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Review.

The Editor

CAST-IRON HOUSE DRAINAGE.

WITH ESPECIAL REFERENCE TO

THE DRAINAGE OF TOWN HOUSES.

BY

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PREFACE.

The following pages are based upon a series of articles which, some few years ago, I had the pleasure of contributing to the "Decorators' Gazette and Plumbers' Review" at the request of its Editor. They have now been revised and amplified for publication in book form.

The advisability of the more general adoption of cast-iron drainage in towns is daily becomming more acute and it is hoped that the present volume may help towards the provision of sounder and safer drains than obtain at present in the majority of cases. If any confirmation of the views expressed by me in the pages of this book were wanting, it is provided by the following extract :—

"The vibration from heavy motor traffic and from underground railways is affecting this district, and indeed the whole of the metropolis, more or less seriously along the main channels of traffic. There have recently been instances of absolutely new drainage becoming defective from fracture of the pipes, and in the writer's opinion in certain situations in which vibration is to be expected the only safe way will be the construction of iron instead of earthenware drainage. Drainage is a costly matter, and when once put down should not require renewal for at least a quarter of a century."

Dr. Wynter Blyth (Medical Officer of Health for the Borough of Marylebone) in his "Monthly Chronicle."

In the following pages I have dealt primarily and chiefly with the materials and construction of the drainage system. The planning and arrangement of the drains and the subject of sanitary fittings have been touched upon briefly,—tho' I hope comprehensively,—in so far as they apply to town houses, but I have not gone into details with these as this would practically involve a reprint of my book—"House Drainage and Sanitary Fittings."

GERARD J. G. JENSEN.

14, Victoria Street, S.W.,
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CAST-IRON HOUSE DRAINAGE

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CHAPTER I.

INTRODUCTORY.—ADVANTAGES OF CAST-IRON DRAINS.

It has been said that a man's happiness is inversely proportionate to the number of gas, water, and drain pipes with which his house is supplied. This saying may be perfectly true where these modern conveniences are put into the house in a careless manner, or with the main idea of cheapness. If, on the other hand, they are skilfully and carefully planned, thoroughly and conscientiously laid and properly maintained, there is no reason why they should not bring comfort and happiness in addition to the promotion and maintenance of the health of the inmates of the house which in itself means happiness.

The happiness to be derived from the death-dealing drainage formerly universal, and of which even to-day not a few specimens are still in existence, cannot, certainly, have been great ; and it is even doubtful whether such a state of matters was really an advance on the conditions obtaining in the days when London rejoiced in the "sanitary" law that :—

> "No man shall cast any urine or ordure-boles into the street before the hour of nine at night. And also he shall not cast it down, but bring it down and

lay it into the channel, under pain of three shillings and fourpence. And if he do cast it upon any person's head, the party to have a lawful recompense, if he be injured thereby."

This state of affairs had at least the advantage that dangers and inconvenience could be seen and to some extent avoided, and that the person injured could, in certain cases, obtain a "lawful recompense," which in the other case he can not.

Nowadays, happily, the evils of either system are apparent, and it is therefore hardly necessary to bring forward arguments at this stage, in proof of the value and necessity of sanitation as we now understand it. Sanitation has long since ceased to be regarded as a "fad" by reasonable people, and even the most superficial observer must admit that to it mainly is due the marked and sustained decrease in the general death-rates and the absence of the appalling epidemics of diseases experienced in former years. The intimate connection which exists between the sanitary condition of the house drainage and the physical well-being of those who reside within its immediate sphere of influence, more especially in the case of town houses, is also acknowledged by all who have given the subject a thought.

Formerly, so long as the drains were out of sight they were also out of mind, and no thought was given to their condition or suitability for the proper fulfilment of their duties, until the appearance of drain-begotten disease. Now it is recognised by all thinking people that, to ensure a healthy habitation, it is essential that not only the principles but also the details and next to-nothings connected with the construction of the house-drains demand the most careful consideration.

With regard to these details, nothing is more important than that the materials of which the drainage system is constructed should be of the strongest and most lasting, so that the possibility of leakage or escape of liquids and gases from the drainage system may be reduced to a minimum. The more this fact has become recognised, the better have been the materials employed, and the more stringent the tests applied for proving the soundness of the sanitary arrangements.

Whereas we were formerly satisfied with brick or stone drains and egg-shaped unjointed, or even round and clay-jointed, earthenware pipes, we now insist upon, at least, sound, socketed and well-jointed stoneware pipes. Even in these there has been great improvement during more recent years. From year to year their selection and laying has become more critical. We have come to recognise more and more that their structure is not capable of withstanding a shock through the settlement of soil or the passage of traffic above or near them, and we have therefore come to insist upon their being partly or wholly encased in concrete, when provided for the drainage of town houses, at any rate. Even this, we now find, is unable to give the absolute security and efficiency which we seek, and we are therefore steadily and surely sealing the doom of the stoneware pipe drain and giving preference to cast-iron piping.

The greater our experience in drainage work, it may even be said, the smaller is our faith in stoneware drains for town houses. They are by no means inexpensive when laid as they should be, and the result is altogether unsatisfactory, partly because the drains wear badly and partly also because they are rarely able to withstand a satisfactory test after the lapse of a short time, although, of course, there are exceptions. This is due at times to the shaking occasioned by railway trains or street traffic, and at others to settlements in the ground. More often than not, the leakage may also have been caused by the expansion and contraction which follows the alternate flow of hot and cold water discharged into the drain, which the brittle stoneware piping is unable to withstand. However caused, leakages in drains are not conducive to health.

Apart, however, from the danger to health which a seriously leaking drain constitutes, the loss of money to house owners and householders, occasioned by the use of stoneware piping, must also be enormous, for although, in many cases, it may be reasonably maintained that the danger which may arise from a minute leakage is practically negligible, the fact remains that an intending purchaser or tenant of a house who takes advantage of an efficient test to protect himself, is able to maintain that the drains are defective if they leak at all. Not infrequently it therefore happens that town houses are drained and re-drained over and over again at short intervals, each new owner or occupier having the drains relaid only to find that they are again inadequate to stand a thorough test at the end of the tenancy, if not sooner.

But cast-iron drains are not only more lasting than stoneware drains, they are also possessed of several other advantages which must not be underrated. These are:—(*a*) The long lengths in which the iron pipes are manufactured; (*b*) the corresponding reduction in the number of joints as compared with stoneware drains; (*c*) the facilities afforded for making strong and reliable joints; and (*d*) the adaptability of the material to every variety of form.

better to have shown 4 stoneware pipes illustrating increase no. of joints

With regard to the two first-named of these considerations, nothing will be more convincing than a comparison of Figs. 1 and 2, which show an ordinary 6-inch stoneware drain pipe and an ordinary 6-inch iron drain pipe respectively. Whilst in a stoneware drain 30 yards long, forty-five joints will be necessary, only ten joints are required in an iron drain of the same length. This in itself is a great advantage, as thirty-five opportunities for imperfections will be avoided. In addition to this, the iron drain will be straighter and smoother in the interior. Consequently more sewage can be discharged in a given time through the iron drain than through the stoneware drain, other considerations—such as fall and dimensions, &c.—being equal. For this reason, and because the iron drain is able to withstand pressure, it is not unusual to reduce the diameter of the drain when iron piping is used, utilising a 5-inch iron drain instead of a 6-inch stoneware drain, a 4-inch iron drain instead of a 5-inch stoneware drain and frequently also a 3-inch or even a 2-inch pipe where in the ordinary way a 4-inch stoneware drain would have been necessary. This reduction in the diameter of a drain has, as will be

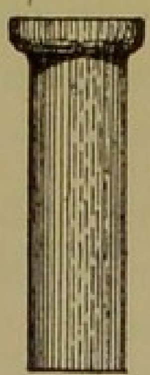


FIG. 1.

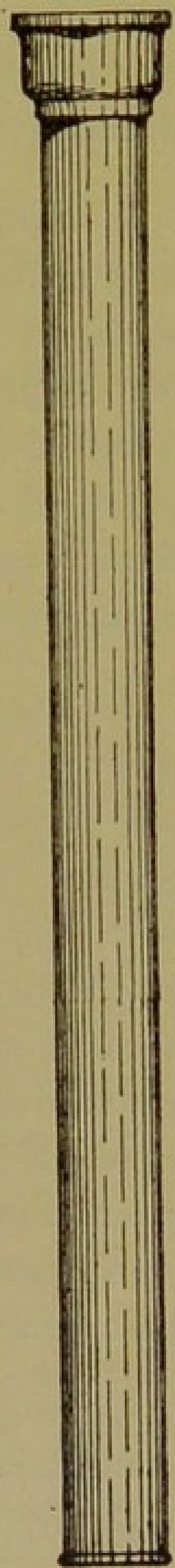


FIG. 2.

subsequently pointed out, a great bearing upon the self-cleansing, and consequently sanitary, construction of the drainage system.

Iron drain pipes, it may be here pointed out, are made in lengths of 3 feet, 6 feet, and 9 feet, exclusive of the sockets. Stoneware pipes are usually manufactured in 2 feet lengths. Stoneware pipes 2 feet 6 inches, and even 3 feet long, are made, but the extra length is generally obtained at the cost of trueness, as pipes which are longer than 2 feet are notoriously twisted or "baggy," being as a rule neither straight in the barrel nor true in section.

As regards the nature of the joints, it need hardly be pointed out that the strength of a solid lead joint bears no comparison to that of even the best of Portland cement joints. Stoneware pipes, it is true, may now be obtained with iron sockets and spigots which will allow of a caulked lead joint, but it is of but little use for the joint to withstand a strain which the barrel of the pipe upon which it is made is unable to bear. The strength of a chain is the strength of its weakest link. Nor is the frequency of the joints done away with, while the extra cost involved in most cases suffice to pay the difference between the iron and stoneware drains.

Coming now to the adaptability of iron for meeting the peculiarities of every case, it is hardly necessary to state that, by altering a pattern for the foundry, the molten metal can be poured into any shape or form required; the necessary shape being thus assured. The castings can also, if necessary, be cut. With stoneware it is different, as the pipes and appliances must be worked in as they come from the pottery.

If connections of special shapes have to be used and made—more especially so in the case of connections of a new form—the same can be produced quicker and with greater certainty of success in iron than in stoneware, for in the case of the latter material there are frequent and unexpected failures in the kilns, leading to annoyance and loss of time and money.

Of other advantages possessed by iron drains, it may be said that they can be laid, joined and covered as quickly as it is possible to open up the ground, which in friable soils or in other cases in which expedition is desirable or essential, is no small recommendation in their favour. Nor are the pipes or joints affected by frost or other such condition, and the drains may therefore be laid at all times. Two or three pipes can also safely be joined above ground and then laid in water-logged ground or drawn through a tunnel under a floor or elsewhere where a floor cannot be disturbed or the space necessary for making joints in trenches cannot be provided.

A further advantage possessed by cast iron over stoneware drains is their suitability for being delivered complete and ready for fixing in any situation and at any distance from the place of manufacture. All that is necessary for the purpose is to supply the manufacturer with accurate drawings, to scale, of the plans and sections of the buildings to be drained; the positions of the various drains, closets, sinks, soil and ventilation pipes, and other adjuncts to the drainage system being accurately marked thereon.

The manufacturer will then be able to fit the various parts together in his workshops. The whole drainage system is put together by him and completed in all but jointing and then carefully marked (as in Fig. 3), so that

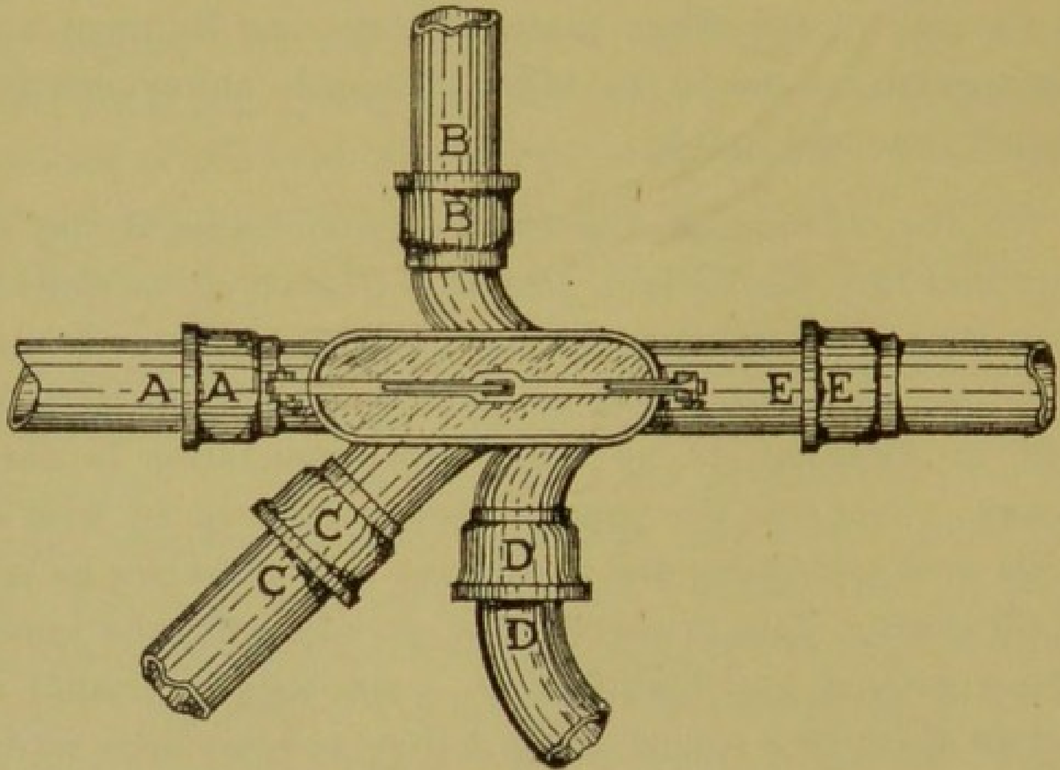


Fig. 3.

each part can be rearranged on arriving at its destination. As an alternative each pipe may be marked by a distinctive letter or number which is shown on the plan at the point at which the pipe is to be laid.

The advantage of such a procedure is obvious, and in strong contrast to a jumbled up delivery of stoneware pipes, half-channels, gullies, cement, &c., &c. Nor will the success of the installation be necessarily dependent upon the intelligence and experience of the workmen employed, since even the most unskilled men will be able to fit together the various parts and place them correctly. In the case of several buildings recently re-drained on the Continent, this method was adopted and the drainage satisfactorily completed in each case.

The use of cast-iron piping further enables us to avoid the expense which is necessary to ensure air and water-tight manholes, and ensures also a rapid current of fresh air for the ventilation of the drainage system, by avoiding the large accumulations of drain air which are unavoidable in the case of the ordinary inspection chambers with which stoneware drains are generally provided. These considerations will be subsequently treated with in detail.

Iron drains can also be fixed in exposed positions, such as on the face of a basement wall or under a ceiling, either of which is impossible in the case of stoneware drains.

In the United States of America, where great improvements have in recent years been made in house sanitation, the advantages and superiority of cast-iron drainage are so well recognised, that in New York and many other cities it is compulsory to construct house drains of iron to a distance of 10 ft. on the sewer side of the intercepting trap, beyond which point stoneware piping may be used.

The only objection which can be fairly urged against the use of cast-iron piping is that of cost, for in practice it is found that a complete, well laid, cast-iron drain is from 10 to 30 per cent. more costly than a well-jointed stoneware drain, of similar dimensions, laid in concrete. The additional security which is obtained by the use of iron drains and their longer life, are, however, an ample return upon any reasonable additional outlay involved, whilst in value there is and can be no comparison between the two materials.

CHAPTER II.

CAST-IRON DRAIN PIPES AND THEIR JOINTS.

HAVING once adopted cast-iron piping for the construction of the drainage system, the points to be considered are—(*a*) The nature, strength, and weight of the pipes necessary, (*b*) the available means for preserving them, (*c*) the nature of their joints, and (*d*) the character of the connections and accessories best suited to the pipes.

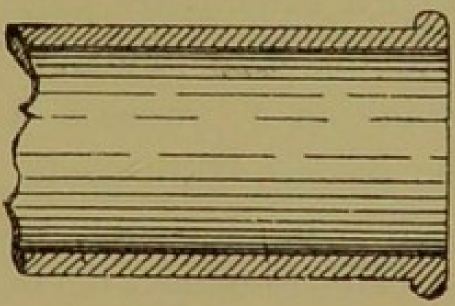


Fig. 4.

All cast-iron pipes used in drainage work should be made of good tough grey iron from the second melting run from the cupola. The pipes should be cast with the sockets downward and with an extra bead of at least one foot of metal. All pipes above 4 in. diameter should be cast in a vertical position; whilst the moulds for all pipes of 4 inches or less in diameter should be inclined at an angle of 45°. The pipes should be straight, true in section, even in thickness of metal, perfectly smooth inside and free from air and sand holes and other defects.

Their sockets must be strong, deep, and sufficiently wide all round to leave room for caulking up the joint; whilst the spigots of the pipes must be provided with a bead on the end. This bead (see Fig. 4) causes the spigot of one pipe to lie in the socket of the other in such a way that the pipes are concentric when joined (see Fig. 5). The bead will also ensure an equal annular space all round the inside of the socket, and help to keep the lead used in making the joint from running into the interior of the pipes. The walls of the sockets should not be less than a quarter of an inch thicker than the walls of the pipes, whilst the internal diameter of the sockets should be from $\frac{1}{2}$ in. to $\frac{3}{4}$ in. larger than the external diameter of the pipes, so as to leave a sufficiently large annular space all round the pipes for the lead joints. The pipes must be capable of withstanding a pressure of 200 ft. head of water and must be coated, both inside and out, by some anti-corrosive solution or substance such as Dr. Angus Smith's solution to prevent deterioration through oxidation

In specifying the pipes, it is in all cases desirable to state the limit of variation permissible in the weight and strength of the piping. This should not exceed 5 per cent of the average weight of the pipes specified, if it is desired to avoid the use of unduly light or weak piping.

The proportions and weights of cast-iron piping suitable for underground work as supplied by one of the leading manufacturers are shown in the following table :—

Table I.

Proportions and Weights of cast-iron Drain Pipes.

Diameter of Pipe.	Thickness of Pipe.	Length of Pipe.	Diameter of Socket.	Thickness of Socket.	Depth of Socket.	Weight of Pipe.		
Inches.	Inches.	Feet.	Inches.	Inches.	Inches.	Cwts.	qrs.	lbs.
3	$\frac{3}{8}$	9'	$4\frac{1}{4}$	$\frac{5}{8}$	$3\frac{1}{2}$	1	0	0
$3\frac{1}{2}$	$\frac{3}{8}$	9'	$4\frac{3}{4}$	$\frac{5}{8}$	4	1	1	0
4	$\frac{3}{8}$	9'	$5\frac{1}{2}$	$\frac{5}{8}$	4	1	2	0
$4\frac{1}{2}$	$\frac{3}{8}$	9'	6	$\frac{5}{8}$	4	1	3	2
5	$\frac{3}{8}$	9'	$6\frac{1}{2}$	$\frac{5}{8}$	$4\frac{1}{2}$	2	0	0
6	$\frac{1}{2}$	9'	$7\frac{1}{2}$	$\frac{3}{4}$	$4\frac{1}{2}$	2	2	0

Piping of these proportions will be found to have a long life and be able to withstand any strain or wear to which it may be subjected. Such pipes also comply with the requirements of Urban Sanitary Authorities. The London County Council's Bye-Laws, for instance require that the pipes shall be in accordance with the following table, viz :—

Table II.

Thickness & Weights of cast-iron Drain Pipes required by the London County Council's By-Laws.

Internal Diameter in Inches.	Thickness of Metal not less than :-	Weight per 9ft. length (including socket and beaded spigot or flanges, the socket not to be less than $\frac{3}{8}$ in. thick) not less than :-
3	$\frac{5}{16}$ of an inch	110 lbs.
4	$\frac{3}{8}$,,	160 ,,
5	$\frac{3}{8}$,,	190 ,,
6	$\frac{3}{8}$,,	230 ,,

Although it is found that cast-iron piping which is washed by ordinary sewage shows little or no sign of interior rusting, even many years after it has been laid, owing to the greasy nature of the liquids discharged, the protective coating which is thus imparted to drains must not be entirely relied upon for their preservation. The pipes should therefore be coated by some artificial preservative. Of these Dr. Angus Smith's solution and the Bower-Barff process are the best known and more widely used.

To apply the former—which should always be done before the pipes leave the foundry—the pipes are carefully cleaned and freed from sand, rust, and scale. They are then dipped vertically into a mixture of coal-tar and coal-oil, which is maintained at a temperature of about 400 deg. Fahr. After being immersed for the space of ten minutes the pipes are withdrawn gradually and all surplus solution allowed to run off

When dry the coating should be uniform in thickness (about one hundredth inch thick), hard, and firmly adhering to the iron surfaces without showing any tendency to scale off.

The Bower-Barff process is applied by raising the pipes to a white heat (about 1,200 deg. Fahr.) in a chamber into which superheated steam is passed. After exposure to the steam for some eight or ten hours the pipes become coated with a hard, protective coating of black oxide of iron.

Although frequently used, pipes coated by the Bower-Barff process are often found to be imperfect owing to the appearance of blisters of oxide on the interior surfaces of the piping. The process is also more expensive than Dr. Angus Smith's, and for these reasons the latter mode of protecting iron pipes is the one most frequently used and to be generally preferred of the two.

Cast-iron pipes may also be obtained coated in the interior with a preparation of glass enamel which not only protects the interiors of the pipes, but also renders them perfectly smooth. Should these pipes be used, the exterior of the piping must be well tarred with two or three coats of coal-tar in order to preserve the outer surfaces, should they not be otherwise protected. The disadvantage of these otherwise excellent pipes is the difficulty experienced in cutting them, as it is difficult to avoid chipping and otherwise damaging the lining by so doing. To some extent the lining is also affected by changes of temperature due to the flow through them.

While there are several ways in which the jointing of iron piping may be effected, the joint which is generally adopted and which leaves nothing to be desired as regards

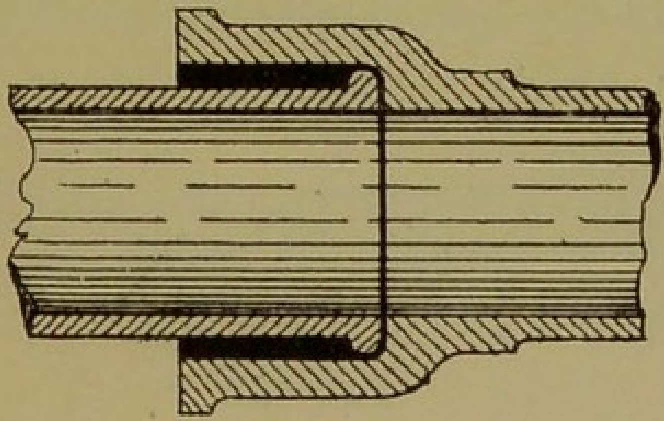


FIG. 5.

security and durability is the ordinary spigot and socket joint shown in Fig. 5, in which the joint is made with molten lead, well caulked whilst cooling. The quantity of lead so used varies according to whether the joint is made with yarn or, as is desirable, entirely of lead. The average weight of lead necessary for a good sound joint is, however, as follows:—

TABLE III.

Average weight of lead used in drain joints.

For 3	in. pipes	...	... 2·5	lbs	of lead.
" 3½	"	...	... 3·25	"	"
" 4	"	...	... 4·0	"	"
" 4½	"	...	... 4·5	"	"
" 5	"	...	... 5·0	"	"
" 6	"	...	... 6·5	"	"

It has already been stated that the walls of cast-iron drain sockets should be not less than a quarter of an inch thicker than the walls of the pipes. This in spigot and socket joints is necessary to give the sockets sufficient strength to resist fracture when the lead joints are being caulked. The sockets must, however, also be strong in other ways to resist fracture, and for that purpose must be suitably shaped in order to give them sufficient strength at the right points. As the dimensions of the various

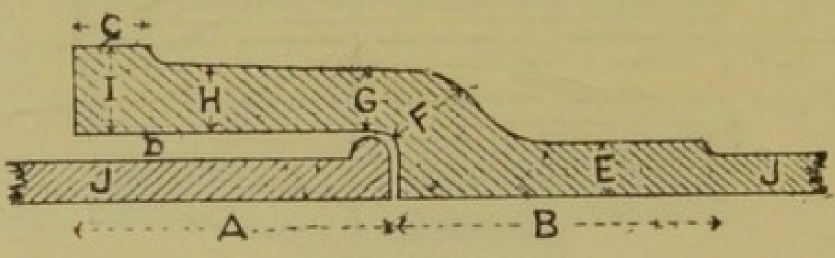


FIG. 6.

portions of the sockets must be in proportion to the sizes of the pipes, the following illustration (Fig. 6) and table of dimensions may be given as a guide.

Table IV.

Dimensions of Spigot and Socket joints for Cast-iron Pipes.

Diameter of pipe.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Inches.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
3	3	3	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{3}{8}$
$3\frac{1}{2}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{3}{8}$
4	$3\frac{1}{8}$	$3\frac{1}{8}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{3}{8}$
$4\frac{1}{2}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{3}{8}$
5	$3\frac{1}{4}$	$3\frac{1}{4}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{3}{8}$
6	$3\frac{1}{2}$	$3\frac{1}{2}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{5}{8}$	1	$\frac{3}{4}$	$\frac{13}{16}$	$1\frac{1}{16}$	$\frac{1}{2}$

When, as occasionally happens, two spigot ends of this kind of piping have to be joined together, the connection is made by means of a "collar." A collar often used is shown in Fig. 7. This, however, is not of a very good form, as there is nothing to hold it in place whilst the joints are being made. A better collar—especially for pipes which have been cut and thereby

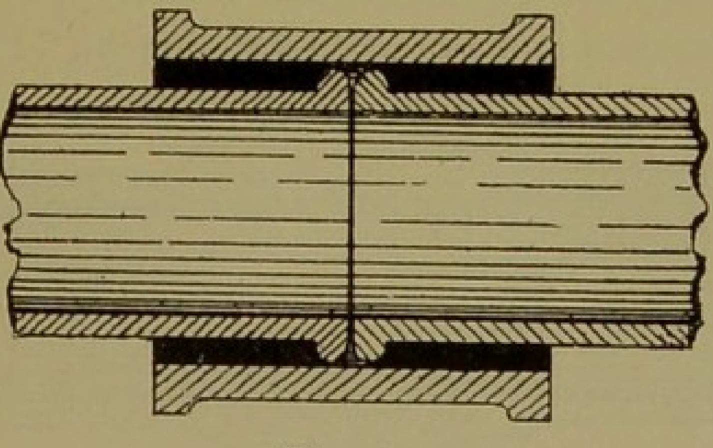


Fig. 7.

deprived of the bead on the end of their spigots—is shown in Fig. 8. As will be seen, it practically constitutes a double socket.

The last-named collar cannot, unfortunately, always be made use of, however, as there are occasions when the collar has to be slipped right over one of the pipes before

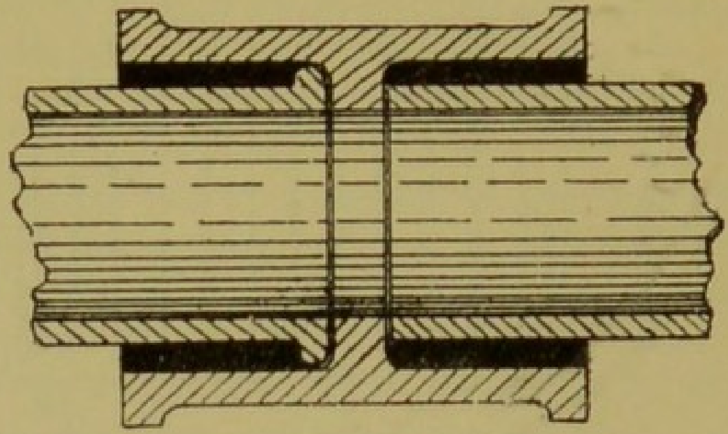


Fig. 8.

the two spigots can be placed together. In such a case it is necessary to make use of the collar shown in Fig. 7; every precaution being taken to ensure a good joint. It need hardly be pointed out that two lead joints are necessary in the case of either collar.

Modifications of the spigot and socket joint known as the "Full-turned and Bored" joint and the "Half-turned

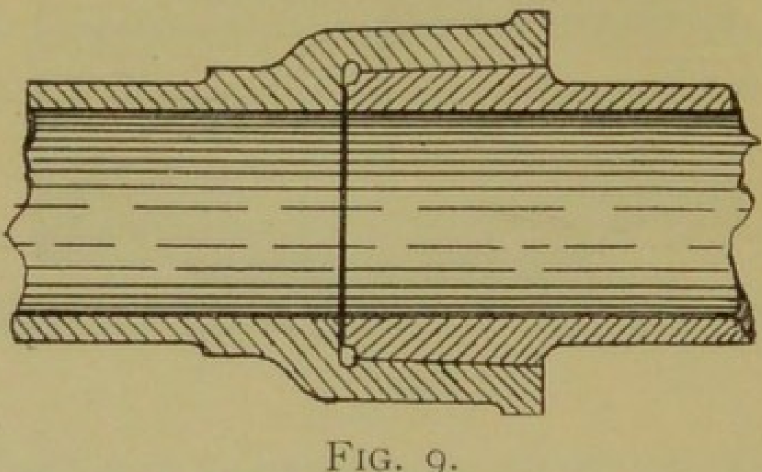


Fig. 9.

and Bored" joint are shown in Figs. 9 and 10 respectively.

These joints, of which the last-named is the more generally employed, have a portion of their sockets and spigots bored and turned respectively so that, when put

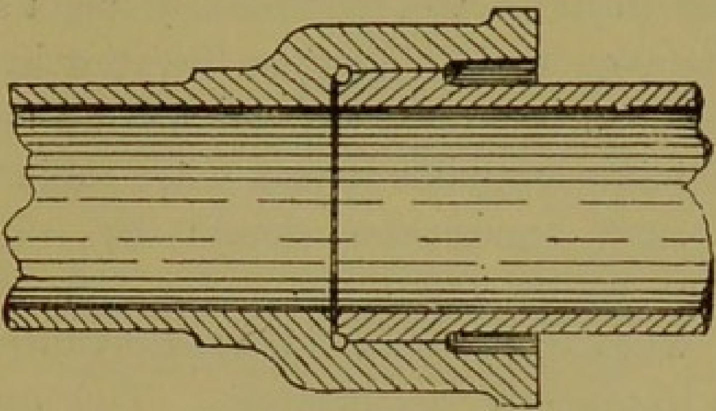


FIG. 10.

together, the two machined surfaces form a perfect joint. For jointing the pipes the faced surfaces are coated with red-lead cement or painted with sal ammoniac, which latter will form a rust joint. In either case the pipes are forced together tightly when the joints are being made. Either of the joints may be made more secure by providing the pipes with lugs cast on the spigots and sockets (as in Fig. 11), so that the joints may be drawn

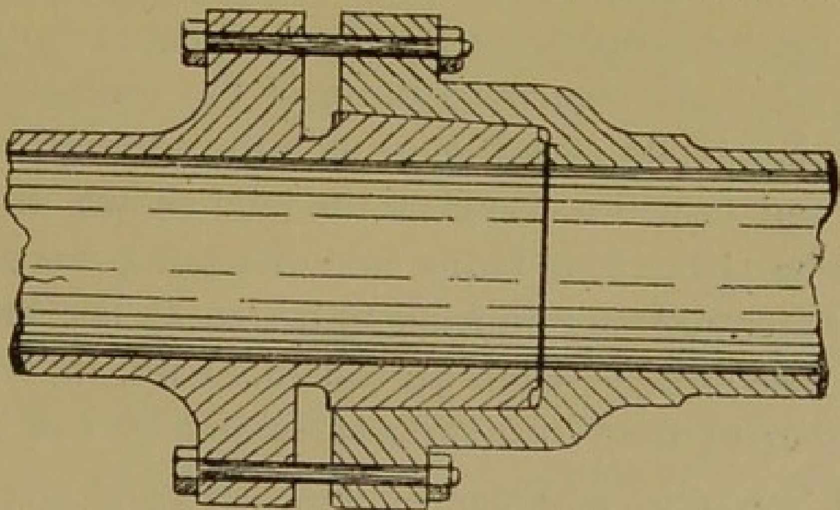


FIG. 11.

together tightly by means of bolts and nuts. The joints are useful in positions where water has to be contended with as this would interfere with the making of a molten lead joint. This, however, is the only advantage which these joints possess over the ordinary spigot and socket joint in drainage work. They, on the other hand, possess several disadvantages of which perhaps the most serious is that the joints are liable to leak when subjected to the expansion and contraction caused by variations of temperature within the drain. For this reason it is advisable, when these joints are used, to introduce lead joints as frequently as possible. The same reason renders half-turned and bored joints preferable to full-turned and bored joints as they may be partly run with lead and caulked should they be found to leak. A further drawback tending against the general adoption of turned and bored joints is that bends, junctions, and other similar connections cannot readily be turned and bored in a lathe and must therefore be joined to each other and to the drains by means of caulked lead joints.

The proper proportions for the sockets of turned and bored joints are similar to those of the ordinary spigot and socket joints (see Fig. 6) with the addition that the bored and turned portions on the joint shown in Fig 10, should be 1¼ ins. long in the case of pipes 4 ins. and less in diameter and varying from 1⅜ ins. to 1¾ ins. in length in the case of pipes from 4½ ins. to 12 ins. in diameter. The taper of the faced surfaces should be 1 in 32.

Cast-iron pipes with flanged joints, of which an example is shown in Fig 12, although frequently used for water mains are but rarely employed in drainage work. The joints of these pipes are usually made with millboard, steeped in warm water and coated with equal parts of white and red lead mixed with boiled linseed oil; or with copper-wire gauze or india-rubber insertions. These

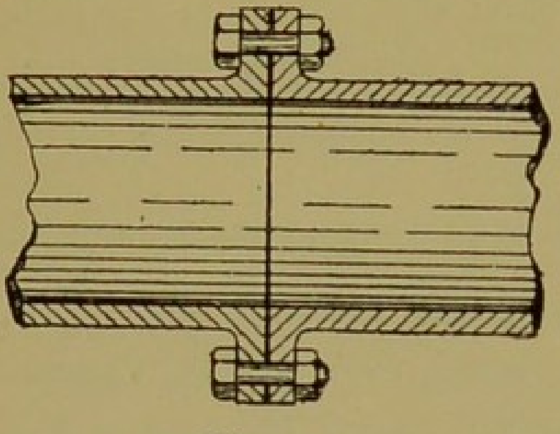


Fig. 12.

substances or "insertions" are placed between the flanges of the pipes, which may be faced or rough, or possibly specially shaped, and the pipes drawn together by means of wrought-iron bolts. Flanged joints are however neither so simple nor so satisfactory for drainage work as the ordinary spigot and socket joint, and should only be used when the latter is not available.

Piping which is provided with flange joints is also unsatisfactory in that it cannot be cut and must therefore be used in the lengths in which it is cast. Should now a pipe have to be fitted between two fixed points, the utmost accuracy will be necessary at the foundry to ensure that the pipe is of exactly the right length. If the pipe is half an inch, or less, too long or too short, it will be quite as useless as if it were a foot or two out in its length. A socketed pipe, on the other hand, may be cut to the right length on the site of the works. As some manufacturers now make pipes of varying lengths with a socket at each end, the piece cut off need not necessarily be wasted.

If flanged pipes are made use of, the thickness of the flanges and of the thickened portions of the pipes should be one and a quarter times the thickness of the pipe barrel.

CHAPTER III.

SPECIAL PIPES.

BENDS—JUNCTIONS—TAPERS.

Accessories pertaining to drain pipes—such as bends and junctions, traps, inspection-chambers, &c.—are all available of the same material, substance, and strength as the quality of piping selected for use. That the accessories utilised be of the same nature as the piping, is of course essential, in order that, when completed, the whole of the drainage system may be uniformly strong and reliable.

Bends.—Although bends should be as far as possible avoided in drainage work, it is sometimes necessary to make use of them. That being so, great care must be

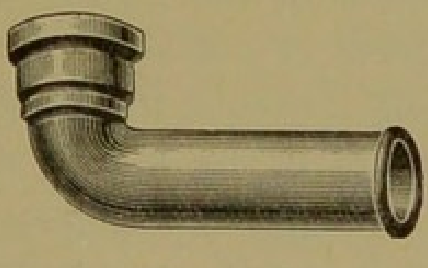


Fig. 13.

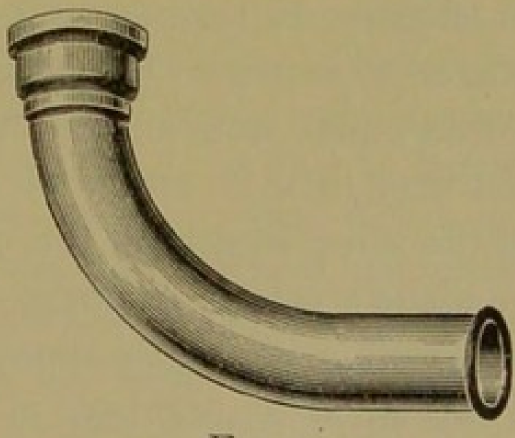


Fig. 14.

exercised in their selection in order to reduce to a minimum all risk of chokage to the drains, and interruption in the velocity and flow of the sewage. The sharper the bend through which sewage has to pass, the greater is the resistance (friction) offered, and the greater, consequently, the check to the flow. In a sharp bend this resistance may be so great as to equal that which would be offered by a pipe thirty-eight times its diameter

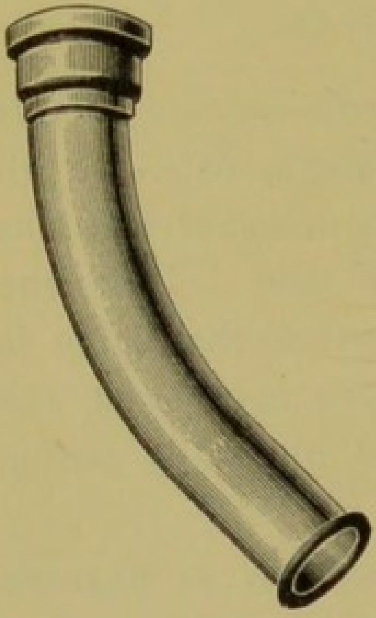


Fig. 15.

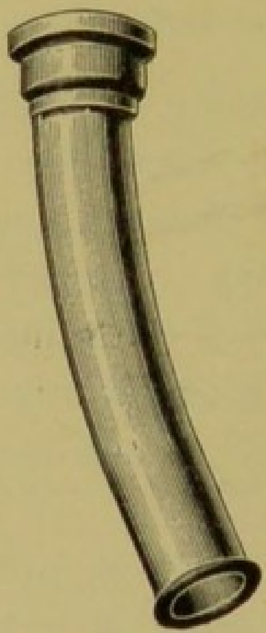


Fig. 16.

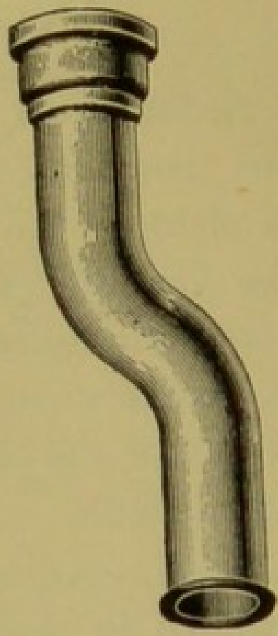


Fig. 17.

in length. In practice, it has been found that the friction offered to water in its passage through a bend having a radius equal to five times the diameter of the piping, is but very little in excess of that offered by a straight pipe of the same length as the bend; and it should, therefore, be made a rule in drainage work never to use a bend of less radius than five times the diameter of the piping. That is, if a number of four-inch bends are placed together in such a way as to form a complete circle, the radius of the latter should be not less than 1 ft. 8 in., and the diameter, of course, not less than 3 ft. 4 in. Similarly, the diameter of a circle composed of six-inch piping should not be less than 5ft. These remarks will explain

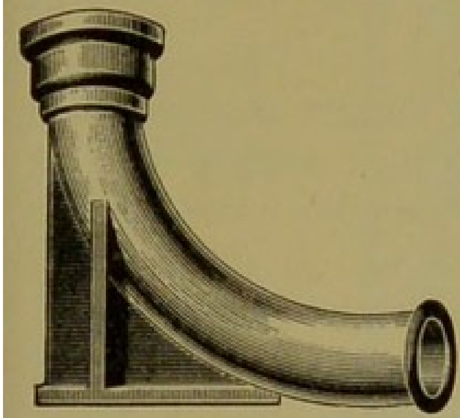


Fig. 18.

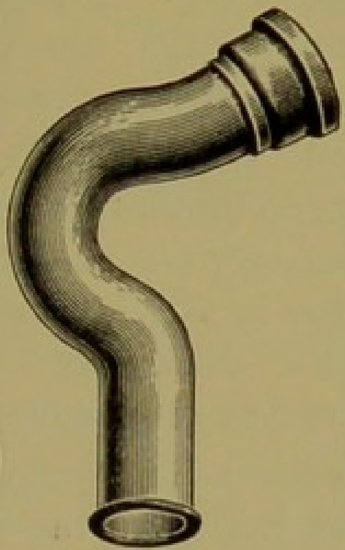


Fig. 19.

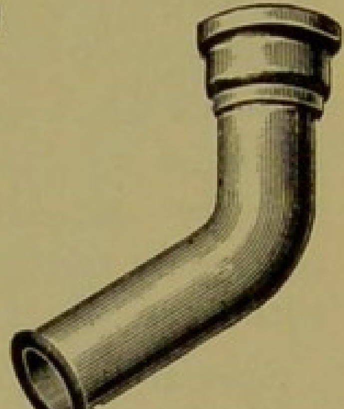


Fig. 20.

why the bend shown in Fig. 13 is inadmissible in drainage work; the bend shown in Fig. 14 being, on the other hand, a good form of bend to use. Even worse than the loss of velocity in the flow through drains due to the use of sharp bends, is the liability to stoppages which they cause.

The bends most frequently used, and which are always stocked by manufacturers, are known as "one-quarter," "one-eighth," and "one-sixteenth" bends. These are shown in Figs. 14, 15 and 16 respectively. By a one-quarter bend is understood a bend having a curve equivalent to the quadrant of a circle, so that if four of these bends are put together they will form a complete circle. Eight one-eighth and sixteen one-sixteenth bends will similarly form circles. As the length of the piping forming each individual bend is usually the same in all bends, it follows that the radius of the circle is smallest in the case of a one-quarter bend, and largest in the one-sixteenth bend.

One-quarter, one-eighth, and one-sixteenth bends form, and are consequently suitable for rounding off, angles of 90°, 135°, and 157½° respectively. Bends forming angles of 95° and 112½° are also stocked by some manufacturers, whilst bends cast to any other required angle may be had to order.

Bends which are to be fixed in an upright position, such as under soil-pipes, should be provided with a foot for stability—as shown in Fig. 18, which illustrates what is commonly termed a "ducks-foot" bend. If not provided with a foot, the bend must be embedded in concrete.

Special bends, such as the "double-elbow" or "swan-neck" bend, shown in Fig. 17, the "obtuse-elbow," shown in Fig. 20, the "roof-syphon" or "eaves-bend," shown in Fig. 19, and many others, must sometimes of necessity be used for passing round awkward corners, rain-water gutters, and similar obstructions. They should, however, only be used for soil and ventilation pipes, and then only when absolutely necessary. For underground drains they are inadmissible, and can also be dispensed with if a little thought and care are bestowed upon the planning of the drainage system.

Junctions.—What has been said as to the necessity for an easy sweep in bends, applies with equal force to junction pipes, whose branches practically form bends with the main pipes. The branches should always be curved in the direction of the flow in the main drains, and must be struck with a radius similar to that advocated for bends. The easier the sweep, the smaller the chance of stoppage; whilst conversely it may be said that the nearer the form of the junction pipe is to a "right-angled" junction (shown in Fig. 21), the greater is the likelihood of a blockage, and the greater also the difficulty of unstopping and cleaning the drain. As with

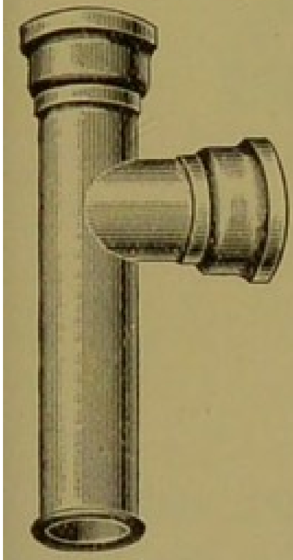


FIG. 21.

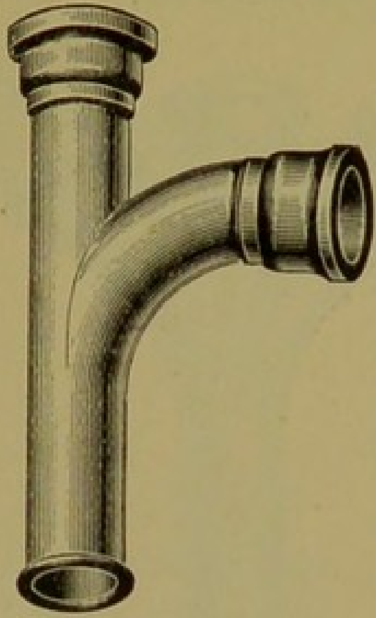


FIG. 22.

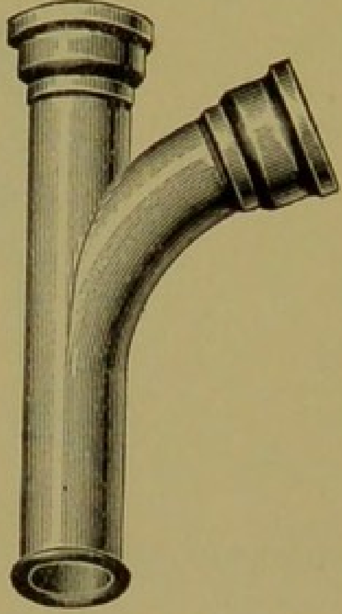


FIG. 23.

bends, the angles of the branch pieces more generally

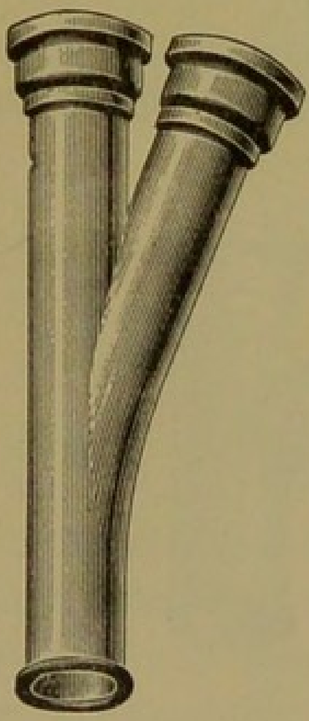


FIG. 24.

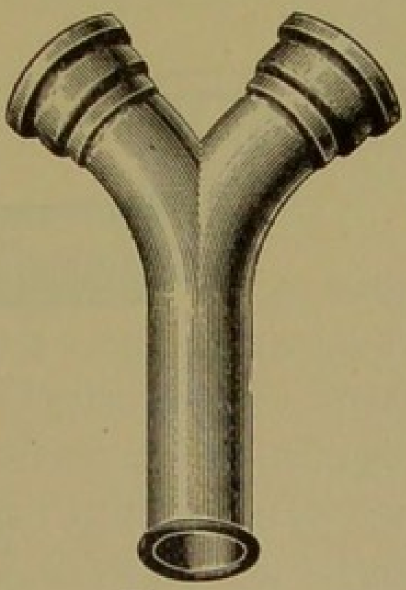


FIG. 25.

stocked by manufacturers are 90°, 95°, $112\frac{1}{2}$°, 135°, and $157\frac{1}{2}°$. The first, third, and fifth of these are shown in Figs. 22, 23 and 24 respectively.

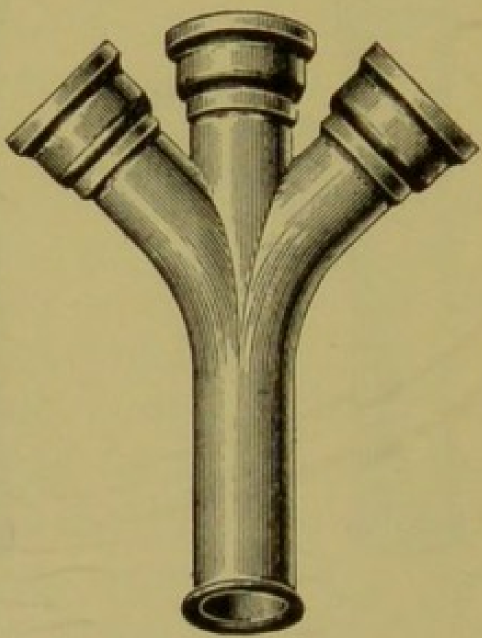


FIG. 26.

"Y" junctions, as shown in Fig. 25, should be avoided, as the branches are liable to discharge their contents into

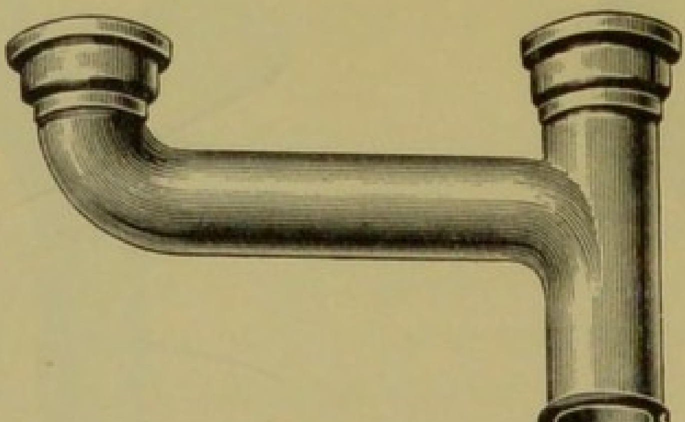


FIG. 27.

each other. Deposits on the sides of the drains are thus formed above the level of the ordinary flow, and these in time will, by accumulating, choke the drains. The same

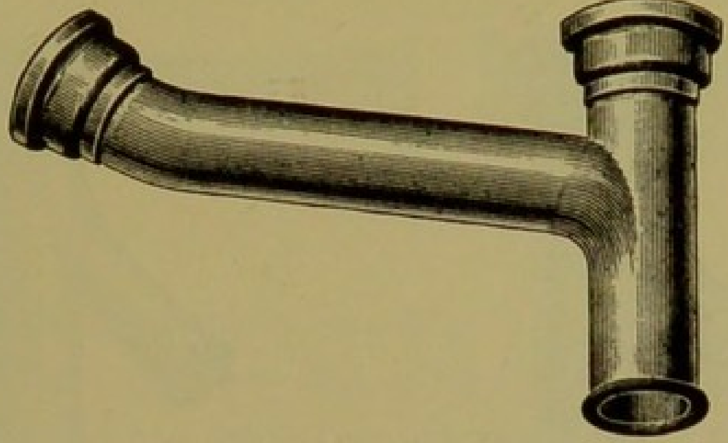


Fig. 28.

objection applies to the treble or "double branch" junction shown in Fig. 26.

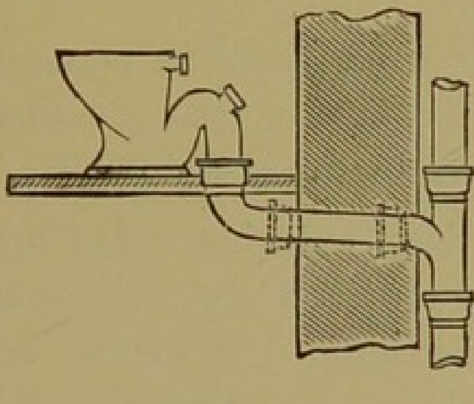


Fig. 29.

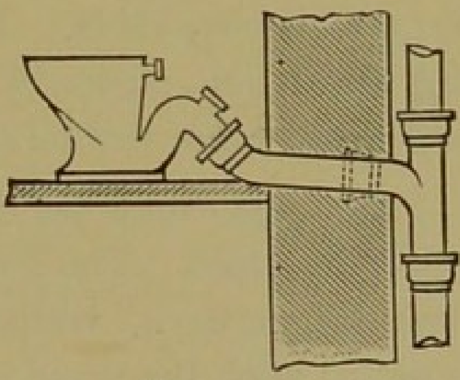


Fig. 30.

Junction pipes with specially formed or specially long branches (as shown in Figs. 27 and 28 are made for use under special circumstances. The two shown would, for instance, be suitable for connecting a closet having an "S" or a "P" trap (see Figs. 29 and 30 respectively) to a soil pipe, thus avoiding one or two joints, which, as indicated by the dotted sockets, would be necessary were ordinary junction pipes used.

Junction pipes with reverse branches of various diameters and with or without sockets (see Figs. 31 and

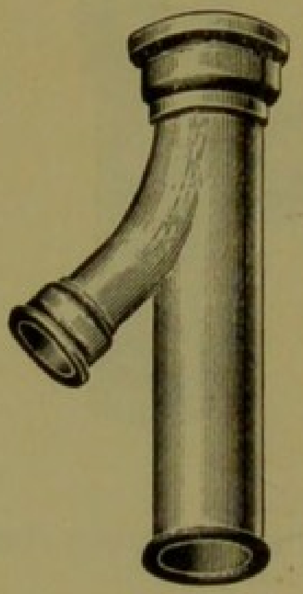


FIG. 31.

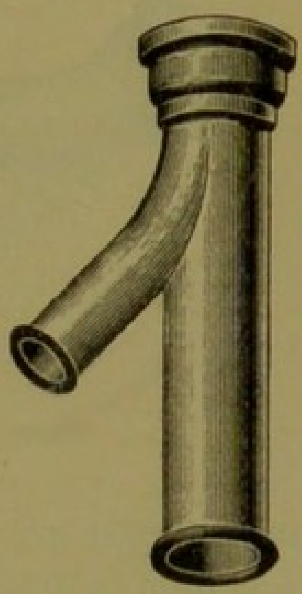


FIG. 32.

32) are also available. They are chiefly used for connecting ventilation pipes, of which latter and their junctions and bends more will be said in a subsequent chapter.

Taper pipes may be divided into reducing pipes and enlarging pipes. The former are provided with sockets on their larger ends, whilst on the latter the sockets are supplied upon the small ends of the pipes. Whatever their form, taper pipes should be comparatively long in order that the enlargement or reduction in the size of the pipe may be gradual. The pipes should also be tapered on the crown and on the sides only, the bottom of the pipes being left straight (as in Fig. 33) in order that the invert of the drain may be straight and even throughout the whole length of the latter. For some reason or other these points are not taken into consideration in the manufacture of iron tapers, unless specially ordered; the taper pipes usually stocked by the makers being short and altogether well calculated to break up and check the flow through

FIG. 33.

FIG. 34.

them as much as possible (see Fig. 34). An explanation may be found in the fact that tapers are mostly used for water mains and but seldom for drains. In drainage work taper pipes are but seldom used, as the changes of diameter are usually made in manholes.

CHAPTER IV.

SPECIAL PIPES (*continued*).

DISCONNECTING, SURFACE AND GREASE TRAPS.

Cast-iron disconnecting traps are, happily, not made in such an endless variety of type and form as their earthenware prototypes. Those made are also generally of

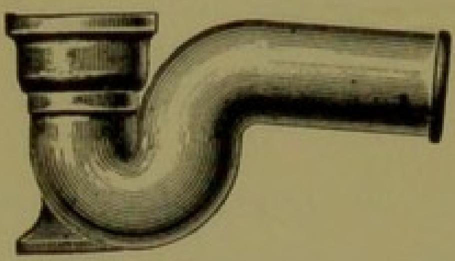


FIG. 35.

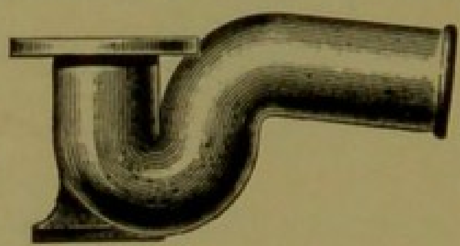


FIG. 36.

sanitary construction and are all simply syphon traps, differing but slightly from each other, and then only in so far as they may be designed for adaptation to some special position and circumstance. Thus, the ordinary

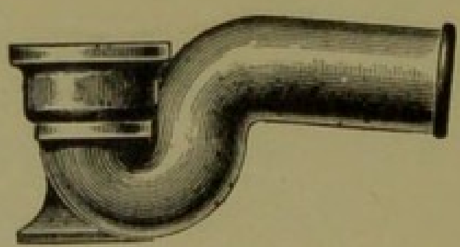


FIG. 37.

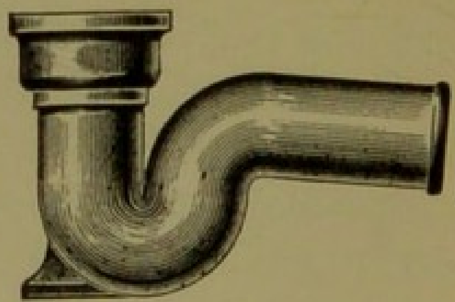


FIG. 38.

syphon trap shown in Fig. 35 may also be obtained with a flanged instead of a socketed inlet (as in Fig. 36), or with a specially low or high inlet as in Figs. 37 and 38 respectively. It is also made with a contracted "throat," as in Fig. 39 to obtain an increased cleansing or scourging action through the trap. Any of the traps are of course obtainable with vertical outlets (S traps), as well as with the horizontal (P traps) shown.

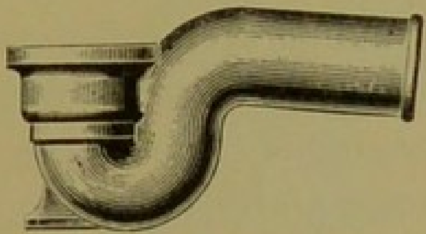


FIG. 39.

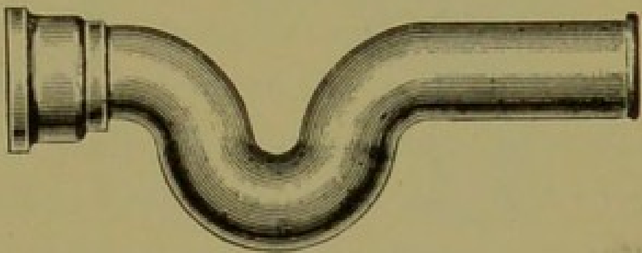


FIG. 40.

The cardinal points to bear in mind in selecting a trap are :—That the type and construction thereof be such as to ensure its self-cleanliness ; freedom from liability to blockage, and the provision of an efficient "seal" with a minimum quantity of water. To obtain these advantages, the interior of the trap must be as small as possible, and perfectly smooth and free from all corners

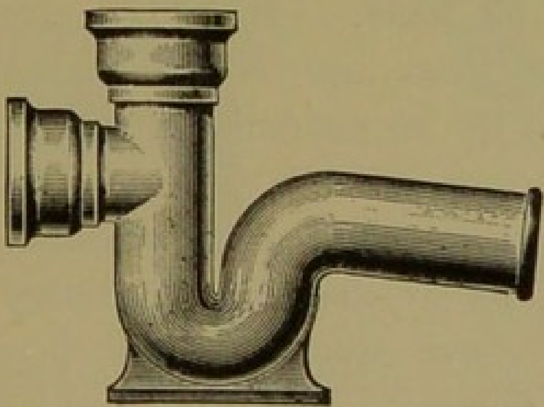


FIG. 41.

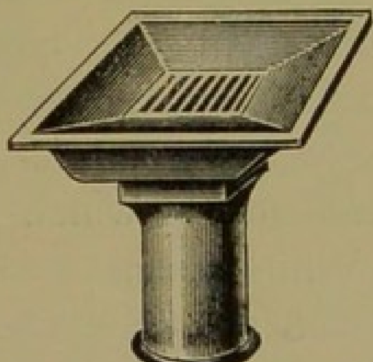


FIG. 42.

and recesses in which sewage may accumulate. The trap must also be void of all mechanism—which is liable to go wrong—and must provide or be capable of being fixed so as to provide a clear drop of at least three inches between the invert of the incoming drain and the surface of the water in the trap. This drop is of the greatest utility in keeping the trap free of deposit, as, in flowing into the trap, the sewage will form a cascade, and thereby break up and drive out all matter which would otherwise tend to collect at the inlet. The "running syphon" trap shown in Fig. 40 is not provided with, and does not admit of such a drop; the flow through it is consequently very sluggish and insufficient in strength to clear the trap, which must therefore be looked upon as insanitary. The trap has a further disadvantage in that it cannot be properly ventilated nor reached for the purposes of cleansing when necessary. These objections do not apply to the modification of the same trap shown in Fig. 41, which is of an excellent type. As will be seen from the illustration, it is provided with a socket, over its inlet, to which a ventilation pipe may be joined, and through which the trap may be reached, and it has also a drop between the inlet drain and the water level. It is properly formed in the interior and does not contain more water than can be changed by an ordinary discharge through the drain. The trap is suitable for drains on the outlet of which no inspection chamber is provided.

Whilst special iron gully traps are made, the ordinary P or S shaped syphon traps above described, and illustrated in Figs. 35 to 39, are generally also made use of for the purposes of surface traps, being readily adapted to all circumstances by fixing above them the gully inlet or branch piece most suitable to each individual case.

Examples of plain gully inlets and gratings for taking surface water from yards, &c., are shown in Figs. 42 and 43, the latter figure showing the inlet fixed to the trap.

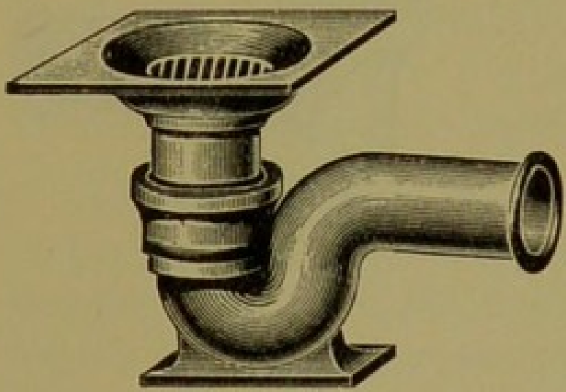


FIG. 43.

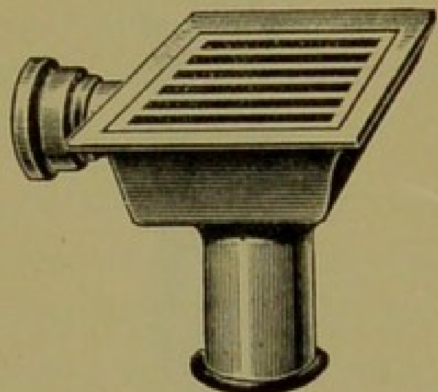


FIG. 44.

Fig. 44 illustrates a similar inlet, which in this case is provided with a side branch, to which may be connected a rain-water pipe or waste-pipe. The same inlet is also made with two, three, or even more branch inlets of any dimension and at any angle or in any position required. Another type of inlet is shown in Figs. 45 to 47. Figs. 45 and 46 respectively show the inlet with a horizontal

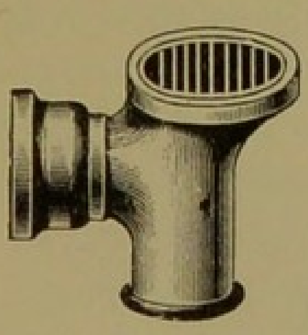


FIG. 45.

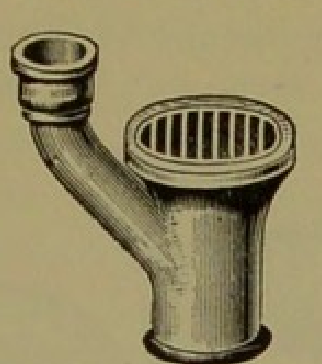


FIG. 46.

FIG. 47.

and a vertical branch. The branches may in this case also be had of various dimensions and number and at any angle. The same inlet is also made without any branches (see Fig. 48), or, as shown in Fig. 47, adapted to receive a channel instead of a pipe branch.

Should it be necessary to fix the traps at some depth from the surface of the ground, the inlets may be con-

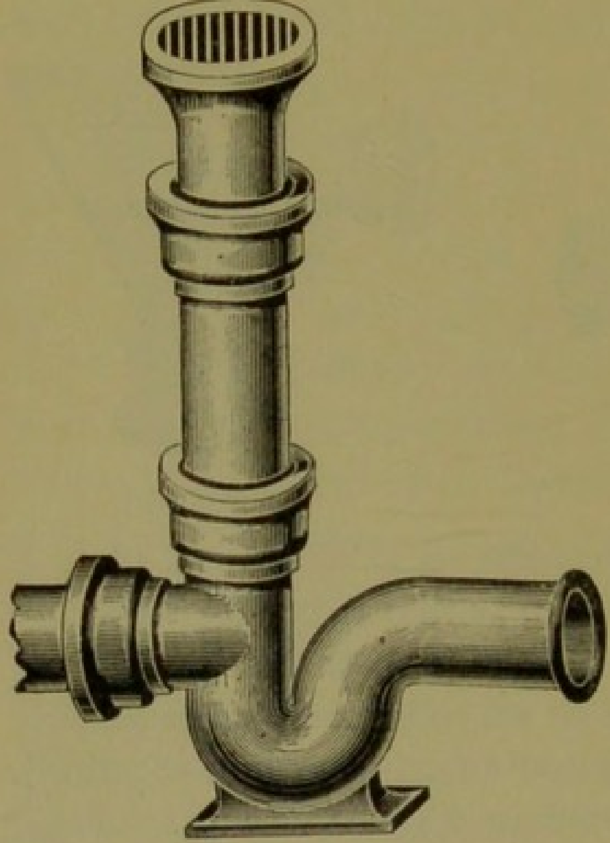


FIG. 48.

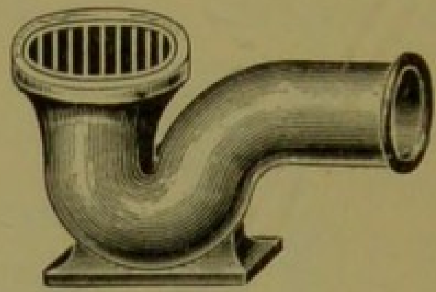


FIG. 49.

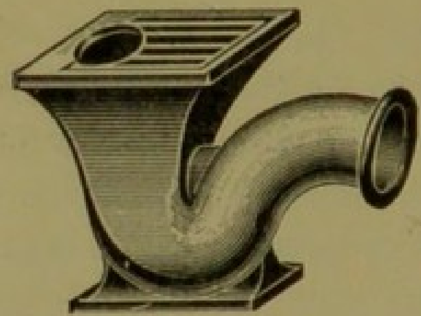


FIG. 50.

nected to them by means of iron piping, as shown in Fig. 48.

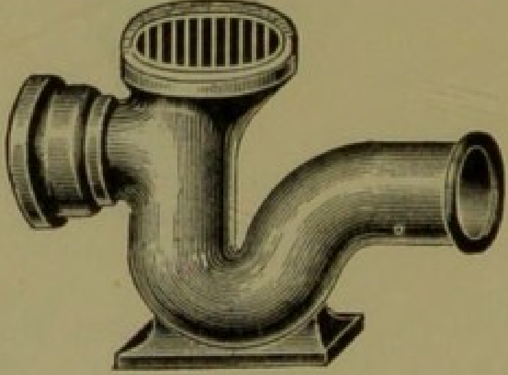


FIG. 51.

Types of specially-made surface traps are shown in Figs. 49, 50 and 51, these being respectively suitable for the reception of surface water drainage, a rain or waste pipe, and a branch drain.

Grease Traps.—Under the head of surface or gully traps must be included grease traps, which although not desirable appliances, nor strictly necessary ones, are nevertheless frequently used.

Two types of the more efficient varieties of grease traps, made of iron and suitable for utilization in connection with cast-iron drains are shown in Figs. 52 and 53. The principle of the traps shown in Fig. 52 which

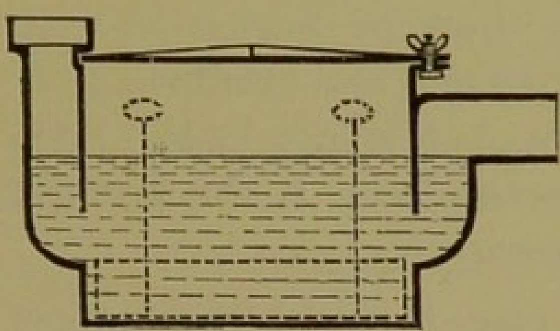


FIG. 52.

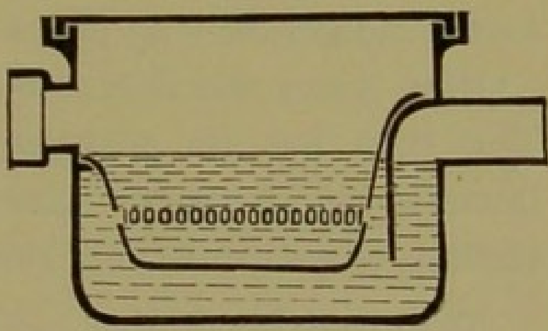


FIG. 53.

is common to nearly all grease-traps, is to admit and remove the waste water to and from the bottom of the apparatus. The grease is thus retained, as it naturally seeks the surface of the water contained by the trap. It is subsequently removed by hand, either by being scooped out or by lifting out the tray with which some of the traps are provided. In the trap shown in Fig. 53, the grease is discharged into a tray which is perforated half-way down. The waste water flows out through the holes, whilst the grease and detritus are retained in the tray.

Fig. 54 illustrates a grease trap which is provided with a water-jacket for cooling the grease immediately after it enters the trap. As will be seen from the illustration, the apparatus consists of two chambers. The inner one

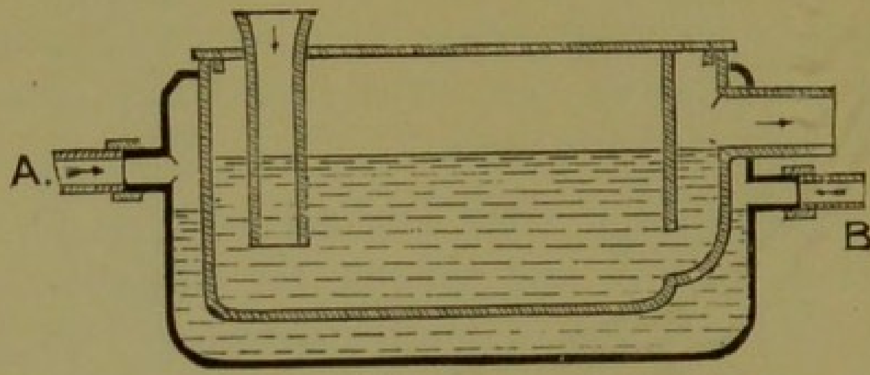


FIG. 54.

forms the grease-trap proper, whilst the outer retains the cooling water which is admitted at A and overflows at B. The trap has its advantages, but is not looked upon favourably by water companies, nor is the artificial cooling of grease strictly necessary.

Flushing-rim Gullies.—In cases in which it is desired to pass grease into the drains, it is necessary to cool and solidify it before it is brought into contact with the drains, as it will otherwise tend to adhere to the sides of

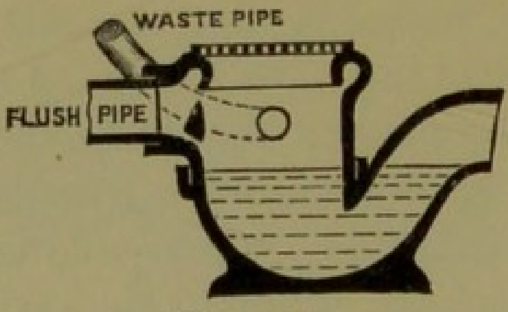


FIG. 55.

the piping and, by accumulating, eventually choke the drains. The trap illustrated in Fig. 55, which is known as a "flushing-rim gully," is designed with this object. Into it the grease is discharged through the waste-pipe as shown, and is retained in the trap for a sufficiently long time to allow of its solidification on the surface of the water contained. From time to time it is then broken up and flushed out of the trap and through the drains by the discharge of an automatic flushing tank or bath whose discharge-pipe is connected to the flushing rim arm.

CHAPTER V.

SPECIAL PIPES—(*continued*).

ACCESS PIPES.

It being an important rule, in well-planned systems of drainage, to provide means of access to all parts of the system, and more especially at such points at which bends and junctions occur, it is necessary to utilise what are usually termed "inspection chambers" or "manholes." These names (derived from the "chambers" or "manholes" usually built on stoneware drains) are, strictly speaking, misnomers, as the appliances here referred to

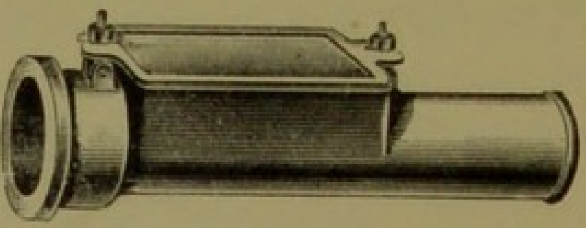


FIG 56

are neither "chambers" nor "manholes," but simply pipes (plain or of special form), to the interior of which access can be had. Their proper names, therefore, are rather "access pipes" or "inspection pipes." "Inspection chambers" or, better, "manholes" should be reserved for the *built* shafts in which it is necessary to fix the access pipes when the drains are underground. These will be discussed in a future chapter. It will suffice to say here that every pipe and connection included in the drainage system (in which are comprised the portions above ground, no less than those below ground) should, if possible, be made accessible throughout. This is necessary for the purposes of cleansing, inspection, and testing, and also for the removal of any stoppage which may occur in the piping. Such obstruction is liable to take place in the best of drains, as various matters—such as brushes, floor-cloths, spoons, and other articles—which cannot be

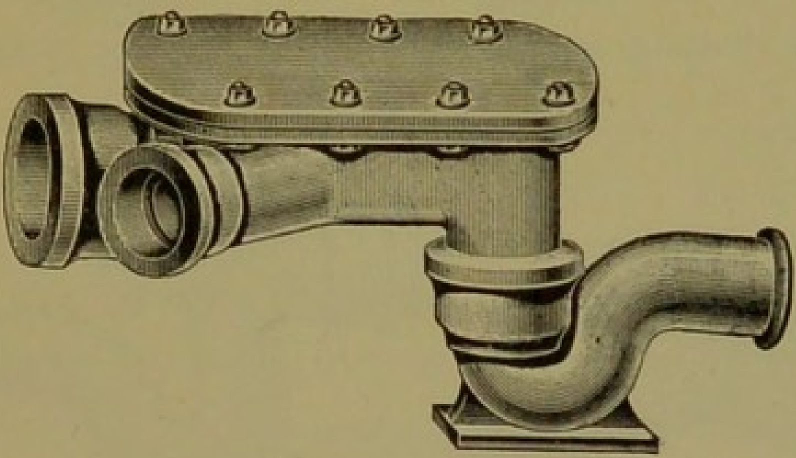


FIG. 57.

removed by mere flushing, occasionally find their way into the drains and their connections.

Types of access pipes suitable for horizontal drains are shown in Figs. 56—61, the pipe shown in the last-named illustration being shown with its cover removed. The chief points to be considered in regard to such pipes are that their interiors be so formed as not to provide any nooks or corners for the accumulation of sewage, and that their covers be air-tight. The latter is dependent upon the construction of the cover and the means adopted for closing it.

The covers of inspection pipes are usually so constructed that the walls round the opening on the pipe fit into a U-shaped groove round the rim of the cover (see Fig. 62). Sometimes the groove is provided on the pipe (as in Fig. 63); whilst, less frequently, both the cover and the opening are, as in Fig. 64, made with flat edges. In any case the joint is made air-tight by the aid of suitable and lasting packing—such as asbestos or vulcanised india-rubber.

The means adopted for compressing the packing (thereby making an air-tight joint) and for keeping the

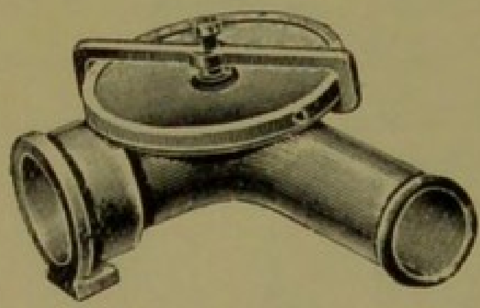


FIG. 58.

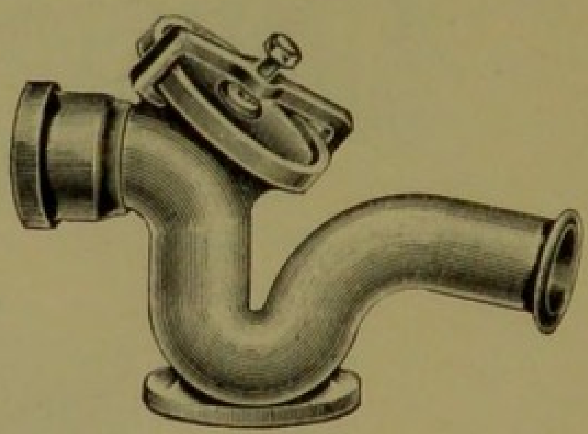


FIG. 59.

covers in place, are, usually, either a lever-locking gear, a bridle and pinching screw, or bolts.

The lever-locking gear, as applied to the pipe, is shown in Figs. 60 and 61, and in detail in Fig. 65. It consists of a hinged iron bridge piece, fixed to the pipe and laid across the cover, in which works a lever whose lower end is shaped as a cam. By depressing this lever sufficient pressure is exerted to ensure an air-tight joint. The arrangement, it will be seen, is extremely simple, and such as cannot get out of order. Where adopted, the covers are easily removed and equally quickly replaced and made air-tight.

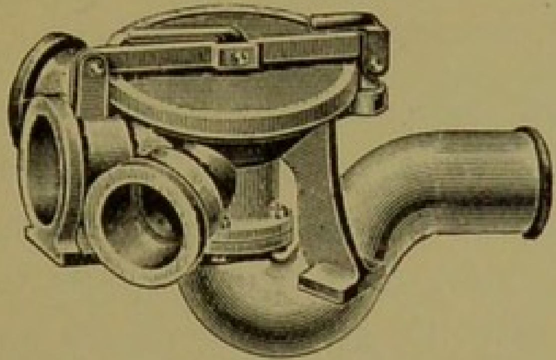


FIG. 60.

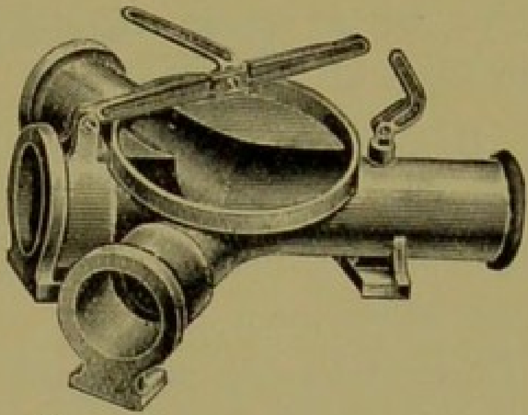


FIG. 61.

The application of the bridle and pinching screw to the pipe cover is made clear by Fig. 66, in which the appliance is shown in detail. Where used, the necessary pressure is obtained by screwing up the screw, or bolt, in the centre of the bridle. The arrangement answers its purpose well

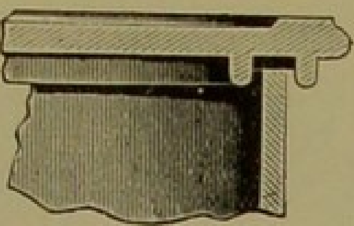


FIG. 62.

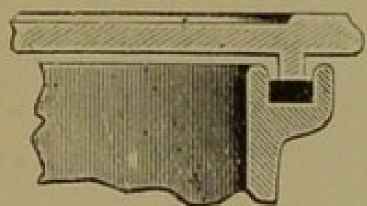


FIG. 63.

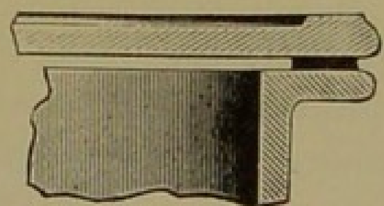


FIG. 64.

if the bolt is made of gun-metal or other non-corrosive material. An iron bolt should never be used, as its metal is liable to rust. Should the bolt be so attacked, it is very apt to rust into the bridge-piece and defy all attempts at unscrewing. The bridle and screw, as applied to the pipe, whose cover need not of course be round, is shown in Figs. 58 and 59.

Bolts, as a means of fixing covers to their access pipes (see Fig. 57), cannot be recommended, as it is obviously a tedious and unsatisfactory job to unscrew half a dozen, and often even a dozen or more, nuts before access is obtained to the pipe, and then to screw them all on again ; especially if the bolts are loose and have to be removed from and then again inserted into their holes.

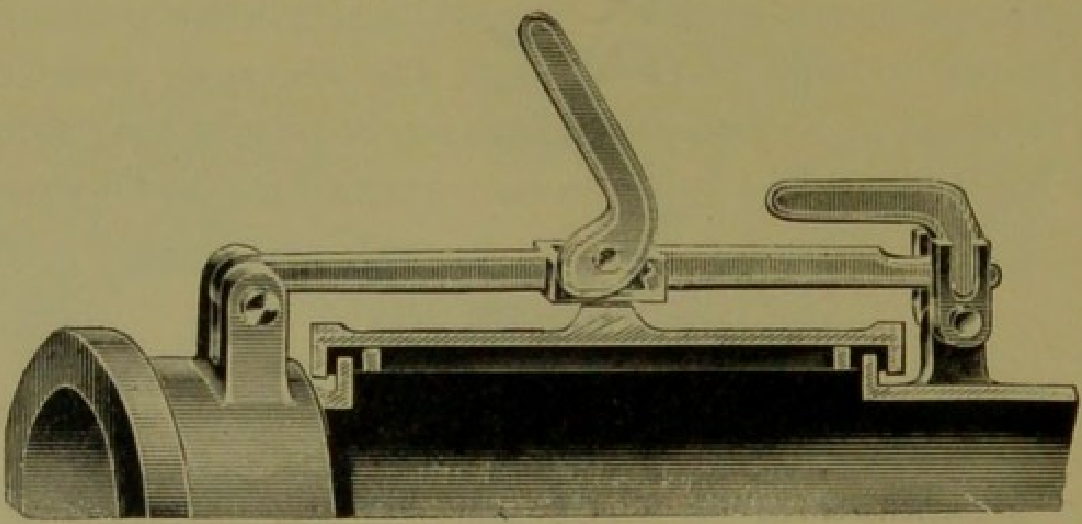


FIG. 65.

If bolts *are* used, they should be as few as possible in number. Two—one at each end—are usually quite sufficient for an ordinary cover if suitable packing material is used for making the joint. For reasons already stated, the bolts should of course also always be made of non-corrosive material. Galvanised iron bolts are not sufficiently satisfactory, as the smallest flaw in their coating may, so to speak, prove to be the beginning of the end, by providing a weak spot at which rust can

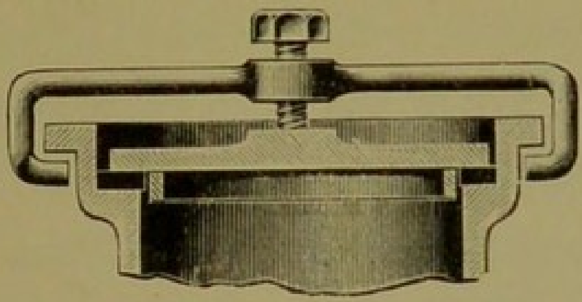


Fig. 66.

commence its attack. If bolts are used they should preferably also be arranged as shown in Figs. 56 and 67. As will be seen from these illustrations, the bolts are hinged to the pipe and pass through slits (as opposed to

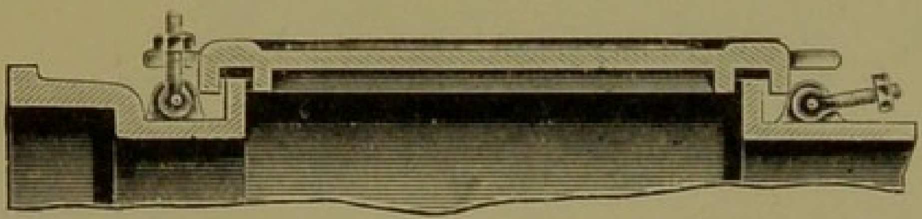


Fig. 67.

holes) in the ends of the cover. Hence it is not necessary to remove the nuts, but simply to loosen them. The bolts may then be bent over (see Fig. 67) and so withdrawn from the cover. The latter is thus free to be removed ;

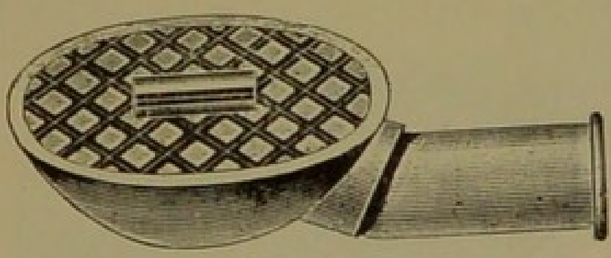


Fig. 68.

whilst its subsequent replacement and screwing up is also quickly accomplished.

As will be seen from the illustrations (Figs. 56 to 61), inspection covers can be adapted to any shape or form of bends and junctions and to disconnecting traps. The more usual forms of access pipes are stocked by manufacturers, whilst those of special patterns can be cast and supplied at short notice.

An access pipe somewhat different from those already described, but which is also intended for underground drains, is shown in Fig. 68. This is commonly known as a "terminal," and is fixed on "blind ends" (left for future

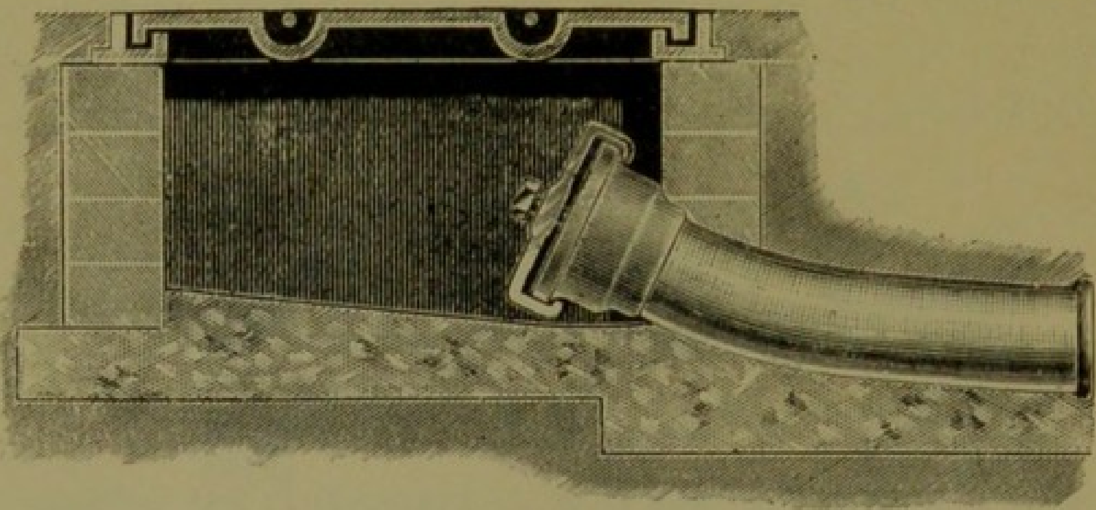


FIG. 69.

connections) or at the head of drains. As will be seen from its cover, it is intended to be fixed at the ground level. Whilst the appliance is satisfactory so long as its

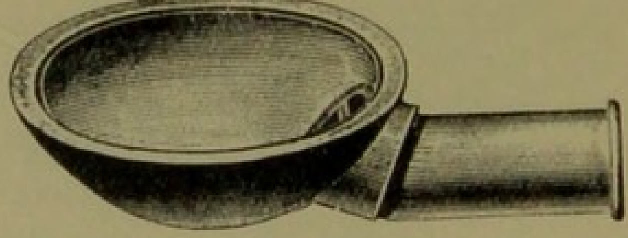


FIG. 70.

cover is air-tight, the joint between the cover and the rim of the opening, which is usually made with tallow, is obviously inferior to the joints of the access pipes already described. Not only is the jointing material more perishable, and the cover exposed and liable to be displaced, but there is also the strong probability that the tallow will not be renewed or replaced on occasions when it has been found necessary to remove the cover of the

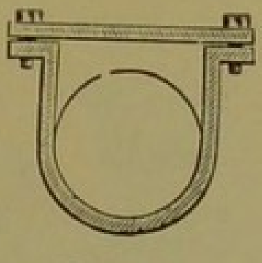


FIG. 71.

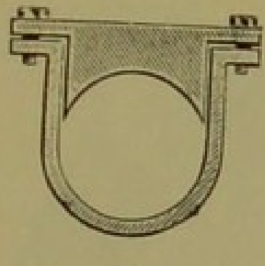


FIG. 72.

terminal. A weak point in the drainage system is thus provided. It is therefore preferable to fit "blind ends" with a cleansing eye similar to those which will be described for piping fixed above ground and to provide access thereto by means of a small brick chamber fitted

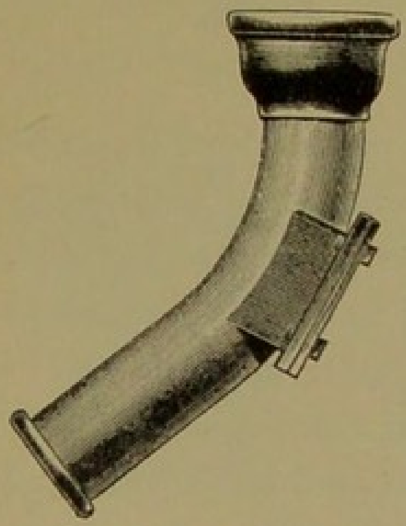


FIG. 73.

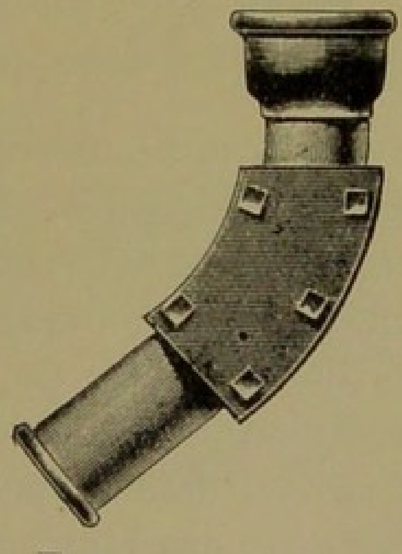


FIG. 74.

with an ordinary manhole cover (see Fig. 69). The "terminal" can, of course, also be utilised if an air-tight cover is provided over the mouth of its outlet as in Fig. 70.

Access pipes which are intended for vertical piping should be provided with covers whose interior is so formed that the pipe will remain cylindrical throughout. Should the reverse be the case, the flow within the pipe would be broken up and a space provided for the accumulation of sewage. Fig. 71 shows this evil, and Fig. 72 the precautions which should be taken to avoid it. The

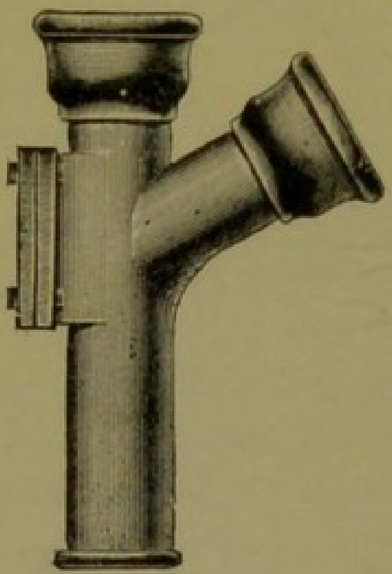


FIG. 75.

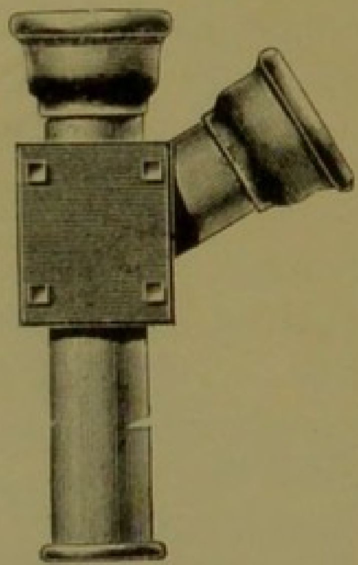


FIG. 76.

covers, or rather the openings in the pipes, should also be as small as possible. They must, of course, be sufficiently large to allow of the access for which they are provided, but need in no case be as large as the openings in horizontal piping; for, whereas the latter are provided in order that the whole of the interior of a drain, or possibly of several drains, may be reached, openings in vertical piping are generally only intended to provide access to a particular point or portion. Hence the names "sweeping eyes" and "inspection eyes" which are frequently applied to them. If made at the proper point, the size of such openings can usually be restricted to a minimum.

This is readily seen by comparing the access pipes (bends) shown in Figs. 73 and 74 respectively. These remarks must not, however, be taken to imply that Fig. 74 illus-

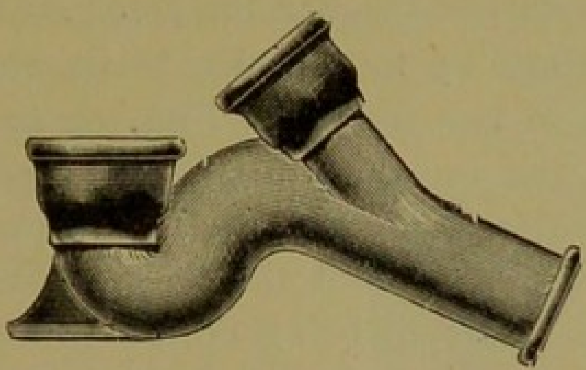


FIG. 77.

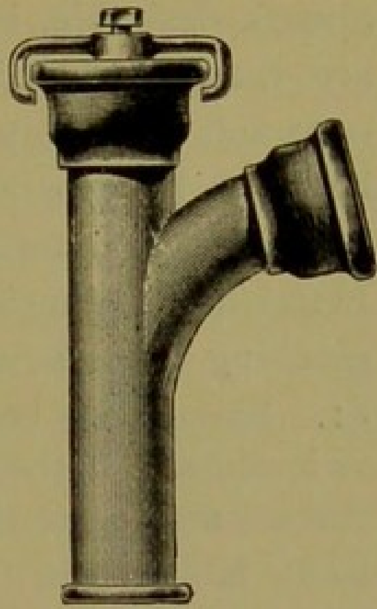


FIG. 78.

trates a bad form of access pipe. On the contrary, there are positions in which the use of this pipe would be imperative, and that of the pipe shown in Fig. 73

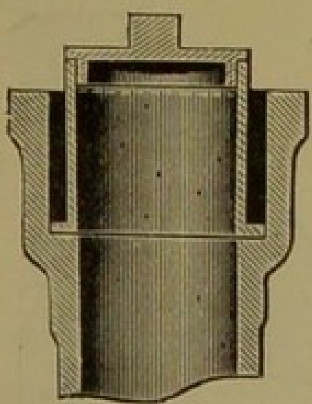


FIG. 79.

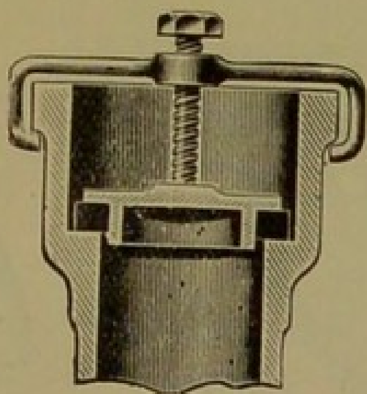


FIG. 80.

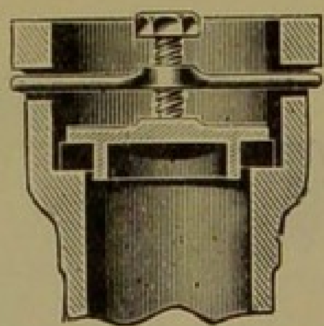


FIG. 81.

impossible. Other forms of inspection pipes are shown in Figs. 75 and 76.

Means of access to special points are also frequently provided by means of extra sockets in the piping (such as in Figs. 77 and 78) in which are sometimes bedded brass sleeve pieces with screwed caps, as shown in section in Fig. 79. These means of closing the openings are not always desirable, however, as the various metals which are thus combined—iron, lead and brass—expand and contract unequally; the sleeve pieces and caps being liable to become loosened in consequence, should both cold and hot water be discharged through the pipe. It is better to close such openings by means of a bridle and pinching screw as shown, in two forms, in Figs. 80 and 81. Should this be done, the cap used should be shaped as is shown in the illustrations, in order that a portion thereof may enter the pipe and prevent the packing-ring from falling into the pipe or from being otherwise displaced. The bridle shown in Fig. 81 is removed from the socket by sliding one of its ends through the socket wall, and then withdrawing the loose end through the mouth of the socket.

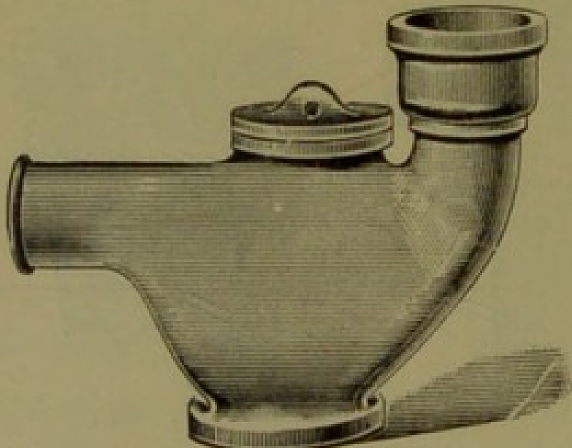


Fig. 82.

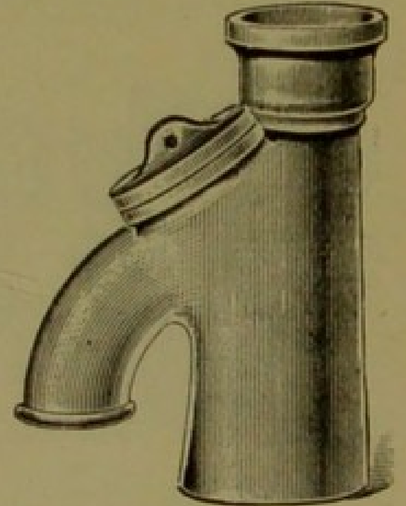


Fig. 83.

Rust Chambers.—These are a species of access pipes which are, or should be provided at bends in iron ventilation pipes. It is a common experience that the latter, even though properly protected on the interior surfaces, are liable to rust. Hence, as the pipes do not as a rule receive a proper flush of water in their interior, the scales of rust, as they peel off, fall down the pipes to the nearest bend, there to accumulate and in time block the pipes. Rust chambers should therefore be fixed at all points on which an accumulation of rust is liable to take place; the object of the appliances being to provide a recess or pocket into which the rust may fall, and to a certain extent accumulate, without restricting the sectional area

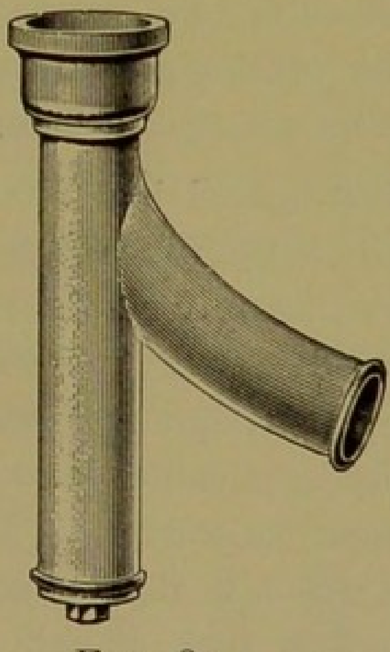


FIG. 84.

and efficiency of the ventilation pipe. Each pocket must, of course, be provided with an access cover (capable of being closed hermetically), through which the accumulations can at intervals be removed. Various forms of rust chambers suitable for different positions are shown in Figs. 82 to 84. Other shapes can be made to suit specific circumstances.

CHAPTER VI.

DRAIN LAYING AND PIPE FIXING.

LAYING DRAINS.

In laying, or, more correctly, in constructing, the underground portion of the drainage system—made up for the most part, of the pipes and appliances described in the preceding chapters—the two points requiring especial attention are :—the jointing of the various parts and the proper support of the whole structure.

Of these, the first-named has already been touched upon in the second chapter, in which details are given of the various joints commonly made use of for iron pipes. Of the joints there described, preference is given to the ordinary caulked lead spigot and socket joint, as being the most generally applicable, least expensive and, on the whole, the most satisfactory. As a matter of fact, it is also the joint which is almost exclusively adopted in drainage work and, as such, it will be sufficient if the following details of drain-jointing are confined to a description of that particular joint.

To make the joint, it is a very ordinary practice to place a few strands of oakum or gasket all round the spigot end of the pipe, after the latter has been inserted in the socket of the next pipe, and to caulk the oakum into the bottom of the socket so as to prevent the molten lead, of which the joint is made, from running into the interior of the pipe. Should this yarn or oakum be used it should be steeped in red lead or tar, which will tend to preserve it and also help to make a good joint, as the heat of the molten lead will turn it into a jelly and hermetically seal the joint. Being an organic substance, the oakum is, however, very liable to decompose and disappear, and if this occurs, a space is left at each joint in which accumulations of sewage may be retained. These, in decomposing, will give off noxious gases. Whilst it lasts, moreover, the oakum provides a very suitable nidus for the retention and propagation of bacteria, and this is a matter for serious consideration owing to the danger which would arise should pathogenic bacteria find its way into the drainage system. It is, therefore, better to dispense with the oakum altogether and to substitute lead rope (sold for the purpose) or split cast-lead rings, either of which may be caulked into the socket of the pipe in the same way as the oakum or gaskin.

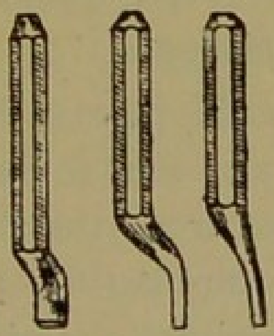


FIG. 85.

When the joint has been thus prepared a roll of well-tempered clay is placed round the socket of the joint in order to provide a mould for the molten lead, which, when cast, should project slightly beyond the face of the iron socket. When the molten lead has been poured into the joint the clay is removed and the lead caulked, whilst cooling, by means of caulking tools—such as shown in Figs. 85 and 86—and a stout hammer.

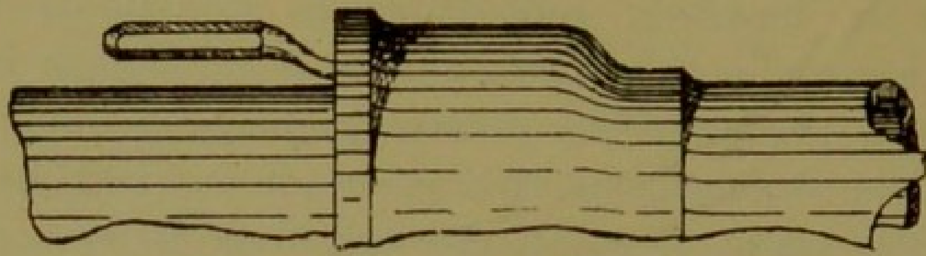


Fig. 86.

In small joints, in which comparatively little lead is used, the lead should be run in very hot, so that it may not be cooled by contact with the cold iron surfaces before it has had time to fill the socket completely. When much lead is used it is, however, better to pour it in only moderately hot, as the hotter the lead is the more it will expand, and the greater, consequently, will be the contraction on cooling. This might be so considerable that the socket of the pipe would be only partially full when the joint was finished.

Before being laid, each pipe should be tested as to its freedom from cracks and similar defects which may have been caused in transit from the foundry to the works. This may be done by tapping the pipes with a hammer. If a jarring sound is emitted the pipe will be found to be faulty; if, on the other hand, it "rings," the pipe will be found to be sound.

Should the socket of a pipe split in the process of caulking the joint, the pipe should be immediately removed and a sound pipe substituted, as all patching will be found unsatisfactory or as costly as a new pipe if done properly.

Should it be necessary to cut a pipe to a required length care must be taken that the end is left clean and even so that it may fit closely against the bottom of the socket to which it is to be jointed. The effect and evil of a ragged and uneven end will be apparent on reference to Fig. 87, from which it will be seen that the continuity

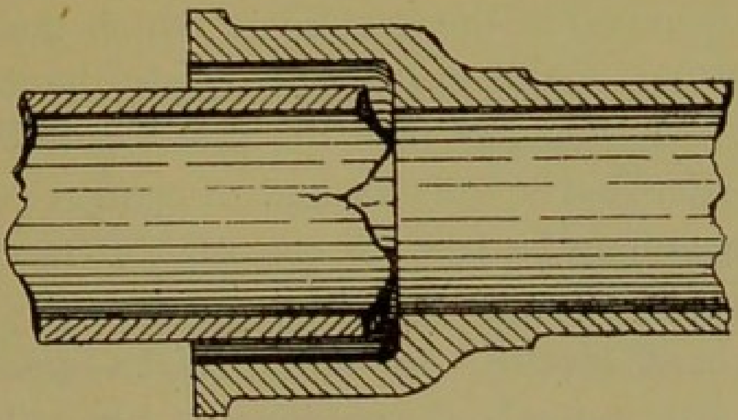


Fig. 87.

of the inner surfaces of the finished drain will be broken and permit sewage matter to be caught and retained. The probability is also that some of the jointing material will find admittance to the interior of the drain when the joint is being made and either remain there or prove difficult to remove.

When a pipe has been cut, it is also a wise precaution to well paint the surfaces of the iron exposed at the cut with red lead or gold size or some other similar solution, which should also be applied to the interior of the pipe to a distance of a few inches in order that the iron may be protected against rust if, as is possible, the protective coating of the pipe has been slightly damaged in cutting.

It has already been stated in a preceding chapter, when treating with means of access to the various portions of the drainage system, that underground drains must be laid perfectly straight from manhole to manhole, both in direction and inclination. In order to do this efficiently, it is necessary that the trenches in which the drains are to be laid should be excavated, not only true in line, but also with an even and regular fall, and that the bottom of the trench be perfectly smooth. And according to the firmness of the ground in which the trench is cut, the bottom of the trench should also be made from four to six inches deeper than the invert of the proposed drain, in order that a suitable bed of cement concrete of that thickness may be laid for the support of the pipes. This concrete having been filled in and carefully smoothed and levelled to the required gradient and provided with suitable depressions or "hand-holes" at the proper points for the reception of the sockets (in order that the pipes may be supported throughout their length—instead of upon their sockets only—and also to permit of the making of the joints), the drains are laid, and, as soon as securely jointed, their sides haunched up with concrete, as indicated in Fig. 88.

The foundation of concrete (which should project at least six inches on each side of the drains) is necessary in order to secure absolute rigidity for the drains, and to reduce to a minimum all chances of breakage through the settlement of the soil. In exceptional circumstances the concrete bed may have to be made thicker, or, on the other hand, may be safely dispensed with. Its provision is nevertheless a desirable safeguard in all cases. In positions in which the drains are laid at but a small depth from the surface of the ground and exposed to heavy traffic above them, or when laid near underground railways or in other positions in which they would be exposed to considerable vibration, it may also be desirable to cover them, and to completely encase them in concrete to a distance of six inches all round, as shown in Fig. 89.

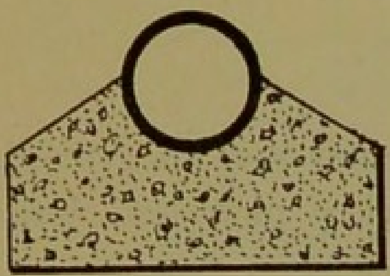


FIG. 88.

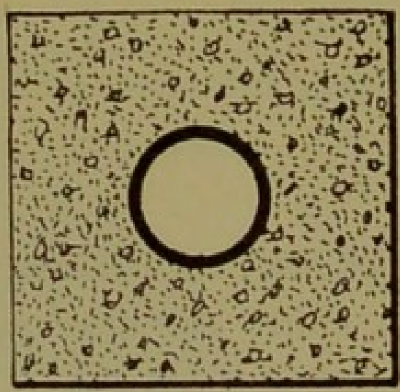


FIG. 89.

Where a drain passes through or under a wall, a relieving arch—of which two forms are shown in Figs. 90 and 91—built in cement should be turned over the drain, in such a way as to leave a clear space of a few inches round the pipe and concrete, in order to prevent such damage as might be caused by a possible settlement of the wall. A similar purpose will be served by a relieving girder built into the wall and properly supported.

Although the above-mentioned method of laying drains is the simplest and most usually adopted, the material of which iron drain-pipes are made, and their rigidity and capacity to resist fracture, render it possible to so fix the

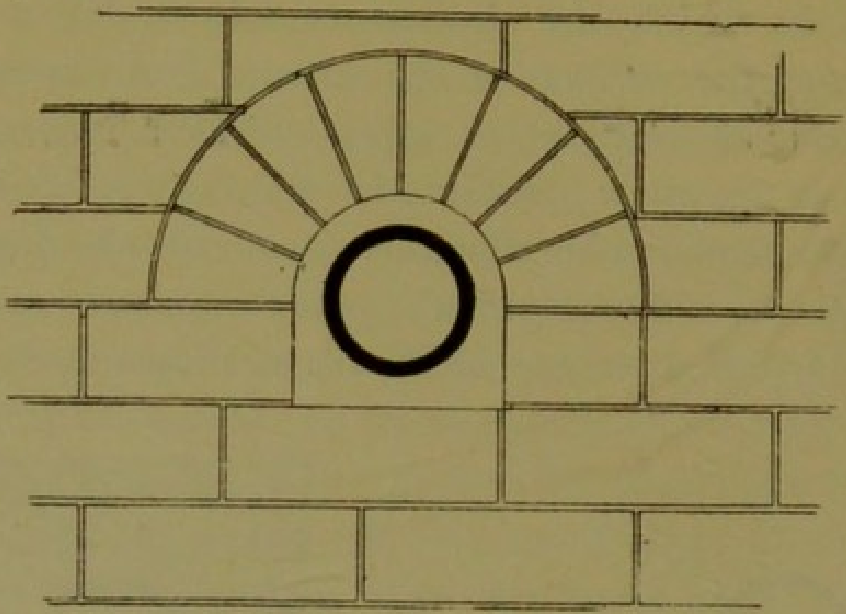


FIG. 90.

pipes that, even though beneath the surface of the ground, the entire drainage system, and every pipe and joint

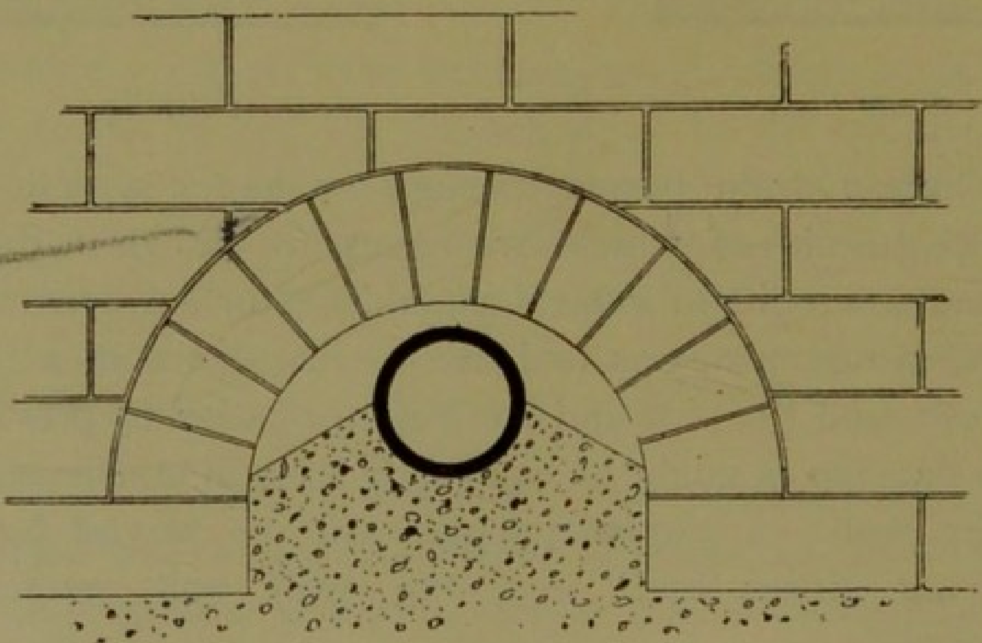


FIG. 91.

comprised by it, is rendered visible and accessible, both in the interior and the exterior of the drain, at all times.

Where this system is adopted, every pipe and joint may be periodically inspected, and repairs and alterations carried out without the necessity of inconveniencing the household by more or less extensive excavation of the ground.

The system consists of laying the drains in culverts or or channels constructed beneath the level of the ground, as indicated in Fig. 92. This particular illustration shows the manner in which the present drains of the London Foundling Hospital have been laid. In this case the old brick sewers, which formerly acted as "drains" for the institution, were utilised after having first been thoroughly

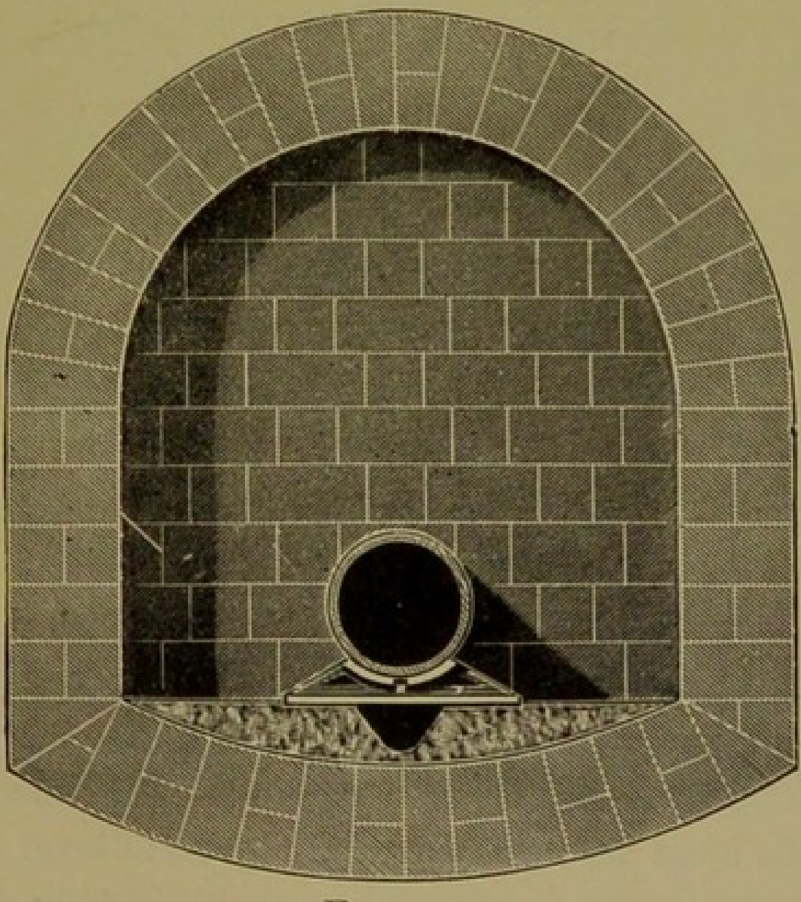


FIG. 92.

cleaned, disinfected, and whitewashed. In these culverts, which are sufficiently high to permit a person to walk through fairly comfortably, the iron drains were laid upon cast-iron chairs fixed on the invert of the old sewers ; a channel being formed underneath them to take away surface and drip water. This channel, it need hardly be said, is separately and efficiently disconnected from the drain into which it eventually discharges, and by which it is connected to the public sewer. A similar arrangement has been adopted for the drainage of the Houses of Parliament and other important buildings.

In smaller buildings, where no such sewers exist, and where the cost of specially-built culverts would be prohibitive, a similar purpose will be served by the

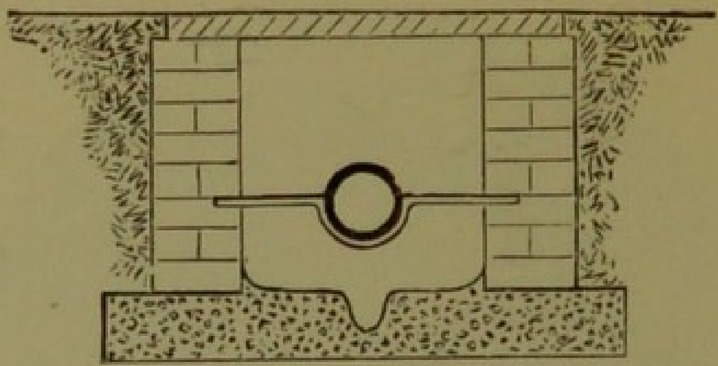


FIG. 93.

construction of brick channels. These may be about 2ft. 6in. or 3ft. in width, and of a suitable depth, and may be formed of two brick walls upon a floor of concrete, as indicated in Fig. 93. In these the drains may be laid upon iron chairs, or, as is shown in the illustration, upon suitably-shaped wrought iron bars built into the walls on either side of the channel. The channels, it need hardly be added, must be covered at the ground level by loose slabs, plates, or gratings, which may be readily removed when it is desired to inspect the drains.

Whether channels or culverts be made use of, they should be arranged to extend throughout the whole length of the building which it is desired to drain, and allowed to communicate with the external air at both ends. This ensures a current of fresh air from end to end of the culverts and all round the outside of the drain-pipes. Should such a mode of construction be impracticable, other means must be provided for ventilation.

It occasionally so happens in town houses, and more especially in the case of business premises, or of ware-

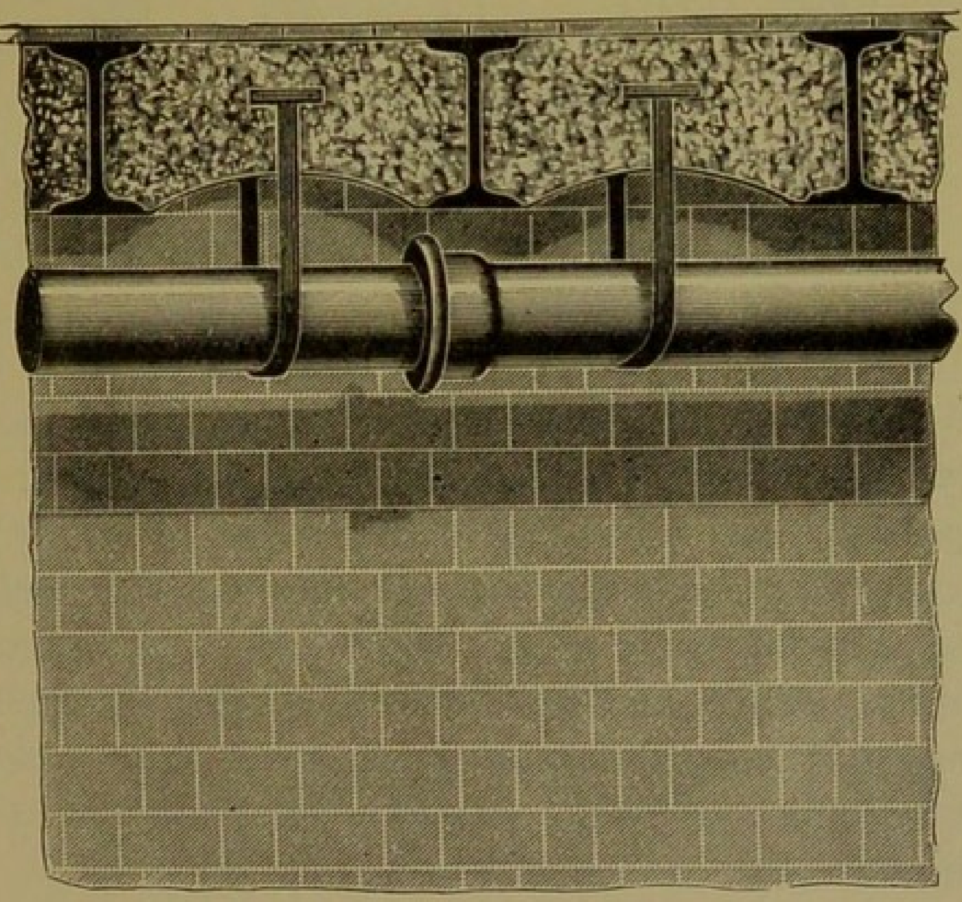


Fig. 94.

houses with deep storage cellars, that the lowest floor of the building is at a considerably lower level than the public sewer in the street. In such circumstances it is manifestly impossible to lay the drains underground, and the difficulty may be solved by laying them over the floor, or by suspending them from a ceiling or on the side of a wall. For such eventualities cast-iron drains are eminently suitable.

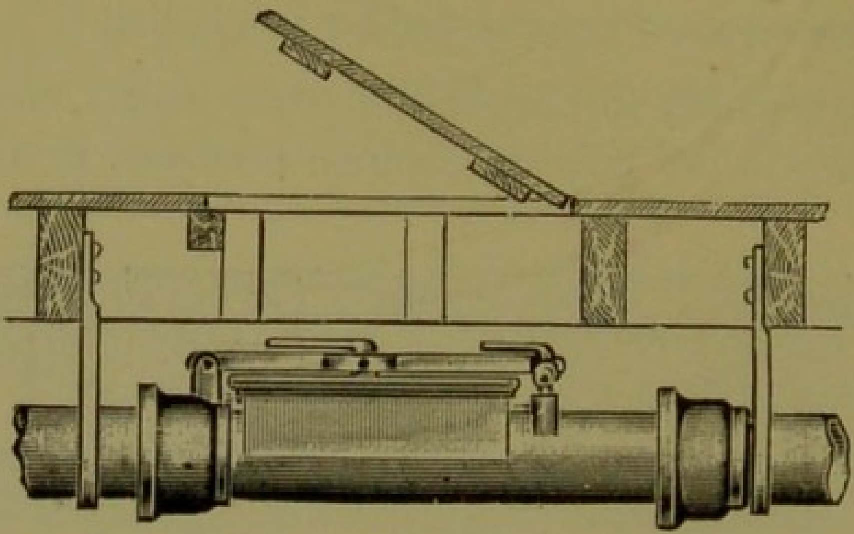


FIG. 95.

If laid over the floor, the drains may be supported upon brick or concrete piers of suitable height. If suspended, they may be held in position by strong iron brackets (Figs. 96-8 and 94) built into walls or ceilings. Figs. 94 and 95 show drains which have been suspended from the ceilings, and it will be noticed from the last-named that access to inspection chambers on such drains may be obtained by the provision of trap-doors in the floor above.

All drains, unless supported throughout their length, should be provided with means of support at, at least, every socket. The supports, moreover, should be placed upon the lower edge of the socket in order that the piping may be prevented from slipping. An occasional iron strap laid over the drain and bolted down upon the chair or bracket upon which the drain is laid will also prove advantageous for the proper fixing of the drain-pipes.

CHAPTER VII.

DRAIN LAYING AND PIPE FIXING (*continued*).

PIPE FIXING—TESTING.

When the pipes of which the drainage system, or any portion thereof is made up, are fixed against walls, either horizontally, as in the case of drains, or vertically, as is the case with soil, rain, waste, and ventilation pipes, the piping should invariably be arranged to project some two or three inches off the face of the wall. This will prevent the accumulation of dust and débris which would otherwise take place in the recesses formed between the pipes and the walls and, at the same time, allow all parts of the piping to be visible and accessible for inspection, painting, &c. The making of the joints at the time of fixing or of repairing them subsequently, if necessary, will thereby also be greatly facilitated, as

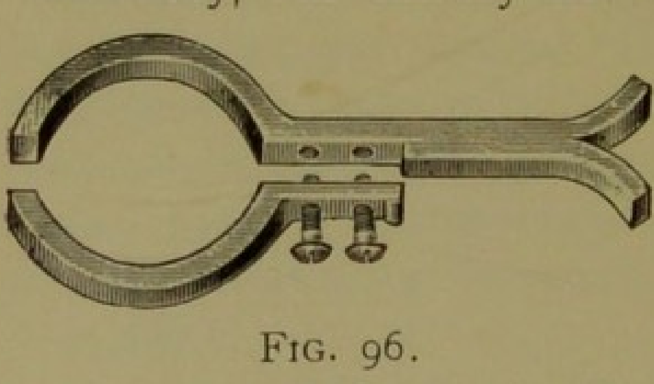


FIG. 96.

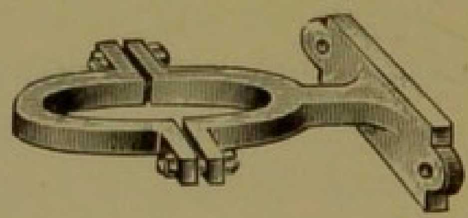


FIG. 97.

sufficient "hand room" will be provided to obviate the necessity of cutting into the walls. When choosing appliances for fixing and supporting the pipes, these objects must, therefore, be kept in mind.

Clips and brackets for the support of iron piping are made in great variety of form, and may be fashioned to suit any given purpose. They should, however, in all

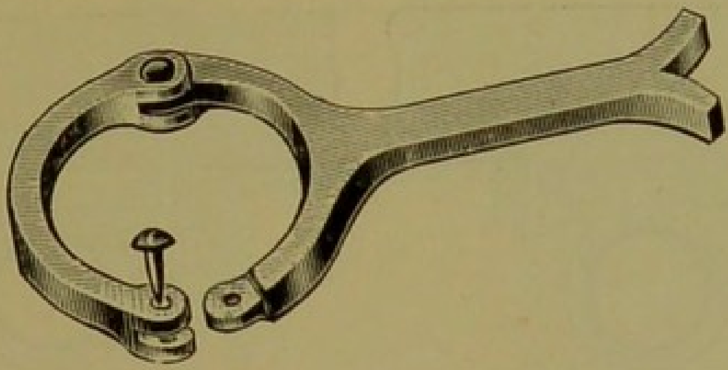


FIG. 98.

cases, be strong; and preference should be given to those which will permit the pipes to be detached if necessary. Examples of such are given in Figs. 96, 97 and 98. It is also desirable that the clips should not grip the piping too firmly, but that they should rather have a tendency to permit the pipes to rest upon them by their sockets, under which the clips or brackets, as the case may be, should be fixed. If—as is occasionally the case even with the heavy iron piping used for soil pipes—the pipes should be provided with "ears" at their sockets, they may be fixed so as to project from the walls by providing blocks of hard wood between the pipe ears and the walls, as indicated in Fig. 99. A similar object may be attained by passing the nails, by which the pipes are fixed, through short lengths of wrought-iron tubing as shown in Fig. 100.

The system of fixing pipes in such a way as to stand clear of the walls may be adopted with equal advantage in the case of vertical lead pipes, which, as will be gathered from the next following chapter, frequently occur even where cast iron is made use of in the construction of the drainage system. Lead pipes may be so

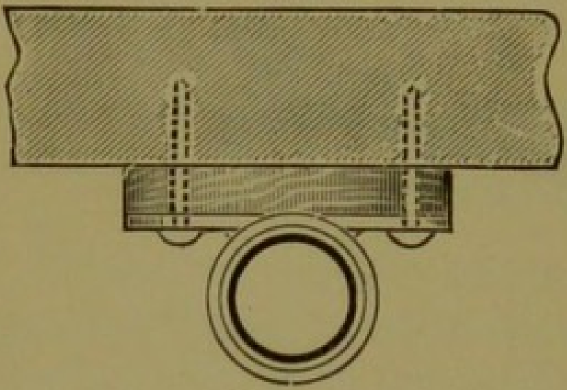


FIG. 99.

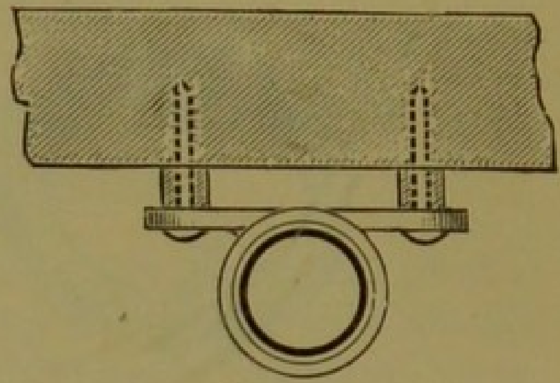


FIG. 100.

fixed by making use of some such brackets as are shown in Figs. 101 and 102. It will be seen that these brackets are flat on the top and provided with a circular opening through which the piping is passed, and it may be added that the diameter of the opening should be slightly larger than the outside diameter of the piping for which it is required. This latter is not only necessary for convenience in fixing, but also—and this is of greater importance—in order to permit the pipe to expand without injury when heated by the sun or by the flow of hot water through it.

In fixing the pipes, should a joint occur at one of the brackets, the lower pipe may be tafted over the bracket and a flanged or block joint made. By this means a support for the pipe will be provided in making the joint. At any other point at which support is required a strong lead collar may be wiped to the pipe in order to form a flange on which the pipe may rest. This is indicated in Fig. 103, which shows a lead pipe fixed by means of these brackets. In order to efficiently support and securely fix the pipes, it may be added, the brackets should not be fixed more than five

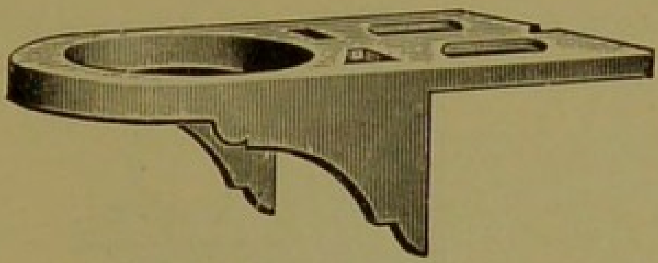


FIG. 101.

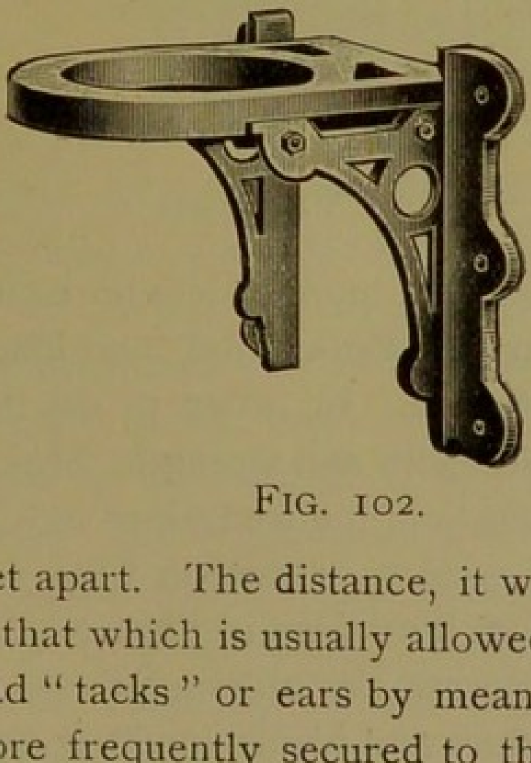


FIG. 102.

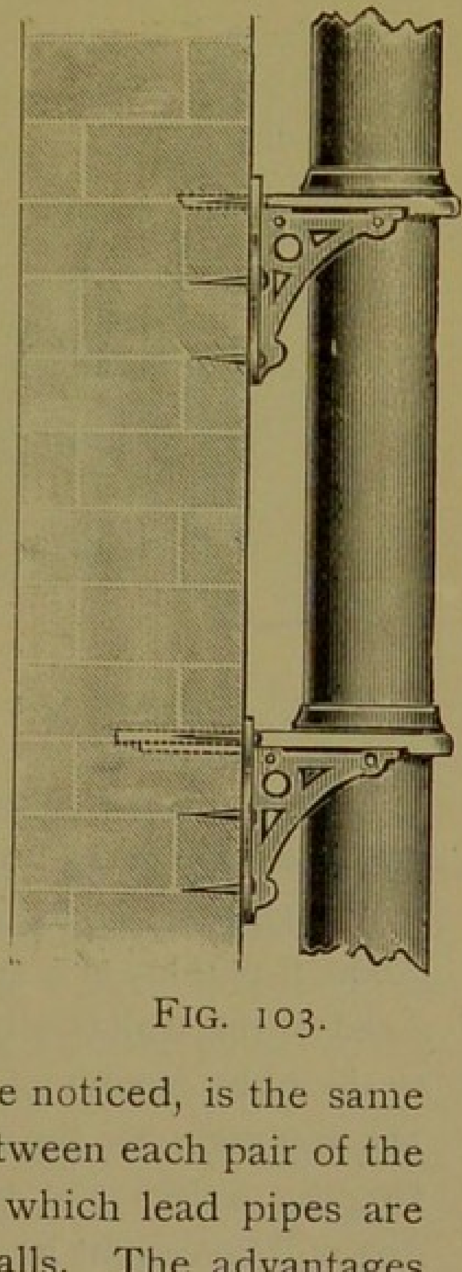


FIG. 103.

feet apart. The distance, it will be noticed, is the same as that which is usually allowed between each pair of the lead "tacks" or ears by means of which lead pipes are more frequently secured to the walls. The advantages which are derived from fixing lead pipes upon brackets as against making use of lead "tacks," are not, however, merely confined to keeping the piping off the walls. In addition, as will be obvious, the pipes will be supported equally all round their periphery instead of being hung from the back only ; the danger of the piping tearing away from its supports being thereby avoided.

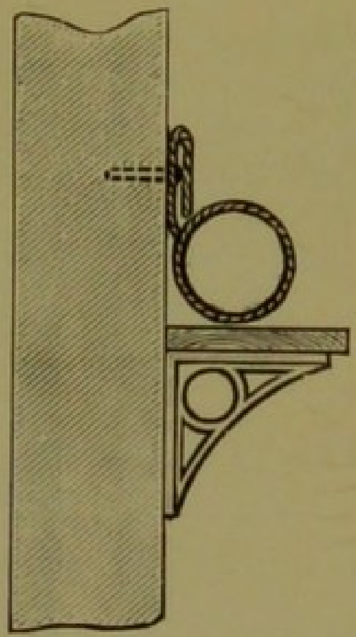


FIG. 104.

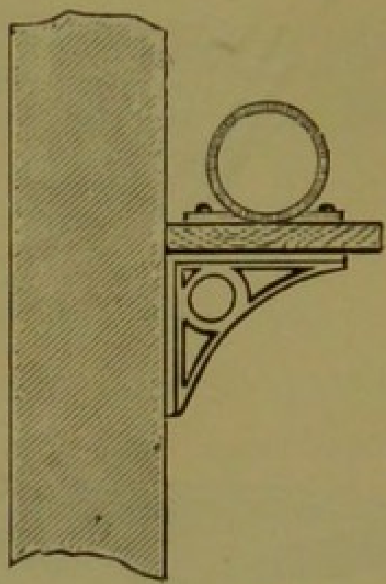


FIG. 105.

Lead pipes which are fixed in a more or less horizontal position require to be supported throughout their length if "sagging" is to be avoided. In order to do this, wooden planks, of a suitable width and strength, must be fixed to the walls by brackets, and the lead pipes secured to them by means of lead tacks as shown in Figs. 104, 105 and 106. Of the methods illustrated in Figs. 104 and 105, the latter is to be preferred, for although dust and dirt will be caught by the pipes and planks in either case, the last-named arrangement is the one which lends itself best to cleansing by hand. The pipe will also be more accessible for repairs and inspection than were it fixed as indicated in Fig. 104.

The above remarks are, of course, chiefly applicable to long pipes such as soil and ventilation pipes and waste pipes from the upper floors. Short waste pipes, as, for instance, that from a basement sink, which is merely carried through the outer wall and then arranged to discharge into a gulley trap outside, will be sufficiently well fixed, in the orthodox manner, with suitable lead

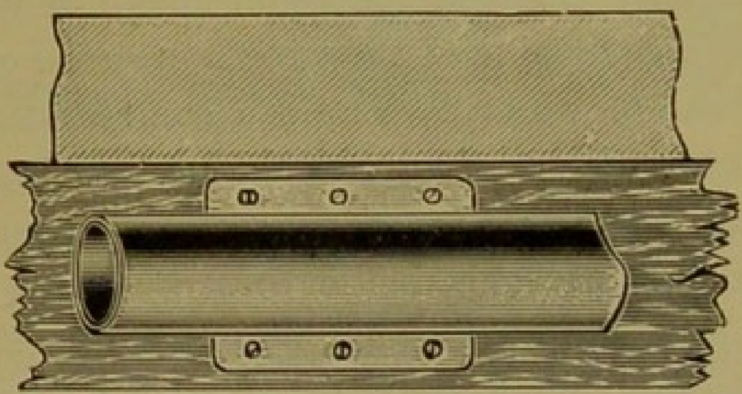


FIG. 106.

tacks. Whatever mode of fixing is adopted, however, all nails or spikes made use of for securing the supports of the pipes to the walls must be driven into the *horizontal* joints of the brickwork. If driven into the vertical joints, the mortar will crumble beneath them so soon as the weight of the piping comes to bear upon them ; the pipes being thereby gradually permitted to slide downward. The distance between horizontal joints in brickwork being 3 inches, it follows that nail holes in iron brackets or lead tacks must be made either 3 inches or 6 inches apart.

TESTING.

The drainage system or any portion thereof being completed, it is essential that efficient tests be applied in order to prove its soundness, and in so doing it is necessary to bear in mind that it is not sufficient that the drains or their connections be merely "watertight." Watertight they must be, and also air-tight, but their soundness must be proved by means under which a distinct force or pressure is brought to bear upon each pipe and each joint. In the by-laws framed by the London County Council, the requirement is made that the drains "be capable of resisting a pressure of at least two feet head of water." This is a somewhat moderate test, in the case of iron drains, seeing that a two-feet head of water is equivalent to a pressure of only 0.87 lb. per square inch, but it must be borne in mind that the by-laws are equally applicable to stoneware drains. In the United States of America, where in some cities the use of iron drains is made compulsory, it is not unusual to test up to a pressure of from 30 to 35 lbs. Nor is this pressure any too severe, as it will be borne in mind that good cast-iron drains properly made with good piping and joints should be well able to resist a pressure of some 200 feet head of water, that is, about 86½ lbs. to the square inch.

In actual use, however, a drain when blocked will but rarely be called upon to withstand a higher pressure than from ten to twenty feet head of water, and it will, therefore, generally suffice to test up to, or slightly above, this pressure. In testing, it must be remembered that if a minimum pressure to be withstood is specified or desired, then that pressure must be withstood by the head of the drain as well as by other portions thereof.

The two forms of tests which are available for testing under pressure are the "hydraulic" or water test and the "pneumatic" or air test, which latter may or may not be combined with a "smoke test."

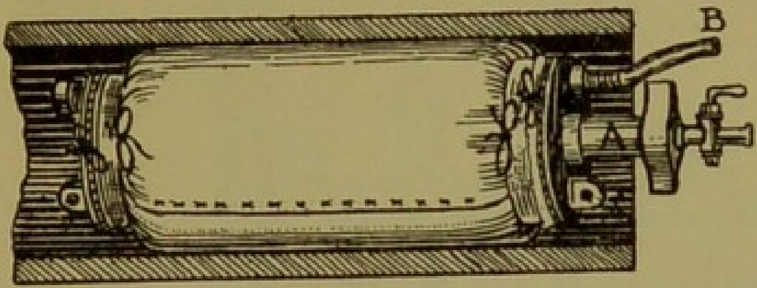


FIG. 107.

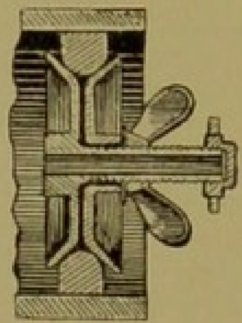


FIG. 108.

In order to apply the former the outlet of the drain, or other portion of the drainage system to be tested, is securely stopped with a "drain-bag" or "drain-plug" (Figs. 107 and 108) and filled with water to the required height; all intermediate openings—such as gulley traps—being, obviously, also plugged. If a soil-pipe is available in that portion of the drainage system which is to be tested, the required head of water may be obtained by partly filling this pipe, say up to the first-floor closet. In the opposite case a vertical pipe of suitable length must be temporarily connected to the drain or an "indicator" (Fig. 109)—placed at a suitable altitude—joined to the drain by means of a suitable drain-plug. When the drain has been fully charged, the water must be permitted to remain in the pipes for at least half-an-hour and the water level carefully watched meanwhile. If the drain be sound, the water level will remain constant; if the drain leaks, the level of the water will be lowered. In the latter case the point or points of leakage (which will be disclosed by the outflow or oozing of water) must be ascertained and the defects made good; the test being subsequently repeated.

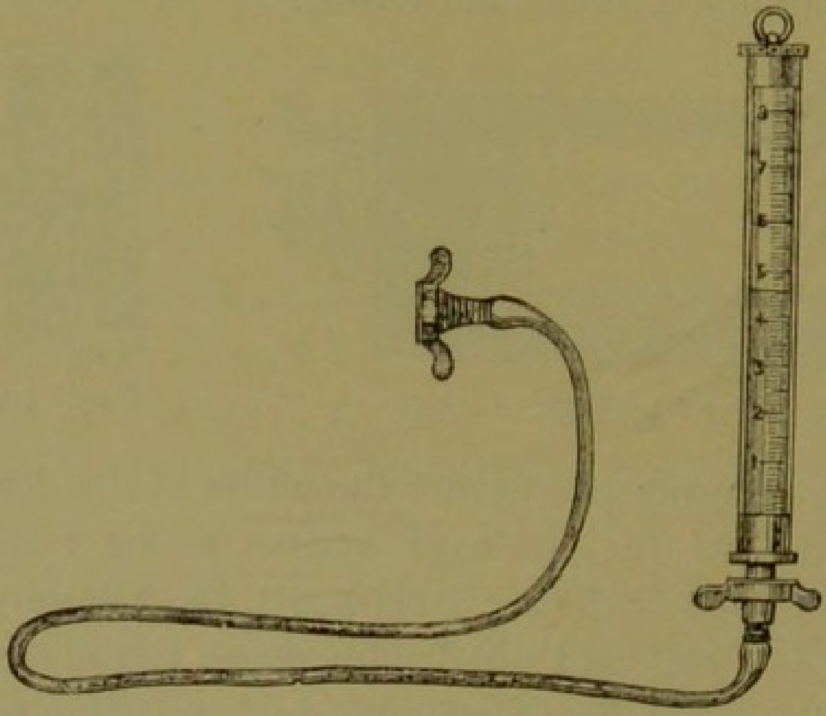


FIG. 109.

In applying the pneumatic test, all the openings on the drain to be tested are hermetically sealed by means of drain plugs or bags, on the top of which a small quantity of water may be placed to ensure absolute air-tightness. The drain is then charged with compressed air by means of a small force pump suitably connected to one of the stoppers, and the pressure within the drain raised to the desired point. Pneumatic drain-testing machines (Fig. 110) being provided with a pressure gauge the pressure within the drain is of course indicated. When the desired pressure has been obtained and registered upon the gauge, pumping is discontinued and the gauge watched in order to ascertain whether any reduction in the pressure takes place. Should this be the case, the drain is obviously defective and the defect must be traced and rectified.

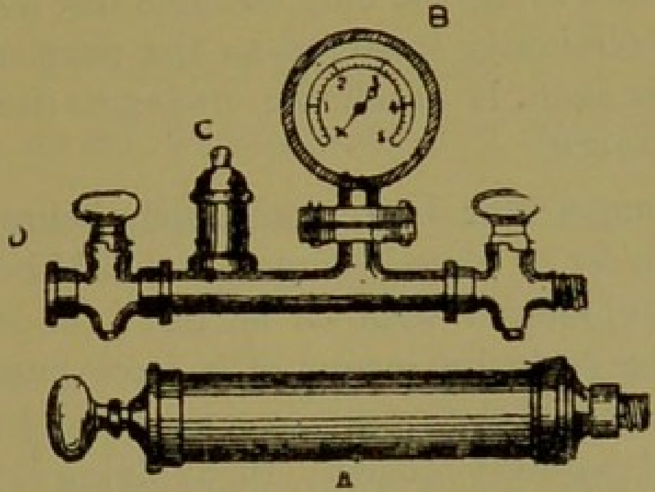


FIG. 110.

"JENSEN" Pneumatic Drain-testing Machine.

A, Force pump. B, Pressure gauge. C, Valve. D, Stop-cock for connecting force pump. To be turned off when drain is charged. E, Stop-cock for connection to drain.

The great advantage which the pneumatic test possesses over the water test is that the pressure applied is uniform and of equal severity on each part of the drainage system, whereas it varies greatly in intensity in the case of the hydraulic test ; the lower portion of the drain having to withstand a much greater pressure under this test than the upper end. In addition to this, the test may be applied at all times and under all conditions without reference to weather or lack of water. A rainy day or the discharge of a fitting during the test, for instance, is fatal to a water test, as the admission of water to the charged drain will render it impossible to ascertain whether the drain is sound or leaking. The air test, moreover, gives no opportunity to a dishonest contractor to mislead the engineer or inspector by surreptitiously supplying the drain with just sufficient water to replace that lost by leakages. For soil and ventilation pipes, the pneumatic test may be said to be the only suitable test available. A water test is obviously unsuited to the purpose, whilst a smoke test, as such, is unreliable, owing to the absence of sufficient pressure.

When a smoke test is applied, such being frequently desirable in order to trace leakages, it should be invariably applied in conjunction with an air test; the smoke being driven into the drain by means of a force pump or other appliance, by which the pressure within the drain may be distinctly and suitably raised. In applying it, the smoke should also be driven right through the drain, or other portion of the drainage system to be tested, before the latter is finally plugged. This is necessary to ensure that the drain is fully charged with smoke from end to end. It should be added that all underground drains must be tested and proved sound before the trenches are filled in, and again after the earth has been filled in. The object of the latter test is to make sure that the drain has not been damaged in filling in the ground.

Peppermint, chemical, and other "smell" tests, although useful under certain circumstances, are of no value whatever for proving the soundness of drains, &c., and should, therefore, never be made use of in connection with new drains. Their usefulness is chiefly in connection with old drains, whose testing is altogether different to the testing of new drains. For these tests, as also for fuller details of tests and testing apparatus generally, the reader must be referred to a small volume devoted to the subject, namely :—"*Modern Drainage Inspection and Sanitary Surveys.*"

CHAPTER VIII.

SOIL, WASTE, VENTILATION AND RAIN PIPES.

THEIR MATERIALS, AND CONSTRUCTION.

Soil Pipes.

The materials of which soil pipes may be efficiently constructed and which are most generally available, are cast-iron and lead. Stoneware pipes have occasionally been made use of for the purpose, but it need hardly be said that they are quite unsuitable. The joints required are difficult to make and maintain thoroughly air-tight, and, in number, out of all proportion to the length of the piping. The pipes are liable to be fractured, are difficult to fix properly, and also very unsightly. Moreover, great difficulty is experienced in making suitable bends and offsets where such are required. Wrought-iron and steel pipes with screwed joints are also frequently made use of in the United States of America. They answer well for the purpose, and possess certain advantages, of which the most important are the long lengths in which they are made and their comparatively small weight. These are considerations which are doubtless of great moment when the pipes are used in connection with "sky-scraper" buildings.

In our own country, however, cast-iron and lead pipes are, as already stated, almost exclusively used, and it will therefore be sufficient to consider these only.

Comparing the two materials, and assuming that the piping made of each is the best of its kind and suitable for its purpose, each has its advantages and drawbacks.

The advantages of iron soil pipes are :—1. The pipes are cheaper than those made of lead, and do not require the amount of skill necessary in the proper construction of lead soil pipes. 2. Nails cannot be accidentally driven into them, nor are the pipes liable to be dented or otherwise damaged by light blows. 3. They are not readily affected by the changes in temperature of the air, nor by the discharge of hot water from slop hoppers, which must be connected to soil pipes. On the other hand, the advantages of lead soil pipes may be summed up as follows :—1. They are smoother in the interior than iron soil pipes. 2. They cannot corrode and if ventilated are not readily affected by gases ordinarily present in sewage and in the air of towns. 3. The material of which they are made is pliable and workable; the pipes can therefore be adjusted as required, and their bends and junctions made on the spot, and, if necessary, "humoured" in fixing. 4. The pipes are lighter in weight and less bulky than those made of iron. 5. Although more expensive than iron in first cost, lead pipes wear better, require less attention, and are undoubtedly cheapest in the long run ; whilst even when the pipes are worn out, the material is still of some value. It will be seen from the above, that both materials are really good, and that the choice of either must be left to the special circumstances of each case. The advantages of both materials may to some extent be combined in making use of lead-lined iron pipes, of which more will be said in connection with ventilation pipes.

Ordinary cast-iron pipes for soil pipes, should such be decided upon, should fulfil all the conditions previously laid down for cast-iron drain pipes (see Chapter II), but need not be so strong and heavy. The thickness of the metal need not be more than one-quarter of an inch, and the weights of the pipes as follows :—

TABLE V.

Weights and Thickness of Cast-Iron Soil Pipes.

Diameter of pipe in inches.	Thickness of pipe in inches.	Length of pipe in feet.	Weight of pipe in lbs.
3½	¼	6	54
4	¼	6	60
4½	¼	6	70
5	¼	6	80
6	¼	6	98

Pipes of this substance will be found efficient, and will comply with the by-laws of local authorities, which in most cases specify a certain weight as a minimum, the weight required being as a rule slightly less than that given in the above table.

The joints of cast-iron soil pipes, it need hardly be said, must also be of the nature recommended for cast-iron drain pipes; that is, they should be run with molten lead and well caulked and in all other respects be made in accordance with the rules already laid down. Where it is necessary to join a lead pipe—such as a branch from a water-closet—to the iron soil pipe, the connection must be made in such manner that the joint will be equally secure and efficient as those on the remainder of the soil pipe. For this purpose it will be necessary to pass a strong brass ferrule over the lower end of the lead pipe,

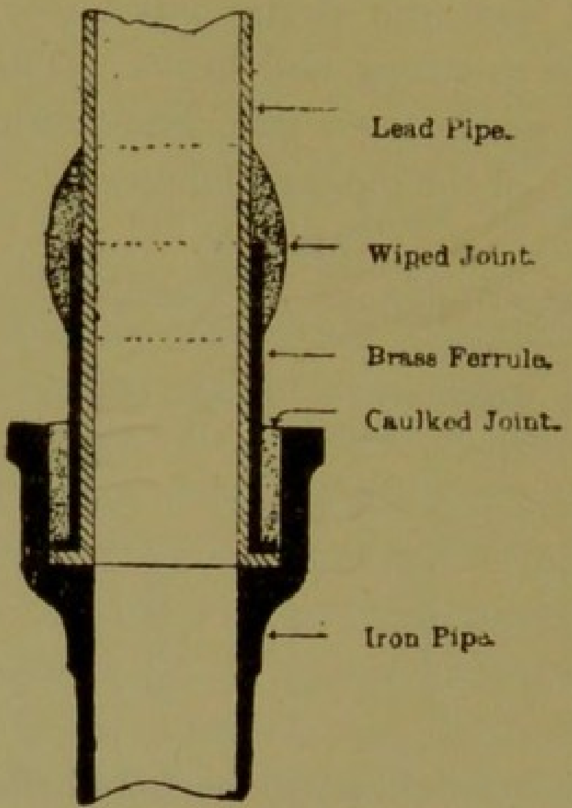


FIG. 111.

and to dress the lead up and round the flange with which the ferrule is provided. A "wiped" lead joint is then made round the upper end of the ferrule, to thoroughly join it to the lead pipe, and the ferrule placed in the iron socket provided for its reception on the soil pipe. The joint is then made with molten lead in the ordinary manner. A section of the completed joint is shown in Fig. 111.

As in the case of drains, so also in iron soil pipes, all bends and junctions and other special pipes must be of similar strength to the remainder of the piping. They should also be of easy sweep, curved in the direction of the flow—be that sewage or air—and should be carefully ordered so as to require no cutting.

Where lead soil pipes are adopted, the piping made use of should be of the description known as "hydraulic drawn," perfectly smooth and free from blisters and scratches, both in the interior and externally. The metal should be of the best quality, of even thickness in all parts, and as soft as ordinary sheet lead of the same strength. The lengths of pipes used should also be as long as possible, in order to avoid all unnecessary joints. Bends and offsets, it need hardly be said, should be made by hand on the pipe itself, care being taken that the lead is not weakened at those points.

The walls of the pipes should in no case be less in thickness than that of a piece of sheet lead weighing seven pounds per superficial foot. Eight-pounds lead is better, and should be made use of by choice; whilst ten-pounds lead should be utilised in all cases where the soil pipe, or any portion thereof, is unavoidably situated within a building.

The weights (per 10 ft. length) of hydraulic-drawn lead piping, of various thicknesses and diameters, usually made use of for soil, ventilation, and waste pipes are given in the following table, viz.:—

TABLE VI.

Weights of Hydraulic-drawn Lead Pipes of various diameters and strengths per 10ft. length.

Internal diameter of pipe.	6 lbs. thickness.	7 lbs thickness.	8 lbs. thickness.	10 lbs. thickness.
ins.	lbs.	lbs.	lbs.	lbs.
2	33	39	45	57
2½	41	48	55	70
3	49	57	66	83
3½	57	67	76	96
4	65	76	87	109
4½	72	85	97	122
5	—	94	108	135
6	—	112	129	161

The joints of lead pipes should in all cases be properly made with well-wiped solder joints ; the ends to be jointed being properly prepared, and care being taken that no solder finds its way into the interior of the piping. Where, of necessity, the pipe passes through a floor or sill or is fixed in a chase, a well-made block-joint may be made use of where, or as, may be necessary.

As regards the connection between the lead soil pipe and the cast-iron underground drain, the joint must be made with the greatest care, in order that it may prove permanently satisfactory. It is best made by connecting the foot of the soil pipe with the socket of a duck's-foot bend, (Fig. 18), on the drain by means of a brass ferrule, the joint being in all respects similar to that shown in Fig. 111. The joint should also invariably be above ground, in order that the necessity of continuing the lead pipe below the surface of the ground may be avoided. In order to avoid damage to soil pipes by kicks, &c., it is a good plan to construct the pipe of iron to a height of a few feet above the ground level.

Soil pipes, whether of iron or lead, to be self-cleansing, should not exceed 3½ or 4 inches in diameter, nor need they in any case be larger, since the discharging capacity of pipes of those diameters is sufficient for a greater number of closets than will probably be fixed upon them in a town house, or, it might even be said, in any building, for it is to be borne in mind that the closets will not be flushed simultaneously.

Unless impossible, soil pipes should without exception be fixed on the exterior of the building, in order that all foul air discharged—should the pipes at any time be damaged—may be liberated in the open air, and so prove less dangerous than should the leakage take place within the building. Bends should be as far as possible avoided and the pipes ventilated, full bore, above the roof in a similar manner to that which will be described for ventilation pipes.

Waste Pipes.

For waste pipes from baths, sinks, and kindred fittings, lead is the most suitable if not the only admissible material. Lead pipes are much smoother in the interior than the best iron pipes of small diameter, be they cast or of galvanized wrought-iron. They are also much easier to bend and adapt, and the bends and junctions may be made with a much easier sweep than is the case with iron pipes. Lead-lined cast-iron pipes are perhaps equally good as regards smoothness and durability and even superior as regards capacity to resist damage by violence, but the bends, &c., must be worked in as they come from the foundry, and cannot be adapted to irregularities in the brickwork, &c.

Lead piping for waste pipes should be hydraulic-drawn, and of a substance of from 6 lbs. to 8 lbs. lead, the joints being of wiped solder on such portions of the piping as are situated within the building, or on such pipes as are only of short length or provided for cold water only. When, however, fixed on the exterior of the buildings and of considerable length, or provided for the removal of hot as well as cold water, it will be desirable to provide "slip" joints, which, whilst air and water-tight, will permit the pipes to expand and contract without injury. These joints, of which an example is shown in Fig. 112, are designed to permit the stack pipes to expand and contract without risk of injury or of "sagging." For this purpose the upper end of each length of pipe is enlarged so as to form a socket into which the lower end

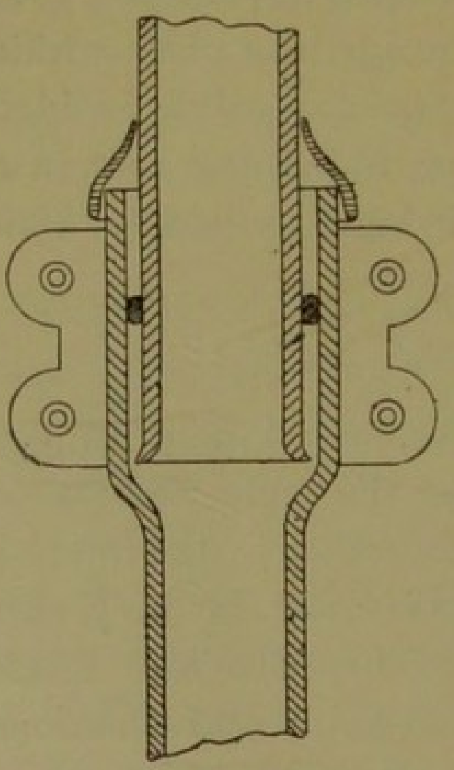


FIG. 112.

of the pipe immediately above it may be inserted. The actual joint is made by means of a tight-fitting, vulcanized india-rubber ring, which, however, is not everlasting and requires to be renewed occasionally. As each length of piping will be hung from lead ears fixed in proximity to the socket, it is necessary that branches from fittings should be joined to the main stack pipe near the sockets. If this is not done the stack pipe will not have free play between the point at which it is fixed to the wall and that where it is held by the branch pipe.

The treatment of waste pipes will be dealt with in a succeeding chapter and it will therefore only be necessary to indicate here their proper diameters. These, where the pipes are to be provided for existing fittings, must to some extent be governed by the outlets from the various appliances. In new work, however, where it has been possible to select apparatus with suitable outlets, the dimensions of the waste pipes should be in accordance with the following table, viz:—

TABLE VII.

Table of Diameters for waste pipes from various fittings.

	Ins
Lavatory wastes	1¼ or 1½
Pantry sink wastes	1¼ „ 1½
Scullery sink wastes	1½ to 2
Bath wastes	1½ or 2
Urinal wastes (for connection to soil pipes)	1¼ „ 1½
Safe pipes	1 „ 1¼

Waste pipes of the above dimensions will be sufficiently small to prove self-cleansing and yet large enough to provide a "quick" waste for the fittings under which they are fixed. They will thereby not only empty the appliances expeditiously but also, to a certain extent, assist to flush and keep clean the underground drains. Stack pipes, or main waste pipes, need in no case exceed 2 or at most 2½ in. in diameter, even though taking the discharge of several fittings, since it is very improbable that many will discharge at exactly the same moment, and, if they did, no harm could result; the most serious consequence being merely that one or more of the fittings might take a little more time than usual in emptying.

Ventilation Pipes.

Soil and drain pipes, through which there is a flow of sewage, are almost from the commencement of their life covered in the interior with a greasy film or coating of a slime-like nature. So long as this remains moist, as it invariably does when the pipes are in use, the iron of which the pipes are made is very effectually protected, both against the adhesion of foul matter and corrosion. If scales of rust were formed, moreover, they would be immediately removed by the next flush of water. No such film is, however, formed in ventilation pipes. It will thus be seen that these, to be permanently satisfactory, must be constructed of materials which will effectually resist the gases present in the atmosphere and in the drains. This cast-iron is unable to do, even when properly coated with one or other of the protective coatings advocated in a preceding chapter. The coating is usually lost after the lapse of a few years in ventilation pipes, which are then rendered liable to oxidation in the interior through being exposed to the moist air arising from the drains, and on the exterior through exposure to the atmosphere. So well is this now recognised that iron ventilation pipes are frequently fitted with rust chambers (Figs. 82-4) at bends and other changes of direction, in order that the falling scales of iron-rust, which would otherwise accumulate in and choke the pipes, may be collected and arrested at points in which no harm can result and from which they may be conveniently removed. The rust, even if prevented from obstructing the air current, however, soon weakens and wears out the pipes, and it will therefore be seen that the proper cure for the evil lies in the avoidance of iron in favour of lead, and lead only.

Ventilation pipes should, therefore, be invariably constructed of lead—be it in the form of lead pipes or lead-lined iron pipes—and this recommendation may be advantageously carried so far as to include even those portions of iron soil pipes that are provided purely for ventilation, that is, the portions of soil pipes above the points at which the uppermost closets are branched into them.

If drawn-lead piping be the material chosen, the ventilation pipes should be constructed as recommended for soil pipes in all respects, except that their thickness need not be greater than that of 7 lbs. or 8 lbs. lead. The advantages of a drawn-lead ventilation pipe, as far as construction is concerned, are similar in every way to those obtaining in the case of a lead soil pipe. So also are its disadvantages, *viz.:* their liability to "creep" owing to the expansion and contraction, caused by changes in temperature, and their liability to damage by kicks, &c., in exposed positions. The latter evil is, however, more imaginary than real; since all portions liable to damage by violence may be effectively protected by means of sheet-iron guards or shields.

If preferred, however, lead-lined cast-iron piping (Fig. 113) may be made use of. This consists of ordinary cast-iron coated piping with wide sockets into which is fitted a drawn-lead pipe of whatever strength is desired. The pipes usually stocked by the manufacturers are lined with from 5 lbs. to 8 lbs. lead. The lead lining is in no way attached to the iron, but is simply a lead pipe slipped inside the iron casing and worked tight into the socket and turned back over the outside of the spigot end to a distance equal to the depth of the socket. When a pipe is cut this outside piece can be formed from the lining—this being tafted and bossed over—or a separate piece can be fitted on and the joint to the lining made by burning or fusing.

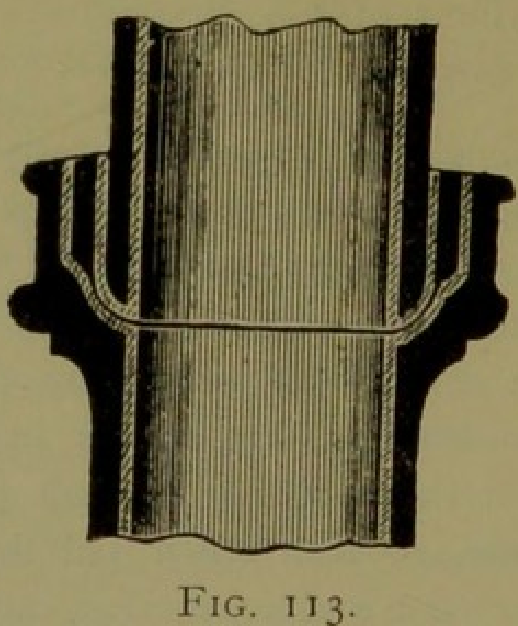


FIG. 113.

Joints on this description of piping are made in the manner described in connection with ordinary iron spigot and socket pipes, by filling up the sockets with molten metallic lead and tightening up the joints with a caulking tool. There is now also on the market a material known as "lead wool" which consists of shredded soft lead. This is placed in the socket cold and when well caulked a very satisfactory joint results.

Junctions, bends and other accessories are made to correspond with the straight pipes in every way.

Glass-enamelled iron pipes, which consist of ordinary iron pipes coated in the interior with a glassy surface about $\frac{1}{8}$ inch thick, are frequently recommended for ventilation pipes, but their employment is not always desirable. It is certainly reprehensible when the ventilation pipes are exposed to changes in temperature, be these due to atmospheric conditions or discharges into the drains.

An important feature of glass, or any other lining which is of an entirely different character to the metal it is required to adhere to and to which it is rigidly fixed, is that it should expand and contract with the variation of temperature in the same proportion as the metal to which it is attached, and thus avoid fractures of the glass surface. This property the glass enamel now used does not entirely possess. The result is that the lining is frequently cracked. The iron being thus exposed is soon attacked by rust which, spreading under the enamel, sooner or later leads to the breaking off of the lining. The practical impossibility of cutting the pipes without injuring the enamel is a point which must also be taken into consideration.

As regards the sizes of ventilation pipes, these must, of course, be governed by the purposes for which they are provided. Thus, for the ventilation of drains, soil and waste pipes, their diameters must be similar to those of the pipes upon which they are fixed. Anti-syphonage pipes for water-closet and slop hopper traps should be from 2 to 2½ inches in diameter; whilst anti-syphonage pipes and "puff" pipes from the traps of other fittings, may be suitably made of piping having slightly smaller diameters than those of the traps upon which they are fixed. The remaining points concerning ventilation pipes will be found fully treated in a succeeding chapter.

Rain-water Pipes.

As regards the materials made use of in the construction of rain-water pipes, drawn lead piping is perhaps the most advantageous. Inasmuch, however, as it is also unduly expensive for the purpose in most cases, light iron piping is generally made use of for the purpose. These iron pipes should however be invariably galvanized as the ordinary unprotected or merely painted iron rain-water pipes are a source of constant trouble and annoyance owing to their liability to choke from internal rust. The joints of these pipes are best made with real lead putty containing chopped up horse hair.

Chapter IX.

DISCONNECTION (PRIMARY AND SECONDARY).

In the preceding chapters have been discussed the various details of which a cast-iron system of house-drainage is made up and the manner in which they are put together—in other words, the materials and construction of the drainage system. It will now be well to devote attention to the principles which should govern the design and construction of the drainage scheme as a whole and in its component details. Inasmuch as cast-iron drains are mostly made use of for the drainage of town houses—partly on account of their relatively higher cost, as compared with stoneware drains, and partly also by reason of the additional security which it is desirable to obtain in the case of town houses, where the drains must of necessity pass through or under the building—the following remarks will be chiefly devoted to the consideration of systems of drainage for town houses. Most of the remarks will, nevertheless, obviously also apply to suburban and country dwellings.

The objects to be attained in carrying out a perfect system of house drainage are the following:—

1. The primary disconnection of the house drains from the public sewer. (*Treated with in the present chapter*).

2. The secondary disconnection of the rain and waste-water pipes, &c., from the sewage drains. *(Treated with in the present chapter).*

3. The thorough ventilation of the entire drainage system. (*Dealt with in Chapter X*).

4. The immediate and entire removal of all matter discharged into the drains. (*Treated with in Chapters XI and XII.*

5. The provision of means of access for inspection and cleansing (*Dealt with in Chapter XIII*); and lastly,

6. The provision of fittings (such as closets, sinks, &c.) which are sanitary, in fact no less than in name, both as regards their construction and treatment. (*See Chapters XIV to End.*)

By "disconnection" is understood the severance of the direct line of aerial communication between two portions of a pipe or two lengths of piping, in such a way that, while the foul air contained by the lower portion is "intercepted," or excluded, from the upper, no actual interruption is caused to the flow of liquid in the pipe or pipes. This is arrived at by forming in the pipe a dip, which is capable of retaining a constant volume of water in such a way as to prevent the passage of air through it. This dip is known as a "trap," and the water standing in it is said to "seal" the trap; the effective seal being the portion of water retained between the level of overflow and the lowest point of the soffit at the dip. Unless, however, this water is frequently changed, it is liable to absorb foul gases to such an extent as to pass them through readily; and again, pressure in the trapped-off portion of the pipe may force gases through the water. In either of these cases the trap would cease to be a "trap," and the disconnection would consequently be ineffective. Hence it is necessary to ventilate the upper portion of the pipe—that is, the pipe or piping which discharges into the trap—so that any gases which may enter it from the lower pipe will be immediately diffused and carried off, and "disconnection" thus completed.

By the primary disconnection of the house drains is understood their isolation from the public sewer. This is arrived at by the insertion of a "disconnecting trap" or "intercepting trap" on the outlet of the drains, as near as possible to the sewer, and the thorough ventilation of the drainage system.

Primary disconnection is essential in order to protect the house drains against infection from sewers and other drains, be that infection merely one of offensive air, or of dangerous gases and germs of disease. It may still be an open question whether or not the specific *germs* of a disease can be communicated to the inmates of a house by way of the sewers and a defective drain, but the connection which exists between infectious diseases—more especially typhoid fever—and bad exhalations cannot be denied. Not only do the general health statistics all go to prove it, but there is actually specific information as to the certainty of the connection. Whatever the immediate poison may be, there is no doubt that it exists, that it is dangerous to the lower animals, and much more so to man. The fact was strikingly brought out in a series of experiments by an Italian bacteriologist—Dr. Guiseppe Alessi—who found that the exhalations of sewers predisposed such animals as rats, guinea-pigs, and rabbits to typhoid fever. This is all the more remarkable when it is borne in mind that typhoid fever is essentially a *human* disease, and that other animals are comparatively immune to its influence.

It is evident, therefore, that no system of drainage is complete which does not provide for the disconnection of the drains from the sewers, for, however well the drains may be constructed, there is at all times a risk of leakage, through an accidental flaw or breakage, by which sewer air will be at liberty to escape if the drains are not "disconnected." Nor is such risk of leakage merely con-

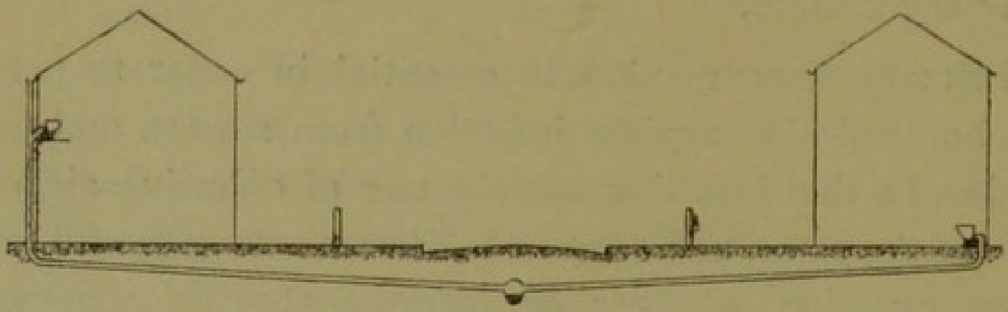


FIG. 114.

fined to possible defects. By reference to Fig. 114 it will be noticed that the only protection which exists against the entrance of sewer air or sewer gases into the houses shown (whose drains it is assumed are structurally sound) is the water contained by the closet traps. This protection is very frail, and liable to fail at any moment. Some additional protection may, of course, be provided by the ventilation pipes, as they would tend to carry away emanations from the sewer, but even this is unsatisfactory, as the shafts may at any time become blocked or otherwise inactive.

Should the germ or other theory of direct infection be favoured, it will be noticed from the same illustration that the drains of both the houses shown are in direct aerial communication with each other and with the sewer. It will therefore be evident that, in the case of an infectious disease taking place in one house, the germs of the malady (contained in the patients' excreta and the water used for washing his or her clothing) will be communicated to the sewer, and thence, in all probability, to the drains of the other house. Should, now, the drains of the latter be imperfect, the germs will find their way into the interior or the surroundings of the building,

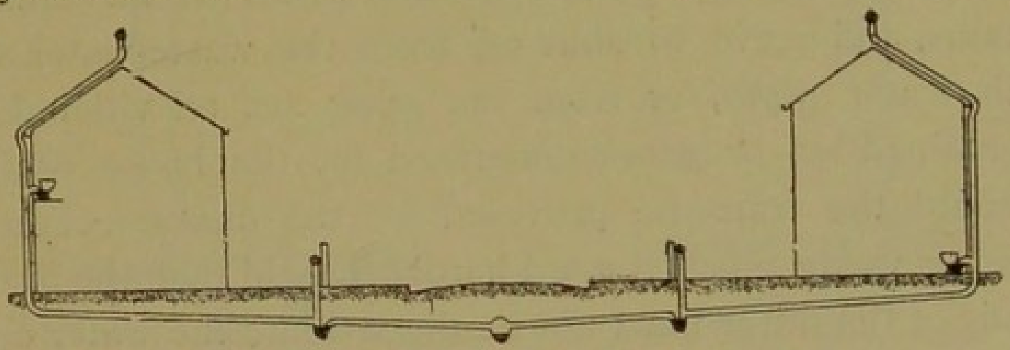


FIG. 115.

and possibly spread infection. In the case of Fig. 115, in which both houses are shown as "disconnected," the infection will only be communicated to the sewer, the drains of the other house remaining immune. So also, in the event of imperfect drains, will each house be exposed to the emanations of its own drainage system only. Although not by any means desirable, this will, at any rate, be a far smaller source of danger.

Primary disconnection could be dispensed with if all the sewers and drains of the whole district were thoroughly constructed and ventilated. Unhappily, this is, one may safely say, never the case. It would, however, be risky even then, as drains are, as already stated, apt to deteriorate or go wrong. Should a leakage occur in the drains of any one house, the latter would be, until the defects were discovered and remedied, in direct aerial communication with the sewer and, through the sewers with the rest of the house-drains of the district.

The second object—viz., the secondary disconnection of the rain and waste-water pipes, &c., from the house drains—is effected by means of gully traps—also known as surface traps—which are virtually small disconnecting traps. These are placed at the heads of all branch drains, and serve to shut off from the waste-water and rain-water pipes, or from the open air, all vitiated air contained by, or gases generated in, the house drains. Should the traps be provided for the disconnection of rain or waste pipes, it need hardly be said that the outlet ends of the latter must not be dipped into the water contained by the traps. The outlets, in fact, must be perfectly open in order that air may enter into the pipes at that point for the purpose of ventilation. This ventilation of waste pipes, &c., is, of course, necessary for proper disconnection, for similar reasons to those which have been mentioned in connection with the ventilation of the drainage system.

Examples of properly disconnected waste pipes are shown in Figs. 116 and 117. From these it will be noticed that the pipes may discharge either over or else under the grating, the point of discharge being, however, above the level of the standing water in both cases.

Either system has its advantages and drawbacks. If the pipe is arranged to discharge *over* the grating, there is a risk that the latter may become obstructed by leaves, &c., or by the matted hair, soap, and grease discharged by the pipe, in which case waste water would overflow on the surrounding ground surfaces, and possibly soak into the foundations of the house. The waste pipe would, however, still be ventilated, as its outlet would remain free. Should, on the other hand, the pipe discharge *under* the grating, any matter discharged by the pipe would pass direct into the gully, and thence to the drain,

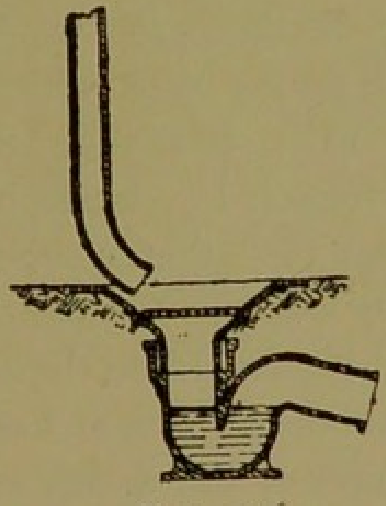


FIG 116.

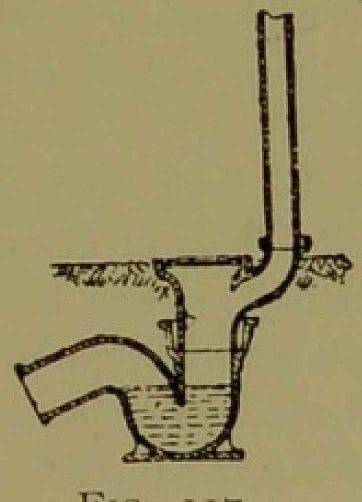


FIG. 117.

without the chance of obstructing the grating. The latter would, however, still be liable to blockage by leaves, &c., in which case ventilation could not take place. The drawbacks of either system can, however, be avoided by a little attention on the part of the householder. The provision of a channel in connection with the surface trap is neither necessary nor desirable. Owing to the formerly frequent adoption of double disconnection for waste pipes by means of hopper heads (a practice which, as will be pointed out in the next following chapter, is very objectionable), and the absence of traps under sanitary fittings in the house, it was very usual to discharge the pipes into an open channel leading to the surface trap, in order that any drain-air which might escape at the trap should not enter the waste pipe and be liberated inside the house or near windows. Under the improved methods now adopted for the construction and ventilation of waste pipes this risk no longer exists. The channels are, therefore, unnecessary. Being speedily covered with foul deposits, they are also objectionable.

A consideration of secondary disconnection would not be complete without reference to grease traps, which may be necessary or unnecessary evils, according to the standpoint from which they are regarded. Grease having a totally different character from the other components of ordinary sewage, it materially adds to the difficulties of the latter's final purification. If passed into the drains without being first cooled and solidified, grease has also a tendency to adhere to the surfaces of the drains and to accumulate there until sooner or later a blockage is caused. Hence it is desirable to intercept the grease before it enters the drains, and grease traps (Figs. 52 to 54) become a necessity. The proper removal of grease from grease traps and the cleansing of the latter being, however, impossible by automatic means, and therefore dependent upon manual labour (generally entrusted to servants), the traps are apt to become abominations through neglect, the grease being permitted to putrefy in the traps and, after a time, to escape into the drains. Under such circumstances, grease traps must be studiously avoided and the grease passed through the drains under sanitary conditions by being discharged into a flushing rim gulley (Fig. 55) and thence automatically flushed through the drains when cooled.

The solution of the grease problem would probably be the institution in every community of special provisions for the frequent and regular periodical removal of grease from grease-traps. This could be undertaken by local authorities or by private enterprise, and could be carried out under strictly sanitary conditions. The grease being a valuable commodity and the cost of its purification trifling, it would amply repay the cost of collection. The quantity of grease which might be collected from the West End of London alone would probably more than suffice for the lubrication of the wheels of every vehicle in London. Under existing conditions the use of grease traps is best avoided in the case of town houses.

CHAPTER X.

VENTILATION.

The third of the six objects named in the preceding chapter as necessary to insure a sanitary system of drainage—viz. :—the thorough ventilation of the entire drainage system—is, as already stated, essential for proper disconnection. It is also necessary for the following purposes, namely :—for the innocuous dissemination of any gaseous products generated in the house drains or waste pipes, and for the oxygenation of the drainage system and sewage ; the latter in order to retard decomposition until the sewage has been removed.

Ventilation denotes the continuous passage or circulation of a current of fresh air through the space which it is desired to ventilate. It is therefore obvious that to accomplish and maintain this condition there must be means of ingress as well as of egress for the air. Moreover, as the whole of the drainage system has to be ventilated, it is also necessary that the openings be, whenever practicable, at the extreme opposite ends of the drain or drains to be ventilated. The apertures—inlet and outlet —must also be at an appreciably different level ; that is, the inlet must be at the lowest point practicable, and the outlet at the highest point possible. Were it otherwise, there would be a tendency to equilibrium caused by the collection of the heavier gases, such as carbonic acid, at the lowest points of the drain ; thereby virtually causing the formation of an air-trap in the drain itself. The need for a difference in level between the inlet and outlet openings will also be readily understood when it is borne in mind that two of the causes which produce an air current through drains are the inequality of temperature within and outside the drain, and the aspirating effect produced by a current of air (wind in the case of drains) passing at right angles across the aperture of a pipe. This latter will be understood by referring to Fig. 118. Whilst wind is a useful auxiliary to ventilation, it is the first-named of the two conditions mentioned which is the most constant, and upon which ventilation is assumed to depend chiefly.

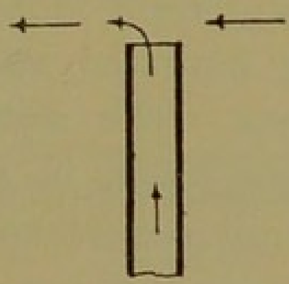


FIG. 118.

The temperature within the drain being usually higher than that of the exterior, the air which is contained by the drain is expanded and reduced in weight ; a portion is consequently discharged, whilst the remainder is dispelled by the heavier cold air which presses in through the inlet shaft. There is thus a more or less constant pressure of fresh air into the low inlet, and a corresponding pressure of warm air towards the higher outlet, producing an air-current whose speed is determined by the difference in temperature within and outside the drain. The greater the difference of temperature, the greater the difference in weight of the air inside and outside, and the greater, consequently, the rapidity of interchange. Whilst this is the most generally accepted theory regarding the ventilation of drains, and doubtless to a great extent a correct theory, there is reason to believe that the currents of air passing through the drainage system are in part, at any rate, due to other and perhaps more important causes. Amongst these there can be no doubt that the relative humidity of the atmosphere plays a most important part; the velocity of an air current in a drain varying directly as the relative humidity of the atmosphere. In other words, as the external air becomes drier, the velocity of the air-current increases, and as the air becomes more nearly saturated with watery vapour, so the current diminishes. The materials of which the drainage system is composed, in so far as their heat-retaining properties are concerned, no doubt also, to some extent, affect the air currents.

Soil pipes (which have to be ventilated above the roof of the house) provide convenient and inexpensive up-cast ventilation shafts, and are therefore usually made use of for the purpose. In town houses it frequently happens—one might say, it usually happens—that the soil pipe is at the back of the house and near, if not actually at, the head of the drain. In such a case the problem of ventilation is readily solved by the provision of an inlet shaft at the opposite end of the drain; that is, at the point of disconnection. Such an arrangement is shown in section in Fig. 115. Occasionally the soil pipe is in front of the house. In such a case the soil pipe should be branched into the drain at a point as near as possible to the disconnecting trap, and the air-inlet pipe provided at the head of the drain (see Fig. 119) More rarely the soil pipe is situated in the centre of the drainage system, in which case it is necessary to either provide an inlet at each extremity of the drain, or to branch an air-inlet pipe into one end of the drain and provide a subsidiary ventilating

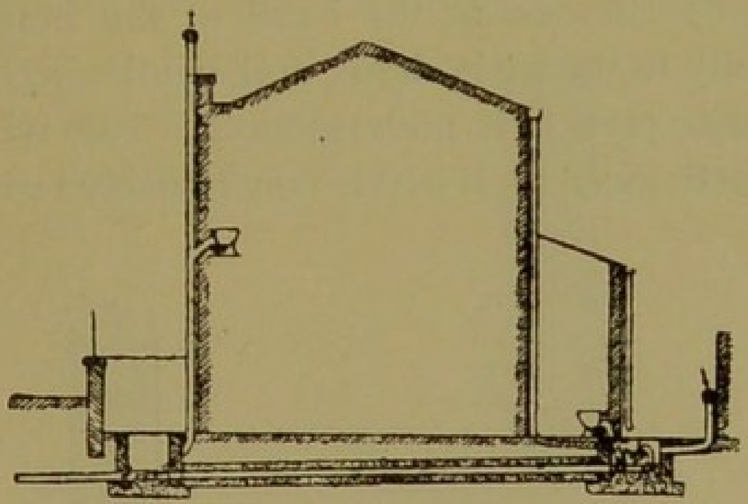


FIG. 119.

shaft at the other extremity. The former is the more efficient arrangement for, whereas it is invariably found that two inlets act simultaneously, it is the exception rather than the rule for two outlets supplied by only one inlet to act at the same time. The system is not, however, always permitted. The drainage by-laws of the London County, of Manchester and of certain other cities, for instance, rather tend to require the additional outlet shaft. An additional shaft must also be connected to the head of any branch drain which may exist, should its length be considerable, in order to avoid the formation of an unventilated "dead-end." Short branches, on the other hand, require no provision for ventilation, since the flow through them will, as a rule, suffice to displace the air contained by them and bring it under the influence of the air current in the main drain. It frequently occurs, however, that branches are too long to be safely left unventilated, yet too short to warrant a special ventilation shaft. In such a case, the solution of the problem lies in placing the surface trap, which in the ordinary course, would be situated at the head of the branch drain, in proximity to the main drain, and continuing the waste or rain-water pipe to it underground. This will also avoid a 4-inch branch drain which may possibly be insufficiently

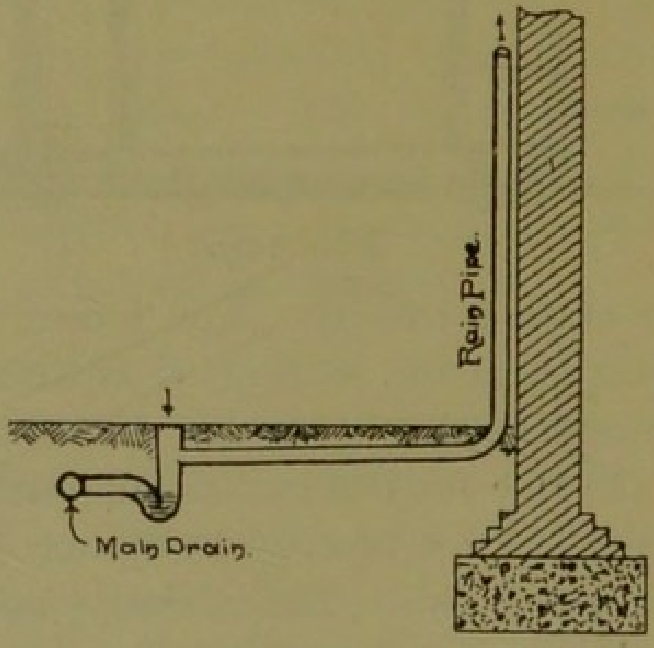


FIG. 120.

flushed by the discharges of the waste pipe which it serves. The method advocated is shown in Fig. 120, whilst Fig. 121 shows the alternative to be avoided. In continuing the waste pipe underground to the surface trap, it is, however, desirable to provide a cleansing eye (not shown in the illustration) at the change of direction in the waste pipe, in order that obstructions may be easily removed, should they occur. The arrows in the illustrations indicate the air currents.

This plan of regulating the positions of surface traps with a view to the more perfect ventilation of the drainage system, is equally applicable to manholes, the positions of which are not always chosen to the best advantage. Fig.

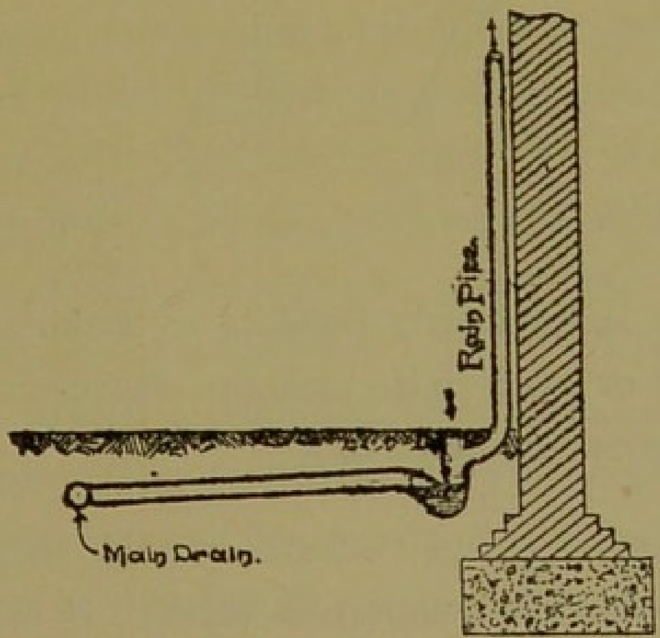


FIG. 121.

122 for example, shows the position, relative to drain inlets, which manholes frequently occupy. The arrangement is somewhat improved upon by constructing the manhole in the position shown in Fig. 123. By this means, in this instance, an unventilated and badly-flushed branch drain will be avoided. A slight saving in the quantity of drain-piping used will also ensue.

As to the ventilation pipes themselves, these should be so arranged and fixed as to involve the minimum possible number of bends. By the exercise of a little care and

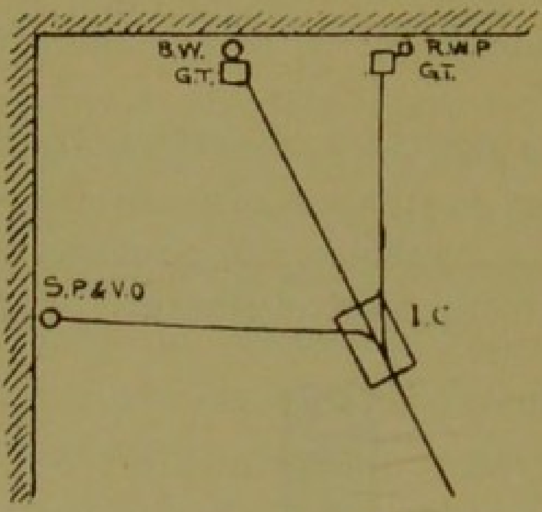


FIG. 122.

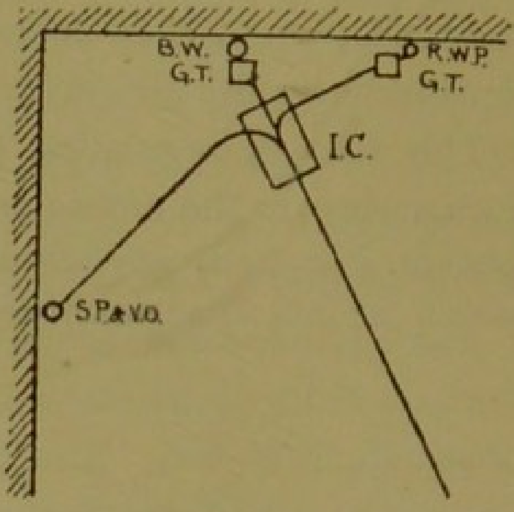


FIG. 123.

ingenuity it is frequently possible to make a ventilation pipe almost or even quite straight where, at first sight, bends might appear necessary.

Bends, angles, and offsets should be, if at all possible, avoided in ventilation pipes. If they must be made, they should be as obtuse as practicable, in order to impede the air current as little as possible. Angles and bends increase friction and impede the circulation of air. Under other conditions, as with steam at high pressure, it is recognised that a bend in the pipe means a higher velocity for the steam passing it; an increase which can be brought about when the necessary pressure is available. With the very small margin of force existing in an ordinary ventilation pipe, however, only a decrease of velocity can result. As a matter of fact, it has been found by experiment that a right angle will diminish the air current by as much as one-half, so that a ventilation pipe with two such bends will only have one-quarter of the ventilating power of a straight pipe of similar length and diameter. If a sharp bend is unavoidable, then, to maintain the air-current unimpaired it will be necessary to reduce the friction due to the bend. This can only be attained by suitably enlarging the sectional area of the pipe at the point at which the bend occurs, because it is obvious that if the velocity is decreased the bulk must be increased if a certain amount of air is to be passed through in a given time. With this object the writer has designed "Jensen's Bend," shown in Fig. 124, which is supplied by the manufacturers of suitable proportions for each individual case, having regard to the radius and degree of curve. As the relative discharging capacity of pipes varies as the square root of the fifth power of the diameter, or as $d^{2 \cdot 5}$, the enlargement of the pipe at the bend is made in that ratio. In the case of a sharp right angle bend the reduction of the air current is practically one half and the diameters of the bends in relation to the diameters of the pipes are therefore made in accordance with the following table in the case of bends of that description :—

Table VIII.

Table of Diameters of "Jensen" Bends for Ventilation Pipes.

Diameter of Ventilation Pipe.	Diameter of Bend (roughly).
inches	inches.
2	$2\frac{3}{4}$
$2\frac{1}{2}$	$3\frac{1}{4}$
3	4
$3\frac{1}{2}$	$4\frac{1}{2}$
4	$5\frac{1}{4}$
$4\frac{1}{2}$	6
5	$6\frac{1}{3}$
6	$7\frac{3}{4}$

Up-cast shafts from drains, be they special ventilation pipes or soil pipes, should be continued full bore, or more correctly, of full capacity, to some convenient point above the ridge of the roof of the house and arranged to discharge all air passing through them, well out of the way of all windows, chimneys and other openings into the building upon which the pipes are fixed, and those adjoining. The outlets should at the same time be placed in as exposed a position as possible, in order that the wind may blow freely across them from all quarters and thus assist ventilation and disperse all vitiated air issuing from them. The openings of the pipes should be simply protected by copper wire guards. These will prevent birds from building their nests on the mouths of the pipes, and will not obstruct the air currents. Cowls, designed for the purpose of assisting the air currents, are unnecessary ; they are frequently also apt to get out of order, to shelter birds' nests, and to generally prove inefficient or detrimental. This liability to prove undesirable is not only present when the cowls are inefficient, but equally probable when, for the time being, the cowls are fulfilling the purposes for which they were designed.

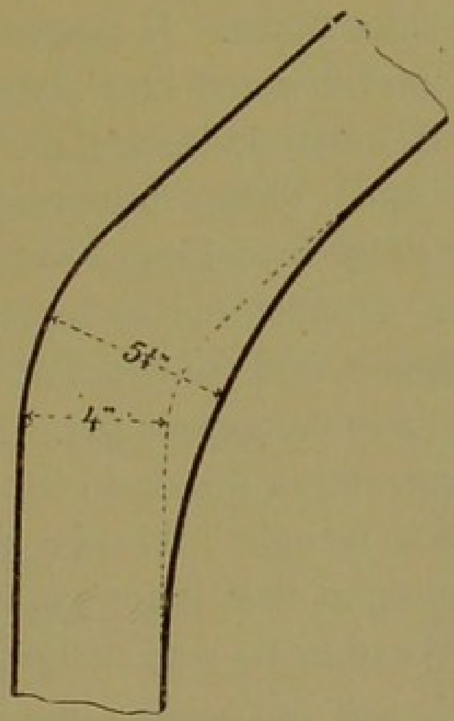


FIG. 124.

It has, for instance, been found that the resistance offered by cowls placed upon soil pipes, (those designed to create "up currents," no less than those arranged to prevent "blow downs") to back-currents created by the discharges of closets, has been so great as to permit of the syphonage of the closet traps. Under such conditions cowls are dangers to health. The free ingress of air to the soil pipes at the right moment is of much greater importance than the extraction of a large quantity of air or the prevention of an occasional back-draught, and in this connection also it is necessary to prevent any impediment to the air which might be brought about by the use of unsuitable bends.

Air-inlet pipes to drains should be placed at or near the surface of the ground, and in the positions in which they will be least liable to prove unpleasant should a "back-draught" take place. If possible, their openings should be quite unobstructed and simply protected by copper wire guards, but, if necessary, mica flap non-return valves may be utilised. These, however, require frequent inspection if their proper working is to be assured and are at best unreliable. It must further be borne in mind that in a properly designed and constructed drainage system there is at no time any dangerous gas. Hence, should at any time the air current in the drain be momentarily reversed and a "back-draught" through the air-inlet pipe caused, the air issuing at that point can at the worst only be a little offensive and in no way dangerous.

The ventilation of soil and waste pipes claims attention, as numberless cases are to be seen daily in which these pipes—even though recently constructed—are inefficiently or improperly ventilated and, in some instances, even quite unventilated.

With regard to soil-pipes (from closets, slop hoppers, and urinals), little need however be said; their ventilation being extremely simple. The inlets are supplied by the drains, to which these pipes should be connected without the intervention of a trap, whilst the outlets are provided by continuing the piping *full bore* to some convenient position above the roof, in a manner similar to that advocated for out-let ventilation shafts. The portion of the piping above the junction of the highest water-closet on the stack is in fact, and should be treated entirely as, an outlet ventilation pipe.

As regards Waste Pipes, by which is understood the discharge-pipes of sinks, baths, and lavatories, it is no uncommon experience to find them constructed in the manner shown in Fig. 125. That is, the fittings are arranged to discharge into hopper heads fixed on the stack pipes outside the house. It is obvious that this arrangement is highly insanitary, for the stack pipes and hoppers are soon coated with offensive deposits, emanations from which are liberated near windows and thence

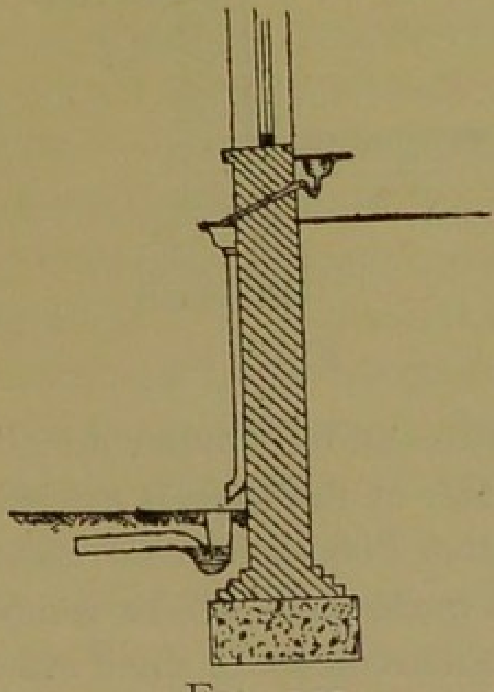


Fig. 125.

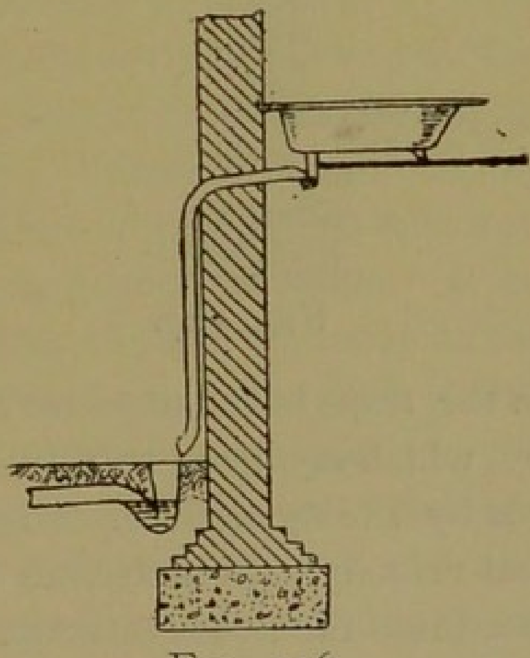


Fig. 126.

drawn into the house. Not infrequently, as shown in Fig. 126, the waste pipes are fixed without attempt at ventilation. Under these circumstances two evils arise. In the first place, when there is water in the traps under the fittings, the water will at all times be exposed to the noxious gases generated in the waste pipes. These gases it will absorb and in time pass through into the house. An even more serious drawback is that the water

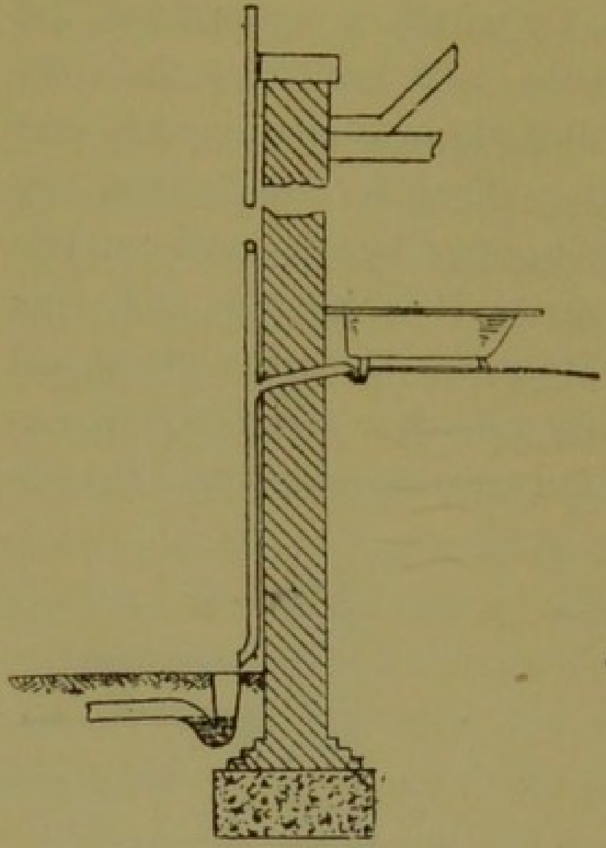


FIG. 127.

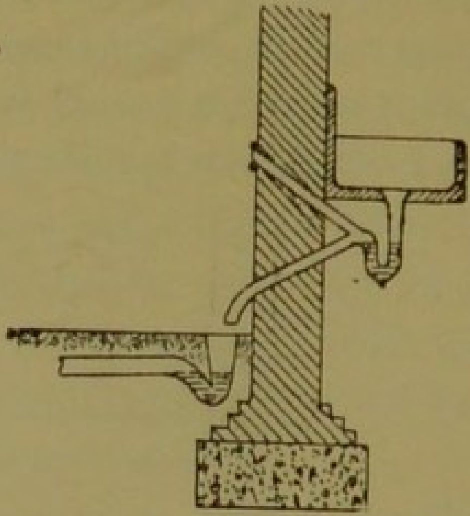
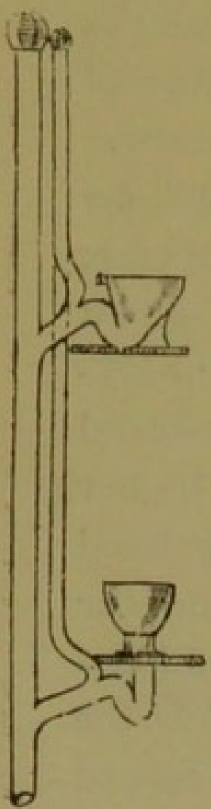
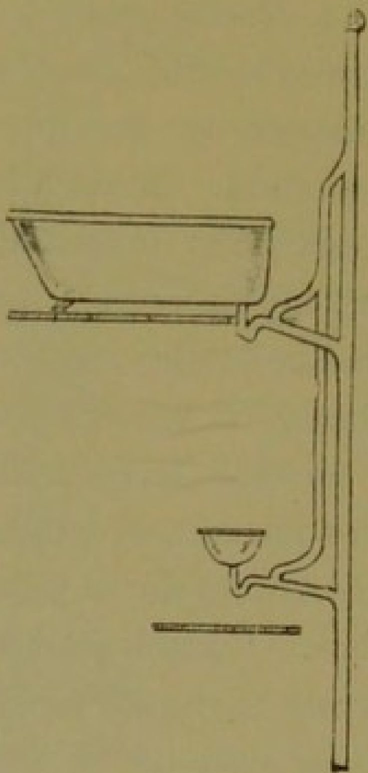


FIG. 128.

in the traps is liable to be drawn out by "momentum," by which is meant that the water of the traps is carried out by the momentum or impetus due to its own mass and velocity. In such cases the waste pipes will be ventilated into the house directly. The remedy for these evils is to ventilate the pipes above the eaves of the roof, as indicated in Fig. 127. This, of course, is only necessary in the case of waste pipes from fittings fixed upon the upper floors, as these pipes provide a considerable area of fouling surface, and a correspondingly increased amount of foul emanations. Short waste pipes from fittings upon the lowest floor, are sufficiently well ventilated by the provision of "puff" pipes carried to the exterior, as shown in Fig. 128.

Reverting to long waste pipes and to soil pipes, there is of course, no objection to the discharge of a number of fittings into a stack pipe common to all. Such an arrangement, in fact, has its advantages, as the pipes will be better and more frequently flushed. If such be the case, however, trap ventilation becomes essential to guard against what is known as "syphonage" and "back-pressure." "Syphonage" is due to the suction produced by the rapid descent of a body of water from a higher level which, in passing the branch from a fitting fixed upon a lower level, tends to suck out, or syphon out, the contents of the latter's traps, unless air is admitted independently in front of the trap. "Back-pressure" is the reverse of syphonage, and is due to the air which is forced down in front of a descending column of water. If no ready exit be provided for this air, the tendency is for it to be forced through the seal of any trap which it may pass in its descent. Either evil will be prevented by the provision of anti-syphonage pipes. These are subsidiary ventilation pipes taken off the lowest traps of the tiers (see Figs. 129 and 130) and carried upwards, either to the same height as the ventilation pipes of the stack pipes, or to a point a few feet above the level of the uppermost fittings, where they may be branched into the main pipes. The two systems are illustrated in Figs. 129 and 130 respectively. On the way up branches are taken off the anti-syphonage pipes and connected to the traps of all intermediate fittings, as shown in the illustrations. The same remarks apply to a horizontal tier of traps such as shown in Fig. 131. Of the two methods of treating anti-





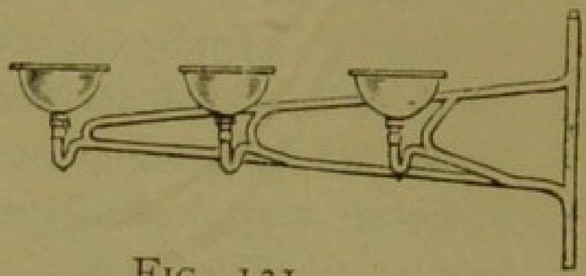


FIG. 131.

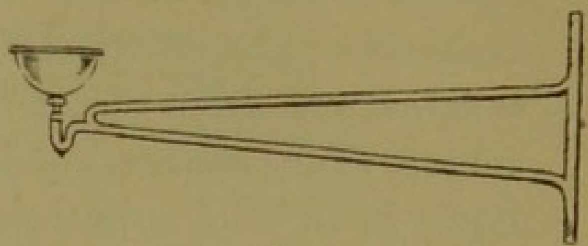


FIG. 129. FIG. 130. FIG. 132.

syphonage pipes illustrated in Fig. 129 on the one hand and Figs. 130 and 131 on the other, the latter is perhaps the one to be preferred. By adopting it, the intake of air for the anti-syphonage pipe is brought much nearer to the fittings than would be the case were the pipe treated as shown in Fig. 129. The air would for some distance, be drawn through a comparatively large pipe ; resistance by friction being thereby reduced. At the same time some benefit will be derived by the in-rush of air into the stack pipe which follows the discharge of a fitting. The system is also the cheaper one, owing to the materials and labour saved.

To avoid the formation of "dead ends" in waste pipes, trap ventilation is also necessary in the case of single appliances when the branch waste—measured from the fitting to its junction with the vertical pipe—is of appreciable length. An anti-syphonage pipe as applied to such a fitting is shown in Fig. 132. The portion of piping which lies between the two junctions on the stack pipe may be left out if desired, but the saving is usually very small and hardly worth considering. There are cases, however, in which the ventilation of the branch waste will be greatly facilitated by the omission. In that case the anti-syphonage pipe must be of equal diameter to the waste pipe and its bends made with as easy a sweep as possible and enlarged in accordance with the dimensions given in Table VIII.

CHAPTER XI.

DIMENSIONS AND GRADIENTS.

Assuming that the piping and appliances made use of in the construction of the drainage system are well shaped and efficiently put together, the immediate and entire removal of all matter discharged into the drains is dependent upon three essential factors; (1) The size of the drain pipes; (2) the inclination at which they are laid; and (3) automatic flushing.

Although the proper sectional areas or "sizes" of drains—as represented by their diameters—to be provided for any given case are gradually receiving more and more attention, it is still a matter of everyday occurrence that drains 6 inches, 9 inches, and occasionally even 12 inches in diameter are provided for town houses in which a 4-inch, or at most a 5-inch, drain would have been amply sufficient for all requirements. This tendency to make drains much larger than actually necessary for the work which they are required to perform, is entirely adverse to the principles of sanitation, and, in addition, a great mistake on economic grounds.

It must be clearly understood that the efficiency of a drain is not increased by the fact of its being larger than absolutely necessary; on the contrary, its efficiency and cleanliness are greatly impaired. On reference to Fig. 133, which shows the same quantity of sewage flowing through a 4-inch, a 6-inch, and a 9-inch drain

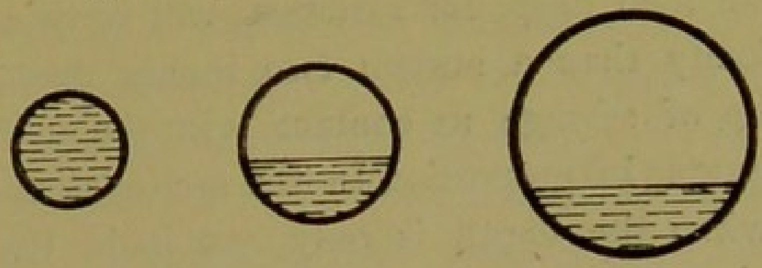


FIG. 133.

laid at the same gradient, it will be seen that whereas the sewage is sufficient to fill a 4-inch pipe, it only causes the 6-inch pipe to run less than half full, and the 9-inch pipe only about a quarter full. It will, therefore, be obvious that, whilst the 4-inch drain will be self-cleansing, ample room will be provided by the larger-sized drains for splashings and deposits. These will, in time, not only decompose and give off noxious gases, but, frequently, also accumulate and gradually stop up the drains. Whilst, therefore, the larger drain may have been provided to avoid stoppage, it is it which is actually the more liable to be blocked.

Apart from the foregoing, however, there is an even more important consideration in favour of the utilisation of small piping. This is the velocity of the flow through the drain. The velocity of the flow of liquids through a pipe varies, as may be readily conceived, at different points of the same cross-section of the stream. It is greatest at the centre and smallest, owing to friction, at the points at which the flow is in contact with the periphery of the pipe. The mean velocity of sewage flowing through a drain, therefore, varies directly as the depth of the flow of sewage. The greater the depth, up to a certain point, the greater the velocity. A stream of sewage one inch deep, for instance, will have a smaller mean velocity than a stream two inches deep, because the surface of sewage in contact with the sides of the drain is greater in proportion to the sectional area of the stream, when the depth is only one inch, than when the depth is two inches.*

It will be readily seen from the foregoing that, to obtain a scouring and cleansing flow,—a flow which will remove all solids,—it is desirable that the mean depth of the flow (usually known as the "hydraulic mean depth"†) be, generally speaking, as large as possible. This advantage, as already stated, is obtained by the use of comparatively small piping.

As a cardinal rule, it may therefore be laid down that a drain should be as small as possible; for, the smaller the drain, the better the flushing and the removal of deposit. In addition to this, the first cost in material and labour of the smaller and more efficient drain is much less than that of the larger. Under these conditions it is a matter for regret that the by-laws of various sanitary authorities should still insist upon six inches as the minimum diameter for main drains, for under such circumstances the evils entailed through the use of too large drains cannot be avoided. At the same time, no drain should be less than four inches in diameter, nor should it be too small to carry off at all times such rainfall as may

* It is interesting to note that the velocity is greatest when the flow equals in depth five-sixths of the diameter of the drain, and that when flowing full the velocity of the sewage passing through a drain is exactly the same as when flowing half-full.

† The hydraulic mean depth is found by dividing the sectional area of the stream by its wetted perimeter—*i.e.*, frictional surface of the pipe.

enter it in addition to the sewage proper of the house.

In designing a system of drainage, it is therefore necessary to carefully calculate the quantity of sewage and rain-water to be removed by each drain, be it a main drain or a branch drain. Branch drains, perhaps, need no calculation as regards their dimensions. They should not be less than four inches in diameter, nor need they be larger, as a 4-inch drain laid at a gradient of one in forty has a discharging capacity of no less than 151¼ gallons per minute, which is amply sufficient for all requirements. The only calculations which are therefore necessary for branch drains is to ascertain the maximum hourly flow through them, in order that the sizes of the main or collecting drains may be regulated, and, if necessary, graduated accordingly.

For general purposes, the maximum quantity of sewage proper passing through house drains may be taken to equal the average daily consumption of water used for domestic purposes. This is about thirty gallons per head per day. The discharge of sewage being, however, very unequally divided over the twenty-four hours of the day, it is always assumed in calculations that one-half of the daily discharge takes place in six hours; that is, that for every inmate of the house fifteen gallons of sewage will be discharged into the drains in six hours. This gives two and a half gallons per head per hour as the quantity of sewage to be provided for in calculating the sizes of house drains. The maximum number of inmates to be provided for may, of course, be ascertained by counting the bedrooms of the house.

In addition to the sewage, provision must be made for the removal of rain- or storm-water. To calculate the quantity of storm-water likely to enter the drains, local circumstances (as regards rainfall, which varies in the various districts of the country) must, of course, be taken into consideration. As a general rule, it is however sufficient to calculate the quantity on a basis of a maximum rainfall of one inch per hour. One inch of rain on a superficial foot is equal to half a gallon of water, and as the whole of this water will find its way into the drains when the rain falls upon impervious surfaces, it is necessary to allow for that quantity for all non-absorbent surfaces to be drained; that is, such surfaces as paved yards and areas, and roofs, the latter being measured horizontally. When falling upon pervious surfaces, such as gravelled walks, a proportion of the rain-water will naturally be absorbed by the ground; hence it is only necessary to provide for half an inch of rainfall on these surfaces, or, in other words, for one quarter gallon per hour for each square foot.

It will thus be seen that the total hourly flow of liquid to be provided for in planning a system of drainage is one consisting of two and a half gallons for each inmate of the house, and half gallon for each square foot of impervious surface to be drained, and a quarter gallon for each absorbent square foot of surface. Keeping these figures in mind, there should be no difficulty in providing drains of a calibre consistent with the work to be done; nor any excuse for drains excessive in diameter. As a means of ready reference, and for convenience in ascertaining the discharging capacities of various drains, laid at different gradients, the following table may prove useful:—

Table IX.

Table of Velocity (V.) in Feet per Minute and Discharge (D.) in Gallons per Minute, of Drains, with Various Falls, when Running Full.

Diameter.	4 inches.		5 inches.		6 inches.		9 inches.		12 inches.	
Fall.	V.	D.	V.	D.	V.	D.	V.	D.	V.	D.
1 in 20	395	214·90	441	375·40	481	589·18	582	1604·2	664	3254·16
1 in 25	353	192·07	395	335·52	432	529·15	525	1447·6	600	2940·28
1 in 30	322	175·21	360	306·07	395	483·84	481	1326·0	551	2700·67
1 in 35	298	162·18	333	283·31	366	448·34	446	1229·3	513	2514·09
1 in 40	278	151·25	311	264·21	342	418·95	418	1152·53	481	2357·47
1 in 45	261	142·02	291	248·09	322	394·43	395	1088·8	454	2225·19
1 in 50	246	134·04	278	234·15	307	375·46	375	1033·9	432	2115·98
1 in 60	226	123·11	253	215·06	279	341·20	343	945·98	395	1935·03
1 in 70	209	113·88	234	198·93	257	314·31	317	874·22	366	1792·75
1 in 80	194	105·71	217	184·66	239	292·28	296	816·19	342	1675·44
1 in 90	182	99·15	203	173·20	225	275·18	279	769·39	322	1577·47
1 in 100	172	93·72	192	163·71	213	260·52	264	728·21	306	1498·85

Comparing this table with the data already given, it will be seen that a 4-inch drain, laid at a gradient of one in forty, is sufficiently large for the drainage of a house having twenty-five inhabitants and a superficial area of rather more than 18,000 square feet. Such a drain, therefore, is amply sufficient for the majority of town houses.

Circumstances must, however, be taken into consideration for each case, and there may be instances in which drains of greater discharging capacity may have to be provided. Under such circumstances it may be possible, as it is always desirable, to subdivide the drainage system of the building into sections, utilising two or more main drains of small calibre in preference to one of large diameter. Similarly it may be possible to provide a 4-inch drain for the removal of the sewage proper and a proportion of rain-water, and another drain for the remainder of the storm-water.

It must be clearly borne in mind that even the smallest drain (which in practice, as already stated, should never be less than four inches in diameter) will only run full under exceptional circumstances. During dry weather, for instance, the flow through the drain will consist of merely the sewage proper (*i.e.*, excrementitious matter and waste-water), and as the bulk of this is delivered into the drains through waste-pipes considerably less than four inches in diameter, it will be seen that even a 4-inch drain is hardly self-cleansing under ordinary circumstances. It is therefore necessary in planning a system of drainage, not only to make use of a small drain, but, in addition, to also lay it at gradients which will, as far as possible, tend to provide it with a self-cleansing flow, that is, with a flow sufficiently deep to float fæcal matter to the outlet. In most cases it will also be necessary to provide it with means by which a comparatively large quantity of water may be discharged into it, spontaneously, and in a thoroughly cleansing flush, at regular intervals. This latter is all the more necessary in cases in which the gradients, through one reason or another, are not as steep as could be desired.

The gradients to which drains are to be laid must necessarily, to some extent, depend upon the difference in level between the lowest point to be drained and the sewer. So far as is consistent with this, however, all drains must be laid to self-cleansing falls, that is, to gradients which will ensure for the sewage flowing through the drains, under normal conditions, such a depth and velocity as will keep the latter free of deposit.

It requires no explanation to understand that the flatter the gradient to which a drain is laid, the smaller will be the velocity of the flow through it. In an excessively flat drain, therefore, the flow will be so sluggish as to permit the deposit of the heavier portions of sewage. The steeper the drain, on the other hand, the greater the velocity, but the smaller the depth of sewage on the invert of the drain. This reduction in the depth of the flow of a given quantity of sewage may be so great in an excessively steep drain as to occasion the deposit of the larger floating solids. It will thus be seen that a drain must neither be too flat nor too steep, but that in this, as in most things, a happy medium must be struck.

From various experiments which have been carried out with well-constructed drains of even fall and smooth bore, it has been found that the most suitable gradients are those which will impart a velocity of three feet per second to a stream of sewage equalling in depth one-quarter of the diameter of the drain, or, what is equivalent thereto, a velocity of 4·5 feet per second to the sewage of drains flowing full or half full. These falls are :—

For a 4-inch drain	1 in 42
,, 5-inch ,, ...	1 in 52
,, 6-inch ,, ...	1 in 62
,, 9-inch ,, ...	1 in 95
,, 12-inch ,, ...	1 in 127

These gradients may be conveniently remembered by making use of Maguire's so-called "decimal" rule, which consists of multiplying the diameter of the drain, in inches, by ten, the result giving the number of feet in which the drain should fall one foot. Thus :—

Diameter of Drain.	Gradient of Drain.
4 inches	1 in 40
5 inches	1 in 50
6 inches	1 in 60

These results are sufficiently accurate for all practical purposes.

Whilst, theoretically, drains should not be laid at much flatter gradients than those above mentioned, it is in practice frequently impossible to obtain the falls named for the whole of the drainage system. In such a case

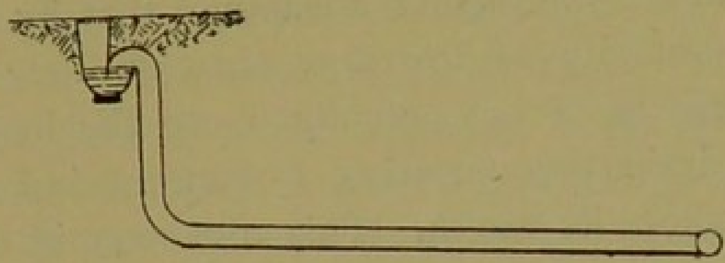


FIG. 134.

the branch drains should be laid, as far as practicable, to self-cleansing gradients and the main drain given a somewhat flatter fall and provided with means for automatic flushing. Such an arrangement is preferable to the sacrifice of the self-cleanliness of branch drains—which cannot all be conveniently flushed automatically—in order that a slightly greater fall may be given to the main drain. If, on the other hand, local circumstances

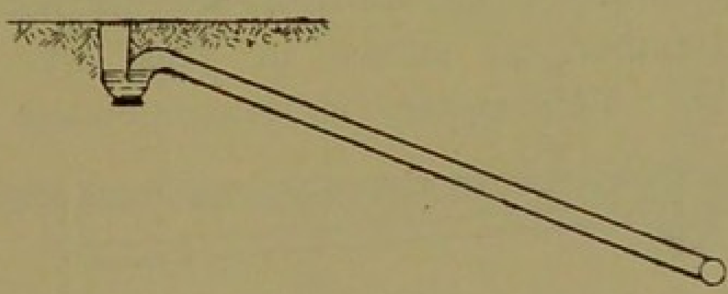


FIG. 135.

would permit much steeper gradients, it will still be better to adhere to the falls named, for, as has already been pointed out, the general impression that "the greater the fall the better" is wholly erroneous.

Where the difference in level between the points to be drained and the sewer is large, the gradients above advocated may be maintained by continuing soil pipes and outlets of gully traps, &c., down vertically into the ground (as shown in Fig. 134 as against Fig. 135). This system has the further advantage that by its means the mean velocity of the flow through the piping is brought near to, if not actually up to the head of the horizontal drain, thus ensuring a scouring and cleansing flow throughout its length. This advantage is, of course, derived through the impetus given to the sewage by its fall through the vertical piping. Greater cost will be involved by the adoption of this system, owing to the additional excavation and length of piping, but the results obtained will frequently justify the additional outlay.

Should, however, the increased cost be objected to, the drains may be laid to the gradients named at a comparatively small depth from the surface of the ground and then permitted to fall vertically into the disconnecting trap or chamber, as shown in Figs. 136 and 137 respectively. This system is recommended by many

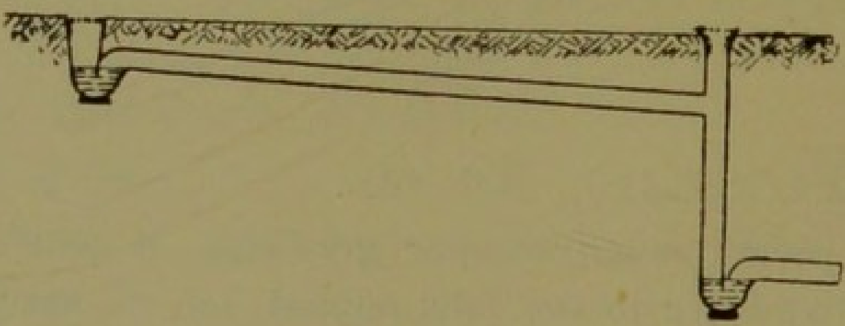


FIG. 136.

owing to the cleansing effect produced in the trap by the force of the falling sewage. Some in fact have gone so far as to maintain that the greater the drop the smaller the need for an inspection chamber to the trap.

Whilst this may be true as regards the trap itself, the need for means of access to the horizontal drain is not diminished by the presence of the drop. An inspection chamber is therefore advisable in all cases. The vertical drop of the drain into the chamber is, in such a case, conveniently arranged as shown in Fig. 137 and should always be formed by piping, as, in the opposite event, sewage will be discharged against the walls of the manhole. Means of access to the horizontal drain should be arranged by the provision of a cleansing eye on the vertical piping immediately opposite the junction.

In deciding upon the gradients of the various drains comprised in the drainage system, it is also essential to bear in mind that it is necessary to make an allowance of

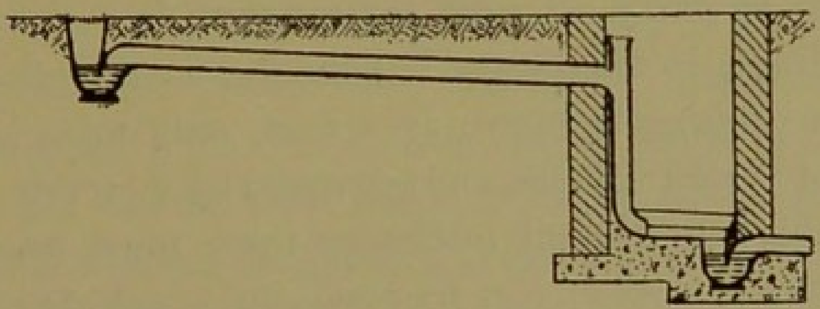


FIG. 137.

from three to six inches (possibly more) for the difference in level between the inlet and the outlet of the disconnecting trap. Wherever there is a change of direction in the drains, either by a bend or through a junction, an allowance of an additional fall of one inch must also be made as compensation for the reduction of the velocity of flow.

CHAPTER XII.

AUTOMATIC FLUSHING.

Automatic flushing, as has already been said, is of the greatest assistance in maintaining the cleanliness of drains, and, as such, desirable in all cases and imperative where, through the position of the public sewer or other reasons, the drains would not be self-cleansing under ordinary circumstances. As we have seen, the only practical way known for *preventing* deposits in drains is to keep the latter flowing constantly with a depth and velocity of flow sufficient to carry all solid matter with it. This in a house drain, is manifestly impossible, as the discharges into the drainage system, as a rule, only take place in spurts of varied volume, and separated by intervals of time. Under this intermittent discharge there must necessarily be occasions, more or less frequent, on which deposits do take place. As they cannot be prevented, they must be removed with the least possible delay, and this is accomplished by the aid of automatic flushing, by which is understood the periodical, regular and spontaneous discharge of a large volume of water at a considerable speed. By such a discharge all deposits will be broken up and forcibly removed, whilst, at the same time, the thorough renewal of the air within the drains will be greatly assisted.

In a preceding chapter it was pointed out that, failing special provisions for the frequent and thorough removal of grease from grease-traps, the latter were liable to become a nuisance and would tend to block the drains by permitting grease to overflow into them and solidify on their sides. It was therefore advocated that, unless there were good reasons for retaining the grease, grease-traps should be altogether dispensed with and the grease passed into and through the drains under sanitary conditions. For this automatic flushing is also invaluable, for, if the water containing the grease is discharged into a properly-constructed flushing gulley (Fig. 55), the grease will be retained, cooled, and then periodically broken up and flushed through the drains *in lumps*, without chance of adhering to the interior surfaces of the drain pipes.

The great point in automatic flushing is to discharge the available water in suitable quantities and spontaneously; that is, at the rate of from two to four gallons per second. For this purpose suitable apparatus—automatic flushing tanks—are necessary, in order that the water may be collected and retained until the desired quantity has been obtained and then suddenly discharged into the drains. Under such a system the merest dribble of water, which would otherwise have no effect upon the cleanliness of the drains, may be converted into a powerful and valuable means of cleansing. More than that, forty to fifty gallons of water so discharged will be of infinitely greater benefit than a thousand gallons discharged in a small continuous stream.

Automatic flushing tanks may be divided into two types, respectively known as the " Tipper " and the "Syphonic."

Flushing tanks of tipper type (Fig. 138) are constructed to discharge their contents from a vessel which works upon a pivot placed in such a position that its centre of gravity varies as the water rises, until a condition of unstaple equilibrium is set up and the tank falls over, tipping out its contents and returning to a vertical position when empty. Syphonic flushing tanks—which are the type more frequently made use of in town houses, owing to their comparatively noiseless action—are, on the other hand, arranged to discharge by means of a syphon. Two such tanks are shown in Figs. 139 and 140.

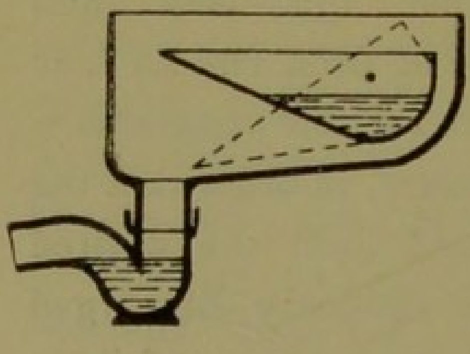


FIG. 138.

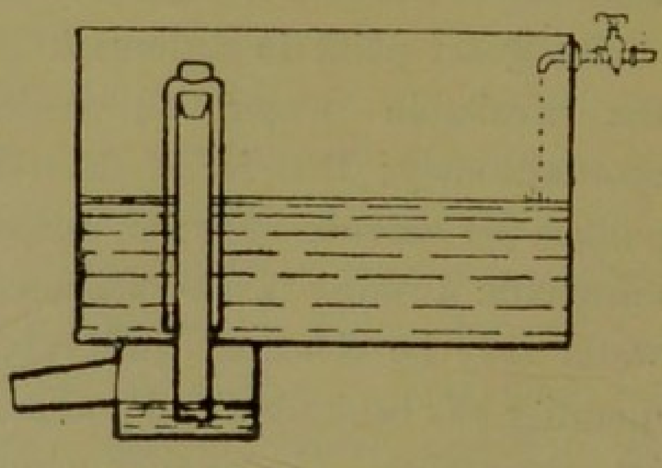


FIG. 139.

To actuate the syphons by means of the very small stream—often the drop-by-drop feed—by which the water is admitted to the tanks, various means are adopted. Of these the two more frequent are either to permit a false level of water to be temporarily maintained in the tank by a confined body of air in the syphon, which, being released or reduced in pressure, permits of a momentary rush, which carries the air along with it and ensures the continuity of the stream ; or to make use of an inverted ball-valve, which turns on a full supply of water when the tank is nearly full. The last-named is the more reliable of the two, as tanks which are constructed to discharge with merely a drop-by-drop

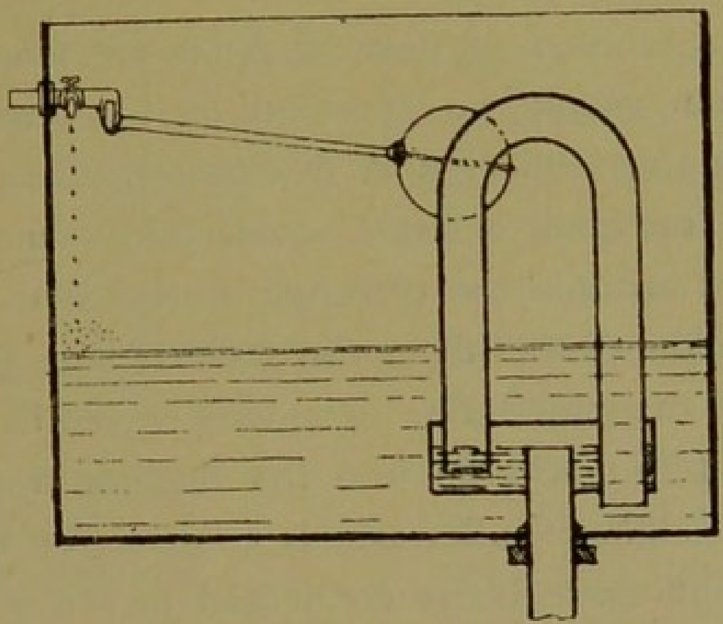


FIG 140.

feed are, through various causes, liable to permit the water to trickle into the drains at the rate at which it enters the tanks after it has once reached the level of the top of the syphon. Under these conditions the tanks will never flush and the water will be wasted. The illustrations referred to (Figs. 139 and 140) show examples of each of these two types of flushing tanks.

A flushing tank should be fixed at the head of the main drain where the drainage system is a small one, and at the head of each of the most important branch drains where the system is extensive. Should more than one tank be provided, the tanks should be arranged to discharge alternatively. Simultaneous flushing will not be conducive to increased cleanliness, but may, on the contrary, prove objectionable by charging portions of drains so full as to render the various surface and other traps connected thereto liable to syphonage.

Where a number of flushing tanks are made use of, one of them should be provided on the branch drain into which the scullery sink discharges, while in cases where only one tank is fixed, some endeavour should be made to so arrange the drainage system that the head of the branch drain taking the scullery sink also forms the head of the maindrain. The tank should in that case be arranged to discharge into the flushing-rim gully to which the scullery sink waste is connected; the flush-pipe and sink-waste being connected to the trap either in the manner indicated in Fig. 55 or as in Fig. 141. By flushing direct into the sink waste-pipe, as is shown in the last-named illustration, the most satisfactory results are obtained, as the waste-pipe will be flushed as well as the drains. The falling body of water has sufficient power to break up the grease congealed in the waste, while the continued flush carries the fragments through the trap and drain. If this arrangement is adopted, the sink-trap must be ventilated (as shown) in order to counteract syphonage.

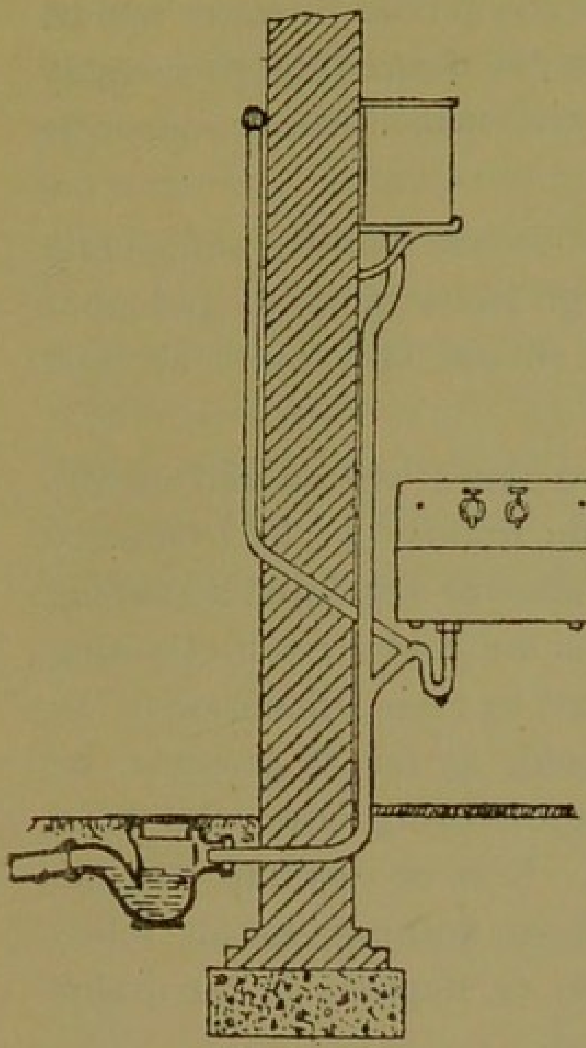


FIG. 141.

Whenever possible, flushing-tanks should be fixed at some elevation—say about six feet—above the inverts of the drains into which they discharge, in order that the water discharged may have attained a thorough scouring force by the time it reaches the drain. The greater the elevation, the greater of course the force imparted to the flush by its fall through the vertical flush-pipe. This flush-pipe, by the way, as well as the outlet from the tank and the connection of the pipe to the drain (which should be by means of a surface trap) should not be less than three inches in diameter for a 4-inch drain, $3\frac{1}{2}$ inches for a 5-inch drain, and four inches for a 6-inch drain.

The capacity of the tanks must necessarily depend upon the diameters, lengths, and gradients of the drains upon which they are fixed. Broadly speaking, it may, however, be said that the following volumes of water will be found to give very good results :—

For a 4-inch drain	30 to 40 gallons.
For a 5-inch drain	40 to 60 ,,
For a 6-inch drain	60 to 100 ,,

For a 9-inch drain at least 200 gallons of water will be required for each flush if it be desired to thoroughly clean its interior. Such a drain will, however, never be necessary for a town house.

Flushing tanks on branch drains will be sufficiently large if arranged to discharge from 25 to 30 gallons of water at each flush, which should take place at least once daily.

A discharge twice or three times weekly will usually suffice for tanks fixed on main drains, but the frequency of the discharges must of course be regulated according to whether or not the drains are laid to self-cleansing gradients, and with due regard to their dimensions. In all cases the discharges should, as far as possible, be arranged to take place in the evening, after the main flow in the drains has ceased. It is at this time that the greatest benefit is derived from flushing, as all solids which would otherwise remain to stagnate in the drains overnight will then be removed.

Invaluable though the benefits to be derived from the proper use of flushing-tanks are, water companies have raised objections to their use on account of "waste." This has even been carried so far as to entirely prohibit the use of flushing-tanks unless the water is paid for by meter—a course which must necessarily be complied with until such time as the control of the water supply shall pass into more liberal hands. The alternatives which have been adopted in some cases—viz., to make use of waste and rain-water for the purpose of flushing—are reprehensible since the former involves the retention of fouled water and the latter is variable and uncertain. There is, however, no objection to the connection of a bath-waste of suitable diameter to a flushing-rim gully, as in that case the water will be in constant movement, and there will be neither time, nor room for the accumulation of deposits. When connected to a flushing-rim gully receiving greasy waste-water, the bath waste will, moreover, frequently be found a very efficient and inexpensive substitute for a flushing tank if the bath is regularly made use of, or frequently filled and emptied for flushing purposes.

CHAPTER XIII.

ACCESS.

The desirability, if not necessity, of providing means of access to the drainage system has already been touched upon in the chapter devoted to access pipes, (Chapter V). It was there pointed out that, as a broad principle, every pipe and connection comprised by the system should be made accessible throughout. This principle is essentially a leading feature of modern drainage, and is of the utmost value. It enables stoppages to be located and removed without loss of time and practically without expense. It assists the inspection, testing, and cleansing of the drainage system; enables leakages—if such should occur—to be located and rectified at a minimum of cost; and, in short, brings all that which would otherwise be out of reach, out of sight, and possibly out of mind, under perfect control.

Means of access must not, however, be provided indiscriminately. Their positions must be carefully chosen in order that the fullest advantage may be derived therefrom, and their number as far as possible restricted, to avoid unnecessary expense; inspection chambers, or even merely access pipes, being obviously more costly than ordinary pipes.

In vertical piping, such as soil pipes and ventilation pipes, the points at which means of access should be provided will usually be obvious. The positions of bends and junctions in these pipes are not, in most cases, appreciably movable ; they must be arranged according to the walls and floors of the buildings, and where they—or the most important thereof—occur, there, clearly, are the points at which access pipes should be fixed.

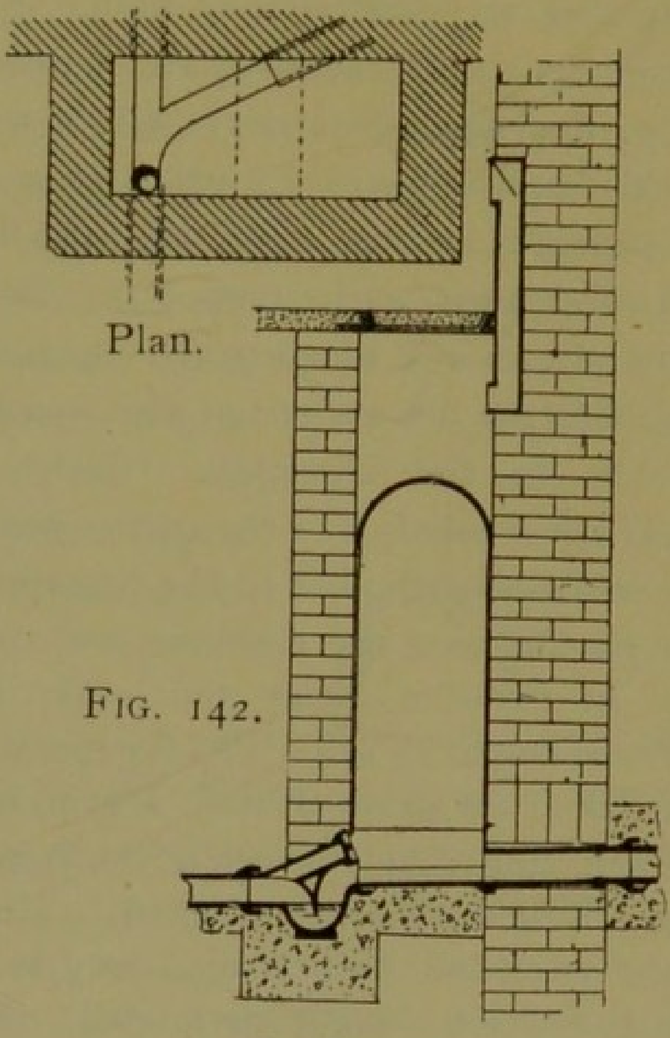
In the case of underground drains, the matter is altogether different, and all depends upon the skill with which the drainage system is designed. Here the position of an inspection chamber is not necessarily dependent upon bends and junctions. On the contrary, the positions of these can, and often must, be adapted according to the most suitable position for the inspection chamber. As a simple illustration of what is meant, reference may be made to the position of an inspection chamber in the case of a recently-inspected drainage system. In this case the chamber and branch drains (respectively from a bath waste, a water closet, and soil pipe) were arranged as shown in Fig. 122. Obviously this arrangement is not so satisfactory as that shown in Fig. 123. By placing the chamber in the position shown in the last-named illustration, equal, if not better, facilities for cleansing, &c., are provided, whilst at the same time two long lengths of unventilated drains (from the bath waste and water closet) are done away with. These are details, but of these perfection is made up. It should be explained that, to economise space the lengths of the various branch drains, as shown in the illustrations, have been considerably reduced in proportion to the original The actual lengths of the three branches varied from 15 to 20 feet.

At all important bends, junctions and changes of gradient, however (these being as far as possible arranged in groups), an inspection chamber should be provided and the drains laid in perfectly straight lines and to true and regular falls between the points at which the chambers are placed. An inspection chamber should also be built at each end of the drains passing under buildings and at the point at which a disconectting trap is provided ; be that the trap by which the direct connection with the public sewer is broken or merely a trap or traps made use of for the sub-division of the drainage system itself. The London County Council's Drainage By-Laws, which may be taken as types of the more modern by-laws of British Cities, provide in the case of drains under buildings, that the builder "*shall*, whenever practicable, cause adequate means of access to such drain to be provided at each end—thereof . . .;" whilst in the case of intercepting traps the by-laws state :—"He *shall*, . . . provide a separate manhole or other separate means of access to such traps . . ."

It being desirable that all inspection chambers be provided *outside* the house, and open space being in certain classes of town houses conspicuous by its absence, the provision and arrangement of suitable manholes for the above mentioned purposes is frequently a matter of great difficulty. In residential buildings, the front and back area or even a vault accessible from the former, are usually convenient and suitable points at which to build inspection chambers. In the case of buildings of the warehouse class, shops and office buildings and similar structures, however, it will be frequently found that no such convenience exists at or near the point desired. Such buildings in the majority of cases abut upon the pavement without the intervention of an area, and, to make matters worse, it may be found that even the basement rooms which in some cases are partly beneath the street pavement are occupied as offices or workrooms.

In such cases, if permission can be obtained from the Local Authorities, an inspection chamber may be built under the pavement, with means of access from the street. Should this permission be granted, it will be usually found that the Local Authority will, in addition to the demand made for a payment for the easement, also impose conditions and strictures with regard to the mode of construction and means of access to the manhole and above all with regard to the dimensions of the manhole and the manhole cover in the foot-path. These dimensions generally bear some relation to the nature and importance of the street and foot-path, and to the amount and nature of the traffic passing over the manhole, and therefore vary considerably in different cities and even in different thoroughfares of the same city. As a general rule it may however be taken for granted that a minimum of space will be allowed, and that the projection from the face of the building will be especially restricted. From eighteen inches to one foot and nine inches may be taken to be the greatest projection usually permitted. In that case the length of the manhole should not be less than 3 ft. 6 in. and this size will as a rule also be allowed, as a smaller chamber would not permit movement to a man and would therefore be useless.

A Plan and section of such a manhole constructed in a northern city are shown in Fig. 142. The dimensions of the chamber are 3 ft. 6 in. × 1 ft. 8 in. up to a height of 5ft. from the invert of the drain, from which point the shaft communicating with the street surface is 1 ft. 8 in. × 1 ft. 6 in. or just sufficient to permit a man to pass through. At the ground level the manhole is covered by a cast-iron "sunk" cover filled with concrete brought to a surface



Plan.

Fig. 142.

Section.

matching the paving of the foot-path. It will be noticed that the drain passes through the chamber at its extreme end in order to render access to the drain and trap as convenient as possible, Had the drain been placed in the centre of the manhole, it would have proved very difficult, if not impossible for a man to reach it. An air-inlet to the drain is formed by an iron air-duct six inches wide and four inches deep built into a chase in the wall. This pipe is connected to the iron access pipe in the bottom of the manhole, where such is used, by means of a special casting, corresponding to the air-duct at one end and four or six inches in diameter at the other to correspond with the circular socket on the drain.

Manholes within the house are, as already stated, objectionable. The reasons for this are that the covers may be accidentally broken or disturbed and thus permit drain air to pass into the building, and that a quantity of vitiated air is liberated into the house whenever the chambers are opened for the purpose of inspection or cleansing.

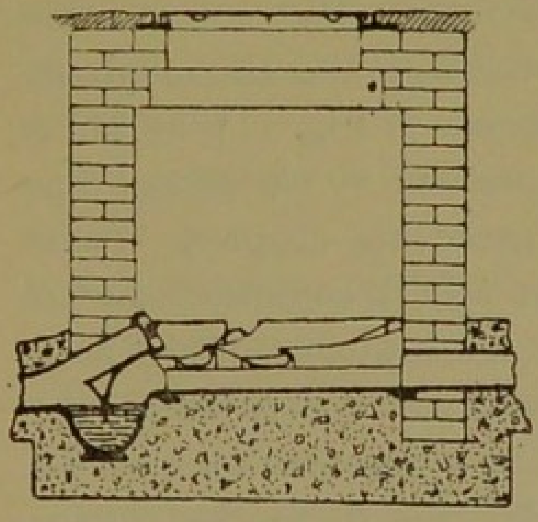


FIG. 143.

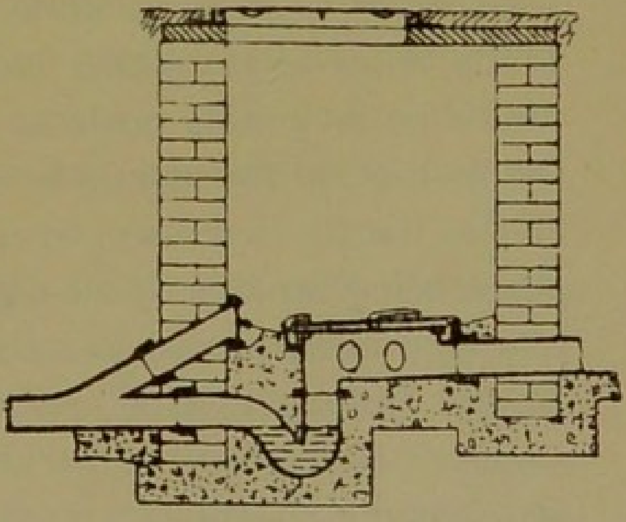


FIG. 144.

The first-named of these objections however applies only to inspection manholes as usually constructed. These manholes, as will be seen from Fig. 143, consist merely of open, cement-rendered brick chambers, more or less impervious to moisture and covered at the ground level by air-tight iron manhole covers, through which the drains pass in the form of open half-channel pipes. Inspection chambers so constructed, more especially when in connection with the drains of town houses, leave much to be desired. They are difficult to construct perfectly air and water-tight and always permit a constant accumulation of considerable volumes of drain air. These manholes, necessarily, also materially interfere with the free current of fresh air necessary for the ventilation of the drainage system and the retardation in the air current, due to loss from friction and regurgitation, may, in a large manhole, cause a loss of as much as 50 per cent. upon the oxidising effects which it is essential to secure in the interiors of the drains and soil pipes.

In cast-iron drainage work such a mode of construction as the above is altogether unnecessary and the manholes should be invariably made as shown in Fig. 144, in which the bottom of the manhole is formed by an access pipe of the nature described in a preceding chapter. These pipes, being fitted with air-tight covers, confine drain air to a very small section and also accelerate, or, at any rate, do not interfere with ventilation. Where used, the materials and general construction of the manholes proper also become a secondary consideration, as neither sewage nor drain air will be brought in contact therewith. Nevertheless, good workmanship and materials are always desirable.

It should be noted that, there being no means of drainage into the drains from manholes constructed as above described, it is necessary to leave a small weeping hole in the concrete of which the bottom of the manhole is formed and in which the access pipe is set, in order that such water as may be formed in the brick manhole by condensation, or which may pass through round the edges of the cover at the ground level, may be enabled to soak away into the ground and thus be prevented from accumulating at the bottom of the manhole. The weeping hole is conveniently formed by a short half-inch pipe passing from the bottom of the manhole through the concrete and into the soil beneath. The concrete bottom round the cover of the access pipe, must of course be shaped to drain into this weeping hole.

Manholes should be sufficiently roomy to permit of the access for which they are provided and to enable a man to work therein, efficiently and comfortably, with drain rods. For this purpose the following proportions will be found convenient :—

For manholes 1 ft. 6 ins. or less in depth, 2 ft. by 1 ft. 6 ins.

For manholes between 1 ft. 6 ins. and 2 ft. 6 ins. in depth, 2 ft. 6 ins. by 2 ft.

For manholes above 2 ft. 6 ins. in depth, 3 ft. 6 ins. by 2 ft. 6 ins.

Manholes more than 7 ft. 6 ins. in depth may be contracted in size to 2 ft. by 2 ft. at a height of 5 ft. above the invert of the drain.

CHAPTER XIV.

THE DRAINAGE OF BASEMENTS.

The drainage of basements, in the ordinary sense of the words, is both unnecessary and undesirable, and is, fortunately, also prohibited by the by-laws of most Cities by a requirement stating that there must be no inlet to a drain within a building "except such inlet as may be necessary from the apparatus of any water-closet, slop sink or urinal."

Surface traps fixed within buildings, as is occasionally done for the drainage of larders and wash-cellars, etc., unless frequently in use, are apt to loose their water seal through evaporation ; when a free passage into the house would be available to drain-air, the water in the trap may also absorb impure air to such an extent as to permit it to be given off inside the house. In the case of cellars in which no water is used, except for the purpose of cleaning the floors, it is therefore necessary to omit all means of drainage, more especially so if the apartments are used for the storage of milk or other foods. When it is necessary to wash the floors of these rooms, the water is capable of removal by the proper use of a mop or floor-cloth.

In wash cellars it is conceivable that means of drainage may be necessary for the removal of spilled water, and, if such be the case, the drainage should be by means of a channel or channels in the floor discharging over a surface trap outside the house. This trap may be conveniently fixed in one of the window areas usually found outside these cellars, when it will also serve to carry away rain-water from the area, and thus reduce dampness round the house. At the same time the trap will be benefited by a renewal or replenishment of the water forming its "seal" whenever it rains. Such a gully can also be fixed in a dry area. Sections of cellars drained as above recommended are shown in Figs. 145 and 146. Where no window-area exists or the area is unsuitably placed, the trap must be fixed below ground and its shaft continued to the surface as shown in Fig. 147.

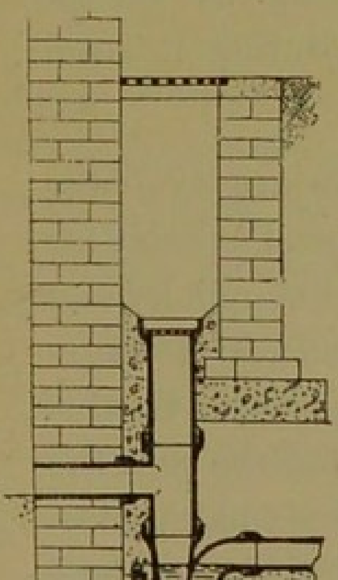


FIG. 145.

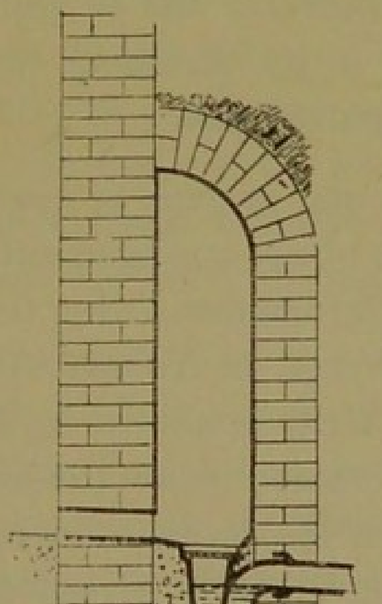


FIG. 146.

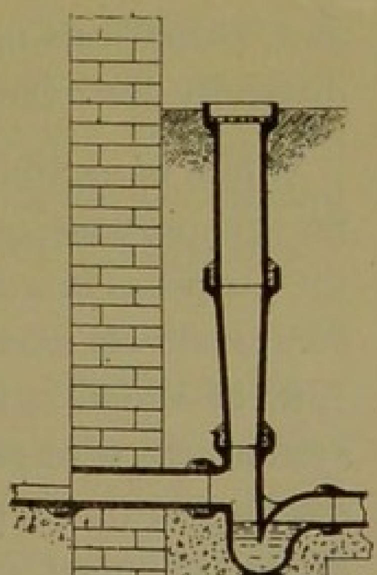


FIG. 147.

A more serious difficulty than the above, arises in the drainage of basements and cellars of town houses, and more especially of those of business premises, hotels, and similar structures, from the occasional necessity of providing means of drainage at a lower level than that of the public sewer. As has been stated in a preceding chapter, the difficulty of providing drainage in structures in which merely the lowest floor is beneath the level of the sewer is solved by suspending the drains from ceilings or by fixing them against the walls of the buildings, as it is by no means necessary that the drains should be beneath the ground. The real difficulty arises when sanitary fittings are fixed upon these low-lying floors, it being then necessary to lay the drains beneath the floor at a level which prevents drainage into the sewer by gravitation. In such cases the solution of the problem lies in collecting the sewage and either raising it by pumping or ejecting it automatically into the public sewer

While more than one system of ejectors are available for this purpose, one of the arrangements most suitable for the purposes of a single house, owing to its simplicity and comparatively small cost, is Adams' Automatic Sewage-Lift, of which one form is shown in Fig. 148. In this system, the sewage created below the level of the sewer is discharged through a low-level drain into a small underground chamber (conveniently placed for access) whence it enters the "forcing cylinder," the inlet pipe to which is provided with a flap valve which effectually prevents the return of the sewage. In some convenient position in the same or another building, but at a higher level than the forcing cylinder, is placed a second chamber known as the "air-cylinder," to which is connected an automatic flushing tank (fixed still higher) from which the energy employed in raising the sewage is derived. The height at which the flushing tank is fixed above the air-cylinder must be at least equal to the maximum height to which the sewage has to be raised, in order that the requisite pressure may be secured, If the tank can be conveniently placed higher than this, so much the better, as less flushing water will be required, the volume of air carried down by the falling water being proportionately greater and the air answering the same purpose as the water. The working of the appliance is as follows:—

When the flushing tank, which is fed by an ordinary regulating tap, is full, the water is automatically discharged into the "air-cylinder" through the "pressure pipe" shown in the illustration. The air contained in the cylinder is thereby displaced and forced into the "forcing-cylinder" through the "air-pipe" shown and by pressing on the sewage contained in the last-named cylinder ejects it into the sewer through the "rising main."

When the "forcing-cylinder" is emptied of its sewage the air-cylinder will be full of the water discharged into it by the flushing tank but this is immediately withdrawn by a syphon attached and air passes in to be again expelled and utilised at the next discharge of the flushing tank. The water thus withdrawn may, if desired, be run off into a storage tank and made use of for closet flushing or other purposes. Should it be desired to regulate the discharges of the flushing tank according to the rate at which the "forcing-cylinder" is filled with sewage, this may be accomplished by means of a float on the sewage connected to the feed tap of the flushing tank. In this manner and by utilising the water drawn off from the "air-cylinder," all waste of water will be avoided.

In adopting this system it is usual to make use of the apparatus merely for the sewage created at the low-level; the sewage derived from above the level of the sewer being disposed of by gravitation in the usual way.

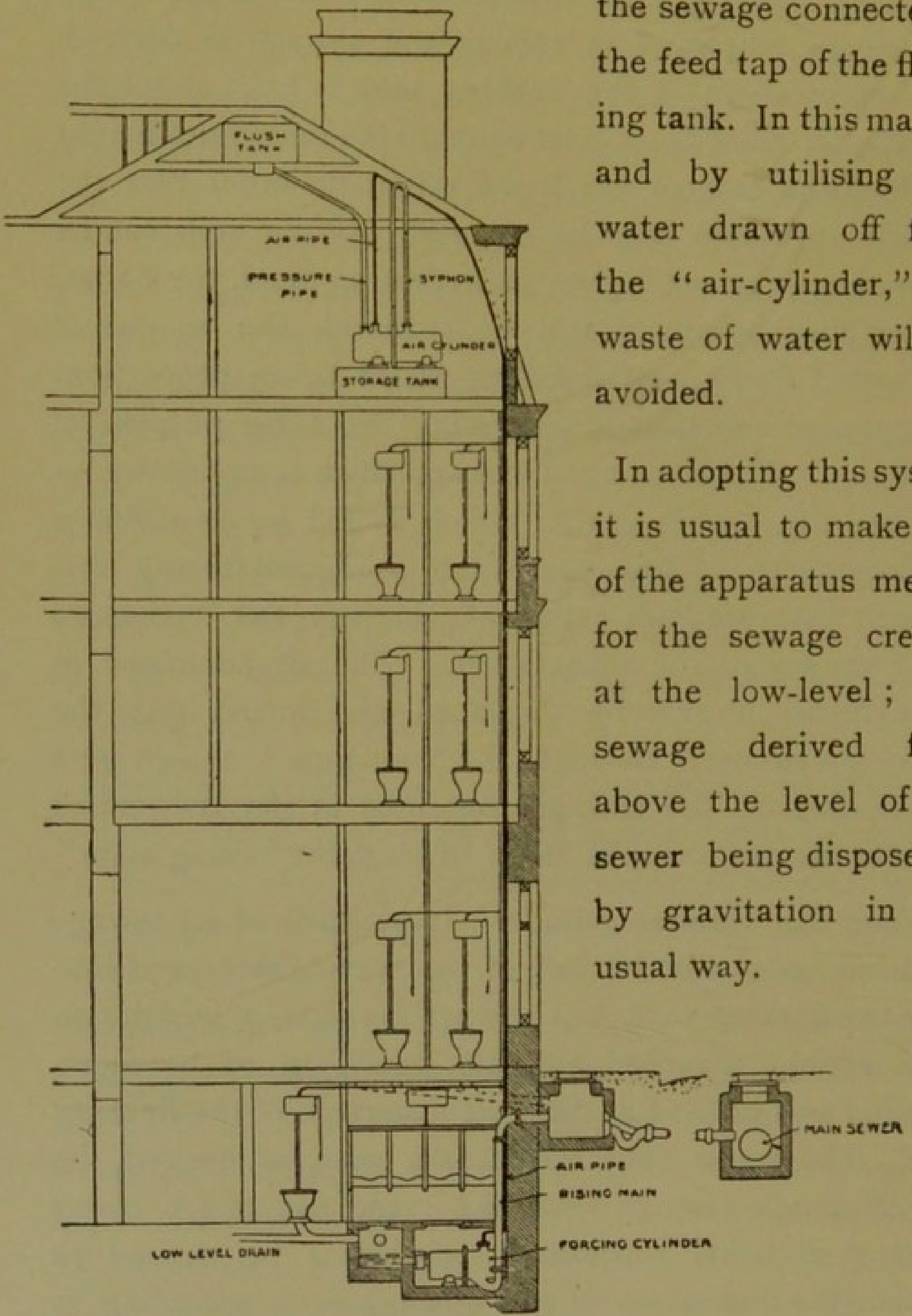


FIG. 148.

CHAPTER XV.

SANITARY FITTINGS.

The importance of selecting for use only such fittings as are efficient, cleanly, and safe, would appear to be so obvious as to hardly need comment, were it not that—to judge by the appliances daily made use of—the subject is greatly misunderstood, and that great diversity of opinion would appear to exist as to what constitutes a really desirable appliance. Great though be the necessity for thoroughly sound and properly designed and constructed drains and pipes outside and under the house, their importance is hardly greater than that the appliances which are fixed within the building should be thoroughly reliable and efficient in design, construction and fixing. A fitting may be perfect as regards materials and fixing, yet its design or shape may be such that, in a short space of time, deposits will accumulate in some portion or other, and constitute a continual nuisance and a standing danger. The appliance may, on the other hand, be of the best possible shape and material, yet an error in the making or fixing may cause the constant or intermittent entrance into the house of foul air from the waste pipes, soil pipes, or drains.

To treat in detail with the numerous classes and forms of fittings made is beyond the scope of the present work, and would require more space than is available. There are, moreover, already a number of text-books treating with the subject exhaustively. The remarks following must therefore necessarily be limited, and of a somewhat

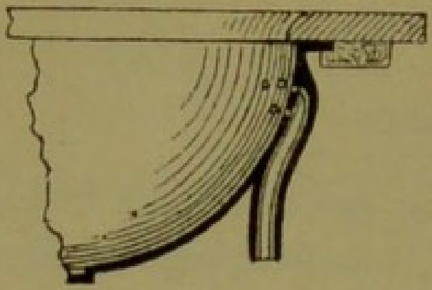


FIG. 149.

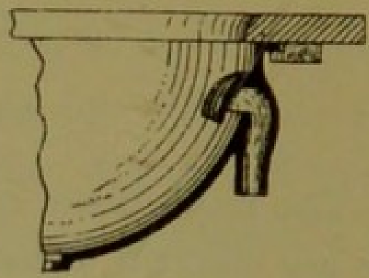


FIG. 150.

general nature, pertaining more to a general guide for the selection and fixing of fittings than to a description and detailed criticism thereof.

An appliance to be reliable, must be simple in its construction, and, whenever practicable, free of mechanism. It must be made of suitable materials and be void of all nooks and corners, which would favour the accumulation of dirt or other undesirable matter. As far as practicable, all the surfaces liable to be fouled should also be self-cleansing; whilst all portions should be get-at-able, and, whenever possible, visible, in order that dirt may make itself evident, and be readily removable by manual cleaning.

The portion of fittings which is most liable to become offensive, in the majority of appliances on the market, is the overflow pipe. Custom in the past, for some inexplicable reason, dictated that this should be invisible, and in consequence, means of overflow were, and are even now, provided, which cannot under any circumstances be cleaned, either automatically or by hand. These overflows, which are generally only called upon to take off the scum or driblets from the surface of the water retained by the apparatus, speedily become coated with thick layers of soapsuds and other filth, which, in decomposing, give off emanations quite as unpleasant and often as dangerous as fouled drain air. It is to these overflows that the mal-odours frequently present in bathrooms and similar apartments may be generally ascribed.

The more usual forms of these overflows are shown in Figs. 149-151. The first, which is the most common, consists of a number of small holes communicating with the overflow pipe proper at the back of the fitting. Fig. 150 shows an overflow pipe masked by some such ornamental device as a shell or a lions head; whilst Fig. 151 illustrates the "secret standing overflow" which

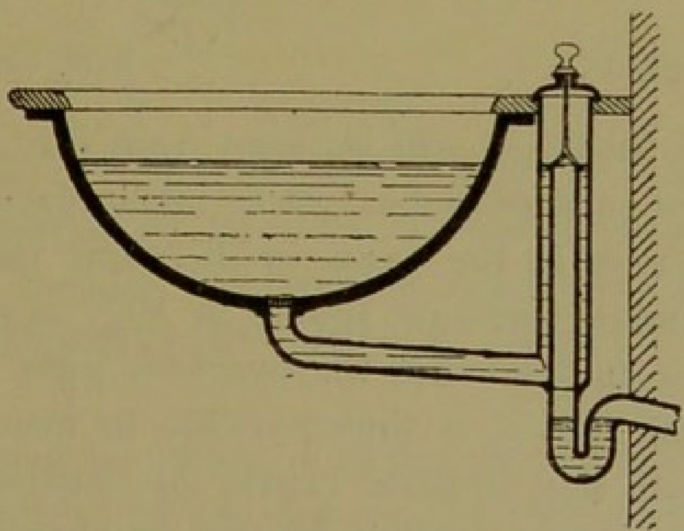


FIG. 151.

in the past has been, and, to a great extent, still is, a general favourite. The overflow shown in this illustration is typical of a number of similar, somewhat varying, contrivances.

It need hardly be said that each of the foregoing overflows renders insanitary any fitting upon which it may be fixed. Nor is there the slightest reason for their continued manufacture and use, as overflows of better design are available. Moreover, the appliances which are provided therewith are not more costly than those with insanitary overflow pipes.

Satisfactory overflows are shown in Figs. 152-4. In

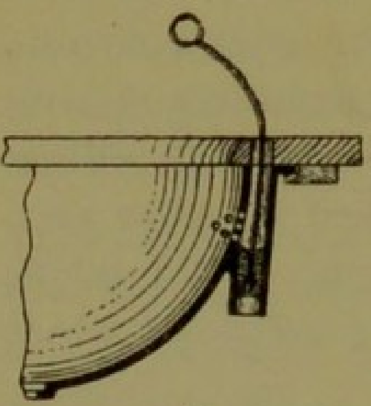


FIG. 152.

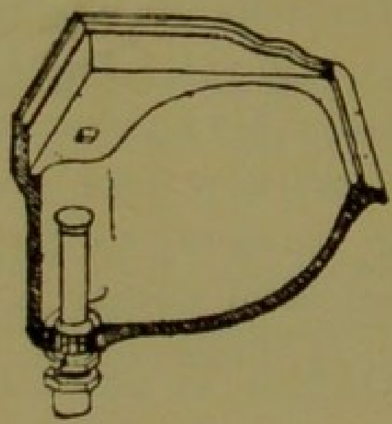


FIG. 153.

the first of these, as will be seen from the illustration, the overflow of superfluous water takes place through a number of holes in the basin, in the same manner as in the undesirable overflow shown in Fig. 149. It will, however, be noticed that the overflow pipe is open at the top, and that it is thus possible to insert a small, long-handled, and flexible brush, by means of which the interior of the pipe may be thoroughly cleaned from time to time. This overflow is suitable for, and is made on, all classes of fittings.

Figs. 153 and 154 illustrate overflows which can only be made use of in connection with lavatories, baths, and sinks, and which are not suitable for closet basins. The one consists of a short, removable pipe, standing in a recess of the basin, etc., which, when placed over the outlet, acts both as overflow and plug. When lifted up the outlet is open, and the contents of the fitting free to pass out into the waste pipe. The other overflow, shown in Fig. 154, is the "Loco" self-cleansing overflow, which in appearance is similar to the foregoing, but which is *pushed down* into the waste pipe, when the basin,

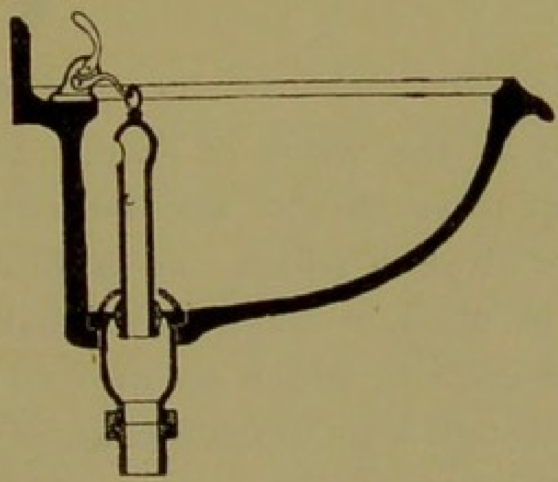


FIG. 154.

or bath, &c., is to be emptied, instead of being *lifted up*. Hence, a portion of the contents must pass out into the waste pipe through the overflow, which is thus washed, both in its interior and exterior, whenever the fitting is used.

Soap dishes in lavatory basins, baths, and sinks, but more especially in the first-named, are also frequently improperly made. They often consist of sunk dishes, drained into small inaccessible pipes through a number of small holes in their bottom (see Fig. 155). To the pipes leading from these dishes to the waste pipes similar remarks apply to those made in connection with inaccessible overflows. The holes of these dishes are also very apt to become clogged, and, should this occur, water is retained in the soap trays. This is unsightly,

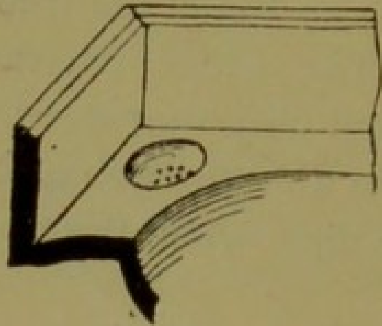


FIG. 155.

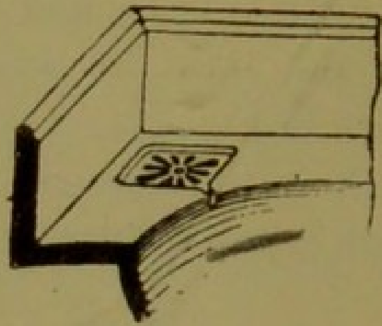


FIG. 156.

and conducive to the waste of soap. For this reason undrained soap trays should also be avoided. Better soap dishes are those of which one is shown in Fig. 156. They consist of shallow trays, with shallow ridges or channels at the bottom, which are drained into the basin or sink, &c., through a small open channel.

Each fitting, whatever its nature or object, must be trapped, as near as possible to its outlet, by means of an efficient trap. By the latter is understood a trap of suitable (*i.e.*, self-cleansing) shape, having an efficient water-seal, which will permit of a certain amount of evaporation before leaving the trap open for the passage of foul air, and which contains a sufficient depth of water to resist any slight pressure which may be exercised by foul air on its outlet side The most suitable depth of water seal in a trap is one of from two to two-and-a-half inches. The only self-cleansing trap at present available is the "syphon trap," which is made with varying outlets, but which, in all cases, consists of merely a suitable bent pipe. The two more common forms of this trap—the "S" and the "P" traps—are shown in Figs. 157 and 158. Syphon traps are frequently contracted at the "throat," to obtain a greater scouring force through them, or, as in the case of the anti-D trap, specially shaped to resist or minimise the risk of syphonage, but these are merely minor, though often important, variations, which do not affect the principle of using only syphon traps. All other traps—such as the "Bell trap" (Fig. 159), "Antil trap" (Fig. 160), "D trap" (Fig. 161), "Bottle trap" (Fig. 162), &c.—have all one or other, or all, of the following faults, namely—(*a*) that they do not provide a sufficiently deep "seal"; (*b*) that they invite the accumulation of dirt; and (*c*) that they contain more water than can be changed by an ordinary discharge of the fitting upon which they are fixed. Many of these traps are frequently made as a part of the fitting, and it is therefore necessary to avoid the apparatus upon which they are provided.

"Mechanical traps," with floating balls or valves, &c., should also be studiously avoided. Mechanism is always unnecessary in a trap, and frequently also detrimental, as it is apt to harbour dirt, and to go wrong.

As a general rule, it is well to make use of only such fittings in which the trap is separate from the appliance proper, as, should it be necessary to remove the latter, the trap need not be disturbed, but may be left on the waste or soil pipe to continue its function of excluding foul air from the house.

The trap, it need hardly be pointed out, must be of the same, or of a smaller, sectional area than that of the outlet under which it is fixed, due allowance being made for the space obstructed by the outlet grating, where such exists. Were it larger, the flow from the fitting would not be of sufficient volume to thoroughly cleanse

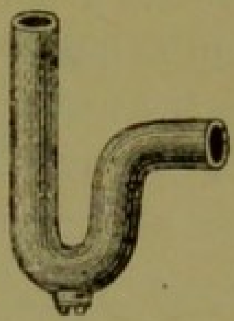


FIG. 157.

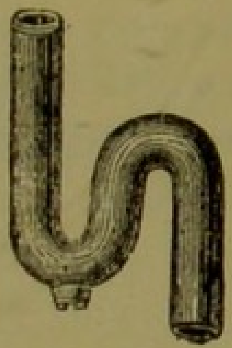


FIG. 158.

it. In fixing the trap, care must also be exercised to see that the overflow pipe from the fitting—where such is separate from the outlet—is connected to the *inlet* side of the trap (preferably above the level of the standing water), and not on the outlet side. Where the latter is the case, the objects of the trap are frustrated, as foul air is able to enter the house through the overflow arm—see Fig. 163.

Although the necessity for trapping water-closets and urinals is generally acknowledged, there are many—usually of the jobbing fraternity, who, not being engineers, have modestly adopted the title, "Sanitary Engineers" *—who dispute the need of traps under lavatories, and other similar fittings, the waste pipes of which dis-

**Sanitary engineering* is a branch of civil engineering. It would be greatly to the benefit of the public health were the title of "sanitary engineer" rigorously guarded, and only permitted to qualified men. The present state of affairs, under which every tinker, ironmonger, and house agent is at liberty to use it, is analogous to that under which any druggist or quack was able to advertise himself and practise as a physician.

charge over surface traps outside the house. When it is borne in mind that the object of trapping these appliances

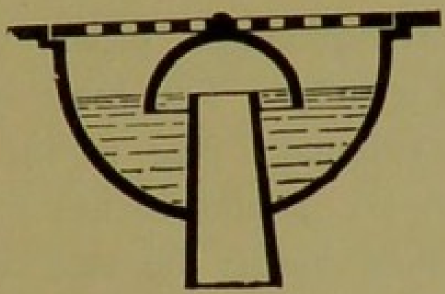


FIG. 159.

FIG. 160.

is to exclude from the house foul air generated *in the waste pipes*, and not drain air, their necessity will be obvious.

When necessary, the traps must be ventilated in the manner, and for the reasons, stated in the tenth chapter. Should this ventilation be provided for by means of anti-syphonage pipes (as is usually the case), their junctions with the waste pipes or outlets from the traps must be curved in the direction of the flow (see Fig. 164), and at

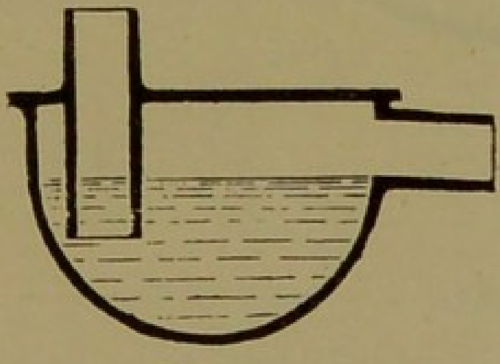


FIG. 161.

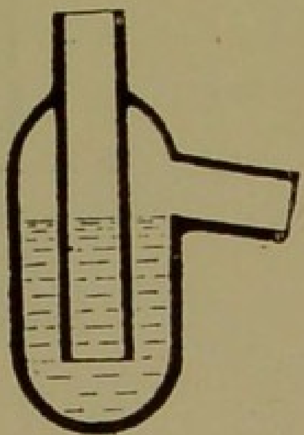


FIG. 162.

some little distance from the crowns of the traps. These precautions are necessary, on the one hand, to minimise the friction to which the air currents will be subjected, and, on the other, to prevent discharges from the fittings from passing up into, and eventually block, the anti-syphonage pipes. That the last-named evils are liable to occur in badly-jointed anti-syphonage pipes, will be evident from a glance at Fig. 165. The most suitable point for joining the anti-syphonage pipe to the waste pipe is at a distance of from six to nine inches from the crown of the trap, and it need hardly be said that the pipe must be joined on to the *outlet* side of the trap.

Should two or more fittings be fixed near each other, it is desirable that each apparatus should be separately trapped (as in Fig. 131), each trap being, of course, efficiently ventilated. In the opposite event, that is, should only one trap be provided—as in the case shown in Fig. 166—a considerable length of fouled waste pipe will be in direct aerial communication with the interior of

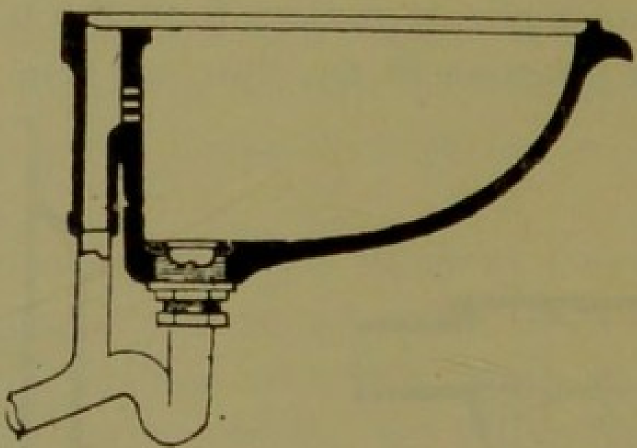


Fig. 163.

the house. This will be evident from the illustration. These remarks would not, however, apply to, say, a pair of sinks, provided that their outlets are in close proximity to each other, and substantially as shown in Fig. 167.

The waste pipes of fittings which discharge at some point in the appartments in which they are fixed (such, for instance, as a housemaids' sink discharging into an adjoining slop-hopper, or a washtub discharging into a channel in the washhouse floor) need not, of course, be trapped, as there is obviously nothing to trap off. Nor need the waste pipe of a drip or draw-off sink be trapped if no fouled water is thrown into it, and its point of discharge is in the open air—such as over a roof or lead-flat—and at some distance from any likely source of tainted air. It is, in fact, desirable not to trust to a trap in the case of such a sink, as there are frequent occasions on which the trap will contain but little, if any, water. It is, in fact, only when the housemaid is careless, and permits the jug or bottle to be filled to overflowing, or does not properly close the tap, that such a trap receives water. The waste pipe may, however, be advantageously fitted with a flap-valve at its outlet, in order to exclude draughts.

Sanitary fittings may be roughly divided into two classes, viz —(*a*) those whose discharges consist of purely

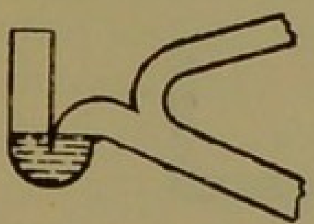


FIG. 164.

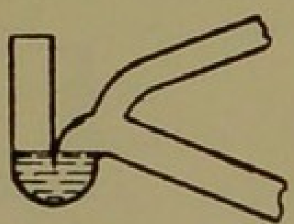


FIG. 165.

waste water, and (*b*) those whose discharges are charged with excrementitious matter. To the first group belong lavatories, baths, and sinks; to the second, water-closets, housemaids' slop sinks, or slop-hoppers, and urinals.

Waste pipes from the former must be disconnected from the sewage drains by being arranged to discharge over surface traps in the manner advocated (see Chapter IX) under the heading of "Secondary Disconnection." Soil pipes from the second group of fittings, being provided

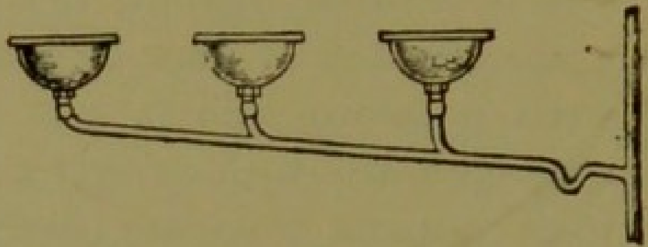


FIG. 166.

for the removal of excreta, &c., must be connected to the sewage drains directly. The word "*must*" is here used for two reasons, namely, because the by-laws of most cities and towns insist upon the direct connection of soil pipes to drains, and also because the system is the more rational. There are engineers who advocate and practice the disconnection of soil pipes from the drains by the intervention of traps and separate ventilation for the soil pipes and drains. Their object in so doing is to prevent the ingress of drain air into the house, should the

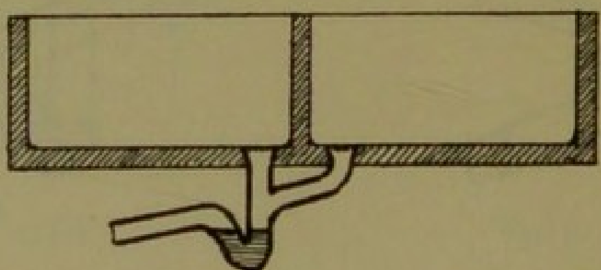


FIG. 167.

fittings be unused sufficiently long to permit of the evaporation of the water seals of their traps. Whilst this may be successful in some cases, there is nothing to prevent the ventilation of the soil pipes themselves into the house, should the evaporation actually take place. Further, should the fittings remain unused for a sufficiently long time to permit of the evaporation of the water in their traps, it is probable that the water in the trap of the soil pipe would also evaporate during that time and in this it would be aided by the air currents passing over the trap into the soil pipe. In that case most of the drain-air passing through the trap will be drawn into the soil pipe by the upward currents therein, and thence be at liberty to enter the house, should the conditions be favourable. Little will therefore be gained by the disconnection of the soil pipes.

As has already been implied, there is no objection to the discharge of two or more fittings into one waste or soil pipe, providing that proper precautions are taken against trap syphonage and trap forcing, and that the fittings are all of the same class, *i.e.*, either all waste-water appliances or all fitments provided for the removal of excrementitious matter. It is, of course, also immaterial whether the appliances are all on the same or on different floor levels. The provision of only one stack-pipe for a number of fittings has, in fact, its advantages. In the first place, it ensures greater cleanliness owing to more frequent flushing and greater flow, whilst, on the other hand, it is frequently conducive to economy in materials, labour, and cost.

Coming now to the position and fixing of sanitary fittings, it is essential that such should only be placed in suitable apartments. Convenience must, of course, be studied. A slop-hopper, for instance, must be fixed in close, though safe, proximity to the bedrooms, as the carriage of slops to a distance—possibly up or down stairs—would involve unnecessary offence, and frequently prove a delicate and somewhat awkward act. The waste of time and exertion involved would also offer a temptation to empty the bedroom slops into the nearest bath or lavatory basin.

Safety must not, however, be sacrificed to convenience. If a suitable apartment is not at hand, one must be made, or adapted, or the fittings altogether dispensed with. A cupboard or dark, out-of-the-way corner is unsuitable for *any* fitment, as it, in such a position, would be bound to become offensive. The lighter and more airy the apartment, the cleaner and less offensive will be the sanitary apparatus.

The apartment in which a sanitary fitting is to be fixed should, therefore, in the first place, be light and well-ventilated. The former condition will render dirt and splashings visible, and thus ensure their removal, and at the same time tend to prevent them, by enabling the user to see what he or she is doing. Thorough ventilation will maintain the purity of the aerial contents of the apartment. This ventilation, whenever possible, should be independent of that of the remainder of the house.

A room which provides the above conditions will usually also provide a second desideratum, namely, that one, at least, of its walls is an external wall. This is desirable in order that the waste or soil pipe may be immediately taken through the wall to the outside of the house. Such pipes, if avoidable, should not be fixed inside the house, as, however well made, they are liable to deteriorate or to be accidentally fractured. Should a leakage occur, the aerial contents of the pipe or pipes will be liberated inside the building (should they be fixed in its interior), and give rise to danger until the leakage is discovered and rectified. The danger will, in comparison, be trifling if the faulty pipe is outside the house. To reduce the waste pipes, &c., to their least possible length inside the building, the sanitary appliances should, whenever praticable, be fixed against the external walls. In order to reduce the number of stack pipes as far as possible, the fittings should also, when practicable, be grouped together. This may be conveniently done by fixing the appliances in adjoining rooms, when on the same floor level, or, more or less, above one another when on different floors.

The walls and floors in the immediate vicinity of sanitary fittings should always be constructed of impervious materials, or rendered non-absorbent by being coated or covered with suitable material, such, for instance, as cement, tiles set in cement, slate, marble, or sheet lead. The actual materials made use of must necessarily be governed by such considerations as cost, the nature and purposes of the appliances and rooms, their positions and similar questions, which may vary in each case, and which must be considered and judged as they arise. The great thing is to prevent the retention of such objectionable matter as may be splashed over and around the fittings.

Woodwork should, for the same reason, be avoided in connection with fittings whenever possible. If it must be used, the wood should be of a hard and close-grained nature. It should also be either painted or varnished.

Casings or enclosures round fittings should be studiously avoided. As ornament and for convenience, they are, on the one hand, unnecessary. On the other, they are conducive to the collection and retention of dirt. Frequently they also prove a last resting-place for filthy worn-out house flannels, buckets, scrubbing brushes, dead vermin, and a motley assortment of similar rubbish, which does not tend to improve the atmosphere of the house. In the case of water-closets, urinals, and other fittings, they are also apt to absorb or hide splashings, which, in decomposing, give off unpleasant and unwholesome effluvia.

Casings are only necessary in connection with the cheaper forms of baths, and for enclosing valve closets. In the former case. the outlay involved is better expended in providing a bath suitable for fixing without an enclosure. When made use of, the casings should be painted or varnished upon their interior, as well as upon their exterior surfaces, and should be so constructed that they may be readily taken down without undue, and, if possible, without any, use of hammer or screwdriver. The floor spaces enclosed should also be entirely covered by lead "safes" capable of collecting and removing all such water as may be spilled over the edges of the fittings.

The majority of fittings are, however, well suited for fixing without enclosures, and should be so fixed. Whenever possible, moreover, the apparatus should be kept well off the walls and floors, in order that fresh air may freely circulate round all parts, and so that all portions may be visible and get-at-able for cleansing. Ornamentations in relief, or sunk into the surfaces of the appliances, should also be avoided, as the numerous nooks and corners which they expose tend to accumulate dust and dirt. Should ornamentation be necessary, the same should be painted on and burnt into the fireclay—in other words, the surfaces of all fittings should be unbroken and smooth.

Lavatories and baths should not be fixed in bedrooms for, apart from the temptations which they offer for the disposal of bedroom slops, there is, even with the best of their class, always a risk of danger, which may arise through a temporary failure of their traps or a hole inadvertently made in their waste pipes, either of which would permit effluvia from the waste pipes to be drawn into the sleeping apartments.

CHAPTER XVI.

LAVATORIES.

Lavatory basins, which are usually made of glazed earthenware, and less frequently of enamelled iron—both of which, being smooth, are satisfactory—may be roughly classed into two groups, that is :—

(*a*) Tip-up lavatories, and

(*b*) Fixed plug basins.

A third group (the Rivulet), in which the water is con-

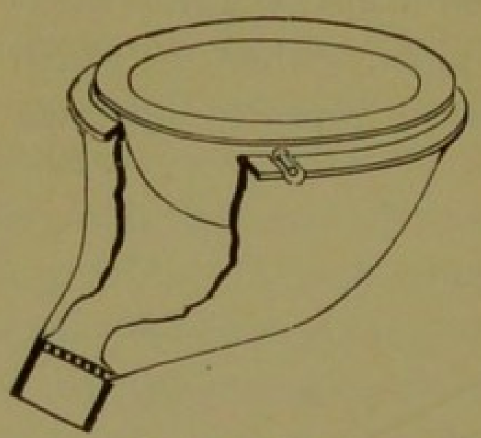


FIG. 168.

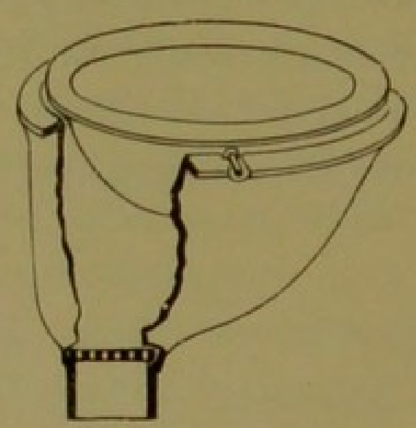


FIG. 169.

stantly flowing into and out of the basin, need not here be taken into consideration, being unsuitable for an ordinary dwelling, owing to the unnecessary waste of water. For the operating theatre of a hospital, a mortuary, or similar purpose, lavatories of this class are, however, very desirable.

Although very popular—doubtless by reason that the basins may be quickly emptied—pivoted or "tip-up" basins cannot be recommended. They are uncleanly at the best, as even the approved appliances of this type permit a certain amount of splashing to take place, with the consequent fouling of the interior surfaces of the "receiver," into which the contents of the basin are discharged. The exterior surfaces of the basin are also speedily fouled through the same cause, and although the more modern forms of basins are removable for manual cleansing, yet prevention is better than cure. Nor do these basins usually receive the frequent attentions which is necessary to keep them in a pure and wholesome condition. When tip-up lavatories are made use of, the selection should be made from amongst those which are provided with removable basins and "back" outlets. The latter, as the name implies, are outlets made at the back of the receivers, and so placed that the contents of the basins are discharged into them directly. This has a tendency to greatly reduce splashing (see Fig. 168 as against Fig. 169). The "receivers" should also be as small as practicable, and suitably shaped.

In the selection of a "fixed" basin, in which the water is retained by an ordinary plug or by a standing overflow, particular attention should be paid to the overflow, the outlet, and the soap trays, all of which have already been treated with in detail in the preceding chapter. It is also necessary to strictly avoid all basins to which the water is admitted through the same orifice as that used for the outlet of the basin or overflow. Clean water entering such an appliance is always polluted by, if it does not actually carry with it, decomposing matter from the soiled surfaces of the waste pipe or overflow. This is neither pleasant nor sanitary, and it may be readily imagined that the indiscriminate use of such a fitting is attended by the gravest dangers to the users. The spread of skin diseases is doubtless, in a great measure, due to appliances of this type, which, for some unaccountable reason, appear to be general favourites for fixing in hotels, public lavatories, and similar institutions. There is, on the other hand, no objection to a lavatory basin to which the water is admitted through a flushing rim or similar arrangement. Such a basin, in fact, has its advantages, as the sides of the bowl can be thoroughly flushed and cleaned by turning on the water for a few seconds before the fitting is used.

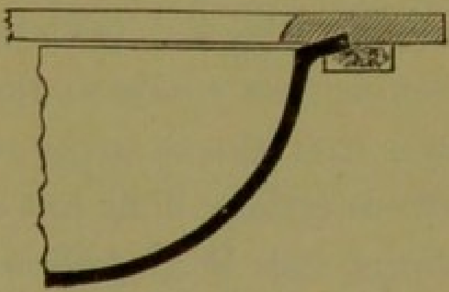


FIG. 170.

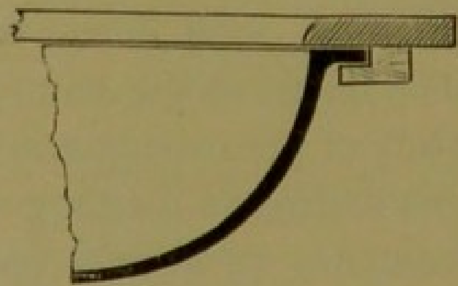


FIG. 171.

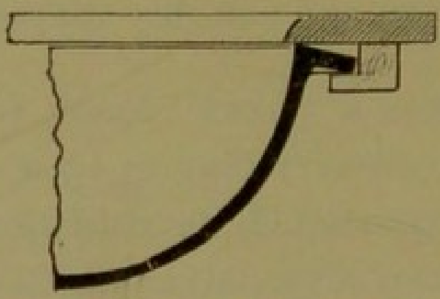


FIG. 172.

Regarding the shape of the basins, it is hardly necessary to say that they must be perfectly free from sharp angles or corners within the bowls. On plan, they should, moreover, be either circular or, more or less, oval. The latter shape is perferable, being more convenient to the user, owing to the increased "elbow room" which it provides, which will also tend to prevent splashing.

Basins which are intended to be fixed under marble or slate slabs should be provided with a rim turning slightly *upward* (see Fig. 170), in order that, when fixed, any water which may gain access to the space between the basin rim and the slab may flow back into the bowl. Should the rim be flat (as in Fig 171), or bent downward as in Fig. 172, the water will be liable to find its way to the floor, and possibly on to the dress and shoes of the user. The edges of the opening in the slab should also be arranged to overlap the bowl, and should be bevelled or rounded at the edge, in order that all splashings may flow back into the basins. Should the lavatory top be of marble, the joint between it and the basin should be made with plaster of Paris, and not with oil putty or other oil cement, as the oil is liable to penetrate the marble, causing unsightly stains, which cannot subsequently be removed. In the case of slate or porcelain, on the other hand, plaster or Paris is better avoided, as it is not of a very lasting nature, but soon breaks away after having been wetted.

As has already been stated, lavatories should not be enclosed by casings of any sort. They are best supported upon plain iron brackets or standards, of which there are a variety upon the market. Brackets, on the whole, are the neater and more cleanly of the two, but can only be made use of when the walls and the positions of the lavatories are suitable. In selecting them, preference should be given to those which are not to ornate, as these are liable to accumulate dust and dirt. A plain, smooth bracket is the best.

CHAPTER XVII.

BATHS.

What has been said of lavatories in the preceding chapter, as regards their overflows, outlets, soap trays, and water supply, applies in equal measure to baths, and needs therefore no repetition. Happily, most water companies now require that water shall be supplied to baths above the level of the overflow—a requirement which, although doubtless chiefly designed to prevent waste of water, is very valuable on hygienic grounds, as it also precludes the possibility of contaminating the incoming water.

With these matters attended to, the only points requiring attention in the selection of a bath are its trap, material, and shape. Bath traps are frequently

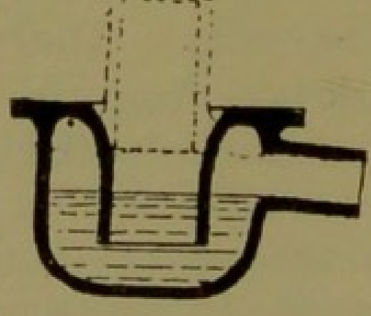


FIG. 173.

made as a part of the apparatus themselves, and are, as a general rule, quite unworthy of the name. They frequently take the form of "dish" or "dip" traps (Fig. 173), which, it need hardly be pointed out, are insanitary; or, even when of good "syphon" form, provide such a small seal of water as to be practically useless. The traps are, moreover, usually made of cast brass or iron, which in itself is objectionable, as the interior surfaces of the traps are seldom, if ever, perfectly smooth. A rough surface, of course, means dirt. Preference should therefore, in all cases, be given to trapless baths to which a good drawn lead syphon trap may be added.

The shape of the bath selected should, of course, be such as exposes no sharp angles for the retention of dirt. If tapering downward, care must also be bestowed upon the width of the bottom, as, if too narrow, a bather may find himself in the predicament of being "wedged in."

The ordinary "plunge" or "slipper" bath, which is the only form of mixed bath usually made use of in dwelling-houses, is ordinarily made of one or other of the following materials, viz., sheet copper, zinc, cast iron, porcelain, marble, or slate slabs, or block marble. With the exception of marble or slate-slab baths, which necessarily expose a number of sharp and undesirable angles and corners, all fittings made of these materials may be said to be sanitary, if properly shaped, and, when necessary, suitably enamelled. Some of the materials are, however, more advantageous than others, and it will therefore be well to point out the advantages and drawbacks of each, in order that a suitable selection may be made for each case as it arises.

Copper baths, which should be made of stout hammered copper weighing not less than 32 ozs. per foot super, and which should have welded and brazed seams, are very durable, and not liable to deteriorate. When damaged, they are readily repaired and re-enamelled. They also absorb but little heat from the water which they contain. Their one drawback is their want of stability, as the thin metal of which they are made requires support, to prevent the sides and bottom from bulging out, owing to the weight of the water and bather. The supports (which are usually provided in the form of a "cradle"—Fig. 174) render enclosures necessary in order that the baths may not appear unsightly.

Zinc Baths.—The material of which these are made is not of a lasting nature. The baths soon become unattractive, if not actually worn out, and require frequent renewal. Their cheapness in first cost is, however, in their favour. For the rest, the remarks made regarding copper baths apply also to zinc baths.

Cast-iron baths are comparatively inexpensive in first cost, and provide serviceable and durable fittings, if carefully selected. It is, however, essential that their enamel be such as will expand and contract in proportion to the iron, as otherwise the enamel will soon crack, and the bath thereby be rendered unsightly, and eventually useless, owing to the attacks of rust on the exposed iron surfaces. The enamel should also be that known as "porcelain enamel," as this is unaffected by acids or by any of the salts usually made use of by bathers and especially by ladies. Painted enamel is acted upon by inferior soaps and by salts, and should therefore be avoided. The baths should be provided with "rolled" edges, and should also be enamelled or painted on the exterior surfaces, in order that they may be fixed without enclosures.

"*Porcelain*" *baths*, which are made of glazed fireclay, are, without doubt, the most cleanly and lasting baths made. They should, however, be gradually heated when about to be used, as their thickness of material renders them liable to crack should their temperature be raised too suddenly. The material, owing to its thickness, also absorbs a great deal of heat from the water, and it is

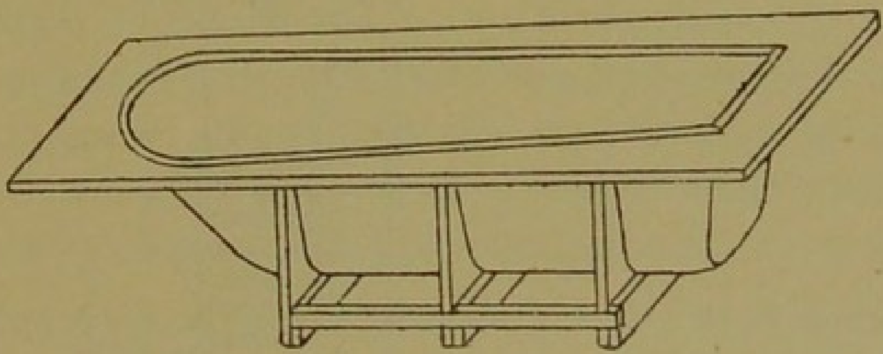


FIG. 174.

therefore desirable that these fittings be only made use of where an ample supply of hot water is available. Porcelain baths are suitable for fixing without enclosures, if glazed on the outside as well as on the inside surfaces. These, although considerably dearer, should therefore be given preference to those glazed internally only. Their edges should, of course, be "rolled" if no enclosure is used. The disadvantages of these baths are their cost, weight and coldness.

Marble Baths.—The general remarks made in connection with porcelain baths apply to these also, their advantages and drawbacks being identical. For ordinary purposes—as may well be imagined, seeing that these baths are cut out from solid blocks of marble—their cost is, however, prohibitive.

Although the simple "plunge" bath is the only kind of bath usually made use of for household purposes, it is occasionally necessary to provide a fitting by which a "douche," "shower," "wave," "spray," "sitz," or similar bath, may be applied for medical purposes, or

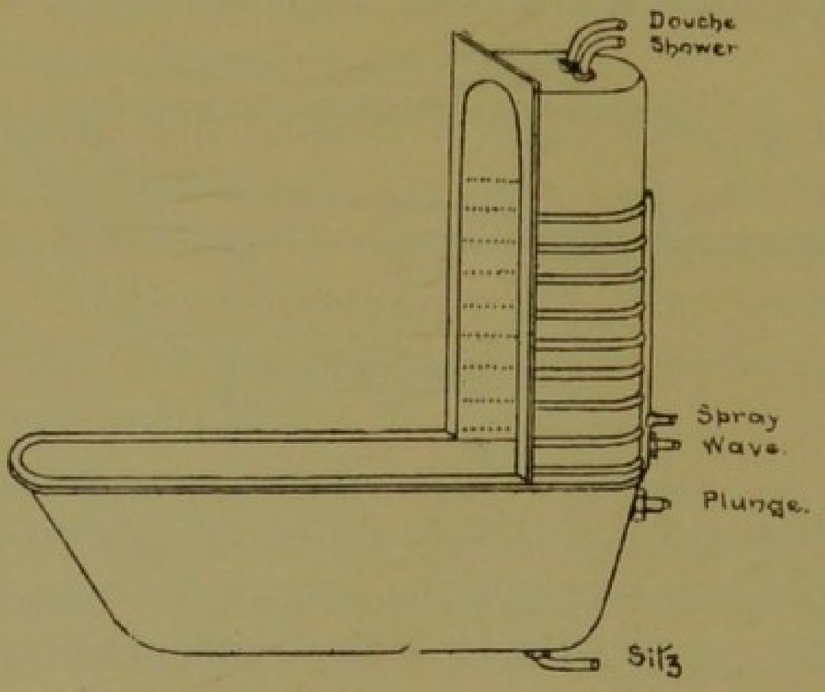


FIG. 175.

simply for luxury. Such an appliance, of which an example is shown in Fig. 175, usually consists of a plunge bath with an attached metal hood at the head, and is usually made of enamelled copper or cast iron. The hood serves the dual purpose of enabling water to be applied at the points required, and to prevent water from flowing beyond the sides of the bath. Some of the fittings are so constructed and ornamented as to be suitable for fixing without enclosures; others require to be encased. The choice should, of course, be given to the former.

As will be seen from the illustration, the hood of this form of bath is perforated at various points in order that water may play upon the bather from different points and in streams of varying shapes, as may be required. To enable water to be applied at all these points, and at only one point at the time, would, in the ordinary course, necessitate a complicated network of pipes and taps—more especially should the bath be supplied with both hot and cold water. This would be unsightly, costly, inconvenient for use, and, above all, would manifoldly increase the liability of leakage and of collecting dust.

Where such a bath is provided, a tier of interchangeable taps (see Fig. 176) should, therefore, invariably be used. In such an arrangement, as will be seen from the illustration, the hot or cold water, or both, is admitted to a common passage, from which it is readily turned on to the required spot. A thermometer may, and should, be fixed immediately over the hot-water tap—where the combined hot and cold water has to pass before reaching any of the other taps—in order that the heat of the water may be regulated otherwise than by experiment, which might have unpleasant consequences. An illustration of the more usual, and reprehensible method of arranging the taps (see Fig. 177) is added for comparison.

In selecting a "spray" bath, or one which provides for such, it should be ascertained that the tubes outside the hood, and the holes through which the water is liberated into the bath, are not too large to be fully supplied by the tap and piping provided for the purpose. Should this be the case, the water will escape so freely from the

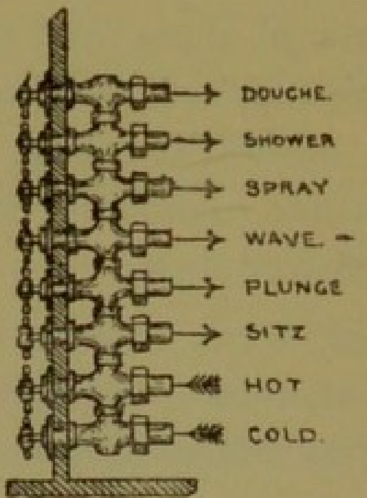


FIG. 176.

FIG. 177.

lower rows of holes as to render the upper ones practically useless. In a spray bath it is also desirable that the hood should form a three-quarter circle, in order that the water may not flow beyond the sides of the bath.

Most of the above-mentioned special forms of bath have, however, some specific object, and should not, as a rule, be provided in ordinary houses. A shower bath, nevertheless, may prove a convenience in most houses, and, if such is desired, one may be easily arranged by means of an arm and rose attached to the wall nearest the bath. A curtain rod and waterproof sheet should be provided in connection with these, in order that the falling water may be confined to the space occupied by the bath. A thermometer on the supply pipe is also a desirable appendage.

CHAPTER XVIII.

SINKS.

Although all sinks should be strong, cleanly, and non-absorbent, much must, in the selection of a sink, necessarily depend upon the special purpose or position for which, or in which, it is to be fixed.

For general purposes, and more especially for houses in which only one sink is provided, nothing is better or more serviceable than a glazed stoneware sink. This is strong, has rounded angles and corners, and is provided with a smooth and non-absorbent surface; which qualities may be found equally in the cheap salt-glazed earthenware sink suitable for small houses, and the more aristocratic and more expensive enamelled fire-clay or "porcelain" sink. The only drawbacks which may be fairly urged against these sinks are: that they are liable to be chipped through having heavy iron saucepans or buckets knocked against their sides or bottoms, and that china and glass are liable to suffer through violent contact with the sinks in the process of washing up. As regards the former, all materials are liable to be damaged by careless use; whilst the second drawback may be avoided by washing crockery in a wooden bowl or tub placed in the sink.

As alternatives to the above, sinks made of stone, enamelled cast-iron, or of metal-lined wood are frequently used. The first-named of these should not be tolerated. They are invariably made of some kind of sandstone, which, even in the hardest variety, is absorbent and never cleanly. Porcelain enamelled cast-iron sinks are not open to this objection, but their enamel is much more easily chipped than that of stoneware sinks, and when once damaged in this manner the iron rapidly rusts, the sinks being rendered unsightly and uncleanly in consequence.

Lead-lined wood sinks are desirable in that the surfaces exposed are soft in comparison to these of the sinks already mentioned. Their great drawback, however, is the liability of the lead to buckle and twist, as a result of the expansion and contraction which follows the variations of temperature involved by the use of both hot and cold water. This disadvantage may, to a great extent, be remedied by lining the bottoms of the sinks with 10 or 12 lbs. lead, and the sides with 8 lbs. lead; the latter being also made to slope, and the angles of the sinks rounded as in Fig. 178. Tinned copper or pure tin are frequently used for lining wood sinks instead of lead. Both materials are, of course, more costly, and also much harder than lead. They are both cleanly and wear well.

Other materials occasionally made use of for the construction of sinks are galvanised iron, wood, and slate.

Galvanised iron sinks (which in all cases should be flush riveted inside) are very suitable for washing vegetables and metallic cooking utensils. If provided for the former purpose they should be fitted with a standing overflow and waste in one of the corners, and this protected by a strainer capable of retaining all scraps of vegetable matter.

If fixed for the cleansing of cooking utensils, the outlets of the sinks should be arranged at a height of a few inches from the bottoms of the sinks, in order that the sand made use of for scouring the pots, &c., may be prevented from passing into the drains. Galvanised iron sinks should, however, never be provided in houses which are supplied with very soft water (such as in Glasgow and Sheffield, &c.), as the action of this water upon the zinc and iron is so rapid as to quickly destroy the fittings. In such cases fireclay sinks should be used.

Wood sinks made of "picked" American birch, pine, teak, or sycamore are very useful for washing glass, china, and silver, but should only be provided and used for this purpose. Their joints should be tongued and grooved, and the sides held together with galvanised iron bolts and nuts. The sinks may be conveniently arranged in pairs, in order

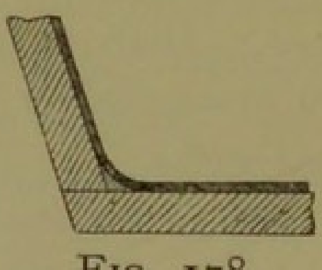


FIG. 178.

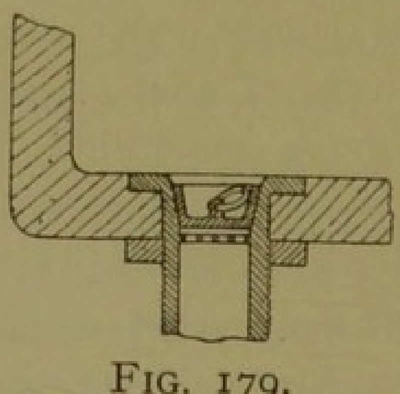


FIG. 179.

that one sink may be available for washing the articles named, and the other for rinsing them.

Slate sinks are only useful for steeping salt meat and for pickling purposes. They are totally unfit for other uses, owing to their sharp angles and corners and their liability to break when supplied with hot water. The sinks are also very liable to leak unless supported throughout.

Almost all sinks—the exceptions being those used solely as scullery or drip sinks—must be fitted with plugs on their outlets, in order that water may be retained by them. Such plugs should invariably be arranged to sink into their sockets to a slightly lower level than the bottoms of the sinks (see Fig. 179), in order that they may not be jammed into their seatings too tightly by the weight of articles placed in the sink. The plugs should also be hollow, in order that the rings by which they are raised may drop down out of the way of whatever might be in the sink (see illustration). Plugs are liable to become tightly fixed in their seatings should they be put in cold when the latter are hot, for, on cooling, the washers contract in size, and may grip the plugs so firmly as to render their withdrawal almost impossible. For this reason it is perferable to supply india-rubber or vulcanite plugs to all sinks provided with hot water.

Sinks which are fitted with plugs must necessarily also be provided with overflows, in order that all surplus water may be removed should the sinks be over-filled. In selecting these overflows, or, more correctly, sinks which are provided with overflow pipes, the same points should be kept in view as those to which attention has been drawn in connection with the overflows of baths and lavatories.

When the outlet of a sink is provided with a grating, attention should be bestowed upon the size of the openings in the latter, in order that the sum of their areas may not be less than the area of the waste pipe. Should this be the case, the trap and waste pipe of the sink will be imperfectly flushed and consequently soon become foul.

Sinks are made in great variety of form and of various dimensions to suit particular purposes. When making a selection it is therefore necessary, as already stated, to keep in view the use to which the fitting is to be put and to be guided thereby. The classes of sinks in general use, of each of which one or more may have to be fixed in large houses, are the following:—

Scullery sinks,
Pantry sinks,
Butler's pantry sinks,
Nursery sinks,
Drip or draw-off sinks,
Larder or dairy sinks,
Vegetable sinks,
Pickling troughs,
Wash tubs, and
Housemaids' slop sinks.

Housemaids' slop sinks differ from all others in that they are provided for the reception of such fouled liquids as chamber slops. Such being the case, they must be looked upon and treated in every way as water-closets, which fittings the most cleanly slop sinks resemble in shape. Like water-closets, these sinks, or rather hoppers, must be provided with flushing rims, and should be flushed by water-waste preventing cisterns. Unlike closets, they should, however, be fitted with a loose grating over their outlets, in order to intercept pieces of soap, scrubbing brushes, cloths, and similar articles which may be carelessly thrown in with the slops. The height of their upper edge in front should not exceed 1ft. 6in. from the floor, in order that pails may be conveniently emptied out. The higher a pail has to be lifted the greater is the probability of the surroundings being splashed·

Where space is available, it is both desirable and a convenience to fix a wash-up sink in connection with the slop sink, for the purpose of rinsing the emptied-out receptacles and for refilling bedroom jugs. The waste of this sink may be conveniently arranged to discharge into the slop hopper, and need not be trapped. Various manufacturers make fittings in which these two forms of sinks are combined and made in one piece. These, as a rule, are of good design and perferable to two separate appliances.

Broadly speaking Housemaid's slop sinks are nuisances which it is desirable to avoid fixing, because they seldom receive the care and attention to cleanliness which they require. It is far better, when possible, to arrange for bedroom slops to be emptied into one or more conveniently situated water closets.

CHAPTER XIX.

WATER-CLOSETS.

Although of late years great improvements have been made in the design and construction of water-closets, there are still being manufactured large numbers of these appliances which cannot be considered to comply with ordinary sanitary requirements.

"Pan" closets, with their attendant satellites, D-traps, "long-hopper" and "short-hopper" closets, "wash-out" closets and "plug" closets may now be said to be "heroes of a bygone age." Their various defects are so well known, and so glaring, that beyond mentioning them it will hardly be necessary to refer to them. The appliances, it is true, are still being made and fixed, but, in view of all that has been written and done to demonstrate their unfitness, their creators and users must be beyond hope of conversion. To recapitulate in detail the various defects of these appliances for the benefit of these gentlemen would, therefore, be merely waste of space. Moreover, these closets are one and all practically prohibited by the Model By-laws of the Local Government Board and the by-laws of most local authorities, which are mostly based upon them. The prohibition is implied, when it is not specifically stated.

As an example of these by-laws may be cited the following extract from the London County Council's by-laws referring to water-closets :—

". . . He shall furnish such water-closet with a suitable apparatus for the effectual application of water to any pan, basin, or other receptacle with which such apparatus may be connected and used, and for the effectual flushing and cleansing of such pan, basin, or other receptacle, and for the prompt and effectual removal therefrom, and from the trap connected therewith, of any solid or liquid filth which may from time to time be deposited therein."

"He shall furnish such water-closet with a pan, basin, or other suitable receptacle of non-absorbent material, and of such shape, of such capacity, and of such mode of construction as to receive and contain a sufficient quantity of water, and to allow all filth which may from time to time be deposited in such pan, basin, or receptacle to fall free of the sides thereof, and directly into the water received and contained in such pan, basin, or receptacle."

"He shall not construct or fix under such pan, basin, or receptacle any 'container' or other similar fitting."

"He shall construct and fix immediately beneath or in connection with such pan, basin, or other suitable receptacle, an efficient syphon trap . . ."

Comparing the construction of the before-mentioned water-closets with the requirements of this by-law, it will be seen that the "pan" closet is not permitted, because it is provided with a container under the basin. Similarly, both types of "hopper" closets fail to comply with the by-law, because, owing to the shape of their basins (that of a funnel), the dejecta or "filth" which is from "time to time deposited therein" does not fall free of the sides of the basins, and directly into the water contained by them; or, rather, by their traps, for closets of these types retain no water in the basins proper. Neither do "wash-out" closets, strictly speaking, comply with the by-law. Their basins do not "contain a sufficient quantity of water" for the immersion of fœcal matter, for which purpose the requirement is doubtless made. Neither are their flushing arrangements suitable for the "effectual flushing and cleansing" of the basin (the dejecta is flushed against the front of the basin, which it fouls), and certainly not for the "prompt and effectual removal" of filth from the trap, as the flushing-power of the water is invariably broken long before it reaches that portion of the apparatus.

"Plug" or "plunger" closets, when properly trapped and in good working order, would doubtless be held to comply with the requirements of the by-law. They are not reliable, however, as the slightest accumulation of dirt on the plug, by which the water is held up in the basin, would prevent its proper closing, and thus permit all water to flow away. In practice, these closets are found to be very filthy and altogether undesirable.

In the more sanitary types of closets, the details of design and construction are not always carried out to perfection. It is therefore well to bear in mind, when making a selection, that the objects to be attained are alike *in all forms of closets*, and that those which provide the most efficient conditions as regards cleanliness and trapping may be safely looked upon as the best. From this it follows that the closets must be so constructed as to expose no surfaces which are liable to be rendered foul without the certainty of cleansing ; that every appliance must retain a sufficient volume of water to preclude the possibility of any such accident, and that the efficiency of its trap must be considered as forming a component part of the sanitary efficiency of the closet as a whole. It is also obvious that no foul discharges must be retained in any part of the apparatus after the closet has been flushed, whatever may be the quantity of water delivered.

The water retained by the closet basin must be of both sufficient area and depth to ensure the immediate and complete immersion of fœcal matter, in order that this may be prevented from staining the basin and from giving off bad odours. The water must also be retained in such a position that fœcal matter must, of necessity, drop into it, and on no other portion of the apparatus. Whilst providing these conditions the quantity of water retained must be sufficiently small to ensure its being completely changed by an ordinary flush of the closet. This is a matter of importance, since the quantity of water permitted to be used is usually very limited, and frequently so small as to prove useless for the cleansing of any but the most perfect appliances of their kind.

The more sanitary types of water-closets, from among which the selection should be made, are the following, viz. :—

1. Wash-down } Pedestal closets.
2. Syphonic }
3. Valve closets.

The "wash-down" closet is, perhaps, the best form of closet apparatus to be had for general purposes. It is equally suitable for the tenement of the poor and the mansion of the rich. It may be made use of for either a ladies' or a gentleman's closet, and, when in a suitable position, may also be utilised as a " slop-hopper, as well as for the purpose for which it is primarily intended. In selecting a closet of this type, the chief points to be attended to are, as already stated, the area, depth, and position of the water retained in the basin, and the depth of the " seal " of the closet trap. The flushing-rim should be such that, in flushing, every portion of the interior of the basin is washed, and that the water forms a jet or cascade directed towards the outlet. This latter is necessary to force fœcal matter out of the basin. Perhaps the best mode of testing the flushing capabilities of such a closet is to crumple up a small piece of tissue paper and throw it into the basin. If good, the flush will immediately remove the paper, if not, two, three, or even more flushes will be necessary. The test is preferable to that of removing a number of pieces of paper placed on the sides of the basin, as the conditions obtaining under it are very similar to those to which the closet will be most frequently subjected when in actual use. In flushing out a number of large flat pieces of paper, the paper will simply be forced into the outlet of the basin, and more or less block it, its removal thence being comparatively easy by the weight of the water above it.

The inside surfaces of the basin should, of course, be perfectly smooth, and as white and free from ornament as possible. The various designs of flowers, &c., with which the interior of closets are frequently decorated only tends to conceal dirt. Similarly, in order to avoid accumulations of dust and other impurities, the outer surfaces of these and all other forms of pedestal closets should be free from all raised ornamentation, and preferably also perfectly white.

Lastly, and this is of great importance, the outlet arm of the closet trap should be so formed and placed that whatever may be its connection with the drain or soil pipe the joint will be in view, and easily accessible This

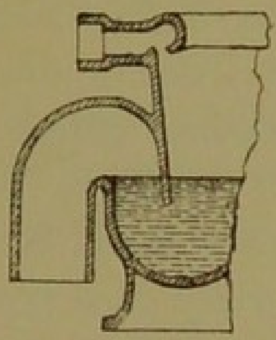


FIG. 180.

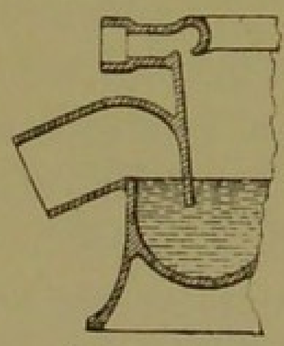


FIG. 181.

is necessary both in order that a good joint may be made in the first place, and that, subsequently, any damage which might occur to the joint will be readily noticed. In other words, when the closet trap is "S" shaped, the outlet arm should terminate at some distance above the floor line, as in Fig. 180; if "P" shaped, the outlet arm should be short (as in Fig. 181), in order that the joint may not occur in the wall against which the closet is fixed.

An after-flush arrangement—be that provided in the flushing cistern or on the closet itself—will be a useful provision, in order that the closet trap may be fully charged should the momentum of the water-flush be sufficiently great to leave the trap partly unsealed.

A modification of the wash-down pedestal closet is the "Corbel" closet which, instead of resting on the floor, projects from the wall into which it is built.

Most of the remarks made in connection with "wash-down" closets apply equally to those of "syphonic" type. With thee, it is, however, also necessary to exercise the greatest care that a really efficient apparatus be selected. As is well known, several of the forms of these closets now on the market are so constructed that a comparatively small quantity of water discharged into them will set up syphonic action, and leave the basin with little or no water-seal between it and the soil pipe or drain. Such an appliance is liable to become dangerous, as servants may not always be trusted to flush the closet on every occasion on which the apparatus has been made use of as a slop-hopper. When of really good type, however, syphonic closets provide very desirable fittings. They retain a satisfactory quantity of water of ample area and depth, and make the best of the scanty supply or flushing water permitted by water companies in towns. Most of them remain cleanly, even where the quantity of the flush is restricted to two gallons.

In selecting a valve closet, it is almost possible to be guided by the cost of the appliance. All such as have the questionable advantage of being "cheap" may be safely avoided. A valve closet is complicated in its construction, and to be well made requires none but the best materials and workmanship. These, of course, must be paid for. An inexpensive closet of this type will invariably be found to be faulty, and, if fixed, becomes not only a constant tax for repairs, but also a permanent source of annoyance and danger. The simplest and cheapest wash-down closet of good design is to be infinitely preferred to a cheap valve closet.

A good valve closet, on the other hand, is a distinct acquisition for fixing in the most important positions in private houses of the better class, and as closets intended for ladies' use generally. They retain a large body of water, are very cleanly, and almost noiseless in use.

The following are the most important points to which attention should be given in selecting a valve closet :—

(1) The overflow arm should be open at the top, to permit of cleansing by hand (see Fig. 152).

(2) The overflow arm should be trapped and arranged to receive a small quantity of water whenever the basin is flushed.

(3) The valve should be so placed that, when opened, it will cover the outlet of the overflow arm where the latter joins the valve box, in order to preclude the possibility of paper, &c., finding its way into the overflow pipe, and thus choke it.

(4) A ventilation pipe (usually known as a "puff" pipe) should be provided on the valve box.

(5) The valve box should be porcelain enamelled in its interior.

(6) The working parts of the valve should be as simple and as strong as possible, and such as to ensure its proper closing at all times.

(7) The flushing-rim should be continuous all round the basin, which should never be flushed by means of a "fan-spreader."

(8) The water-supply valve (and service pipe thereto) should never be less than 1¼ inches in diameter. Where the available head of water is less than 10 feet, it should be 1½ inches in diameter.

(9) A drawn-lead syphon trap should be provided immediately under the valve box, in order to disconnect the closet from the soil pipe. The valve alone is insufficient for this purpose, although it offers additional security.

No mention has been made of trough-closets, latrines, and slop-water closets, these appliances being all wanting in the first conditions of Sanitation. Whatever may be said for them when fixed in open situations, they should certainly find no place in the sanitation of town houses.

CHAPTER XX.

URINALS.

Of the varions sanitary appliances with which it is, or may be, necessary to fit a building, the most difficult to design and arrange in such manner as to remain perfectly hygienic and inoffensive is undoubtedly the urinal. The secret of producing a sanitary urinal, it may be even said, has yet to be discovered. Certainly, even the most modern and most perfect types of urinals at present available are apt to prove never-failing nuisances when in use. In a very great measure this is due to the chemical composition of urine itself.

Urine is a compound of urea, uric acid, and various other organic and inorganic matters in combination with water. The most important constituent is the urea, which is present in urine to the extent of 54 per cent. It decomposes rapidly (it is greatly aided therein by the presence of even the slightest degree of heat), and in so doing evolves large quantities of carbonate ot ammonia, the pungent and offensive odour of which frequently permeates a large portion of the building in which the fitting is situated. Next in importance is the uric acid, which is but feebly soluble in water, and which is consequently very liable to adhere to all surfaces with which it comes in contact. The deposit formed is the well-known "furring" or "stone" so commonly seen in all ill-kept urinals and chamber utensils. If not prevented or removed, this deposit will eventually decompose and give off foul emanations.

It will be seen from the foregoing that the object to be attained in all urinals is the immediate and total removal of the urine discharged, without the possibility of adhesion to the surfaces of the apparatus and before decomposition can set in. For this purpose the following conditions are essential:

1. The soiling surfaces with which the urine may come into contact must be as small as possible consistent with convenience.

2. An entire absence of angles, corners, or unevennesses which could tend to retain deposits of urine or of dirt.

3. Smooth and impervious materials which are incapable of being acted upon by uric or other acids.

4. Absolutely self-cleanliness.

5. An abundant supply of flushing water on each occasion on which the urinal is used.

6. Thorough ventilation, abundant light, and a cool atmosphere.

From what has been said, it will be obvious that the interior of a dwelling, or, indeed, of any other building, is not a suitable position for a urinal. The atmosphere within buildings is always comparatively high, and therefore favourable conditions are at once provided for the rapid decomposition of urine. Moreover, once emanations take place, these will be given off in the spot in which they are most liable to prove dangerous, and from which they are most difficult to displace—namely, within the buildings.

Happily, urinals are not as a rule, essential for domestic purposes. Their place in the dwelling-house may be conveniently taken by the water-closets, which in the men's quarters must be suitably arranged. A pedestal closet with a hinged and, perferably, self-raising flap-seat is the most convenient form of water-closet for the purpose. The worst which may be urged against such an arrangement is the possibility of urine being discharged over and around the closet. This may be guarded against by the provision of an ordinary chamber-utensil in the water-closet apartment. It is certainly an excellent rule never to fix a urinal unless its presence is absolutely essential.

Where the necessity exists, only the most efficient and suitable form of urinal should be provided. The abomination known as a "folding urinal" should on no account be tolerated. This apparatus consists of a hinged basin—most frequently made of metal—which is pulled down for use and subsequently folded back into a container or recess in the wall, from which the urine runs down into the waste pipe. As may well be imagined, this type of urinal is practically impossible to keep clean, and is therefore a fruitful source of nuisance. Its very principle, in fact, is reprehensible, since it hides that which should at all times be in evidence in order to ensure its proper care and maintenance.

For fixing within the house, if a urinal is essential, the least objectionable appliance is a plain basin—such as is illustrated in Fig. 182—provided with a wide lip and continuous flushing-rim all round the basin and lip. The basin should be perfectly white, smooth, and of small size, and should, whenever possible, be flat-backed. If annular, for fixing in corners, the angle at the back of the basin must be well rounded. The floor

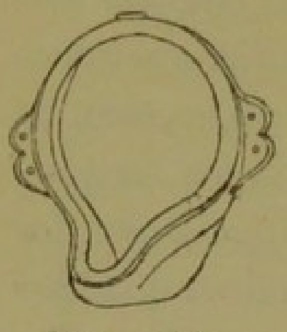


FIG. 182.

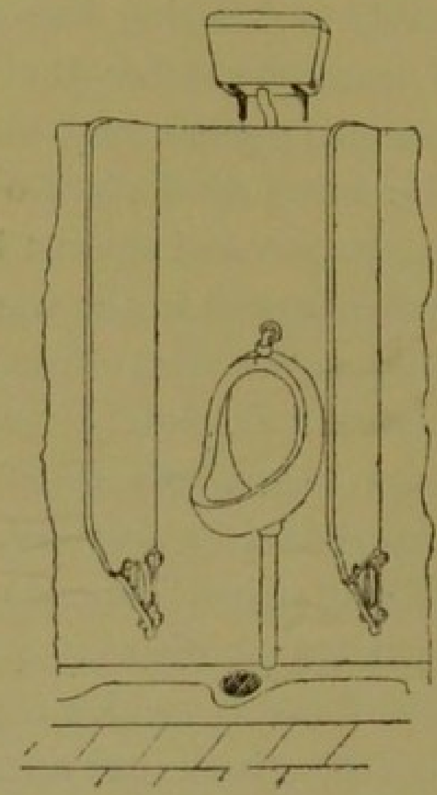


FIG. 183.

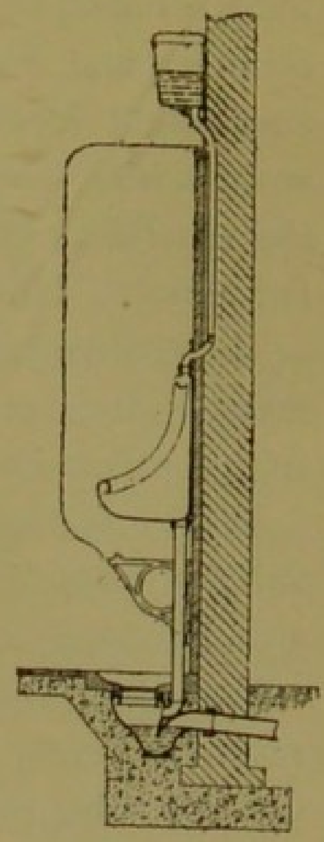


FIG. 184.

and walls in the immediate neighbourhood of the basin must be made perfectly smooth and non-absorbent. Cement-rendering is best for the purpose; tiles, on the other hand, are apt to retain urine in their joints. The trap of the basin should be fixed separately to ensure a suitable appliance. Urinals have to be connected to soil pipes and treated as water-closets in their mode of discharge. Hence it is necessary that their traps should provide sufficiently deep "seals" to guard effectually against the passage of drain air. The shallow traps which are frequently made as a part of urinal basins are totally unfit for the purpose.

Should the urinal be provided outside the house, its most suitable form will be that of a stall urinal, and of these two types, of which the last is the best, are illustrated in Figs. 183 to 185. That shown in elevation and section in Figs. 183 & 184 respectively, is formed by one or more basins fixed between partitions of slate or marble and against a wall of similar materials. Its construction and treatment are sufficiently indicated by the diagrams, and it is only necessary to draw attention to the channel beneath the basins, which is provided for the removal of droppings, and to the partitions between the basins. These latter should not be spaced more than two feet apart, and should not project more than fifteen inches from the back. The comparatively small stall so formed is sufficiently large for comfort and decency, and at the same time compels the user to stand close to the basin ; thus minimising the risk of a discharge of urine elsewhere than in the proper place. The partitions—with the exception of those forming the outer walls—should also stand clear of the floor in order that the latter may be swept clean from end to end.

In Fig. 185 the stall or stalls are made of thick glazed fireclay and with rounded or semicircular backs. The floor is made of similar material and arranged to drain into a channel which can be swept and flushed throughout. A flushing-rim is provided round the upper edge of the stalls for flushing the sides. These stalls, being made of impervious and, ordinarily, indestructible material, and having no angles or corners in which dirt can be retained, provide perhaps the most perfect and sanitary form of urinal at present available. They are however costly. The urinal channel and the trap into which the latter discharges must

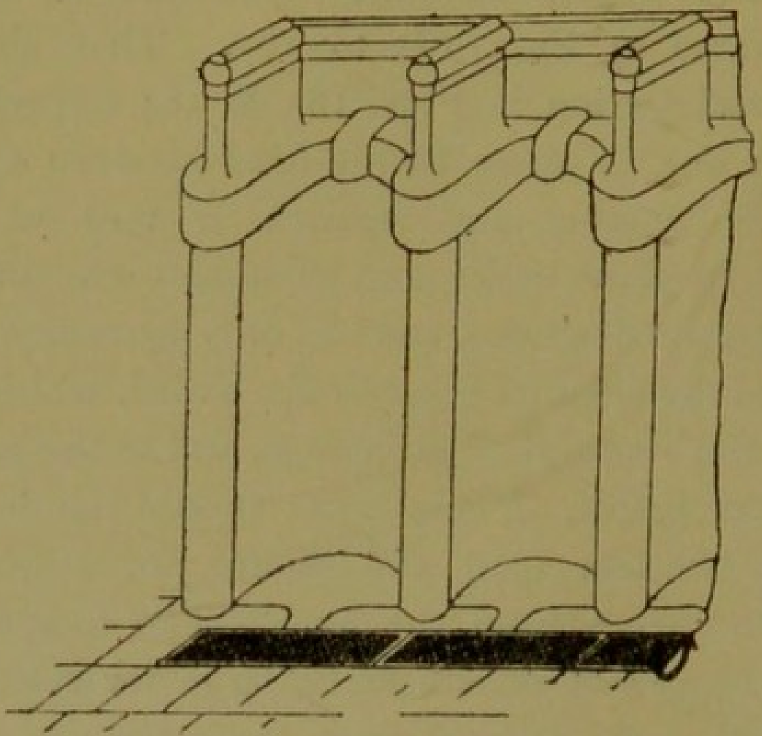


FIG. 185.

be liberally flushed. This is no less important than the proper flushing of the urinal basin or stall itself.

CHAPTER XXI.

FLUSHING CISTERNS.

Water-closets, slop-hoppers, and urinals must be flushed through cisterns having no direct connection whatever with the cisterns used for the storage of potable water or with the water mains. This requirement, which can be enforced by the by-laws of the various local sanitary authorities, is necessary to prevent the pollution of water used for domestic purposes. The bye-laws of most water companies further dictate the use of a separate cistern for each sanitary fitting flushed and, in most cases, also prescribe the maximum quantity of water to be utilised for each flush. The latter varies from two to three gallons, and it may be at once said that a flush of less than three gallons is insufficient for almost all closets at present available. These, however, are hard and fast rules which, until altered, must be complied with, and it will therefore be seen that it is of the greatest importance to choose and provide cisterns which will comply with them, and at the same time deliver the water sufficiently quickly to be of advantage. In the case of water-closets, at any rate, it is always well to choose the closet and cistern together and to select those which, by actual trial, have been proved to give the best results. This is usually possible, since makers of sanitary appliances generally provide their showrooms with fitted specimens.

Flushing cisterns for sanitary appliances may be divided into two groups, namely:—those which are automatic and those which are not. The former are the most suitable for urinals, where the water companies permit their use, or the water is paid by meter; the latter are always made use of for water-closets and slop-hoppers and frequently for urinal basins.

Automatic cisterns have already been dealt with in a previous chapter (see page 127), and since those made use of for sanitary fittings differ from those already described only in dimensions, no further mention need be made of them. It is only necessary to point out that their capacity should be in accordance with the work to be done, and that they should be adjusted to discharge at frequent intervals.

Non-automatic flushing cisterns—which must be actuated by hand—to be of good type, should be simple in construction, and flush properly immediately their handle is pulled; their discharge being certain and rapid even though the handle be immediately released. For this reason the cisterns should be syphonic in their action.

A "valve" cistern should never be used, since its contents will only flow out during the time the handle is held and the valve thereby raised from its seating over the cistern outlet. Unless, therefore, the handle is held until the cistern is empty, the sanitary fitting in connection with which it is provided will be insufficiently flushed. On the other hand, if the handle is held longer than necessary, waste of water will take place, since the water flowing into the cistern will pass down into the sanitary fitting in a stream too small to be of service for cleansing purposes. Syphonic cisterns are not open to these objections, as, when once syphonage has commenced, the whole of the contents of the cisterns will be discharged, whether the handle is held or not. Nor is it possible to prolong the flush, nor to give a second flush until the cistern has been refilled.

Syphonic cisterns are made in great variety of form, and no useful purpose would be served by describing their details of construction, more especially as most of them are simply changes rung upon the same patterns. Suffice it to say that those which are least complicated in their construction and most certain in their action may be safely looked upon as best.

Other points to be noted in selecting a flushing cistern are the outlet, its flushing pipe, and the material of which the cistern itself is made. The shape of the cistern also merits consideration.

The outlet opening, in the first place, should never be less than 1¼in. in diameter, and should by choice be a quarter of an inch larger. The flush-pipe should be of corresponding diameter, smooth in its interior, and so bent as not to unduly retard the flow of water, or in any way restrict it. It should be attached to the cistern outlet by means of a cap and lining in order that it may be readily disconnected if necessary.

The cisterns when fixed in exposed positions should have their angles rounded and the sides slightly sloped to minimise the risk of fracture by frost. They should always be made of materials which are not apt to corrode

—such as lead-lined wood or glazed fire-clay—or should be galvanised if made of iron. The formation of rust is very objectionable, not only because the cisterns are thereby destroyed, but also by reason that the scales of rust are apt to interfere with the working parts of the cisterns and that the water is discoloured and liable to stain the apparatus to be flushed.

It is also necessary that each cistern be provided with a cover, and that it be, as far a possible, silent in its action. Frequently, however, a noisy cistern is ascribable more to the manner in which it is fixed than to the appliance itself.

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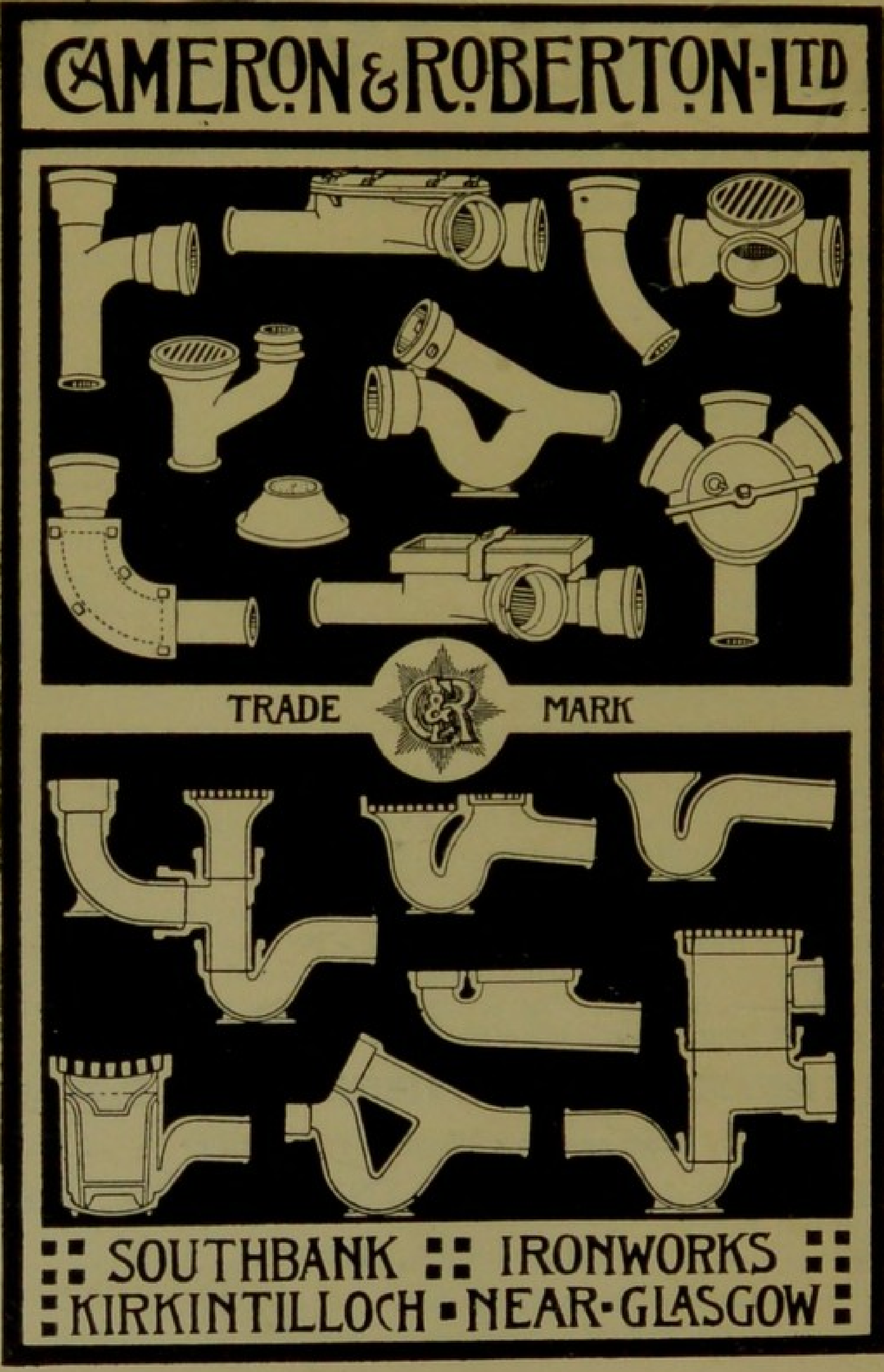
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Contains:—Sanitary Legislation of Past Year; Useful Memoranda for Sanitary Engineers and Surveyors; Directory of Government Departments; Sanitary and Allied Associations, &c.

Water Supply of Villages and Small Towns. By H. C. H. SHENTON. Paper cover, 6d. net.

The Zymotic Enquiry Book. By J. STOREY, Sanitary Inspector, Nantwich. 1s. net. Special terms to Councils for Quantities. [1904

This book is handy in size, and each opening gives all the headings necessary for making a complete report of every case of zymotic disease occurring in a district. It is based upon the results of a long experience in the Public Health Service.

(See page 16.)

(See page 14.)

The illustrations are for the most part well drawn but exception must be taken to at least one Fig 91. where the measuring wand is not shown in ~~the best rec recognised~~ accordance with recognised methods.