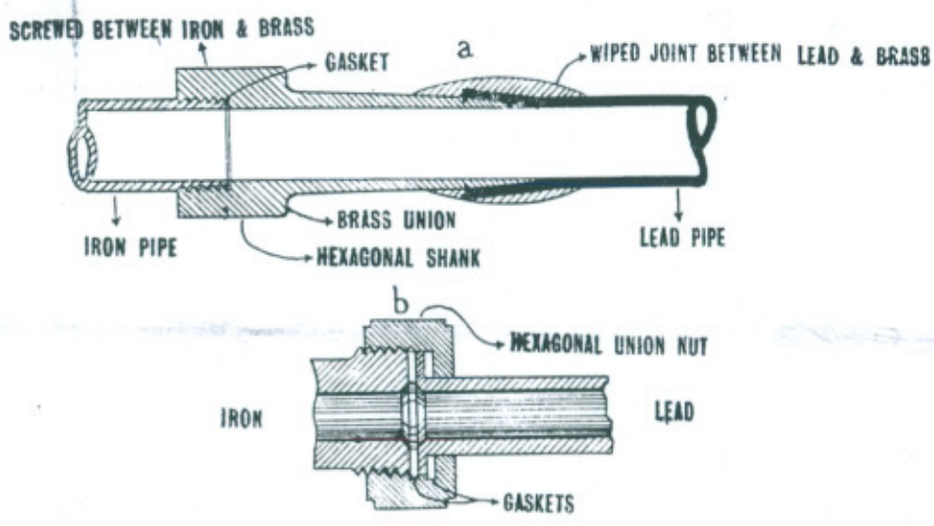


FIG.3

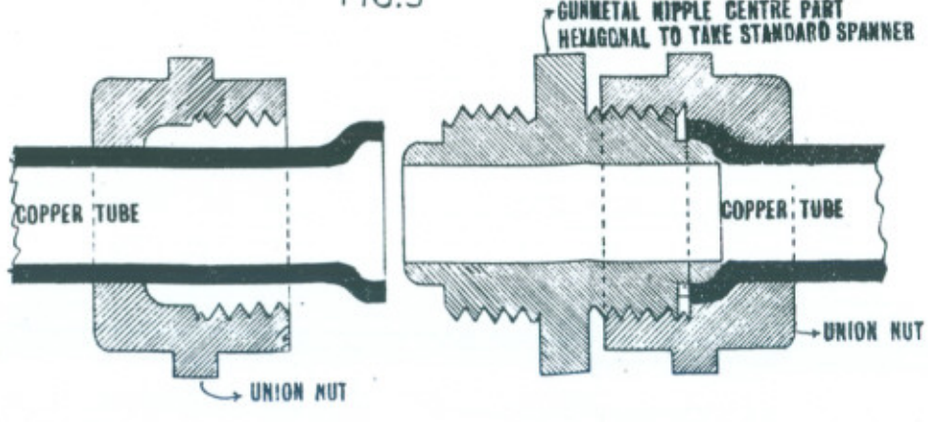




FIG.4

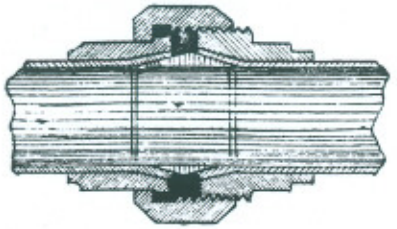


FIG.6
WROUGHT IRON FITTINGS

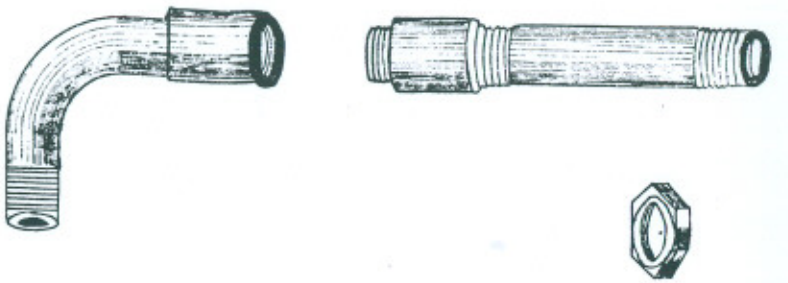
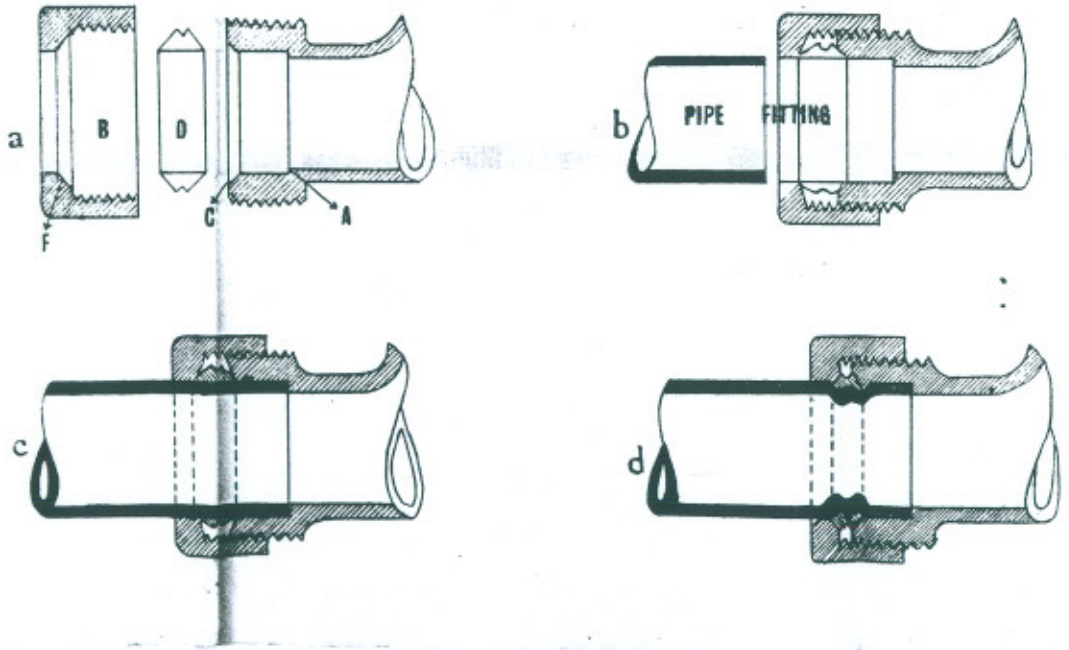
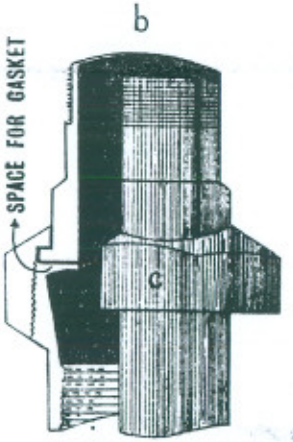


FIG.5





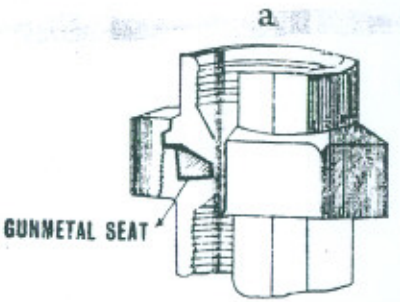
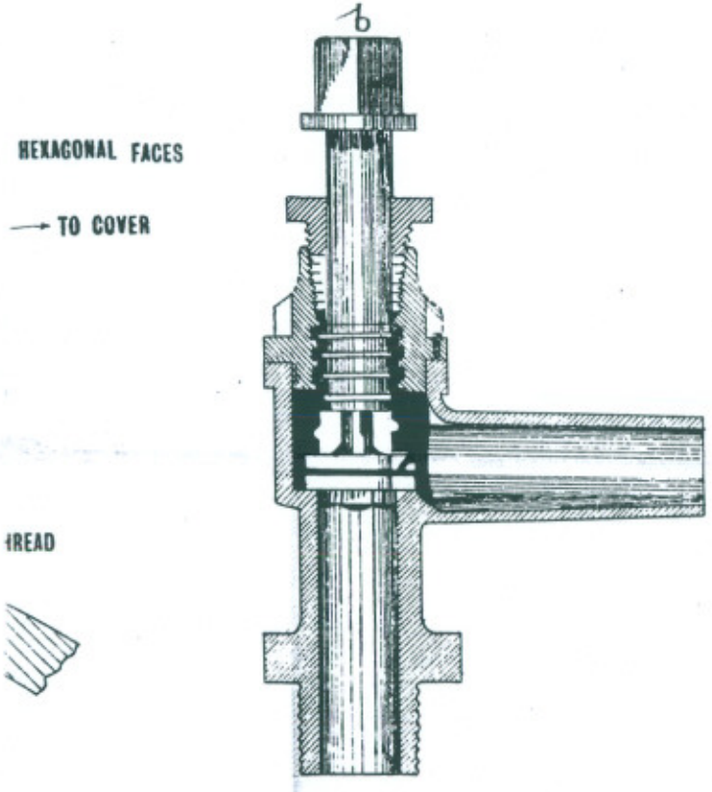


FIG.11



COVER FOR FERRULE b

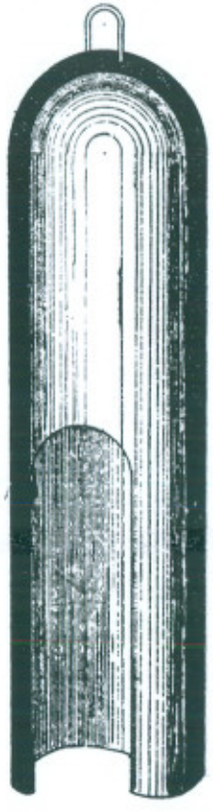


FIG.12

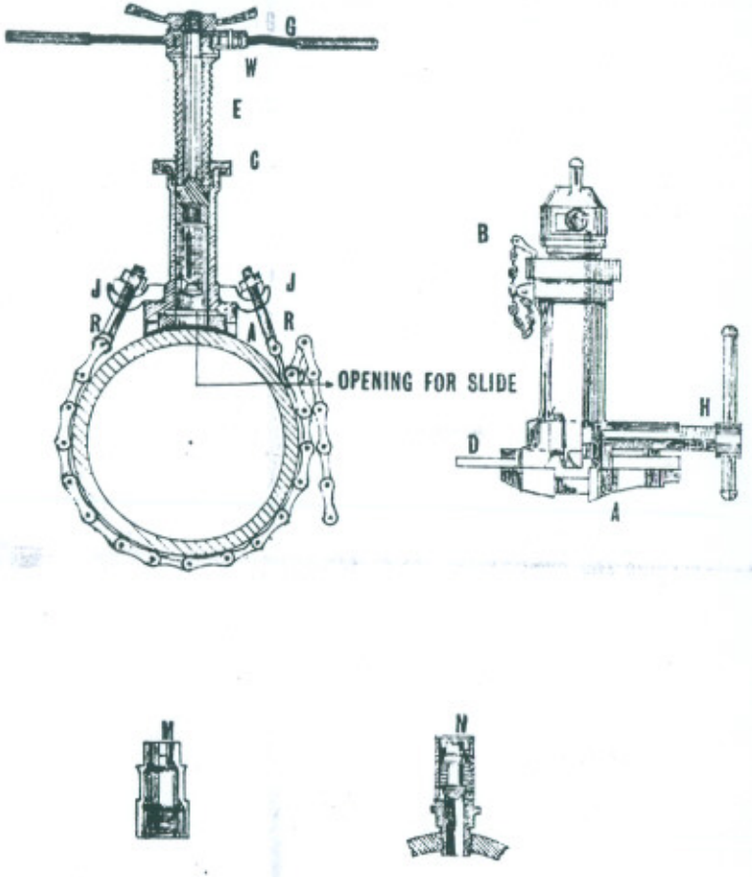
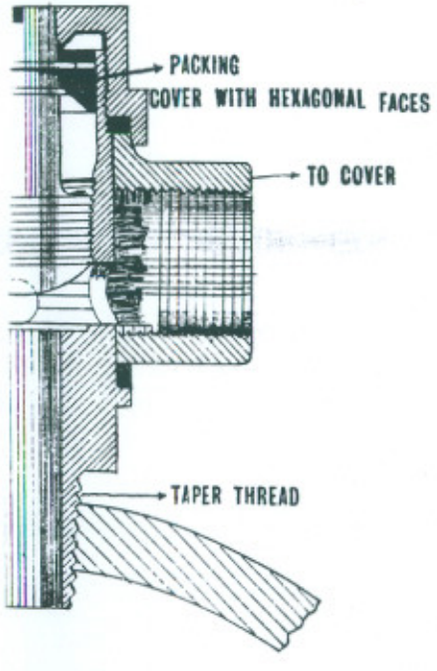
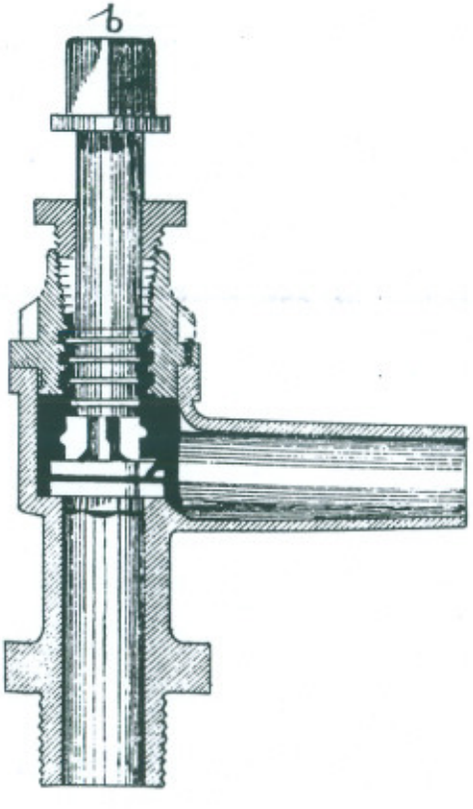


FIG.11





COVER FOR FERRULE b

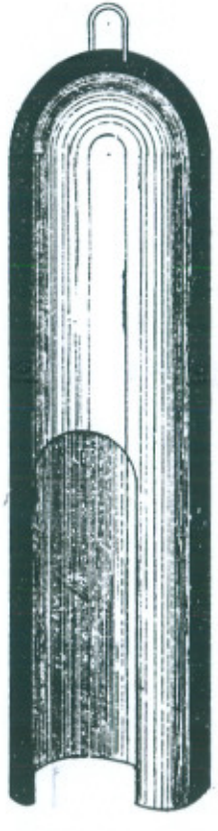


FIG.12

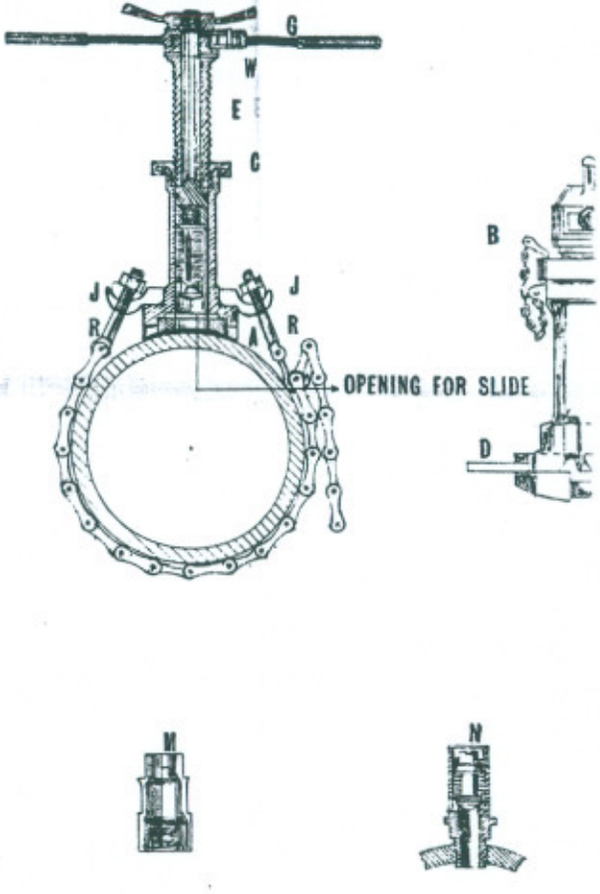


FIG.7

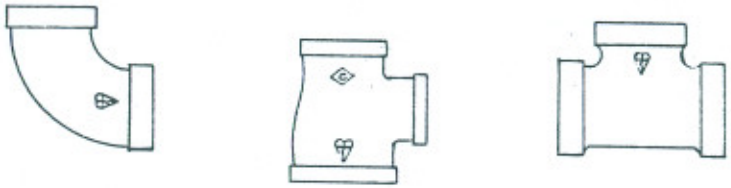


FIG.8



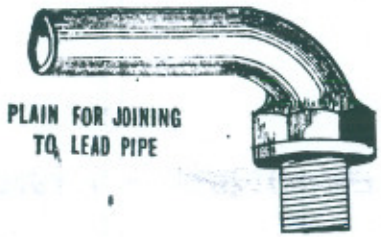


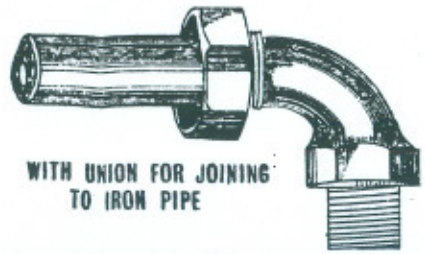
FIG.9





FIG.10





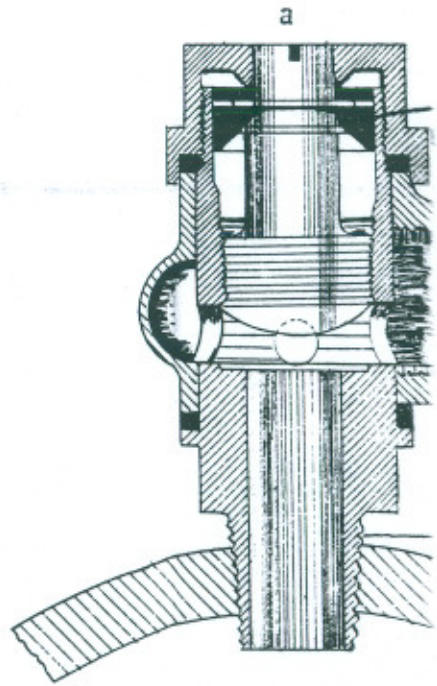


FIG.14

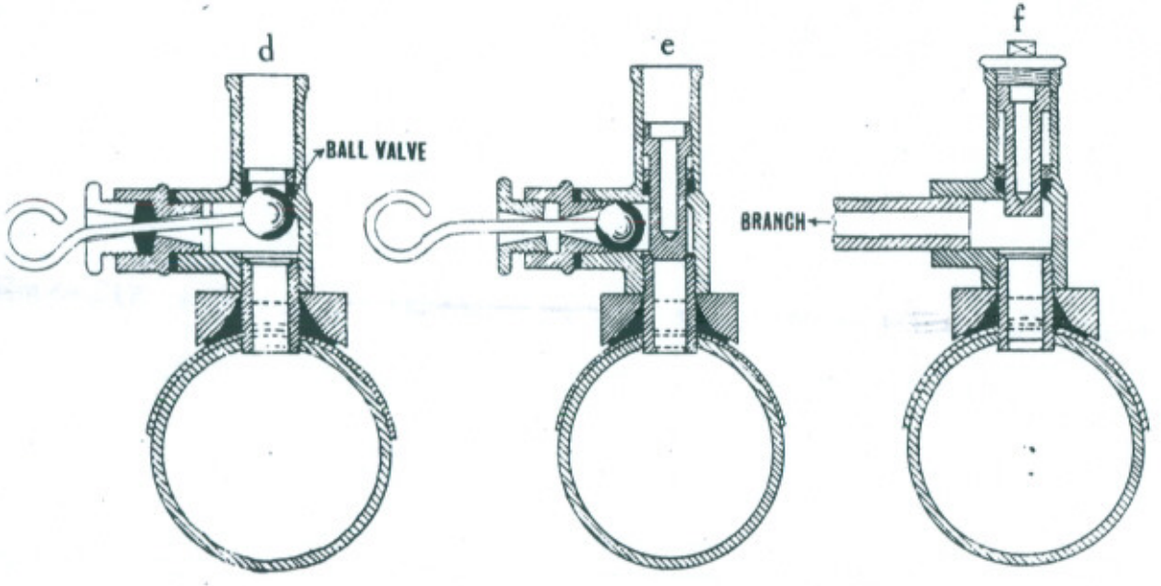


FIG.15

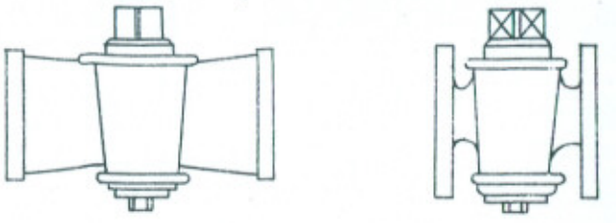


FIG.16

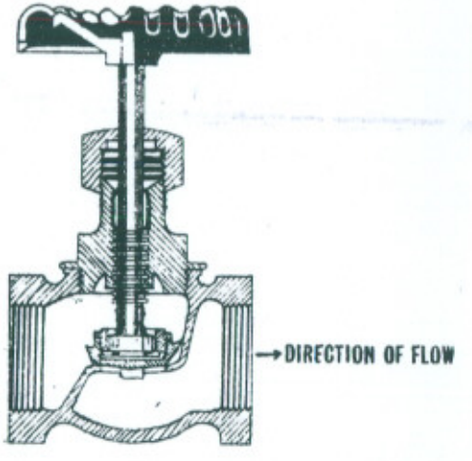
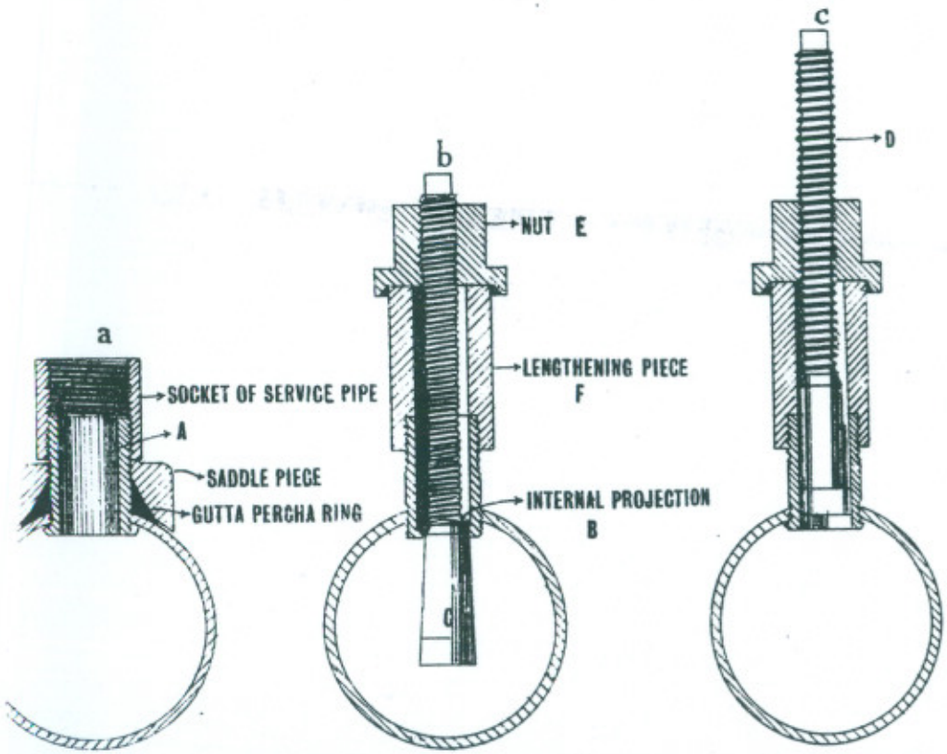


FIG.13


a
b
c
SOCKET OF SERVICE PIPE
A
SADDLE PIECE
GUTTA PERCHA RING
NUT E
LENGTHENING PIECE
F
INTERNAL PROJECTION
B
D
C

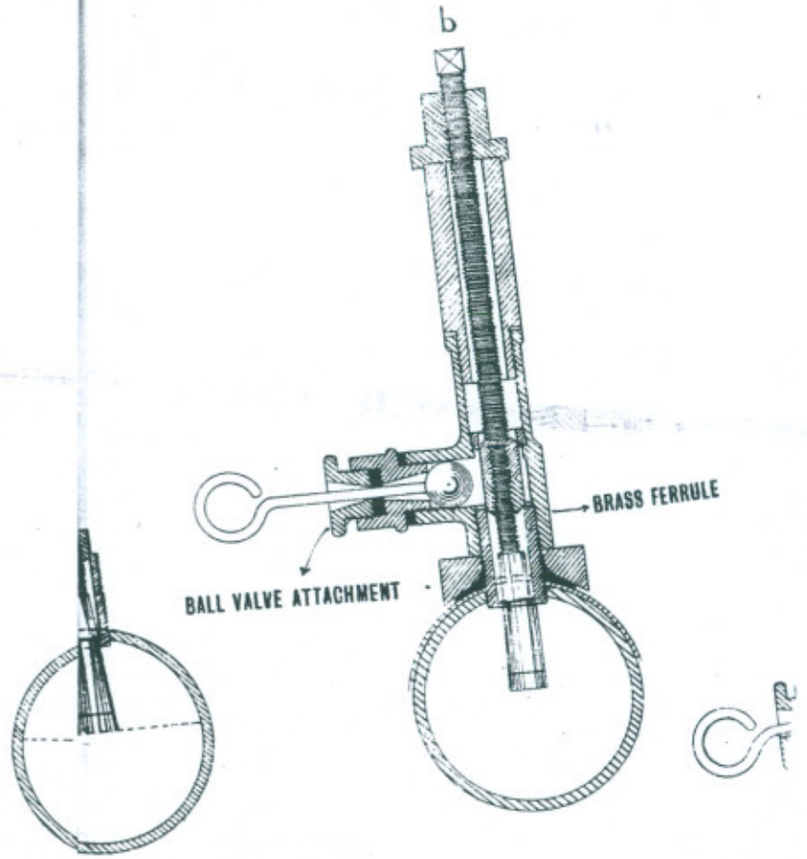
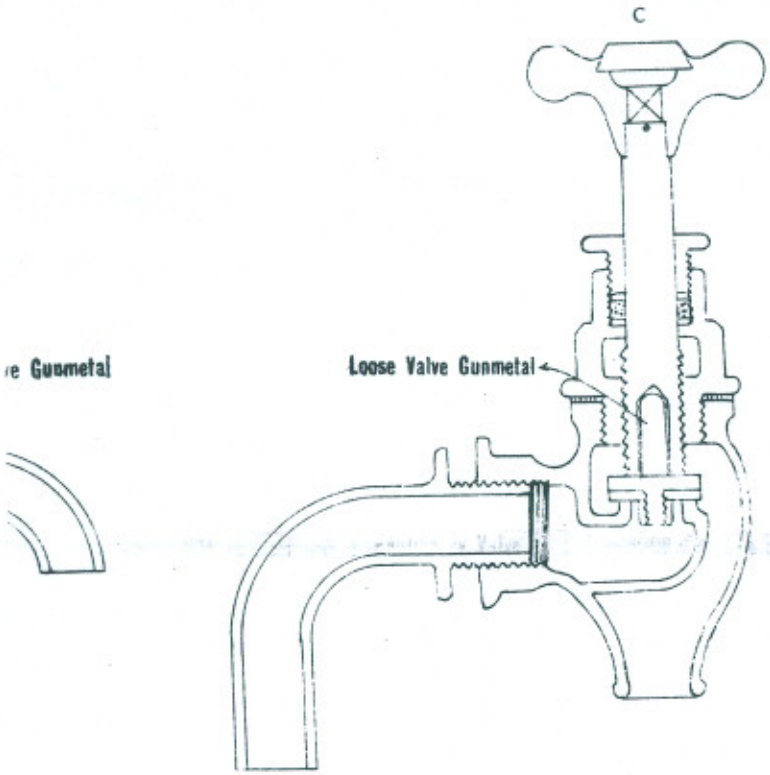

b
BRASS FERRULE
BALL VALVE ATTACHMENT

FIG. 20

GLOBE TAP



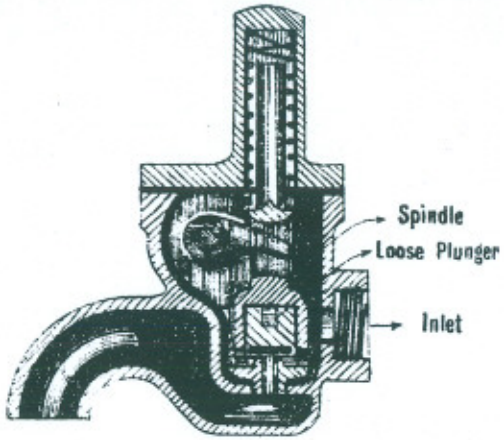


FIG. 21

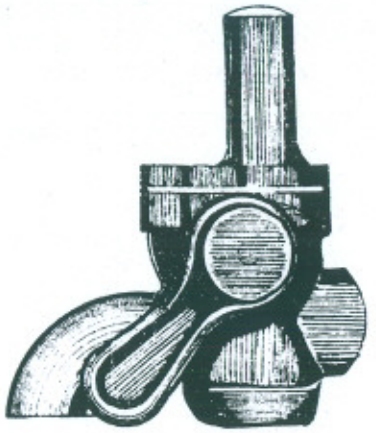
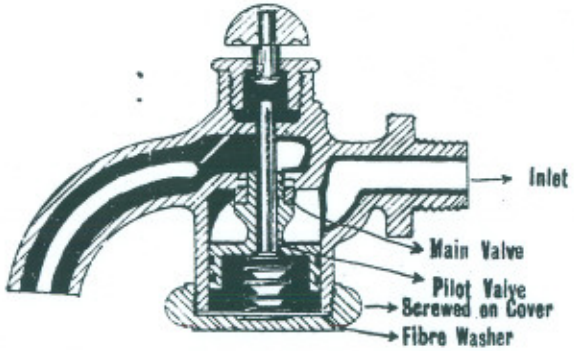


FIG. 21a



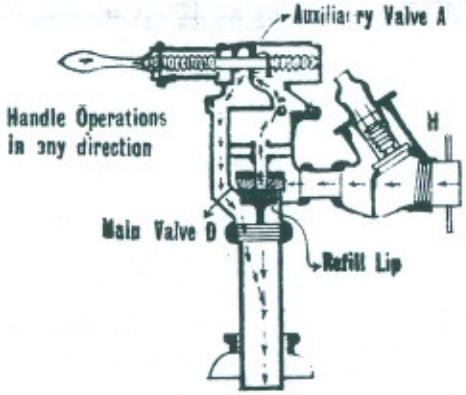
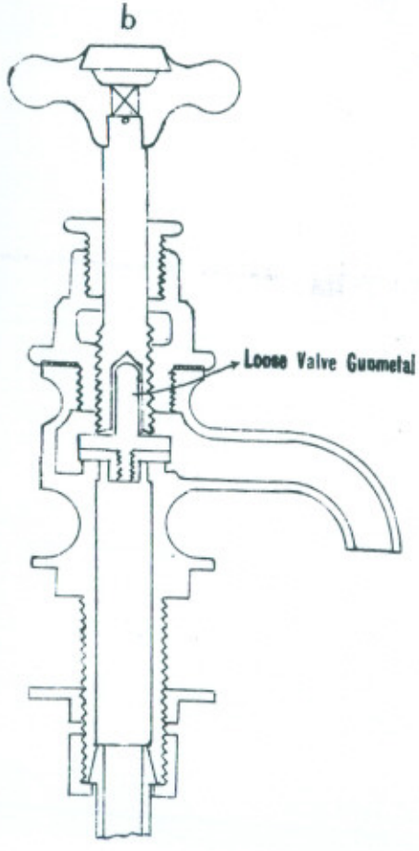


FIG. 19
PILLAR TAP



GLOBE TAP

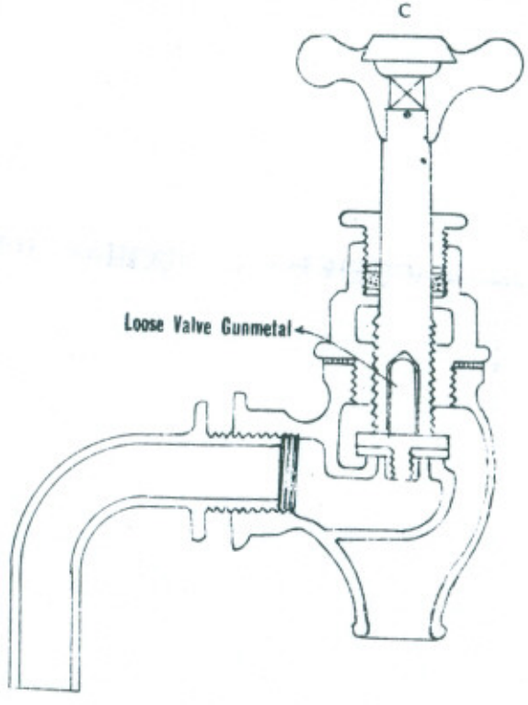
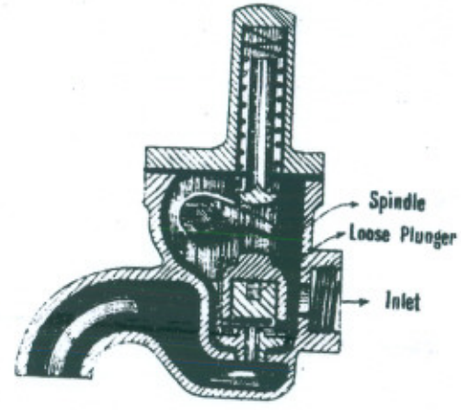


FIG. 20



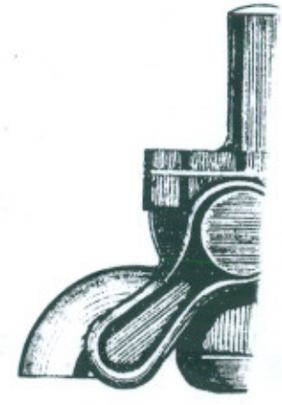


FIG. 21

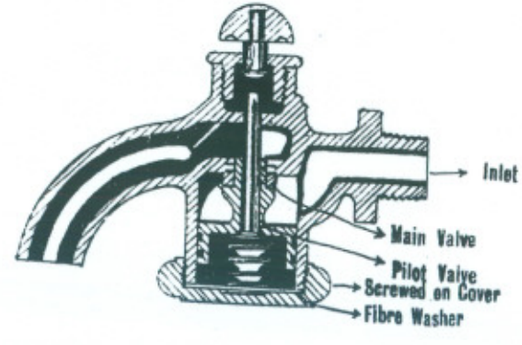


FIG. 2



FIG.17

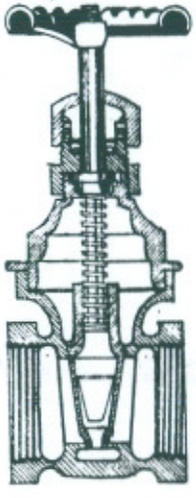
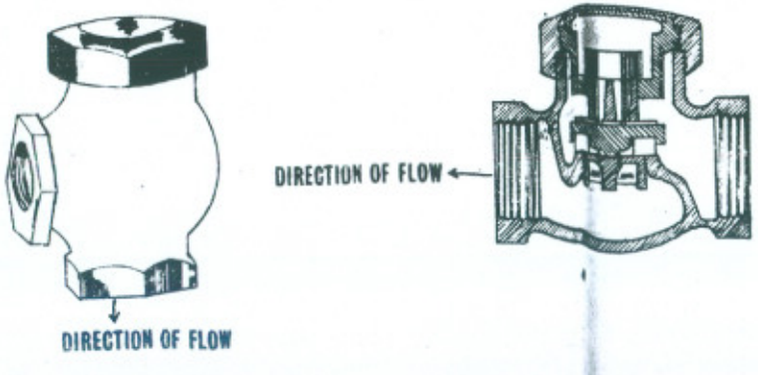


FIG.18



BIB TAP

a

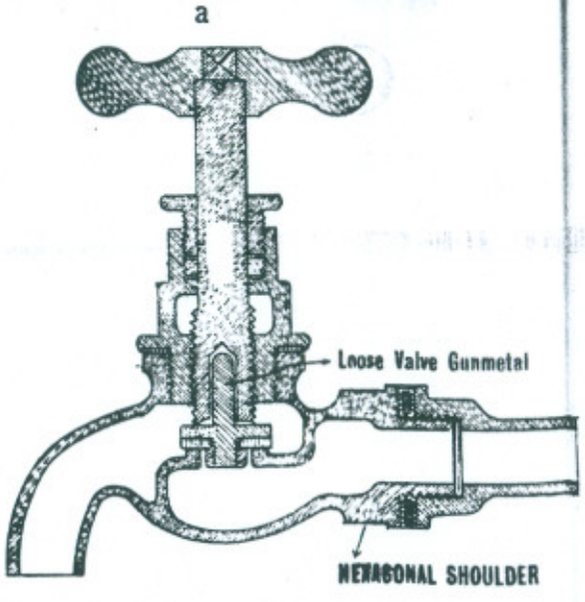


FIG. 25

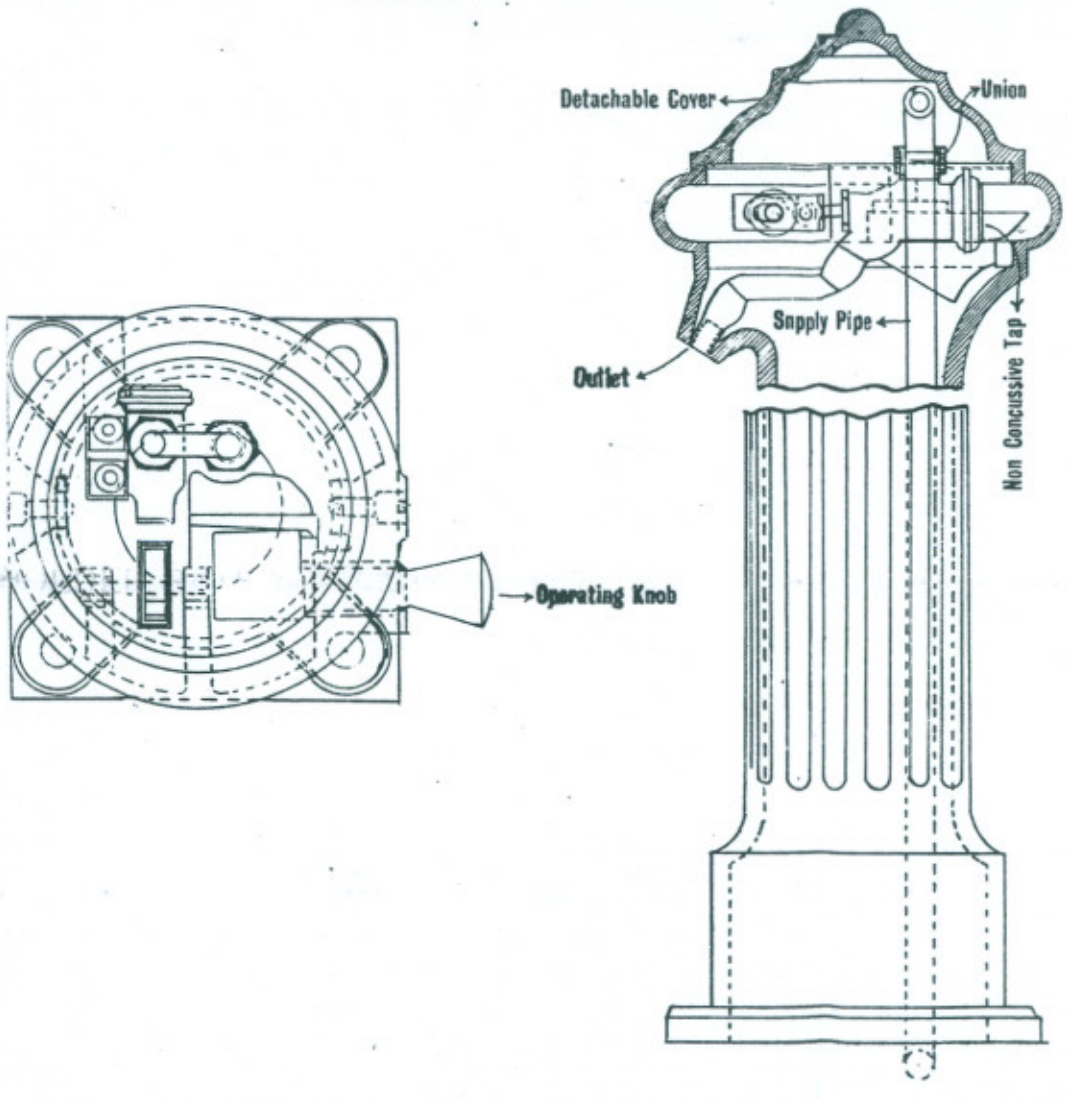


FIG. 26

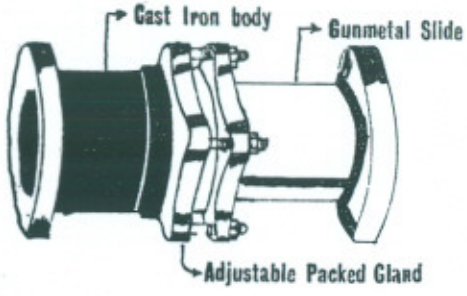


FIG. 27
HOLDER BATS

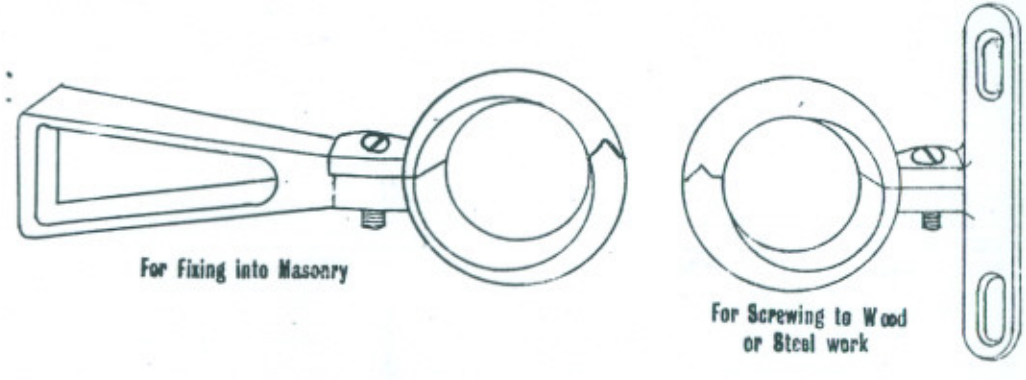


FIG. 22

BALL TAP

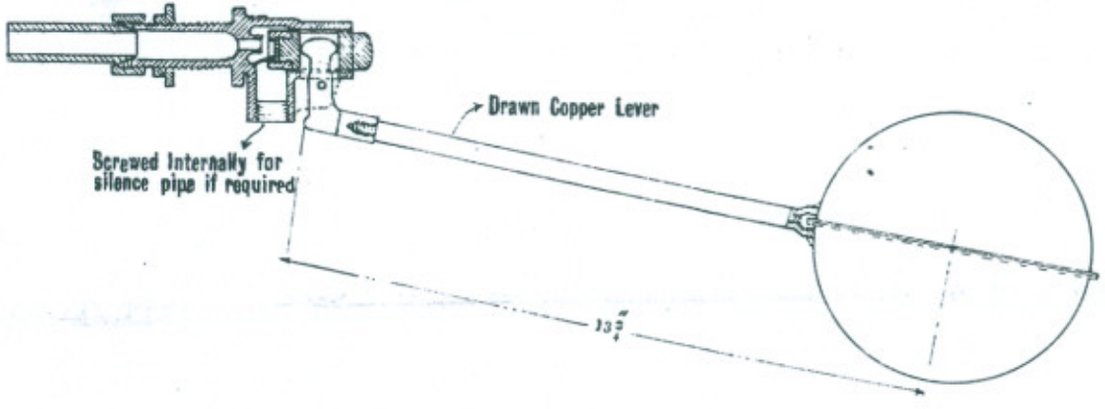


FIG. 23

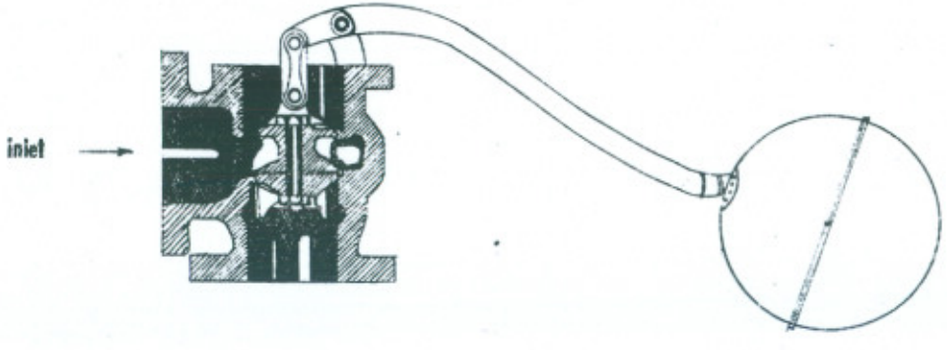


FIG. 24

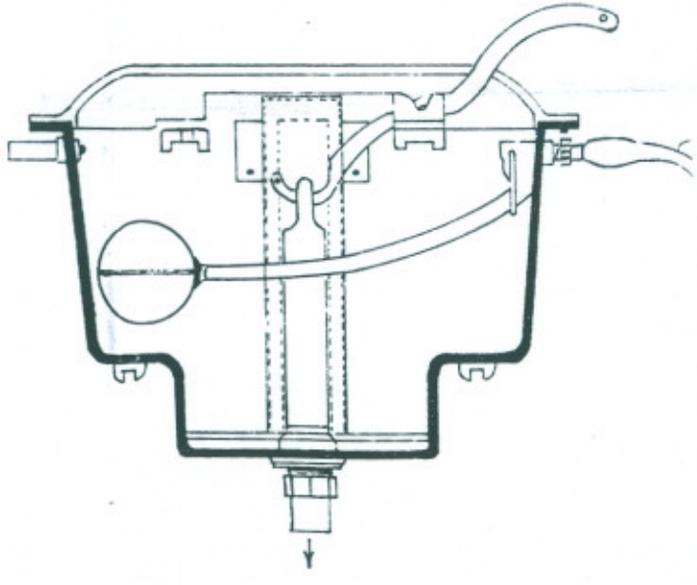
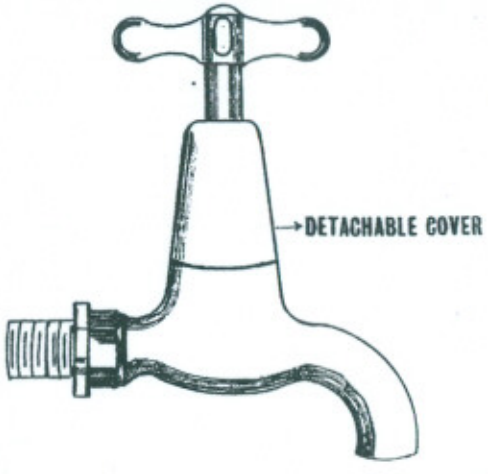


FIG. 31

EASY CLEAN BIB TAP



EASY CLEAN UNION BEND

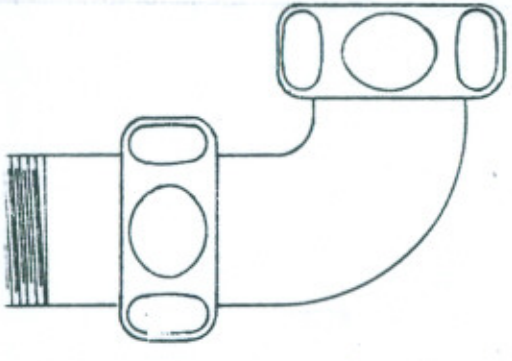


FIG. 32
TOWEL RAIL

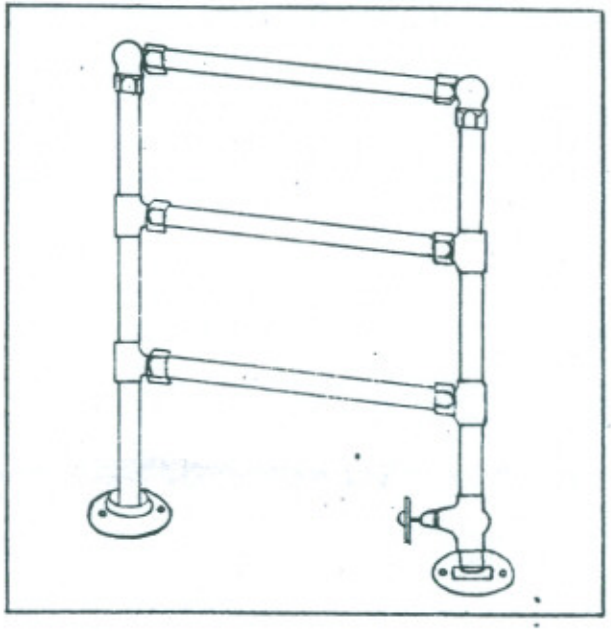


FIG. 33
USE OF CROSSOVER

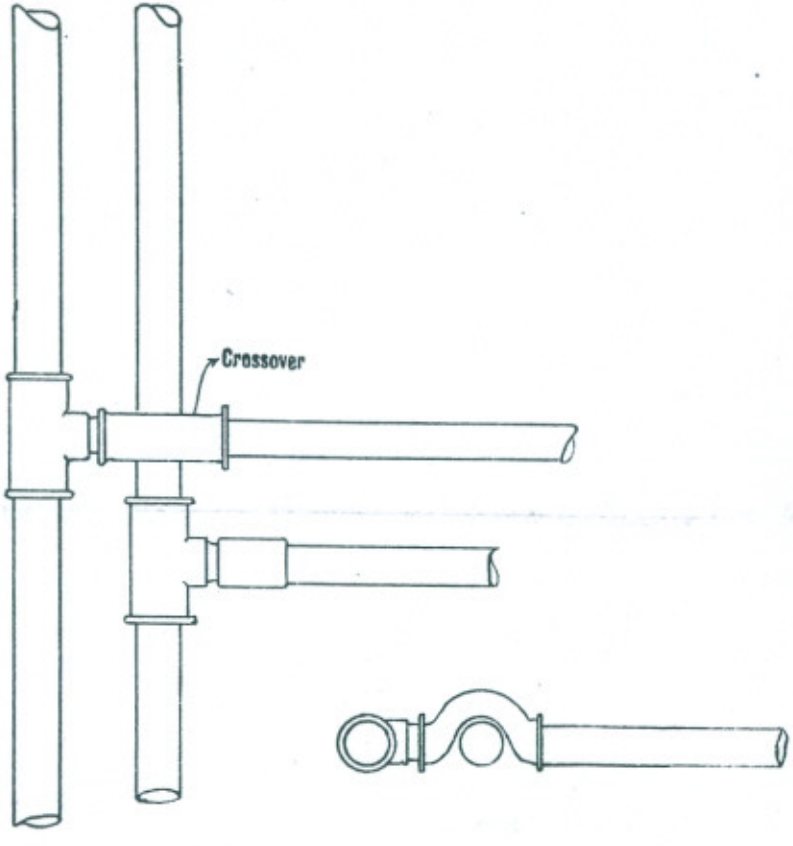


FIG. 28

BURRING REAMER



FIG. 29

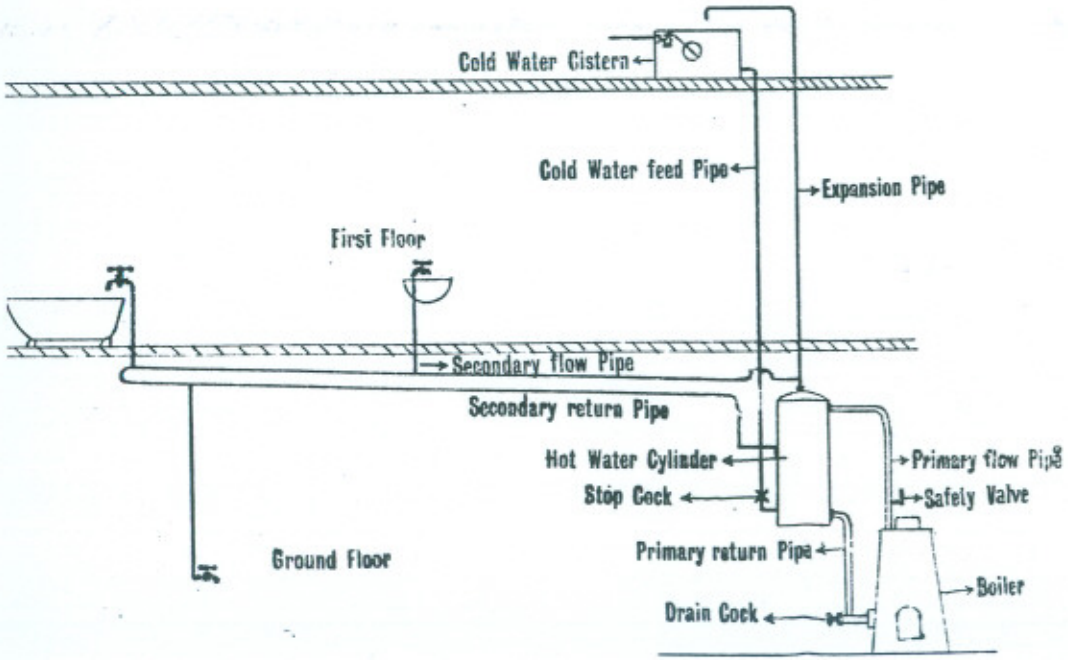
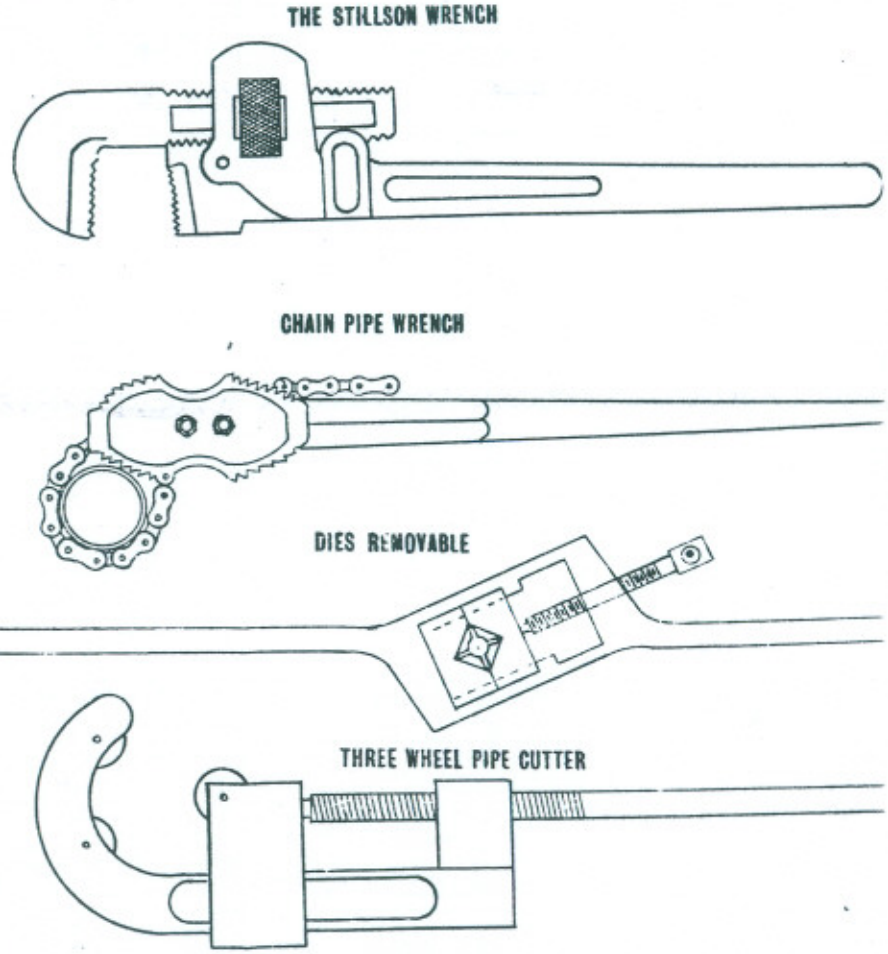


FIG. 30



DISCUSSION.

Mr. D. A. Howell said that unfortunately the author of the paper was absent through illness and he had been called upon to introduce the paper.

The paper gave particulars and details of the varied types of pipes and fittings employed for good class of water service connections and water pipe lines in buildings, suitable for India while an indication was also given of the practice in general vogue in Great Britain which had developed as a result of very long experience and practice. India was notorious as being a country where very inferior water pipes and fittings were used.

Before ever he came to India, he frequently used to notice in the catalogues of various British manufacturers of water fittings that very light, "export" pattern taps and fittings were manufactured, in addition to the "heavy" quality standard fittings generally used in England. These "export" patterns were not permitted to be used in British towns, being absolutely prohibited by regulations and by laws which were rigidly enforced. The same applied to European towns. He soon found out where those fittings went to, as he noticed after coming to India that they were the usual fittings used and in the Lahore bazaars those were the only qualities available for purchase.

The same state of affairs generally prevailed in regard to pipes. The kind of pipe for water service work, used in private buildings in Lahore and sold in the bazaar was a cheap gas quality galvanised pipe. Most people did not seem to know that such a thing as a heavy quality galvanised pipe suitable for water existed.

If the publication of the paper would bring about in this province an improvement in materials and workmanship in regard to water supply distribution, it would have done a great deal.

The classes of pipes and fittings described and recommended in the paper as suitable for water supply purposes were not very much more expensive than the cheap and nasty materials generally employed, while their adoption would reduce wastage and would give long life to the installations and the cost of repairs, renewals and maintenance would be reduced very largely. It was thus in the interest both of the water consumers and of the water supply authorities that the practise described in the paper, which was rigidly followed in the Punjab P. W. D. Public Health Circle, should be adhered to.

R. B. Dewan Amar Nath Nanda congratulated the author of the paper, Mr. Bromage, for the very practical and useful contribution to

the engineering storehouse of knowledge of the Punjab Engineering Congress in respect of the very practical subject of water supply pipes and fittings for domestic purposes and the modern up-to-date practice in relation to that. As the author himself stated towards the end of his paper, there was nothing in the way of original work in the presentation of the paper and therefore there was no occasion for subjecting the paper to any very critical remarks. Nevertheless the collection and the assembling of so much information on proper lines, and based on modern practice must have entailed a considerable amount of labour for which appreciation was due to the author. The author while laying down all the information in proper sequence had not omitted the application of some of that information to the peculiar requirements of this Province. In the text for the paper, special attention had been drawn to the present day defective system of house connections in vogue in this Province and the necessity for remedying them. There was one point however, which the speaker thought, called for a few remarks from him and that was in connection with the use of lead pipes for domestic service. It was a well-known fact, and the members must have inferred this from the introductory remarks of Mr. Howell that the man in the street had always been dominated by the question of economy and his general lack of requisite information had led him to use cheap pipes and fittings so much so that an average householder did not generally discriminate between a black iron pipe and a galvanised pipe and so long as he got the connection from the service main of the Municipality he was quite happy. From his own experience, the speaker stated that he had come across several people who allowed black iron pipes to be used in place of G. I. pipes because they did not know that the zinc coating of the G. I. pipe gave protection against corrosion and rust, and the chief consideration weighing with them was that of cost.

As regards lead pipes, this was such an unfamiliar sort of material that it had not yet found favour in India. The speaker thought that the question of the general use of lead piping was one which had not come to the forefront and there was hardly any warrant or justification for thinking that it would be pilfered if used in house connection. The main objection to lead piping was its cost, which was a serious hindrance to its general adoption for use. In India, the use of galvanised wrought iron piping had given good results on the whole and there was no need to adopt lead pipes.

The speaker congratulated the author for his paper which formed a very valuable adjunct to Mr. Howell's paper presented to the Congress in 1931.

Mr. G. R. Sawhney remarked that there was no doubt that Mr. Bromage had put together a valuable compilation for which he deserved the thanks of the Congress, but the speaker would like to know how this information could help the public who could not distinguish between good and inferior material. He suggested that the paper would serve

a very useful purpose if circulated to Municipalities and Notified Area Committees for their guidance and if they deemed proper some legislation might be enacted to protect the public against the use of inferior pipes and materials.

Mr. L. A. Freak remarked that no information had been given in regard to connections to cisterns, waste connections, etc. This information was important and might be added to the paper.

It would also be advantageous if an appendix could be added giving the names of suppliers of pipes, and fittings of the recommended qualities in order to tell the members where to get such articles.

Mr. D. C. Khanna said that there were a few points in respect of the standard regulations for taps and valves which had been omitted from the paper. Presumably they were considered to be of lesser importance by the author.

They were—(*i*) that the valve should be made in one piece, true all over and machined on the face on which the washer shall be seated ; (*ii*) the top of the valve plate should be clear of the bottom of the cover when the tap was fully opened ; (*iii*) the valve stem should be of such diameter that the stem could slide and turn easily in the bore in the spindle and should be of such length that it could not come out of the spindle when the valve without any washer was resting on the seating and the tap was fully open ; (*iv*) the diameter of the valve plate should be not less than the external diameter of the seating; (*v*) the valve seating should be raised not less than 1-16th of an inch.

There was a difference between the two regulations (British Waterworks Association's regulations and that of the Incorporated Joint Committee on Water Regulations) in respect of the height of the seating. In the British Waterworks Association's Regulations it was laid down that the valve seating should be raised 1-16th of an inch while in the paper which described the regulations of the J.C.S.W.R. it was 3/32". The speaker asked which was the standard practice.

The Standard Water regulations on taps also laid down that the length of the spindle screw should be such that when the valve plate was resting on the seating without any washer a length of the screw equal to not less than three-quarters of the external diameter of the screwed portion of the spindle should be in full engagement with the internal screw of the cover. Also in the Standard Water Regulations the diameter of ball valves was fixed at a minimum of $4\frac{1}{2}$" for 1/2" diameter connections but there were often connections of 3/8" diameter given and he wanted to know whether in this case the diameter of the ball should be less than $4\frac{1}{2}$", or was $4\frac{1}{2}$" the minimum size.

The speaker also pointed out that the specification of ball valves laid down that every high pressure ball valve should close against a

test pressure of 200 lbs. per square inch and every low pressure ball valve against a test pressure of 50 lbs. per square inch ; and every full way ball valve against a test pressure of ten lbs. per square inch and every such valve should have the letters "H. P.", "L. P." or "F. P." respectively cast or stamped on the body of the fitting. It was also specified that every ball valve should be securely and rigidly fixed above the water line to the cistern in connection with which it was provided and should be supported independently of the inlet pipe (unless such inlet pipe was rigidly fixed to the cistern) and in such position that the body of the tap did not become submerged.

Lastly the speaker pointed out an omission in the hot water circuit shown in Fig. 29. An air pipe was needed at the highest point of the circuit and unless this was provided an air lock would occur.

Mr. D. A. Howell in replying to the discussion, agreed with Mr. Nanda with regard to the use of lead pipes. He was of opinion that the time was remote when lead pipes would ever be used on an extensive scale in India. As a matter of fact even in Europe, in Great Britain for example, where lead pipes had been used extensively for the last hundred years, they were now turning to the use of G. I. pipes and the latest regulations in Great Britain allowed the use of G. I. pipes for water purposes, provided the pipes were of steam quality (*i.e.* a quality which was still heavier than the standard water quality which had been recommended in the paper).

In regard to the queries raised by Mr. Khanna, he was afraid he could not answer them offhand because he would have to consult the original specifications of the British Waterworks Association and the J.C.S.W.R. Probably the differences mentioned by Mr. Khanna were due to the fact that the two specifications were at variance to some extent. Personally he thought that so long as the raised seat was sufficient, it did not matter whether the height was 1/8" or 3/32".

With regard to the omission of the air pipe mentioned by Mr. Khanna, he agreed that an air pipe was necessary at the highest point of each circuit, especially as with hot water a certain amount of vapour was given off and an air lock would occur if no vent pipe were provided.

In regard to Mr. Sawhney's remarks, the speaker said that the paper was put forward for the information of the Congress and they could not go round and tell every man in the bazaar what kind of material and workmanship to use. He quite agreed with Mr. Sawhney that the paper would be a mine of useful information to Municipalities and local bodies and also that it was high time that legislation should be introduced to tighten up control over local bodies in regard to material and workmanship employed on water supply installations. In India

the quality of pipes and workmanship was generally very poor and there had been very little general improvement in private work during the time the speaker had been in India.

In regard to Mr. Freak's remarks, the paper was intended to deal primarily with water supply, and not with sanitary fittings. That was the reason why the question of waste connections was not dealt with more thoroughly.

The speaker stated the author would be glad to give information as to the various manufacturers of pipes and fittings if Mr. Freak cared to enquire, but he did not think that such information should find place in a technical paper.

The President in closing the discussion, said that thanks were due to Mr. Bromage in giving the members a compendium of information not only valuable for engineers but also for house and property-owners. Most people, even educated persons, were absolutely ignorant of the proper materials and workmanship which should be used for water supply and similar work in their own houses.