The Sanitary Sewerage of Buildings

THE SANITARY SEWERAGE OF BUILDINGS

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ERRATA.

On page 49 omit second paragraph from bottom. reading, "It will be," etc.

On page 68, fifth line from bottom, reading "alter-ation" should be "alternation."

On page 70, the punctuation in Table 8 should be periods instead of commas.

INTRODUCTION.

"God made the country and man made the
town.
What wonder, then, that health and vir-
tue—gifts
That can alone make sweet the bitter
draught
That life holds out to all—should most
abound,
And least be threatened in the fields and
groves?" —*Cowper.*

OF the many problems incident to modern life, none are so important and none so difficult of solution as that pertaining to the attainment and maintenance of a normal condition of the human physiology, under the man-created conditions of life in cities and other populous centers.

For centuries past, men, of almost every station in life, have wrestled with this problem, prompted thereto by the invasion, or threatened invasion, of a locality by a dangerous epidemic disease; by the presentation of statistics indicating unusually high rates of sickness or mortality; by the desire, born of instinct, for self-preservation; or by the desire, born of philanthropy, to render life in general more pleasant and profitable, dying less terrible, and death more remote. And from the struggle have emanated countless volumes and numberless theories relative to the conditions under which the dweller in a community may hope to fill out the allotted span of three-score years and ten in the full enjoyment of health and its attendant blessings.

In the civilized world it was at one time generally believed—and this belief is still current, though to a much less extent—that epidemics of dangerous diseases were the direct visitations of a Divine Providence.

With the advent of the modern sanitarian came the discovery that the source of many of the dangerous diseases was to be found in the air of sewers and drains; and the necessity for a system of double trapping of house sewers, to exclude this insidious agent of disease and death from the dwelling, was urged upon the people. Laws and regulations for the control of plumbing and sewerage became general; the merits and demerits of certain methods of ventilating the public sewers were widely discussed; charcoal baskets, for the purification of sewer air prior to its exit from the manholes, were recommended; extensive tests were made to determine the relative efficiency of certain patented devices, termed cowls, for the extraction of air from the sewers and its delivery into the air at safe points above the roofs of buildings; the sewers and plumbing of large numbers of houses were subjected to severe tests and careful examinations—in many instances reconstructed along sanitary lines—and their safety certified to by the representatives of the public health departments. And the people heaved a sigh of relief, and cheerfully paid the bills.

But, alas! Swift upon the heels of this general movement for the exclusion of sewer air from the homes and haunts of mankind came the bacteriologist, who, with the utmost sang-froid, informed the people that the presence in air, water and food of certain specific micro-organisms, and not the air of sewers, was responsible for what was then popularly known as the zymotic diseases. Further, that if these micro-organisms should gain access to the sewers, their tenacity was such that they would not readily be liberated from the sewage, or from the moist surfaces of the sewers. And the people accepted the new theories with feelings of surprise, or with stoicism, and, we regret to state, ridicule.

Subsequent researches have revealed to the student of bacteriology the individuality, habits, haunts and methods of transmission of the specific germs of many of the dangerous communicable diseases; and, fortified with this knowledge, the sanitarian of today is waging a determined warfare against these diseases, with varying degrees of success.

It was learned that filth is the handmaid of disease, because it favors the growth and development both of the micro-organisms of disease and the special carriers of infection, and tends to a deterioration of the physical forces in man, hence, predisposing to disease.

It was also learned that filth and disease have their origin in and are disseminated, principally, from the home, and other places frequented by man for the purposes of business, recreation or refreshment; and that, as a natural sequence, measures for the restriction and prevention of the filth diseases must, of necessity, begin with the sanitary removal and disposal of the excrementitious and other organic waste matters pertaining to life in the home.

And the problem is, as yet, but partially solved.

Confining our attention to the question of the proper disposition of those substances included under the generic term of sewage, principally in so far as relates to their removal from the immediate vicinity of the dwelling, we will consider, first, the general principles underlying the sanitary sewerage of buildings, and, in subsequent chapters, the means whereby this may be accomplished.

CHAPTER I.

General Principles.

IN the arrangement and construction of sewers which may properly be termed *sanitary,* the following general considerations must be borne in mind and govern the construction:

1. *The Rapid and Complete Removal of the Sewage.*—Fresh normal fecal matter, unmixed with urine or water, decomposes slowly, but when the feces and urine, or both urine and water, are mixed, as in sewage, the decomposition is hastened, and in the process very fetid odors are liberated. Apart from the consideration of the deleterious character of such effluvia, to which reference will be made in a subsequent paragraph, it will be apparent that the decomposition of sewage should not take place at any point in a system of sewers ventilated, as is usual, by openings, at the grade, in thoroughfares and in the vicinity of buildings. Further, decomposition within a sewer would indicate stagnation of the sewage, due to the faulty construction of, or a lack of fall in, the sewer; and stagnation means a deposition of the solid particles of sewage, which, in turn, may be the forerunners of a complete stoppage in the sewer.

2. *The Oxidation of the Organic Matters Constant in Sewers.*—Notwithstanding that a sewer may be well constructed, and the removal of the sewage sufficiently rapid and, in so far as practicable, complete, there will remain, on the inside of the sewer, a coating of grease and other organic matter, the extent and thickness of which will depend, largely, upon the smoothness, or otherwise, of the materials of which the sewer is constructed, and, in the case of grease, to a considerable extent, upon the cooling action of the sewer and its atmosphere. Decomposition of the organic coating will be continuous, and, in the absence of thorough ventilation of the sewer, the atmosphere of the sewer will be charged with foul and noxious gases.

3. *The Exclusion of Sewer Air From Houses and Other Occupied Buildings.*—Dating back to a period coincident with the general introduction of sewers, and from thence to the present time, the question of sewer air in its relation to health has been a bone of contention among the members of the medical profession and others interested in the subject of hygiene. Investigations, more or less thorough, and with varying results, have been carried out, and voluminous testimony offered, in support of, or in opposition to, the well-grounded belief in the dangerous character of sewer air; and the present attitude of those entrusted with the administration of public health affairs would

indicate a willingness to give the public the benefit of any doubt which may exist in respect to this question.

It is generally believed, and with much reason, that the habitual breathing of air in houses to which sewer effluvia have access, will produce an impaired condition of health, by an interference with the proper functions of respiration, and in a derangement of the digestive organs; and that, for this reason alone, the entrance of sewer air to our homes should be rendered impossible.

That the sewer is a factor in the dissemination of infection, is still a matter of dispute. We have reason to believe, however, that typhoid fever, and possibly other diseases of a kindred nature, may be communicated through this agency, and this belief is shared in by men whose contributions to the study of preventive medicine are standard throughout the civilized world.

Of the measures prescribed for the restriction and prevention of typhoid fever, none are considered of so great importance as the disinfection of the feces and urine, in which the typhiod germ is said to leave the body of the sick person. It is a fact, however, that, in very many instances, the disinfection of the dejecta of persons sick from typhoid fever is not properly carried out, and in many other instances not attempted. In cities, and other localities having a water-carried system of sewerage, these dejecta will usually be thrown into the sewers, and a considerable portion of the same will remain, as a coating, in the sewers. We are informed that so long as the surface of this coating remains in a moist condition, the germs of typhoid fever will not readily be given off, but that if allowed to become dry they may be liberated by air currents, and by them carried, through the usual openings for ventilation, to the outer air, or, through defects in the house sewers, into the dwelling. It is scarcely necessary to state that there are many surfaces in sewers where sewage, containing the germs of typhoid fever, may become dry, and, at certain times, remain in that condition for long periods.

4. *Impermeability and Tightness of the Sewers.*—In order that the solid particles in sewage may be conveyed to the proper outlets, and for the prevention of an unwholesome condition of the ground in which the sewers may be laid, it is essential that the liquid sewage be retained within the sewers, and not allowed to percolate or leak therefrom.

5. *Simplicity.*—The use of complicated apparatus, which may easily get out of order, will tend to frequent interruptions in the proper working of the sewers; and a multiplication of parts may, sooner or later, lead to confusion, or operate to prevent the free flow of sewage from, or the free movement of air in, the sewers.

6. *Durability.*—By reason of the fact that, in many instances, sewers must be laid in ground more or less soft, or carried under the walls of buildings which may settle, it is essential that the materials of which the sewers are constructed shall be able to withstand a reasonable amount of strain, or pressure, without fracture, at any time within the life of the sewers. It is also essential that those parts of the sewers which may be above the ground be able to withstand a reasonable amount of rough usage, without fracture, or a separation of the parts.

CHAPTER II.

Outside Sewers.

PRIOR to the construction of any sewer, a plan of the proposed work, showing the location, size and inclination of the sewer, laterals, and other connections, should be drawn to a convenient scale, and so made that it may be used not only as a working plan but as a permanent record of the work. Such plans are necessary:

1. In localities having plumbing codes, to comply with the usual requirements relative to the filing, with the board having jurisdiction over such work, of a plan, usually in duplicate, for examination and approval, and for a permanent record.

2. To ensure the proper and systematic construction of the sewer.

3. To facilitate the location of the sewer, and connections, at any future time, in the event of necessary alterations or repairs. Much time is usually lost in the location of sewers which have been laid a considerable time, especially where there has been a change in ownership, and, for this reason, a plan of the sewer should be in the possession of the owner of every building, filed with the deed of the property, and transferred, with the deed, to any subsequent owner.

Curves, or bends, in a sewer are objectionable:

1. Because they tend to prevent the rapid flow of sewage in the sewer.

2. Because they are usually made with straight pipes, or with pipes which do not have the proper radius, resulting in imperfect joints. A very common but highly improper method is shown in Fig. 1.

3. Because they render impossible the proper inspection of the sewer, described in a subsequent part of this chapter under the heading "Accessibility."

Fig. 1.

For the reasons mentioned, whenever possible the underground sewer should be laid in a perfectly straight line throughout its entire length. Where this is not practicable, the curve, or bend, should be made with pipes having the proper radius; the radius of the entire curve, or bend, should not be less than ten times the cross-sectional diameter of the sewer; and the inclination of the sewer should be slightly greater in the curve, or bend, to compensate for the increased friction.

Whenever practicable, the entire sewer trench should be dug before any pipes are laid and remain open until the sewer is complete and tested. A bad practice, and not uncommon, is the laying of the sewer in sections, i. e., the digging of a short length of the trench, laying and jointing the pipes therein, and filling in that portion of the trench with the dirt excavated for the next section of the sewer. Where this method is followed it will be apparent that the inclination of the sewer will be subject to wide variations; that where earthenware pipes are used the filling in of the trench before the cemented joints have had time to harden will tend to break the joints, and the proper testing of the sewer will be an impossibility.

It is very important that the bottom of the trench, which is to form the foundation of the sewer, should be firm and have an even slope throughout.

If yielding earth, as "made ground," is encountered, the bottom of the trench should be covered with a layer of cement concrete, not less than six inches in thickness, and well rammed down.

The proper slope of the foundation of the sewer may be formed by the aid of a level, and a long narrow board, with straight edges, and wider at one end than the other. Thus, if the sewer is to have an inclination of one inch in every three feet, a board twelve feet long should have a difference in the width at each end of four inches; and by laying one edge of the board on the bottom of the trench, with the widest end toward the main sewer, and

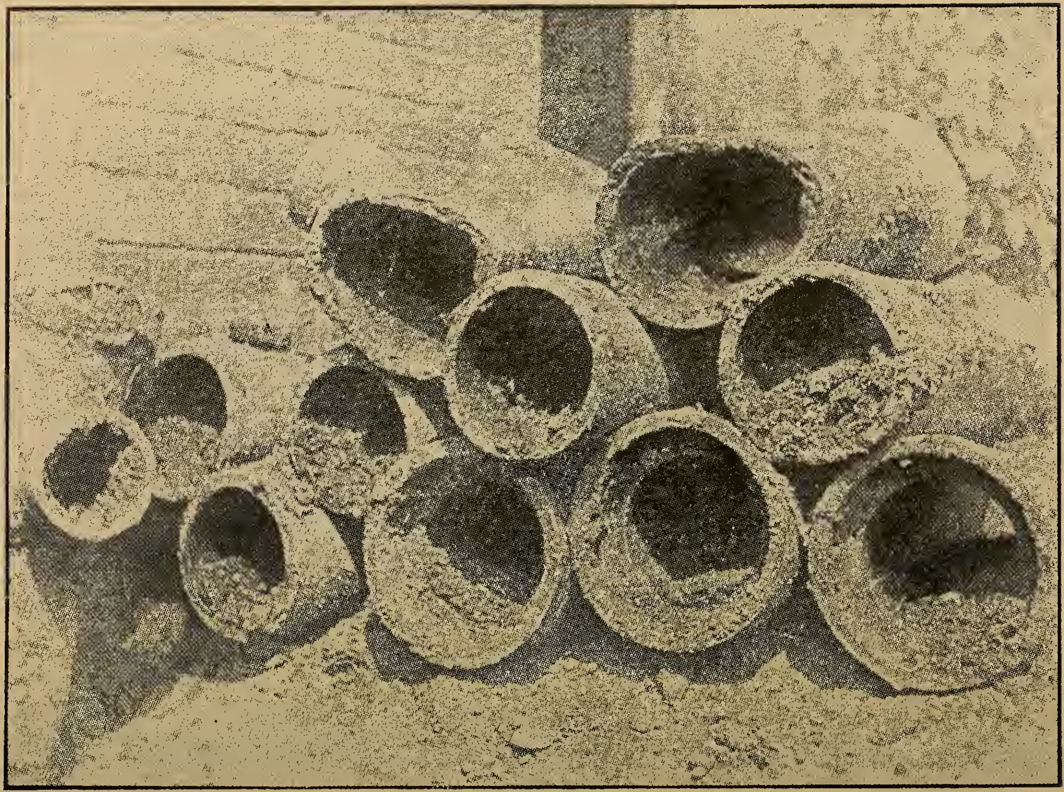

Fig. 2.

leveling the upper edge, the proper slope will be obtained. The longer the board the more uniform will be the slope of the bed of the sewer.

In the choice of materials for the construction of the outside sewer, the principal considerations of strength, thickness, smoothness, durability and impermeability should govern. Brick, stone, cement and wood are entirely unsuited for the purpose and would not be permitted in any locality where the construction of private sewers is under municipal control. Earthenware (commonly known as "crock" or "tile") has, for more than half a century, been in popular favor, but is gradually giving way to the more suitable material, iron, and for the following reasons:

Earthenware sewers are fragile and may be easily broken by the filling in or tamping of earth in the trench, or by the settlement of the earth under the sewers, as is well shown by the illustration of an excavated tile drain, shown in Fig. 2. Iron sewers, of the proper strength, could not be so fractured, except by a considerable settlement of the bed of earth on which they might be laid.

The joints in earthenware sewers, as usually made, may, and often do, become the causes of deposits in the sewers. A little cement forced into the interior of a sewer, and allowed to remain, may arrest the passage of a piece of paper, or other solids, and these, in turn, become the nucleus of a complete stoppage. Again, the lower portions of the joints being out of sight and difficult to reach, a small opening is often left in the cement, allowing liquid sewage to escape from the sewer, and a deposit of solid matters to form in the vicinity of the leaky joints. The same result is often produced by the use of inferior or improperly mixed cement, which, becoming softened by the sewage, is gradually washed out of the lower part of the joint. In the jointing of iron pipes the gasket of oakum, which precedes the molten lead, precludes the entrance to the sewer of the jointing material; and a joint properly made with molten lead will be as tight on the bottom as in any other part, and, under ordinary conditions, will not be affected by the sewage, and will last as long as the sewer itself.

Earthenware pipes being much shorter than iron pipes, necessitate the making of many more joints, thus adding to the cost of construction and multiplying the possible sources of leakage.

Where earthenware pipes are used for the outside sewers the connections between them and the iron inside sewers are not easily made, and defective joints at these points have often proved to be the causes of stoppages and leaks.

When newly laid, earthenware sewers present a somewhat smoother interior surface than do iron sewers, but after they have been in use for a time both will probably be coated with grease or slime to an equal extent.

In so far as relates to the lasting qualities of earthenware and iron sewers, a great deal will depend upon the nature of the earth in which they are laid, the possibility of electrolytic action, and the character of the sewage flowing through them. Without considerable protection iron sewers may be readily weakened or destroyed by the corrosive action of certain soils, by electrolysis and by acids sometimes present in sewage. Earthenware sewers will not be affected to any appreciable extent by these agencies and are usually preferred to iron sewers for the removal of the wastes from laboratories and certain manufacturing establishments, from which strong acids may be discharged into the sewers. Where the danger from corrosion is outside the sewers, iron pipes, well coated with asphaltum, and further protected by a substantial ring of concrete, may be considered safe.

Iron sewers are impervious both to air and water, and, when properly made of the best materials, earthenware sewers are but slightly inferior to them in this respect. There are, however, certain grades of earthenware pipes, designed for the construction of sewers, which are porous in character and entirely unsuited for the purpose.

In the selection of earthenware pipes for sewers only those should be accepted which possess superior qualities as to strength and impermeability, and which are uniform in thickness, true in cross section, straight, well glazed inside and outside, and free from cracks. A good pipe will respond with a clear ring to a smart blow.

By reason of their greater durability, salt glazed pipes are preferable to lead or glass glazed pipes.

The proper minimum thickness and depth of hub for stoneware pipes is shown in Table I. Fireclay pipes should have a greater thickness in each case.

TABLE I.

STONEWARE PIPES.

Size of pipe. Inches.	Minimum thickness. Inches.	Minimum depth of hub. Inches.
3	½	1½
4	⅝	1¾
6	¾	2⅝
8	¾	2⅝
10	1	2⅝
12	1⅛	3

It is to be regretted that in localities where earthenware pipes are permitted for private sewers, the testing of such pipes, as to the requirements before mentioned, is rarely attempted or included in the regulations governing such work. In the absence of municipal standards for earthenware pipes, or of tests relative to the qualities of the pipes sold in the local markets, it would be well for contractors and others interested in the construction of sewers, to obtain from the makers of such pipes sworn statements relative to the qualities of their pipes, with special reference to the amounts of water, if any, which they will absorb, the force required to crush them, and their resistance to percussive action. With such information in their possession it should not be difficult to make selection of the best pipes.

Cast iron pipes for sewers should be of the kind known as "Extra Heavy," the weights of which are shown in Table 2.

Table 2.

EXTRA HEAVY CAST IRON PIPES.

Size of pipe, in inches.	Weight, in pounds, per lineal foot.
3	9½
4	13
5	17
6	20
7	27
8	33½
10	45
12	54

As it would be difficult to remove a defective length of iron pipe from the sewer after jointing, sand holes and weak spots should be detected, by hydraulic test, at the foundry, and not be left to be discovered by the plumber's test.

Cast iron pipes and fittings for outside sewers should be well and thickly coated, by dipping, at the foundry, with asphaltum. Coal tar, pitch and linseed oil are also used, but are inferior to asphaltum.

Wrought iron pipes, as ordinarily sold in the market, are not suitable for outside sewers, because of their liability to corrosion, and for the further reason that the ordinary fittings are not recessed, and would leave rough depressions at the joints, and tend to the collection of solid matters at these points. Where wrought iron pipes are used for this purpose they, together with the fittings, should be rendered proof against corrosion by immersion, while hot, in hot liquid asphaltum, and the fittings should be recessed so as to make flush joints. The weights of such pipes should not be less than those shown in Table 3.

TABLE 3.

WROUGHT IRON PIPES FOR SEWERS.

Size, in inches.	Weight, in pounds, per lineal foot.
3	7½
4	10⅔
5	14½
6	18¾
7	23¼
8	28¼
10	40
12	49

Outside Sewers.

SIZE AND INCLINATION.

In determining the size and inclination of the sewer, the following important considerations should govern the calculation:

1. The sewer should be small enough and have the proper inclination to cause the normal flow of sewage to fill the sewer to such a height as will render it self-cleansing.

2. The sewer should be large enough and have sufficient inclination to remove a considerable volume of sewage, or rainfall, or both, in a comparatively short space of time, without flooding or inconvenience.

The normal and maximum flow of sewage may be determined within certain limits, but the rainfall will vary very considerably and cannot be determined with any degree of accuracy.

The proper amount of water necessary for strictly domestic purposes has been variously estimated at from twenty to thirty-three gallons per day for each person, and this amount may be taken as the normal amount of sewage to be taken care of. Half of this amount will probably pass into the sewer in six hours, and two-thirds in eight hours.

The maximum volume of sewage will occur when a number of fixtures are discharged simultaneously, which, in a small building, is a somewhat remote possibility.

Assuming that a bath tub containing fifty gallons of water, a water closet tank containing four gallons, a laundry tub containing twenty gallons, and a slop sink into which a two gallon pail of slops is thrown and which is then flushed, are all discharging at the same time, we have a total of about eighty gallons of water (sewage) passing into the sewer in a brief space of time, probably not more than two minutes. By Table 4 it may be seen that a four-inch sewer, with an inclination of 1 in 40, and running full, will remove, approximately, 176 gallons of sewage per minute, or more than four times the volume which would be likely to be discharged at any one time from the combined fixtures of a building of moderate size. And yet, in the

TABLE 4.

Approximate inclinations of circular sewers for securing velocities of four and one-half feet of sewage per second, when the sewers are running full or half full. Also the approximate discharge, in U. S. gallons, per minute.

Size of sewer.	Inclination.	Discharge.*
4	1 in 40	176
5	1 in 50	275
6	1 in 60	397
7	1 in 70	540
8	1 in 80	705
9	1 in 90	892
10	1 in 100	1,102
12	1 in 120	1,586

*When the sewers are running only half full the discharge will be one-half the amounts shown.

majority of instances, a sewer of a larger size would usually be provided for such a building. It is not wise, however, even when no rainfall is to be taken care of, to construct a sewer of less diameter than four inches, and this size is frequently stipulated in plumbing codes as the minimum size which will be approved. On the other hand, it is seldom that a size larger than six inches will be required for any ordinary building, and when this is the case, and there are considerable fluctuations in the volume of sewage, it would be better to use two sets of pipes of a small diameter than one large sewer, and for the following reasons:

Up to a certain point the velocity of the sewage will increase with its depth in the sewer, and the depth of the sewage will determine its power to carry along the solids usually present in the sewage, or which may accidentally or through carelessness find their way into a sewer.

A comparatively small volume of sewage which in a four-inch pipe might be sufficient to render it self-cleansing would be a shallow stream in a six-inch sewer, and a trickling stream in a sewer of larger dimensions.

As previously stated, where the rainfall is to be removed by a sewer, it will be necessary to make the sewer large enough to remove a considerable quantity of water in a short space of time, the amount depending upon the size of the roof, or the size of that part of the lot which may be paved, and which may be drained into the sewer.

The amount of rainfall is measured by means of a special gauge, one or more of which, together with the records of the local rainfall, will usually be found in every locality of any size, and is expressed in inches, and in tenths and one-hundredths of an inch. A rainfall of one inch is that amount of rain which falling upon a given surface, and not being diminished by percolation or evaporation, would have a uniform depth of one inch.

In making an estimate of the amount of water which will fall upon a roof, or lot, during any rainstorm, it will first be necessary to learn the amount of the rainfall, in inches, and the area of that portion of the lot covered by the building, or which may require to be drained, in square inches, and by multiplying these two numbers the number of cubic inches of water will be found. This may be converted into gallons by dividing by 231,—the approximate number of cubic inches in a standard U. S. gallon of water. For example, a building 50×25 feet would have an area of 1,250 square feet, or (1,250×144) 180,000 square inches, and 180,000×1 inch of rainfall will equal 180,000 cubic inches, or (180,000÷231) slightly more than 779 gallons of water.

In Michigan the average annual rainfall is about 33.76 inches, or about 2.8 inches per month. If the downfall of this amount of rain was uniform, the amount per day would be less than one-tenth of an inch, and need not be considered in the calculations for the sizes of private sewers.

In the planning of sewerage systems for localities it has been the custom of some engineers to provide for a rainfall of one-quarter of an inch per day, but even this amount would not require more than a passing consideration in the planning of the sewers of individual buildings. Neither would it be considered necessary to make provision for taking care of all the water in excessive downpours of rain,—as two and one-half inches in forty-five minutes,—because a considerable portion will overflow the roof gutters and find its way into the subsoil or the street channels.

In the planning of private sewers into which the rainfall is to be admitted, I would suggest the standard of one inch of rainfall per hour as the maximum amount to be provided for, and such a rainfall could be removed from the roof or lot of any ordinary building, without inconvenience, by a properly constructed four-inch sewer.

In some localities two sets of pipes are laid for the separation of the sewage and rainfall; in others the rainfall is collected and stored in cisterns —some of which have overflows to the sewers; and in many others, particularly in the large cities, the rainfall is removed principally by the sewers.

From what has been said it will be seen that calculations for private sewers, based upon the actual amounts of sewage and rainfall to be taken care of, will be very unreliable and subject to wide variations, even in the case of buildings of the same size and with the same class and number of plumbing fixtures.

For those who wish to make further study of this phase of our subject it is suggested that a number of buildings of each of several classes, and provided with water meters, be selected for extended observations. Averages of the amounts of water used per day for each occupant, the number of hours the buildings are occupied, and the amounts of rain falling in a given time upon the roofs, or other surfaces drained, would furnish valuable information relative to the probable amounts of sewage to be provided for in buildings of similar size and class.

In the new plumbing code of the city of Cleveland, Ohio, the number of fixtures is taken as the basis of the sizes of private sewers, as shown in Table 5.

The inclination of a private sewer will depend largely upon the depth of the main sewer, and the distance of the latter from the highest part of the private sewer, and will vary considerably in the same sewer district. Where the total amount of fall is slight, the head of the sewer should be as near to the surface of the ground as possible without running the risk of freezing, and where the amount of fall is excessive, the head of the sewer should be kept as low as practicable, or the sewer should be given a safe and uniform inclination to a point near to the main sewer and the inclination increased at this point.

It is the unanimous opinion of engineers that the inclination of private sewers should be such as will

Table 5.

Minimum sizes of metal house sewers, for sewage and rainfall, in terms of the maximum number of small fixtures, or their equivalents for larger ones, that may be connected therewith, when laid at the grades indicated. For crock house sewers the diameter is to be one size larger for the same number of fixtures.*

Size of	Inclinations.			
sewer.	1 in 100.	2 in 100.	3 in 100.	4 in 100.
4........	118	163	196	238
5........	216	300	364	435
6........	343	488	585	731
7........	474	722	860	1,060
8........	716	1,000	1,190	1,400
9........	950	1,334	1,616	1,891
10........	1,216	1,750	2,050	2,433
11........	1,585	2,250	2,515	3,133
12........	1,950	2,725	3,310	3,900

*Twenty square feet of roof or yard area, in horizontal projection, counts as one fixture.

Three feet of urinal trough, or wash sink, counts as one fixture.

One bath, basin, sink, or smaller fixture, counts as one fixture.

One pedestal unrinal, or slop hopper sink, counts as two fixtures.

One water closet counts as two fixtures.

cause a velocity of about four and one-half feet of sewage per second, and, for this reason, Table 4 has been limited to those inclinations which will give this velocity, or nearly so. These inclinations may be easily remembered by multiplying the diameter of the sewer by 10, the product being the length of sewer, to which one foot of fall should be given.

Table 6.

Size of sewer.	Minimum inclination.
4	1 in 92
6	1 in 137
8	1 in 183
9	1 in 206
10	1 in 229
12	1 in 227

Where the inclination of the sewer must, of necessity, be small, so that the velocity of sewage would be less than three feet per second, the sewer would not be considered self-cleansing, and special means for flushing would be necessary to prevent an accumulation of deposits of solid matters. Table 6 shows the minimum inclinations for self-cleansing sewers when running full or half full.

CONNECTION WITH THE MAIN SEWER.

In localities having modern systems of sewerage, stoppered openings are usually left in the main sewers opposite to each lot, and, under such conditions, the connection with the main sewer would be a simple process. In the absence of such provision, the connection should always be made under the supervision of the city engineer, or other person in charge of the public sewers.

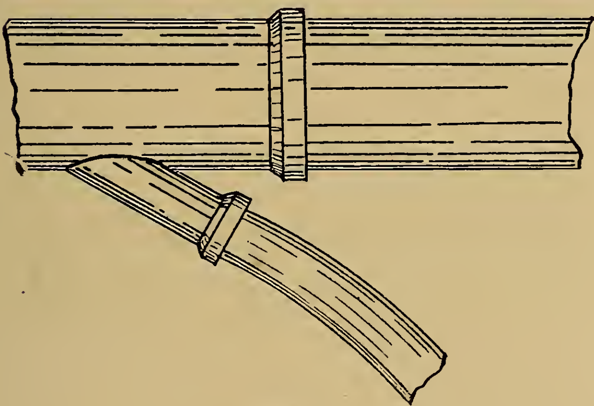

Fig. 3.

The private sewer should enter the main sewer obliquely, so that the inflowing sewage would be projected in the same direction as the flow of sewage in the main sewer, as shown in figure 3. A square connection would tend to an interference with the flow of sewage in the main sewer, and to the deposition of solid matters therein at that point.

If the main sewer is of brick, the connection should be through a glazed stoneware, or cement, block, built into the sewer, and having an annular opening, in the form of a hub, on the outside, for the reception of the spigot end of the first length of pipe of the private sewer, as shown in figure 4.

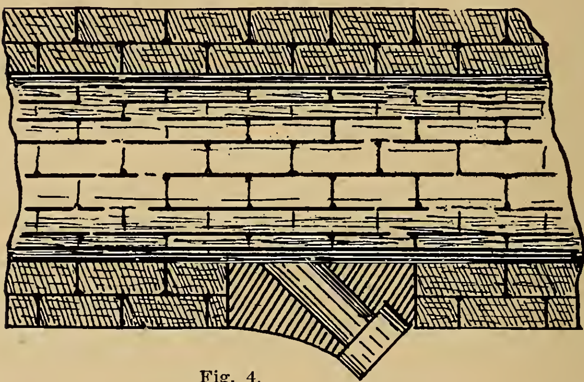

Fig. 4.

Where the main sewer is of earthenware, the connection should be through a "Sanitary T" or TY fitting, as shown in figure 3.

LAYING AND JOINTING THE PIPES.

At, or near to, the connection of the private sewer with the main sewer, provision should be made for the subsequent preliminary testing of the sewer, by the insertion of a fitting which will permit of the plugging of the sewer. For this purpose, where earthenware pipes are used, a "half-socket" pipe, a plain pipe and "saddle chairs," or a plain pipe and collar, or sleeve, as shown in figures 5, 6 and 7, would be necessary. This should be fitted in its

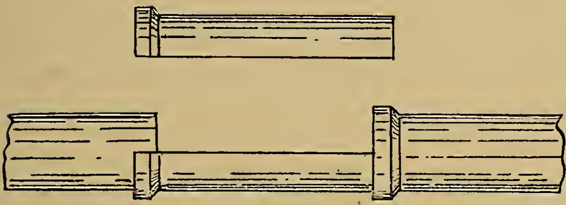

Fig. 5.

place at the same time the other pipes are laid, so that the sewer may have butt joints throughout.

Where iron pipes are used for the sewer, the opening for the testing plug may be obtained by the

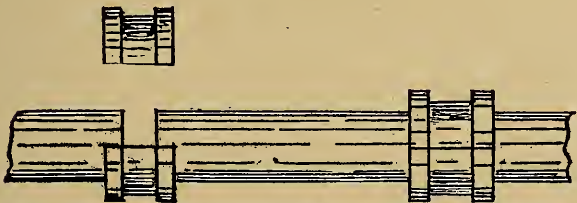

Fig. 6.

use of an inspection piece, similar to that shown in figure 8. This would be caulked in place when the sewer is laid, and such a fitting at this point might, at some future time, be of service in the removal of stoppages, or the cleansing of the sewer.

In laying the sewer pipes, it is important that they have an even bearing throughout their entire length, and not, as is usual, rest simply upon their hubs. This can be accomplished by making a hollow place under each hub, as shown in figure 9, and will serve the further purpose of giving plenty of room to make good joints.

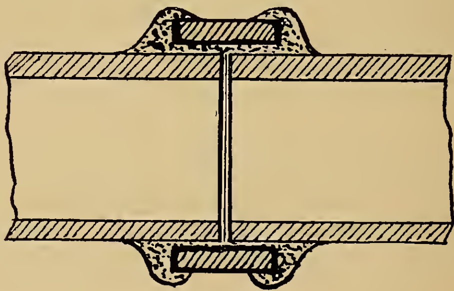

Fig. 7.

Where the pipes are supported by the hubs alone, it is impossible to properly tamp the earth solid under them, and for this reason they would be liable to fracture by the careless filling in of the trench, or by the weight of the superincumbent earth.

In making the joints of earthenware sewers, it is essential that a gasket of oakum precede the cement, and for the following reasons:

Where oakum is not used, each pipe must be cemented, and the inside of the joint examined to see that no cement remains on the inside, before another pipe can be laid; and in placing the next pipe in position, the joint last made would be disturbed, and the cement forced out of its place, and possibly into the sewer. Further, pipes laid one at a time cannot be laid in as true a line as where a number of them are laid and adjusted prior to the jointing.

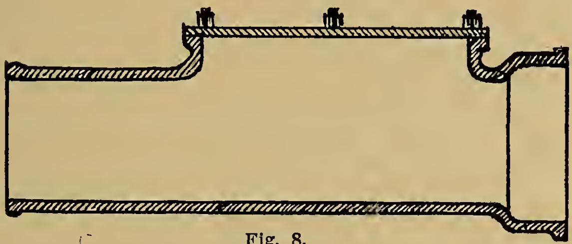

Fig. 8.

Not being provided with rims, in the absence of the gasket of oakum, the spigot ends of the pipes would tend to settle in the joints, and leave a large space at the top, and little or no space for cement at the bottom, as shown in figure 10.

For the joints of earthenware pipes, nothing but the best grades of Portland cement, and clean, sharp sand, in the proportion of one measure of cement to one of sand, should be used, the mixture being tempered with water until it is of the consistency of thick mortar. Cement which has begun to harden before it could be used should not be worked over or mixed with new material.

In properly constructed earthenware pipes, the glazing will be omitted from the insides of the hubs, and from the spigot ends for a distance equal to the depth of the hubs. It has been stated that the lack of glazing at these points will render the pipes porous, but if the cement covers every portion of the unglazed surfaces, it will be impossible for any

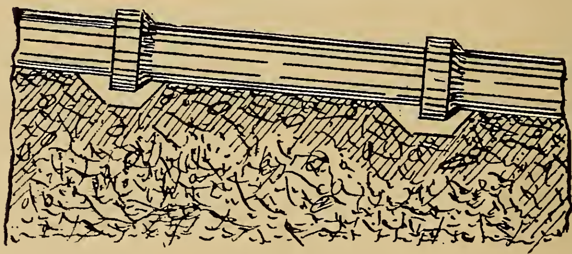

Fig. 9.

liquid, inside or outside of the sewer, to affect the pipes at these points, and the cement will adhere more firmly to such pipes than to those having glazed surfaces at the joints.

In making the joints of iron pipes, the hubs should be filled to one-third of their depth with oakum, well and evenly calked, and the remaining spaces, and to a depth of one-eighth of an inch above the hubs, with molten lead, which should also be well and evenly calked. If the filling and calking have been properly carried out, the lead will remain flush with the tops of the joints when finished.

THE MAIN TRAP.

The utility, or otherwise, of the main trap in the sewerage of buildings has, for more than a decade, been the subject of much controversy, and has recently received much attention at the hands of many prominent sanitarians. For the proper consideration of this question, it will be necessary to review and analyze, at some length, the principal objections

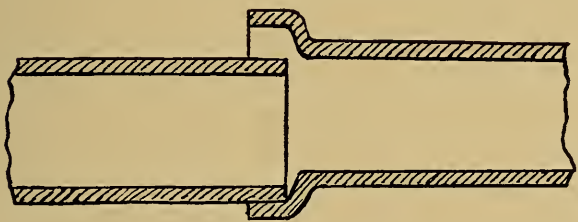

Fig. 10.

which have been raised against the use of these traps, and the benefits which it is claimed would be secured by their discontinuance.

The principal objections raised against the use of main traps may be summarized as follows:

1. That they interfere with the rapid flow of sewage from the private sewers.

2. That they are filth and grease holders.

3. That stoppages in them are of frequent occurrence.

4. That foul odors are generated in them to such an extent as to render them a nuisance, or a danger to health, when a portion of the air which has been in contact with them is forced out of the air inlet.

5. That the water in them is liable to be frozen by the currents of cold air passing over them.

6. That their water seals are liable to be destroyed by syphonage or pressure.

7. That they necessitate the provision of an otherwise useless and objectionable appurtenance, the air inlet.

8. That if the air inlet becomes obstructed, an air locked condition may prevail in the pipes between the traps of fixtures and the main trap.

9. That they tend to accelerate the syphonage of traps located in the lower stories of a building.

10. That they prevent air circulation in those portions of the sewers between them and the public sewers.

Benefits claimed to be derived from the discontinuance of main traps:

1. That the main sewers, and every portion of the private sewers, will be well ventilated by the extensions of the soil, waste and re-vent pipes above the roofs of buildings.

2. That the clogging, by frost, of the tops of soil, waste and re-vent pipes, above the roofs, will be less likely to occur where warm air from the public sewers is constantly passing up them than with the sluggish movement of air incident to the use of the main trap.

Analyzing the several objections, it is found that, with the exception of those objections numbered seven and ten, and possibly number one, the objections are not valid, and that the objectionable features mentioned are due rather to the use of improperly constructed traps, or to improper or imperfect installation of the traps and accessories.

That the sewage flowing through a private sewer will not, ordinarily, meet with any resistance, save that of friction, until it reaches the main trap, is conceded, but if the fall of the sewer near to and on the "house" side of the trap is increased slightly, and the bore of the inlet side of the trap is contracted so that it is slightly less than the sewer, or, better still, if the trap is constructed as shown in figure 11, the sewage will pass through quickly and leave the trap clean.

It is safe to say that any ordinary sewage will pass through a properly constructed main trap, and that if a stoppage should take place in such a trap, it would be due to an article, or articles, of a bulky or heavy nature which might, by accident or design, gain access to the sewers.

If, then, it is possible to render a main trap self-cleansing, the objection relative to foul and dangerous odors from them, escaping at the air inlets, is removed.

The water in a main trap will not be likely to freeze if the trap is below the frost line, and ar-

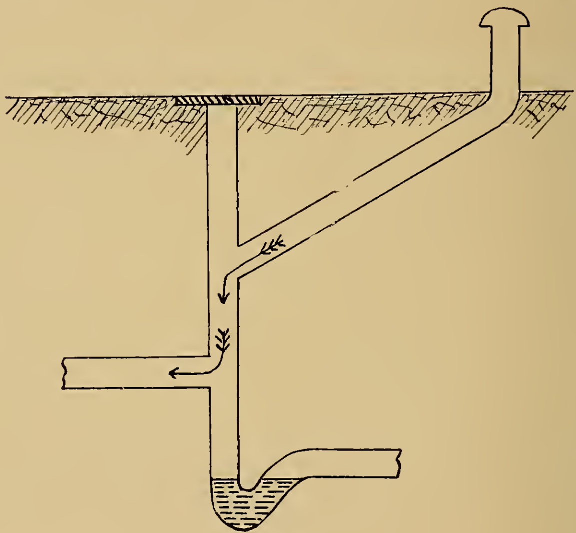

Fig. 11.

ranged as shown in figure 11. Where this trap is inside the building, the air inlet should be arranged as shown in figure 12. It will be seen that, in either case, the inflowing cold air cannot materially affect the temperature of the water in the trap.

The possibility of the water seal of a properly constructed main trap being destroyed by syphonage or pressure is very remote; and if this should take place, the seal would soon be restored, and any sewer air which might pass into the house pipes would be discharged, from the extensions of the soil and other pipes, at a safe point above the roof.

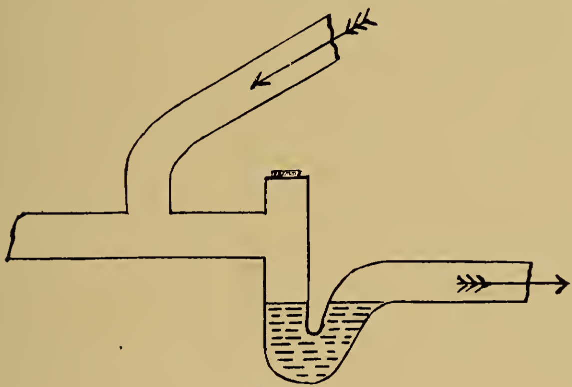

Fig. 12.

That the main trap necessitates the provision of an objectionable appurtenance—the air inlet—is well known to anyone who has had to do with their location, especially where the main trap is in close proximity to a public thoroughfare. There are, however, very many instances in which a suitable location for the air inlet can be found, in many cases by the extension of the same for some distance, horizontally, from the inspection shaft of the main trap.

If the air inlet is properly located and constructed, the possibility of a stoppage in the same, with the consequent air lock in the sewer between the house fixtures and the main trap, is very remote.

From our present knowledge of the conditions under which the syphonage of traps occurs, the statement that a main trap will tend to accelerate the syphonage of traps located in the lower stories of a building, does not appear to have foundation, assuming, of course, that the construction of the trap does not seriously retard the flow of sewage, and that a proper air inlet is provided.

From the standpoint of the individual house owner, the statement that the ventilation of that portion of the private sewer between the building and the main sewer is, by the interposition of a trap, rendered impossible, is really the most logical argument which has been advanced in opposition to such a practice, and yet, in many instances, the length of sewer which would thus be left without ventilation would be very small.

From the standpoint of the general public, the trapping of the public sewers by openings at the grade, especially in narrow streets and congested localities, is objectionable, and may become a source of danger to the passer-by and to those residing in the immediate vicinity of such openings. On the other hand, if the main trap was omitted from each house sewer in a locality, and every such sewer was ventilated by a pipe extended above the roof of a building, the sewer openings in the streets would usually act as inlets for air, and the foul air in the public sewers would be discharged above the roofs of the buildings. Further, the more rapid circulation of air in the public sewers, which would thus be secured, would prevent the accumulation of foul air in any part of the sewerage system; and the temporary discharge of air from the public sewers, at a grade opening, would be much less objectionable than under the plan in general use at the present time.

There is, however, an objection to such a method of ventilating the public sewers, in fact, if a defect should occur in the house pipes, a trap become unsealed, or any pipe or fixtures be disconnected for repairs or alterations, foul air from the main sewers would gain access to the building.

At the present time, there are very many public sewers which are sewers of deposit, and which make their presence known to the olfactory organs of those passing by a sewer ventilator or an untrapped catch-basin in a very unmistakable manner. It is scarcely necessary to state that the entrance to a dwelling of a very small volume of air from such a source would be very objectionable from æsthetic and hygienic standpoints.

With many others, I believe that every trap in a system of house sewerage is a necessary evil, and would gladly welcome any change which would do away with them, together with their usually complicated re-vents; but so long as the unwholesome or dangerous character of sewer air is recognized—and our elaborate system of regulation of plumbing

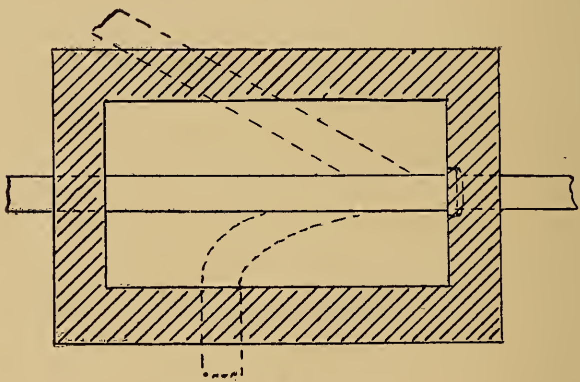

Fig. 13.

work is evidence of this view—so long must we put up the barriers, and there is nothing yet discovered so effectual for this purpose as the water seal.

In order to secure the ventilation of the greater portion of the outside sewer, together with a better flushing of the sewer and the location of the air inlet at a desirable distance from the building, the main trap should, ordinarily, be located as near to the main sewer as practicable, and be surmounted by a manhole to facilitate inspection and cleansing, upon which points more will be said under the headings, "The Fresh Air Inlet" and "Accessibility."

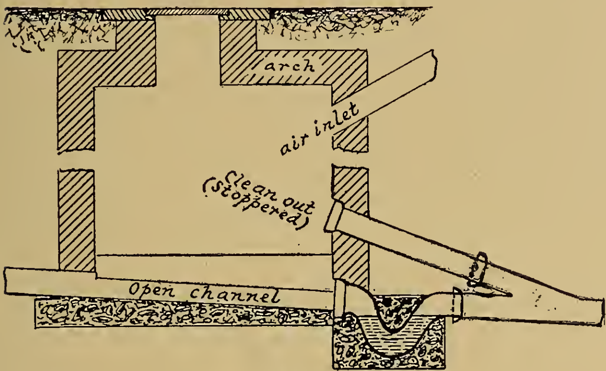

Fig. 14.

A good arrangement of the main trap and manhole is shown in Figs. 13, 14 and 15. It will be seen that the trap is located out of the way of the inflowing cold air and yet is accessible from the manhole.

It will be seen that the trap is located out of the way of the inflowing cold air and yet is accessible from the manhole.

In the absence of a manhole at the main trap it is suggested that the construction and arrangement of the trap and accessories be in accordance with the plan shown in Fig. 11, which consists of an ordinary P trap, and into the hub of which is placed a T fitting. Where the amount of fall is limited, so that the difference between the levels of the sewer on either side of the main trap must be slight, the T fitting can be cut down until the side hub is nearly on a level with the hub of the trap. Sufficient pipe

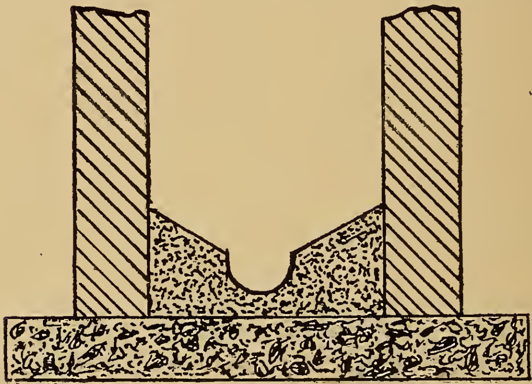

Fig. 15.

should be added to this fitting to reach to within six inches of the surface of the ground, and a brick or cement box constructed around the pipe and finished level with the surface, the whole being surmounted by a flat stone, or a metal plate, to keep out solid matters and provide for easy access to the trap. The trap should have a moderately deep seal and be set level.

THE FRESH AIR INLET.

The location of the air inlet will often tax the ingenuity of the plumber, and will require different treatment in nearly every instance, so that a universal plan cannot be laid down.

The top of a manhole should not be left open for the admission of air to the sewer because of the danger of freezing of the water in the trap, and for the further reason that dirt and other solid matters might thus gain access to the sewer.

The continuation of the inspection shaft of a main trap above grade for the air inlet is not desirable, because it would render the inspection and cleansing of the trap difficult. The arrangement of main traps shown in Figs. 11 and 12 may be carried out, with slight modifications, in nearly every instance.

To be effective in winter, the air inlet should be continued above the grade to a sufficient height to prevent the opening being blocked with snow.

The air inlet should never be placed near to a door or window, or to the fresh-air inlet of the ventilating apparatus of a dwelling, but should be at least fifteen feet distant from all such openings.

Where the main trap is adjacent to a street, and there is a space between the sidewalk and the curbing of the street, the air inlet may be connected with a hollow iron post, placed near to the curb, and having openings in the side and near to the top.

The addition of an iron ring will convert the same into a convenient hitching post.

Where the air inlet can be located in a lawn, or garden, the extension above the ground may be concealed, and at the same time protected against fracture, by surrounding it with large stones, in the form of a rockery, over which vines can be trained, and an unsightly object be thus converted into a thing of beauty.

Where the public sewer is in the rear of a building ,it is sometimes possible and convenient to extend the air inlet above the guter of a low building, provided, of course, there are no windows in the immediate vicinity of the pipe; or if the main trap is near to a blank wall, the air inlet may be carried on the wall to a height of several feet above the grade, and concealed if so desired.

Were all sewers laid in the alleys, as they should be, and not in the streets, the location and arrangement of the main traps and air inlets would be a simple proposition, and the discharge of air from the sewer openings, or from the air inlets, would be much less liable to become an offense to passers by.

ACCESSIBILITY.

That a sewer, however well constructed, may at some time or other become choked, necessitating the provision of openings for the removal of such stoppages, is well recognized.

The provision of access openings to the outside sewer is of considerable importance because, in the absence of such openings, if a stoppage should occur in that part of the sewer it would be necessary to do considerable excavating and to break into and afterwards repair the sewer.

Where there is a manhole, constructed as in Figs. 13, 14 and 15, the passing of cleaning rods and tools through every part of the sewer would not be difficult.

Where there is no manhole, and the main trap is near to the main sewer, the greater portion of the sewer may be cleansed by the insertion of the cleaning tools at the usual access opening at the highest point of the horizontal sewer, and the removal of the solid matter at the main trap.

REMOVAL OF SUBSOIL, SURFACE AND ROOF WATER.

Wherever possible, the water from the subsoil drains, yards, areas and cellar floors should be discharged on the surface of the ground, into a natural water course, or into land drains, and not into a sewer; but where this is not practicable, there should be but one connection with the sewer, and that through a trap, with a deep seal, placed near to and on the "house side" of the main trap, preferably in the wall of the manhole (if any), from which the trap could be easily reached for the purpose of inspection and cleansing. As the seal of this trap will be liable to become weakened, or broken, during a dry spell, provision should be made for keeping the trap constantly supplied with water by the discharge into the drain leading to the trap of some fixture which receives comparatively clean water at frequent intervals. The drip pipe from a refrigerator would answer the purpose, but should not have direct connection with the drain or trap.

Where the main sewer is small, and there is danger of sewage backing up into the private sewer during heavy rains, the subsoil and cellar drains should not be connected with the sewer, but discharge into a well, outside the building, from which the water could be removed by hand, or by means of a pump. This well should not be in close proximity to a building because foul odors may be given off from the stagnant water, even when at rest, and would be certain to occur when the same was being removed.

Where the rainfall is to be admitted to the sewer the connection should usually be through the same trap which receives the subsoil and surface water, but care should be exercised in making this connection so that flooding of the subsoil may not take place during heavy rains.

CHAPTER III.

Inside Sewers.

HEAVY cast iron pipes, having weights corresponding to those shown in Table 2, are the only materials considered to be suitable and safe for the sewers on the inside of a building and for a distance of at least three feet outside the foundation walls. Earthenware pipes are not considered safe for this purpose because of their liability to be broken by the settling of the walls of buildings under which they would have to pass. Where the acid wastes of a laboratory, or any sewage containing strong acids in sufficient amount to injure an iron sewer, are to be removed it would be necessary to make use of earthenware pipes, in which case only the best quality of pipes should be used, and, when laid and jointed, should be encased in a substantial ring of cement concrete, and relieving arches built over each opening in the walls through which the pipes may have to pass. The latter precaution might be observed with advantage where the sewer is constructed of extra heavy cast iron pipes, particularly in the case of buildings of considerable height and in new buildings which have not got through settling.

SIZE AND INCLINATION.

The size and inclination will be governed largely by the size and inclination of the outside portion of the sewer, the methods of determination of which are explained in Chapter II. A size of less than four inches is not desirable, and a four-inch sewer will be large enough for the inside sewer of any ordinary building.

UNDERGROUND VS. HANGING PIPES.

Wherever possible the laying of a sewer under the basement floor of a building should be avoided and the soil and waste pipes run on the walls or ceilings of the basement to the point where the sewer enters the building. Where the sewer must be laid under the floors care should be taken not to place the same in or under any room to be used for the storage of coal, or any other heavy or bulky substance, or in any other position where it would not be easy to reach the sewer in the event of necessary alterations or repairs.

No part of a sewer should be placed in or under a plenum chamber, or other place set apart for the fresh-air room of the ventilating apparatus of a building, because in the event of a leak, or the disconnection of any pipes for alterations or repairs, the air supply of the building would be contaminated.

CONNECTION WITH THE OUTSIDE SEWER.

Where the sewer outside the building is of earthenware considerable care must be exercised in making the connection between the earthenware and iron pipes to avoid leakage or stoppages at this point.

Where the metal and earthenware pipes have not the same internal diameter, a reducer should always be used, and the joint made with oakum and cement in the manner previously described for the jointing of earthenware pipes with those of the same material.

ACCESSIBILITY.

Access openings should be constructed at the end of each main or branch sewer, at every change

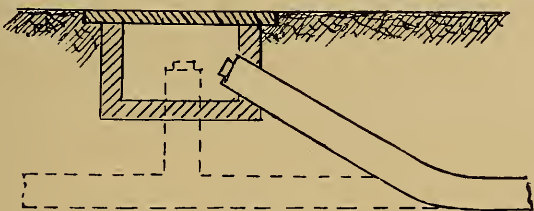

Fig. 16.

in the direction of the sewers, and at such other points as may be necessary to enable the whole of the sewers to be cleaned out in the event of stoppages.

In the construction of the cleanouts at the ends of the sewers, bends of large radii, only, should be used. Square bends are not permissible because they would interfere with the passage of cleaning rods into the sewer.

Where it is necessary, or desirable, to conceal the clean out plugs, they may be arranged as in Figure 16, and such an arrangement at the end of a sewer would render the insertion of cleaning rods more easy than where the plug is brought up square with the floor.

FLOOR DRAINAGE.

By reason of their liability to become choked with coal dust, ashes, dirt, or other refuse, commonly found in basement rooms, and for the further reason that the water seals of traps in such locations soon become broken by evaporation, floor drains should not be permitted in any basement room other than that used for laundry purposes.

For the reasons mentioned in the preceding paragraph, in the construction of the floor drain it will be necessary to make provision for keeping solid matters out of the sewer, and for the maintenance of the seal of the trap. The common practice of using a "Bell" trap (Figures 17, 18 and 19), by itself or in conjunction with any other trap, for this purpose cannot be too strongly condemned, and for the following reasons:

The "well" of the trap and the small hole in the strainer soon become filled with solid matters, to remove which the strainer must be lifted and with it the "Bell" which constitutes the dip of the trap, and when this occurs the seal of the trap is broken.

Even when the trap is clean, the flow of water through it is very slow, and for this reason, when a considerable amount of water is to be removed,

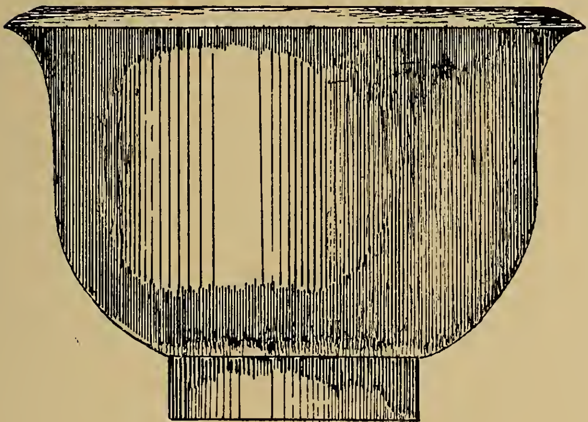

Fig. 17.

the strainer is usually taken off, and quite frequently left off for a considerable period of time.

The strainer being light is easily broken, and a broken strainer usually means a broken seal.

The seal of the trap is very shallow and therefore easily broken by evaporation or siphonage.

When placed on the top of another trap, as is frequently done, an air lock is formed between the traps, and the usual sluggish flow of water through traps of this kind is rendered still more inert, necessitating the removal of the strainer, with the results before mentioned.

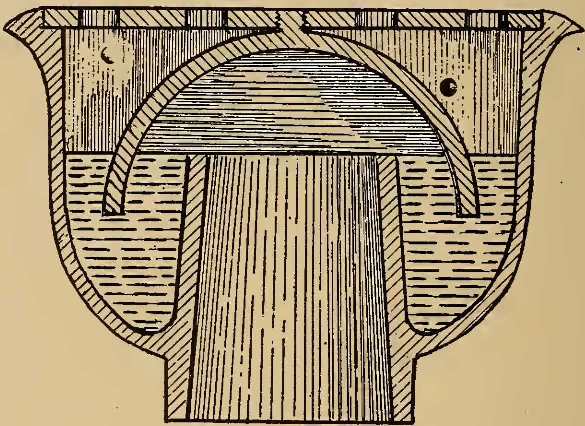

FIG. 18.

A combination catch-basin and trap, for the removal of surface water not only from basements, but also from yards, areas, public toilet rooms, slaughter houses, stables, and many business and manufacturing establishments where washing of the floors is necessary, is shown in Figure 20. The catch-basin should be constructed of cement, preferably circular in cross section and rounded at the bottom to facilitate cleansing. The outlet should be a square elbow, with inspection hole and cover.

ARRANGEMENTS FOR FLUSHING.

In order to carry out the principle of simplicity in the construction of sewers, every possible effort

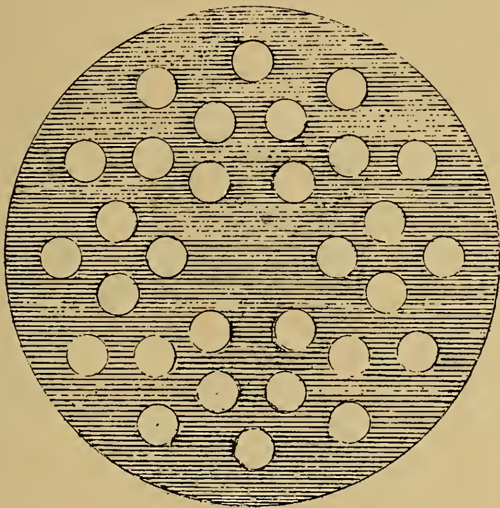

Fig. 19.

should be made to obtain a sufficient amount of fall to render the sewers self-cleansing, and obviate the use of complicated and expensive apparatus for flushing the sewers. But where the fall must necessarily be limited, provision should be made for flushing the sewer at regular and frequent intervals. This can be best accomplished by the sudden liberation of large quantities of water into the sewer at or near to the highest part of the same.

The frequency with which a sewer should be flushed will depend largely upon the inclination of the sewer and the number of closets discharging into it. In many instances a daily flushing will

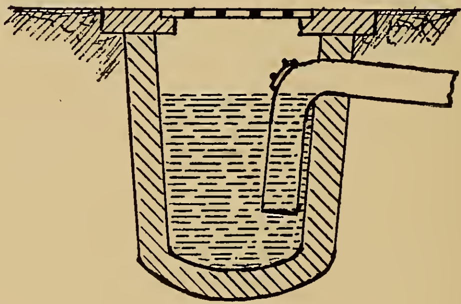

Fig. 20

be all that is necessary to keep the sewer free from accumulations of solid matters.

The flushing tank should be located in the basement, preferably in a small room constructed or set apart for that purpose, and the outlet of the tank properly trapped to prevent the passage of sewer air into the basement during the time the tank may be empty.

There are many different forms of flushing tanks and apparatus on the market, but, by reason of its freedom from working parts and comparatively noiseless action, preference should be given to the siphon tank, such as is used in the flushing of the various forms of trough closets.

The capacity of the flushing tank will depend largely upon the size and length of the sewer, a large or long sewer requiring a more powerful flush that a smaller or shorter sewer.

By experiment it has been found that a velocity of four and one-half feet per second will remove any of the solids likely to find their way into a sewer, and a tank for the flushing of a sewer should be capable of producing this, or even a greater, velocity, and of discharging its contents in the space of one minute, or even less. By reference to Table 4, in the preceding chapter, it will be seen that a four-inch sewer, laid at an inclination which will give a velocity of four and one-half feet per second, and running full, will discharge approximately 176 gallons per minute, and a six-inch sewer, with the proper inclination, 275 gallons per minute. From this it will be seen that for a four-inch sewer a tank holding 200 gallons (27 cubic feet), and for a six-inch sewer a tank holding 300 gallons (40 cubic feet), will produce, in each case, a flushing effect considerably greater than what could be obtained by any ordinary flow of sewage in the sewers.

Where water is plentiful, the flushing tank should be filled from the water mains, but where this would be an objection, the waste water from wash basins or bath tubs may be discharged into the tank, and a sufficient amount of water from the mains added, if necessary, to cause the discharge of the tank to take place at the proper time. The use of waste water for this purpose would necessitate frequent cleansing of the flushing tank to prevent offensive odors from the accumulation or organic matters on the sides of the tank.

Where the rainfall is not stored in cisterns, the whole or a portion of the same may be diverted into the flushing tank and made to assist in the flushing process.

As the sewer would probably be completely filled during the discharge of the flushing tank, and the unusual flow exert a powerful influence upon the traps of fixtures in the lower part of the building, special precautions should be taken to prevent the siphonage of such traps by this means.

Whatever the method of flushing adopted, the entire apparatus should be automatic in its action, and so located and arranged that it will not be liable to freeze, or become a source of annoyance or danger to the occupants of the building.

CISTERN WASTE AND OVERFLOW.

Where the rainwater is to be stored in a cistern in the basement of the building, whenever practicable, the waste and overflow of the cistern should be connected with a drain and not with a sewer. Where this is not practicable, the connection with the sewer should be through a trap which is constantly supplied with water, otherwise the overflow would be liable to act as a sewer ventilator during a considerable portion of the time.

CHAPTER IV.

Soil, Waste and Vent Pipes.

LOCATIONS.

THE location of the vertical soil and waste pipes will be governed largely by the location of the plumbing fixtures, and the proper location of the fixtures will obviate the use of long horizontal runs, or a multiplicity of vertical stacks. For these reasons, the fixtures on each floor should be grouped, and be as near to each other as practicable; and the fixtures on different floors, especially those of the same kind, should be as nearly over each other, vertically, as possible.

For the purpose of securing a good upward draft in the vertical soil, waste and vent pipes, whenever possible, they should be on or in inside walls. They should not, however, be located in smoke or vent flues, as is frequently done, because they would not be accessible for repairs or alterations.

MATERIALS.

For the construction of the vertical soil and waste pipes, and for all vent pipes of two inches diameter and upwards, extra heavy cast iron pipes, or standard lap welded galvanized or "rustless" wrought iron pipes, of the weights shown in Tables

2, 3 and 7, should be used, but cast iron pipes should not be used for stacks of more than one hundred feet in height.

For the branch and vent pipes of less than two inches diameter, standard lap welded galvanized or "rustless" wrought iron, lead, or brass pipes, of the weights shown in Table 7, may be used.

TABLE 7.

Weights, in pounds, per lineal foot, of small branch and vent pipes.

Size of pipe.	Wrought iron.	Lead.	Brass.
1¼	....	2.5	1.09
1½	2.68	3.5	1.32
2	3.61	4.0	1.79

In some localities, the use of light weight cast iron pipes, known as "Standard," for soil, waste and vent pipes, is permitted, while in other localities, its use is limited to the extensions to the roofs of stacks of more than forty feet in height. It should be stated, however, that the most up-to-date plumbing codes do not permit of the use of such light weight cast iron pipes for any part of the construction of a sewerage system, nor can the same be considered suitable for this purpose where strength and durability are desired.

The use of lead pipe will usually be limited to the short wastes of bath tubs and to the connections of the traps of fixtures, generally, with the iron soil, waste or vent pipes.

The use of brass pipe will usually be limited to the short wastes and vents of wash basins and other fixtures where the trap and a portion of the waste are exposed to view. As these parts will be furnished with the fixtures, in the absence of a guarantee from the makers, the quality and probable durability of the brass tubing will be a matter of conjecture on the part of the purchaser.

Certain makes of brass tubing will split, apparently without cause, and in using this material in the construction of soil, waste or vent pipes, only the best annealed pipes should be used.

Many reasons have been advanced for this defect in brass tubing, among which may be mentioned the following:

A lack of or improper annealing of the tubing.

Hardness of the tubing.

Lightness of the tubing.

Detrimental effect of the pickling process prior to nickel plating of the tubing.

Galvanic action, induced by sudden changes of heat and cold, or by the passage through the tubing of acid or alkaline solutions, particularly where they pass through in alteration. By this action, the metallic particles of which the tubing is composed, and which, originally, had crystallized in one direction and were parallel with supposed lines of force, are caused to change their relative positions, and becoming perpendicular to said lines weaken the tubing and render it liable to rupture.

SIZES.

The proper minimum sizes for soil, waste and vent pipes are as follows:

Soil pipes, four inches; waste pipes for slop sinks, three inches; vertical waste pipe stacks for baths and wash basins, two inches; vertical stacks for re-venting of traps, two inches. Larger sizes than these will not be necessary for any ordinary sized dwelling or other building having a corresponding number of fixtures; and for office buildings, apartment houses, tenements, and other buildings, where the toilet rooms would be connected with several stacks, the sizes of the soil and waste pipes need not, usually, be larger than five and three inches, respectively. For exceptionally large buildings of this class, particularly where many toilet rooms are placed above each other in a vertical line, the soil and waste pipes may have to be larger than these sizes.

There is really no scientific basis by which to determine the proper sizes of the soil and waste pipes, and recourse must be had to empirical rules. Such calculations, however, will be subject to wide variations, as will be shown later, and will be governed entirely by the class and number of fixtures on a particular stack, and the number of times the fixtures will be used during a given time.

With the exception of those instances in which the usual rules relative to the minimum sizes of soil and waste pipes must be observed, the combined areas of these pipes will not, ordinarily, require to be greater than the area of the main horizontal sewer with which they may be directly connected.

The cross sectional areas of pipes of the sizes which might be required for the construction of the soil, waste or vent pipes of a building are shown in Table 8.

TABLE 8.

Diameter, in inches.	Area, in square inches.
1¼	1,227
1½	1,767
2	3,142
3	7,069
4	12,566
5	19,635
6	28,274
7	38,485
8	50,266
9	63,617
10	78,540
12	113,098

By reference to Table 4, Chapter 2, it will be seen that a four-inch sewer, laid with the proper inclination to furnish a velocity of four and one-half feet per second, and running full, will remove, approximately, 176 gallons of sewage per minute. Upon the basis of a discharge from a water closet of four gallons of water in ten seconds of time, a four-inch sewer, or its equivalent in vertical stack, would take care of the combined and simultaneous discharges of seven water closets. As probably not more than one-third of the closets in a building would be discharging at any one time, a four-inch sewer would take care of twenty or more closets. By the same rule, a five-inch sewer would take care of the discharges from thirty-three closets; a six-inch sewer, fifty closets; a seven-inch sewer, seventy closets; an eight-inch sewer, ninety closets; a nine-inch sewer, one hundred and eleven closets; a ten-inch sewer, one hundred and thirty-eight closets; and a twelve-inch sewer, about two hundred closets. If we take as the basis of our calculations the simultaneous discharges of but one-fourth of the closets in a building, by the foregoing rule, a four-inch sewer would take care of twenty-eight closets; a five-inch sewer, forty-four closets; a six-inch sewer, sixty-eight closets; a seven-inch sewer, ninety-two closets; an eight-inch sewer, one hundred and sixteen closets; a nine-inch sewer, one hundred and forty-eight closets; a ten-inch sewer, one hundred and eighty-four closets, and a twelve-inch sewer, two hundred and sixty-four closets. It is quite possible that, in actual practice, a larger number of closets than those mentioned above could be taken care of by the pipes of the sizes given in each case. This would also be the case if the sewers were laid with greater inclinations than those shown in Table 4. For instance, a four-inch sewer laid with an inclination of 1 in 23 will cause a velocity of six feet of sewage per second and will discharge 230 gallons per minute, and when laid with an inclination of 1 in 10.2 will cause a velocity of nine feet per second and discharge 346 gallons per minute. Assuming that one-fourth of the closets attached to such a sewer would be discharged simultaneously, when laid with the inclination of 1 in 23 the sewer would take care of forty closets, and with a fall of 1 in 10.2, sixty closets.

Where the soil pipes receive the combined discharges from water closets, bath tubs, wash basins, sinks, etc., the determination of the sizes of the vertical stacks will be more difficult than where only the water closets are to be considered. In all such calculations, the probable maximum amount of water which will be discharged by any combination of fixtures in a given time will be the only basis upon which to determine the sizes of the various stacks.

As illustrating the difficulty which has been experienced in making uniform rules to govern the sizes of soil pipes, the following extracts from the most recent plumbing codes of several of the largest cities in this country may be of interest:

Jersey City.

Sec. 2. The sizes of vertical lines of main soil pipes will be governed by the number of fixtures discharging into same. * * * The following sizes must be used:

For 1 and less than 10 water closets with other fixtures	4 inch.
For 10 and less than 20..........................	5 inch.
For 20 or more..................................	6 inch.

New Orleans.

Sec. 36. Soil pipes are never to be less than 4 inches in diameter. If more than four water closets discharge into it, the soil pipe must be five inches in diameter, and in buildings over 5 stories in height, where more than eight closets connect, it shall be 6 inches in diameter.

St. Paul.

The diameter of soil pipes must be not less than those given in the following table:

Main soil pipes..............................	4 inches
Main soil pipes for water closets on five or more floors	5 inches

Rochester, N. Y.

Soil Pipes.

Minimum Diameter.	*Number of Fixtures.
4 inches	1-30
5 inches	30-50
6 inches	51-

*1 water closet ....2 fixtures
1 bath, etc..1 fixture

Toledo.

Soil pipe reciving waste from six water closets or bathrooms shall be four inches in diameter. Soil pipe receiving waste from six and not more than ten water closets or bathrooms shall be five inches in diameter. Soil pipe receiving the waste from more than ten water closets or bathrooms shall be six inches in diameter.

Philadelphia.

Vertical lines.	Number of water closets.
4 inches	1 to 6
5 inches	7 to 12
6 inches	13 to 20

Milwaukee.

The number of water closets allowed on a stack of soil pipe above the basement floor will be as follows: Four closets on a four-inch soil pipe, ten closets on a five-inch pipe, twenty-five closets on a six-inch pipe, and when more than twenty-five closets are put in, eight-inch pipe will be required.

Washington, D. C.

Vertical runs.	No. of water closets.
4 inches	1 to 12
5 inches	13 to 25
6 inches	25 to 40

Newark and Paterson, N. J.

Main soil pipes	4 inches
Main soil pipes for water closets on five or more floors	5 inches
Main soil pipes for tenement houses or factories exceeding three stories	5 inches

Cleveland and Columbus, Ohio.

Maximum number of fixtures connected to:

Size of pipe. Inches.	Soil and waste. Branch. No. fix.	Soil and waste. Main. No. fix.	Soil pipe alone. Branch. No. water clos.	Soil pipe alone. Main. No water clos.
4	48	96	12	24
5	96	192	24	48
6	168	336	42	84
7	280	560	70	140
8	420	840	105	210
9	580	1,160	145	290
10	800	1,600	200	400
11	1,060	2,120	265	530
12	1,420	2,840	355	710

In the above table three feet of urinal trough or wash sink, 1 bath basin, sink or smaller fixture counts as 1 fixture; and 1 water closet, pedestal urinal or slop hopper sink counts as two fixtures.

	Size of waste pipe. 2.	2½.	3.	4.	5.	6.
Washington, D. C.:						
Number of small fixtures	3 to 5	6 to 9	10 to 16	....	....	....
St. Paul, Minn.:						
Waste pipe	For main.	....	(*)	....	....	....
Rochester, N. Y.:						
Number of baths and small fixtures	7 to 12	13 to 26	27 to 31	....	....	....
Philadelphia, Pa.:						
Number of small fixtures	3 to 5	6 to 9	10 to 16	17 to 25	26 to 40	....
Number of stories for which each size would be the minimum to be used	....	....	5 to 10	11 to 16	17 to 21	21 and over.
Toledo, Ohio:						
Number of sinks on mains	2 to 4	....	5 or more.	....	....	....
Newark and Paterson, N. J.:						
Waste pipe	For main.	....	(†)	....	....	....
Milwaukee, Wis.:						
Number of sinks above basement floor	2 to 4	....	5 to 8	9 to 15	....	....
Number of wash basins above basement floor	4 to 8	....	9 to 25	25 or more.	....	....
Scranton and Allegheny, Pa.:						
Number of sinks or basins	....	....	8	....	....	....
Number of laundry tubs	3 to 7	......	....	....	....	....
Jersey City, N. J.:						
Number of kitchen fixtures	1 to 3	....	4 to 9	10 or more.	....	....
Cleveland and Columbus, Ohio:						
Number of fixtures (one bath, basin, sink or smaller fixture counts as one fixture)	20	32	60	144	288	504

*For sinks on five or more floors. †For sinks on four or more floors.

SIZES FOR VERTICAL WASTE PIPES.

The same difficulty has been experienced in the determination of the proper sizes of the vertical waste pipes, as will be seen by the accompanying summary of the sizes specified in the plumbing codes of the cities previously referred to.

In the several codes the specifications relative to the numbers of water closets or other fixtures which may be connected with the branch pipes are usually one-half the numbers of those which may be connected with the vertical mains of corresponding sizes.

In making an estimate of the number of fixtures which may properly be connected with any soil or waste pipe it should be remembered that in a horizontal sewer the velocity of the sewage due to gravity will be increased very considerably by the force of the falling bodies of water in the vertical stacks connected with it. In a very high building, with the simultaneous discharge of several fixtures on any stack, especially where they are located on the same floor, this would be an important item to be reckoned with, and yet, in the absence of definite information relative to the height of such columns of water and the distances through which they might fall, no reliable estimates could be made of their effect upon the normal flow of sewage in the horizontal sewer.

Another item of more than ordinary importance which should be considered in determining the sizes of the vertical soil and waste pipes is the possibility of siphonage of the traps of fixtures by the effect of the falling bodies of water in such pipes.

Where the quantity of water falling in a vertical pipe would be sufficient to completely fill it, and thus form a plug, its effect upon the water seals of the traps of fixtures on such a pipe would be considerable, and might, under certain conditions, unseal one or more of the traps. For this reason it would be wise to make both vertical and branch soil and waste pipes slightly larger than what would ordinarily be considered sufficient to properly take care of the discharges from the fixtures connected with them. More will be said upon this point, and also upon the subject of the proper sizes and arrangements of the vent and revent pipes, in a subsequent chapter on the siphonage and reventing of traps.

EXTENSIONS TO AND ABOVE THE ROOF.

Soil, waste and vent pipes should, ordinarily, be extended, undiminished in size, to the roof, and increased by one size before they pass through the roof, as shown in Fig. 22, but in no case should any extension above the roof be of less diameter than four inches. The object of the enlargements is to prevent the openings at the tops of the pipes from being reduced in size by frost to such an extent as to interfere with proper ventilation.

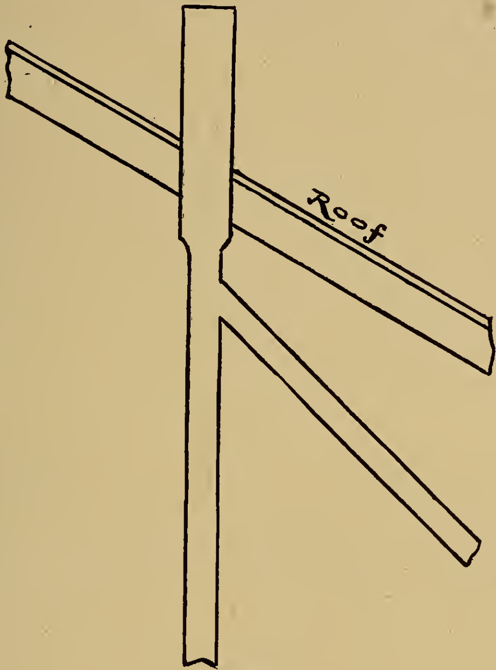

Fig. 22.

The combined areas of the vertical soil and waste pipes which are to be continued above the roof—measured below the enlargements under the roof—should in no case be less than the area of the main sewer of the building, and one of them should be connected with the sewer at or near its highest point, and have the same diameter as the sewer at that point. The areas of the several pipes may be found in Table 8 in this chapter.

Where two soil or waste pipes, or one soil and one waste pipe are not more than say twenty feet apart, and any of them, by itself or in combination with other vertical stacks extended above the roof, is of sufficient size and properly located for the efficient ventilation of the sewer, the two pipes may often be connected with each other above the highest fixture and pass through the roof as one stack. In carrying the one extension over to the other—which would usually be done in the attic—wherever possible, two 45° elbows and an inverted Y fitting should be used, so as to give the pipes a good upward incline, as shown in Fig. 22, and the inclined pipes should be well supported throughout their entire length. The arrangement is applicable also to the vertical extensions of branch soil or waste pipes which are not more than twenty feet from the main stacks. Where the area of the extension which is to be continued through and above the roof would not be large enough for the proper venting of both pipes, the connection should be made above the increasor, in which case the latter should be placed at a point lower down than is usual, and made large enough for the two pipes.

SUPPORTS.

In the construction of the vertical soil and waste pipe stacks the provision of proper supports for the pipes is of considerable importance, because

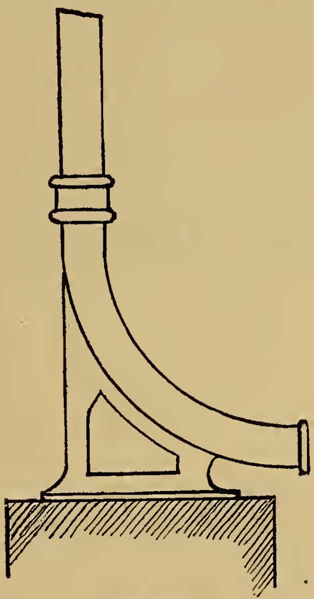

Fig. 23.

the settlement of a stack, however slight, will probably result in a fracture of the sewer at the base of the stack.

The principal support should be at the base of the stack, in the form of a substantial brick, cement or stone pier immediately under the stack, and yet in very many buildings of not more than two or three stories in height this precaution is neglected or not deemed necessary.

Where cast iron pipes are used, in order that the stack may have a solid and sufficient bearing upon

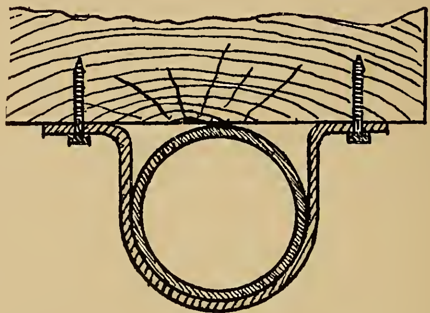

Fig. 24.

the masonry pier, a special fitting (Fig. 23), in the form of an elbow, and known as "heel fitting," "heel rest," or "flat foot," should be used at the base of the stack.

In the case of buildings of more than forty feet in height, in addition to the support at the base of the stack there should be one support in every twenty feet. Where an offset occurs the pipes above the offset should be well supported by a special heel fitting, as at the base of the stack. It should be remembered, however, that there will be considerable expansion and contraction in a long stack into which both hot and cold water are discharged, for which allowance should be made in the construction of supports other than those at the base of the stack.

The vertical soil and waste pipes may be held in place on the walls by means of bands of wrought iron, of suitable width and thickness, fastened to wooden blocks in the walls by corkscrew bolts, as shown in Fig. 24, but the bands should be loose enough to allow of expansion and contraction of the pipes.

Where a soil or waste pipe stack is to be placed in a special groove or chase in a wall it may be supported and at the same time held in place against the wall by iron rests built in the wall on each side of the groove, as in Fig. 25, the hub of one pipe in every twenty feet of stack being made to rest upon one of these supports.

LATERAL CONNECTIONS.

With the exception of the short lengths of lead pipe connecting the traps of fixtures with the branch soil or waste pipes, the latter should be constructed of the same materials as the vertical pipes.

As previously stated, the sizes of the branch soil or waste pipes are usually governed by the sizes of the vertical stacks, that is to say, the number of

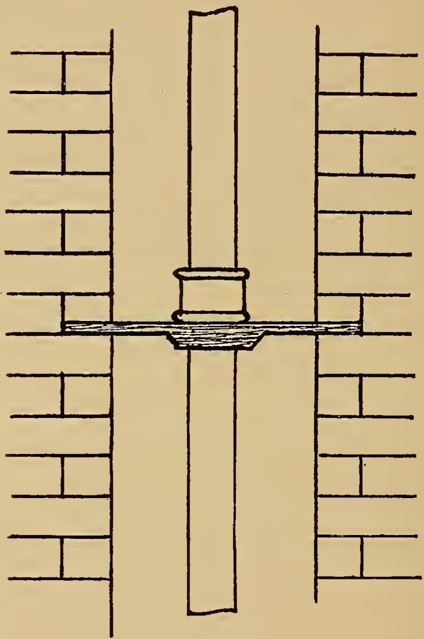

Fig. 25.

fixtures which may be connected with a branch pipe is limited to one-half the number which may be connected with the vertical stack of corresponding size.

By experiment it has been determined that where the branch pipes are not more than three feet in length and are made one size larger than the traps connected with them, the use of special vent or revent pipes will not, usually, be necessary. For this reason, it would be well to place the fixtures and vertical pipes as near to each other as practicable.

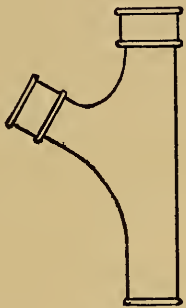

Fig. 26.

The branch pipes should, in every case, be connected with the vertical stacks by means of TY or Sanitary T fittings, and never with ordinary T fittings. An excellent form of fitting for this purpose, and one which would tend to prevent the siphonage of traps by the falling bodies of water in the vertical stacks, is shown in Figure 26.

Where the branch pipes are of considerable length, and serve a number of fixtures, they will require to be continued, vertically, to a point above the roof, but if the branch pipes are not more than twenty feet in length, their extensions may be connected back into the vertical pipes above the highest fixtures.

As the vertical pipes will expand and contract, the branch pipes should be free to rise and fall with them.

Where the appearance of the branch waste pipes in a room would not be an objection, they would be more accessible if carried to the vertical stacks on the walls instead of under the floors.

Every part of the soil and waste pipes, vertical and horizontal, should be in plain sight, but where any part must be concealed, the covering in front of or over the same should be easily removed.

Where the vertical stacks are in a straight line throughout, and are open at the tops, the provision of access openings at the bases of the stacks will usually be sufficient for the removal of stoppages. The ends of the branch pipes should, in every case, be provided with access openings, because stoppages are more likely to occur in them than in the vertical pipes.

CHAPTER V.

Roughing in Test, and Filling in of the Trenches.

HAVING completed the construction of the sewer and the soil and waste pipes and their branches, the next step will be to ascertain the soundness, or otherwise, of the materials and workmanship. This is called the "roughing in" test, and should be applied before any portion of the work has been covered in or enclosed. There will be times, however, when the underground sewer must be covered in before the soil and waste pipes are ready for testing, in which case a separate test must be made of the underground sewer. This test should be very thorough, because a weak spot in the pipes or joints which might be able to withstand a moderate pressure at the time of the test would later be very liable to cause a leak, and, being underground, this would not, usually, be detected from the surface.

In localities which have plumbing codes, the testing is usually done under the direct supervision of an inspector from the department having jurisdiction over such work; in localities which have no such official, the testing will usually be neglected, unless demanded by the architect or by the owner of the building. Reliable tests of this nature often require considerable preparation, and mean a loss of time to the person executing the work, but they are a powerful incentive to good work, and should always be insisted upon by those having supervision of such work.

There are two methods of testing the roughing in work in general use:

1. The hydrostatic, or water test; and
2. The pneumatic, or air test.

The principle in both tests is the same, the pipes being subjected to a pressure from within, in the first case by water, and in the second, by air.

In the hydrostatic test, the pipes are filled with water, and the pressure is usually obtained by the weight of water in the vertical pipes. Where only the horizontal pipes are to be tested, and the pressure of water in the street mains, or other source, from which the pipes are to be filled is not equal to say twenty-five pounds per square inch, a pressure pump will be necessary to make the test.

The pressure of water, per square inch, in a vertical pipe will vary considerably, and may be calculated by multiplying the height of the column of water, in feet, by .4327 (the weight of a column of water one foot high and having an area of one square inch).

The pneumatic test is made by forcing air into the pipes by means of a test gauge pump, similar to that shown in Figure 27. This test is usually applied under a pressure of ten pounds per square inch, which is equal to twenty inches of mercury. Spring gauges, similar to that shown in the center

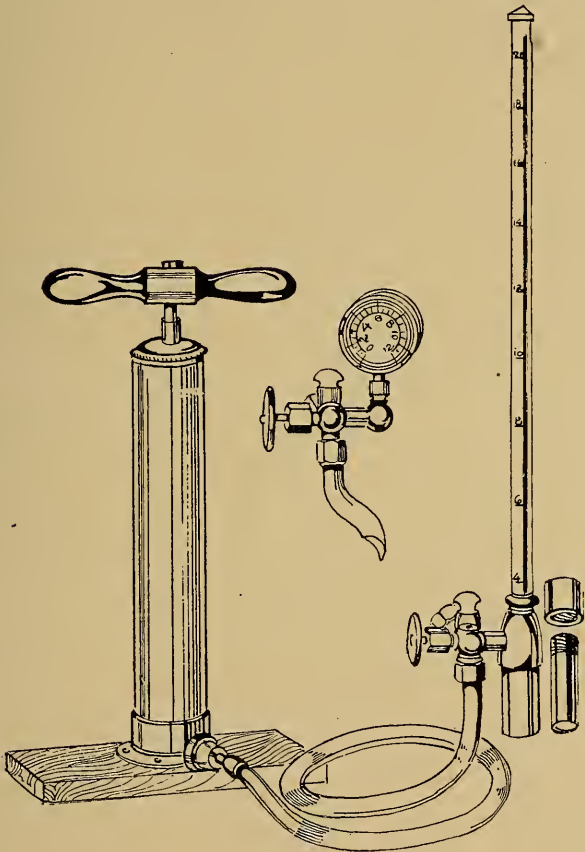

Fig. 27.

of Figure 27, should not be used, because they are not as reliable as the mercury gauge, shown on the right of the Figure.

The hydrostatic test is usually preferred to the pneumatic test, but it should not be used in very tall buildings, because the pressure on the lower portions of the pipes would be too great; nor in very cold weather, because the water in the pipes, or in the oakum packing of the joints, would be liable to freeze and burst the pipes; nor in very warm weather when the relative humidity is high, because the condensation of moisture on the outside of the pipes would be considerable, and render the location of small leaks difficult.

In making the hydrostatic test, all openings except the tops of the soil, waste and vent pipes will require to be securely plugged or sealed, and the pipes should be filled at the lowest point so that defects may be noted before the pipes are wetted on the outside by possible leaks to any considerable extent. When the pipes are full, the water should remain at the same level for a period of at least fifteen minutes. If leaks are detected, the water should be lowered below the defective part, and the same repaired and re-tested.

In plugging the pipes for the test, considerable care will be required to prevent the plugs being forced out and the lower portions of the work flooded. Wooden plugs should not be used, because they would have to be driven in to make them tight, and jarred loose to get them out, and the jarring would be liable to fracture a pipe or loosen a joint. Special plugs, of various patterns,

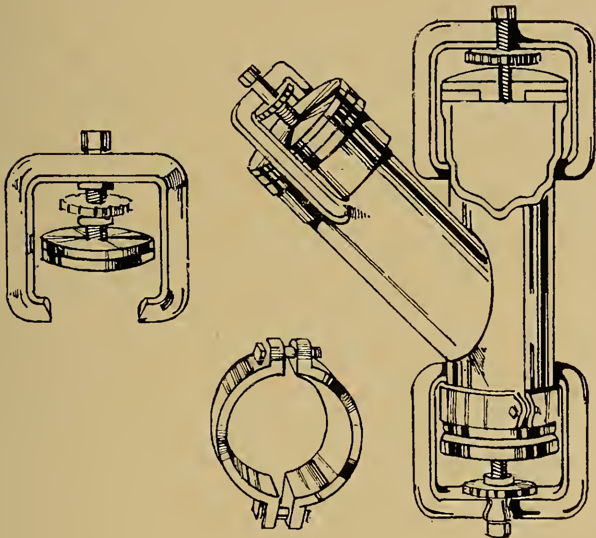

Fig. 28.

are made for this purpose, examples of the two principal forms of which are shown in Figures 28 and 29. Wherever possible, the plug shown in Figure 28 should be used, but where the plug must be placed inside a pipe or fitting, it should extend beyond the hub or it will probably be forced out by the pressure of water.

The ends of lead pipes attached to the branch pipes may be securely sealed:

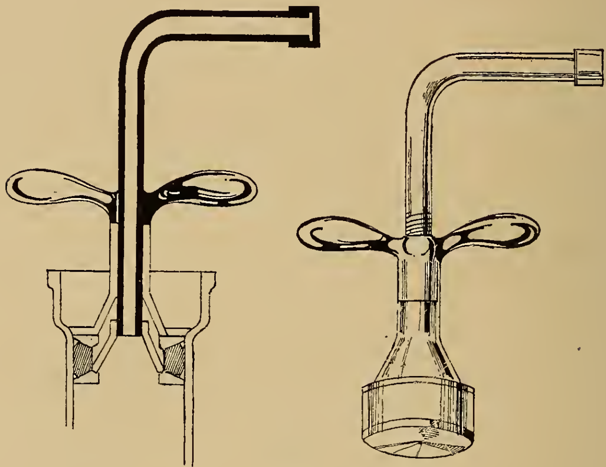

Fig. 29.

In small sizes, by pinching together and soldering over the ends; and

In the large sizes, by discs of sheet lead soldered into the ends of the pipes.

In making the pneumatic test, all openings should be securely closed, and when the pressure has raised the mercury in the gauge to the twenty inch mark it should remain at that level for at least fifteen minutes. If leaks occur, there may be considerable difficulty in locating them, and, for

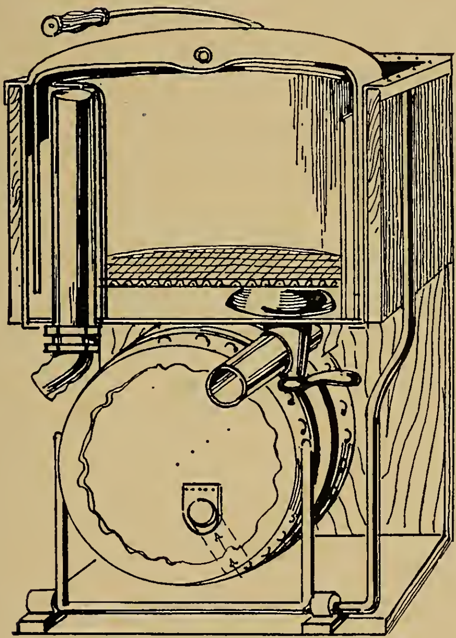

Fig. 30.

this reason much time would be saved by filling the pipes with smoke by means of a smoke-test machine, similar to that shown in Figure 30.

For an excellent and complete guide to the various methods of testing plumbing work, the reader is referred to a recent publication, issued by "Domestic Engineering," entitled, "Testing Drainage, Plumbing and Gas Fitting," by Jno. K. Allen.

After the underground sewer is tested and made good, the filling in of the trench will be in order. This work will probably be entrusted to some person whose knowledge of the strength of sewer pipes to resist percussive action is very limited, and the careless throwing in of the earth, or the ramming of a thin layer of earth over the pipes, may fracture the pipes at some point, and render the sewer insanitary. For this reason, the filling in of the first few feet of earth should be done under the direct supervision of some person having a special knowledge of the requirements of this class of work.

CHAPTER VI.

Plumbing Fixtures and Accessories.

IT IS of the first importance that all plumbing fixtures be constructed of impervious and non-absorbent materials; have smooth interiors and pleasing exteriors; and be free from hidden or other parts which cannot readily be inspected or cleansed.

The materials which most nearly fulfil the first requirement are porcelain, cast iron, steel, copper, zinc, tin, lead, soapstone and slate.

Porcelain is fragile, and therefore not suitable for fixtures liable to rough usage, but, by reason of the smoothness and durability of its enameled surface, is the most popular material for water closets, wash bowls, bath tubs and urinals.

Cast iron is extensively used in the construction of kitchen sinks, slop sinks and bath tubs, and for water closets which would be subject to rough usage or freezing temperatures. Fixtures made of this material should be well enameled on the inside, and well painted or enameled on the outside.

Steel is made use of in the manufacture of kitchen sinks, and for the casings of open copper lined bath tubs, and should always be well protected against corrosion by a coating of enamel or several coats of good paint.

Copper is used for the linings of pantry sinks, bath tubs, and the finishing tanks of water closets, and should always be well tinned on the side which will be exposed to the action of water and other liquids.

In the past, *zinc* was extensively used in the manufacture of linings for bath tubs, but these are being rapidly superseded by the more sanitary open fixtures.

The use of *tin*, in sheet form, is confined almost exclusively to the linings of pantry sinks, and the drip trays and sinks of bars and soda fountains, but, by reason of its softness, it requires to be reinforced by wood and is inferior to copper for the purposes named.

Lead is sometimes made use of for the purposes mentioned in the preceding paragraph, and also for the linings of dish sinks in hotels, restaurants and large kitchens. It is also made use of for the linings of cisterns for storing water, but should not be used for this purpose if the water is soft, or intended for drinking or culinary purposes.

Soapstone and *slate* are used chiefly for laundry tubs, and for the stalls of urinals and shower baths, and where the best grades of soapstone are used and the workmanship is good, fixtures made of this material will possess superior qualities of cleanliness and extreme durability.

In view of the fact that modern plumbing fixtures are, as a rule, constructed in such a manner that wooden casings or enclosures will not be necessary, it is scarcely necessary to sound a warning against the use of fixtures which require such casings or enclosures to give them a finished or pleasing appearance.

CELLAR FIXTURES.

Plumbing fixtures should not be placed in dark, unventilated cellars, nor should they be placed in any cellar unless they will be often used and have proper attention so as to ensure the requisite sealing of the traps and the cleanliness of the fixtures.

Water closets in cellars are especially objectionable, but where they are deemed necessary, as in schools and other public buildings, the apartments in which they are located should have at least one outside wall with windows for light and ventilation, and the closets should be of porcelain and of the siphon pattern. Hopper closets, so frequently made use of for the cellars of dwellings and stores, should never be used in such locations.

Sinks are frequently placed in cellars, and, in many instances, are not often used, constituting a source of danger by the evaporation of the water in the traps.

Laundry tubs are usually placed in cellars, and are really the only plumbing fixtures which may be said to belong to the basement stories of buildings, but they should not be placed in any part of a cellar which has not a smooth and well drained cement floor.

KITCHEN AND PANTRY FIXTURES.

Kitchen sinks, together with their drainer tops and aprons, or splash plates, should be constructed of steel or cast iron, preferably in one piece, with substantial porcelain finish, and should be supported on metal legs or brackets. A movable dish drainer, made of wooden slats, is the only woodwork which should be used in connection with a kitchen sink.

Pantry sinks are usually constructed of sheet copper, and are either oval or rectangular in shape. For small sinks, the oval shape is preferable, because the sink can be made of one piece of metal and will not require any support other than the flange at the top. Where the sink has a flat bottom, the latter will require to be supported by a wooden shelf, giving the sink an unsightly appearance, and furnishing a place for the possible lodgment of water and the creation of an unsanitary condition. Pantry sinks are now made of porcelain, and such sinks are attractive in appearance and easily cleansed, but the washing of fine glassware and fragile crockery in them will be attended with much greater risk than in copper sinks, and, for this reason, the latter will probably be given the preference until some more suitable material is discovered for this purpose.

Grease interceptors may well be included in the class of necessary evils in connection with the sewerage of buildings because, as a rule, they do not receive the attention which they require, and, at best, are disgusting to the senses of sight and smell. They are not considered necessary in ordinary dwellings, in which the amount of greasy water discharged into the sinks would be small, but they are considered necessary in connection with the sinks of hotels, restaurants and large kitchens, where the amount of greasy liquids passing into the sinks would be sufficient to form a considerable coating of grease in the private sewers.

The object of a grease interceptor being the immediate cooling of the greasy water passing into it, and the consequent congealing of the grease—which being lighter than the water, will rise to the surface and form a scum—the interceptor should be constructed of such materials and placed in such a location as will facilitate this cooling action.

By reason of the offensive odors given off during the process of cleansing, a grease interceptor should be located in some place other than the kitchen, as, for instance, in some part of a cellar which is cool and well ventilated, and which is not used for the storage of food or for the fresh-air room of the ventilating apparatus.

The logical place for a grease interceptor would be some point outside the building, but it would necessarily have to be near to the surface of the ground, and consequently liable to freeze up, and the cleansing of the same in winter would often be very inconvenient, if not difficult.

Grease interceptors are frequently constructed of cast iron, and some of the larger sizes are provided with hollow walls, through which water is made to circulate, for the purpose of cooling the water in the interceptor and assisting in the separation of the contained grease. The small cast iron interceptors, intended to be placed on the floor under or near to a sink, are considered of little value, because, when a considerable quantity of hot water is passing through them, the iron will partake of the temperature of the water and tend to prevent the congealing of the grease in the water and to liquefy whatever grease may have accumulated, with the result that much of the grease will probably pass into the sewer. A serious objection to the use of iron for this purpose is the fact that it will corrode and render thorough cleansing of the bottom and sides of the interceptors difficult, if not impossible.

A convenient form of grease interceptor, and one which can be made to suit the needs of any building and which will effectually separate the grease from the water before it can reach the outlet, is shown in Figure 31. The bottom and sides may be made of hard bricks, laid in cement, or of cement and fine gravel. In either case, the inside should be well

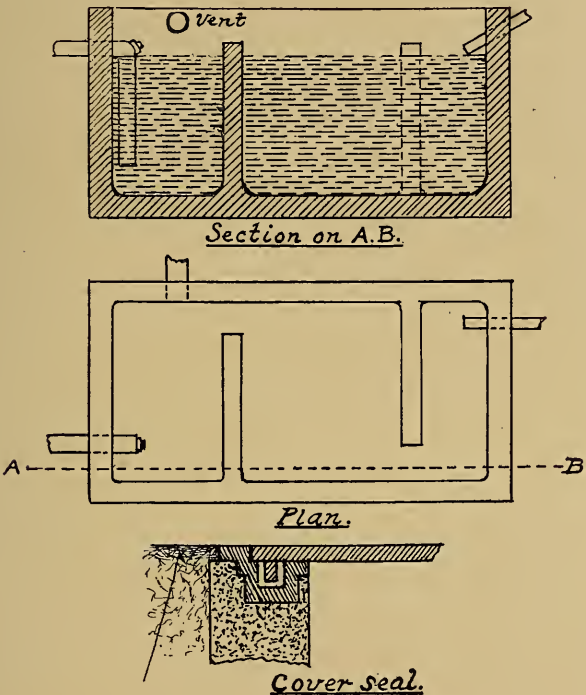

Fig. 31.

plastered with cement and be left smooth. In the ordinary grease interceptor, the inflowing water breaks up the accumulated grease and some of it may be carried along with the water into the sewer. This may be prevented by the construction of baffles, as in Figure 31, and the added distance which the water will have to travel in passing through the interceptor will give the grease a much better opportunity to become chilled and to rise to the surface before it reaches the outlet end of the interceptor. The cover should be of iron, with a frame of the same material, and the latter should be bedded in cement. A tongue on the underside of the cover corresponding with a groove in the frame, and a quantity of heavy oil poured into the groove, will form a good seal and prevent air from the interceptor escaping into the room. A vent pipe should be carried from the interceptor to a convenient point outside the building for the purpose of preventing an air lock between the trap of the sink and the trap of the interceptor, and to allow of the escape of foul odors and steam. The outlet should be much larger than the inlet so that the water in the interceptor may not be siphoned out by the formation of a plug of water in the outlet.

Refrigerators will usually require drainage to the sewer and this should be accomplished by making the waste pipes discharge over well trapped sinks or floor drains. Even though well trapped, the waste pipe of a refrigerator should never be connected directly with a waste or soil pipe.

TOILET ROOMS.

Toilet rooms may be divided into two principal classes—private and public.

Private toilet rooms may be said to include all such rooms which are not accessible to the general public, but the term is intended to apply principally to the toilet rooms of private dwellings, hotel suites, private offices and stores other than department stores.

The plumbing fixtures which will be considered in connection with the private toilet rooms of buildings are water closets, bathtubs, washbasins and slop sinks, two or more of which will usually be found *en suite.*

Water Closets.—To meet the popular demand for a fixture which will effectually remove the excreta deposited in it and without leaving any trace of the same upon any visible portion of the fixture the following conditions must be complied with:

The shape of the bowl and the surface area of the water in the same must be such that the inside of the bowl above the water line will not, ordinarily, be soiled when the fixture is used.

The flush of water must be sufficient to quickly and effectually remove excreta and paper from the bowl; to scour every portion of the bowl, both above and below the water line; and to fill the bowl to the requisite height with clean water after the flushing is accomplished.

The development of the water closet in the past twenty-five or thirty years from the filthy and complicated "pan" closet (Fig. 32) to the "siphon" closet of the present time—one type of which is shown in Fig. 33—is an interesting study, and a brief reference to which may not be considered out of place at this time.

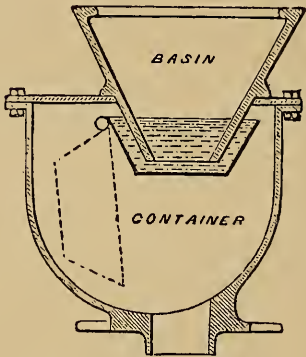

Fig. 32. "Pan" closet.

With the advent of the modern sanitarian came the pronouncement that the "pan" closet was an insanitary fixture, and many new and so-called sanitary fixtures sprang into existence.

The "valve" closet (Fig. 34) was one of the earliest forms designed to take the place of the "pan" closet, and it had many good features to recommend it, principal among which was the large body of water in the bowl, which, being suddenly liberated, insured the speedy removal of excreta from the premises. It was found, however, that the closet and water service valves often got out of

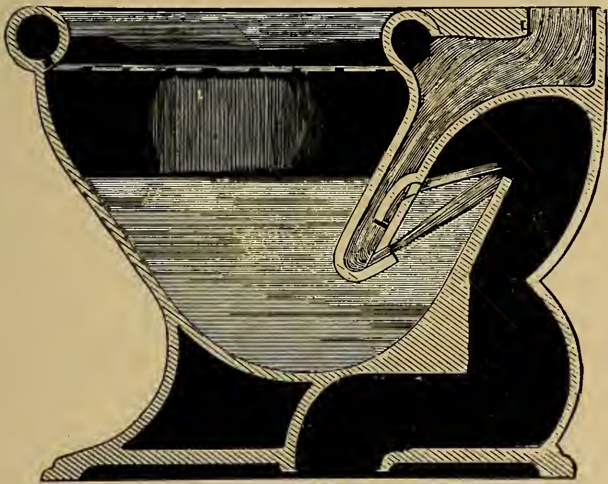

Fig. 33. "Siphon" closet.

order, necessitating frequent repairs, and that paper would lodge between the valve and its seat, allowing the water to leak out of the bowl. But the chief objection to this closet from a sanitary standpoint was the fact that, as ordinarily constructed the trap must, perforce, be beneath the floor, necessitating the removal of the fixture whenever the trap became stopped up.

The "plunger" closet (Fig. 35) was a slight advance over the "valve" closet, in that it provided for a trap above the floor; but the plunger, together with the space in which it worked, were easily

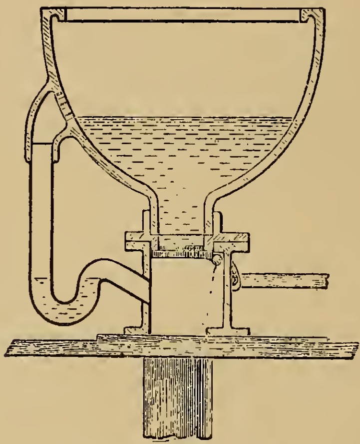

Fig. 34. "Valve" closet.

fouled, making this type of closet a foul-smelling thing. Further, paper would lodge between the rubber ring of the plunger and its seat and allow the water to leak from the bowl.

The defects in the "valve" and "plunger" closet led to a demand for a fixture devoid of valves, plungers or other working parts, and the all earthenware short "hopper" and "washout" types (Figs. 36 and 37) became popular, and were believed to have solved the problem of a simple and sanitary fixture.

It should be stated that prior to this time, by reason of the fact that, under the best conditions, the flush of water did not prevent the bowl from becoming filthy, the long "hopper" closet (Fig. 38) had been almost universally condemned.

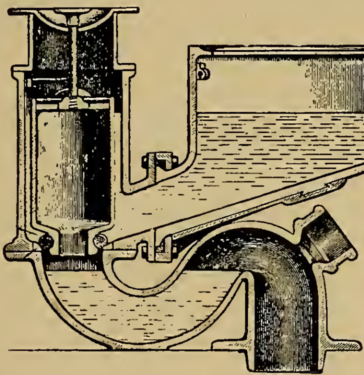

Fig. 35. "Plunger" closet.

The short "hopper" type of closet was found to be defective, in that it did not hold sufficient water to prevent fouling of the bowl, and the shape was changed to remedy this defect, with the result that, ordinarily, a single flush of water was then found to be insufficient to completely remove the contents of the bowl after use.

The "washout" closet was very popular and held sway for many years, but its defects soon became apparent, chief among which was the fouling of the space between the bowl and the trap. The shape was changed from a "back-outlet" to a "front-outlet," and also to a "side outlet" closet, but at no time

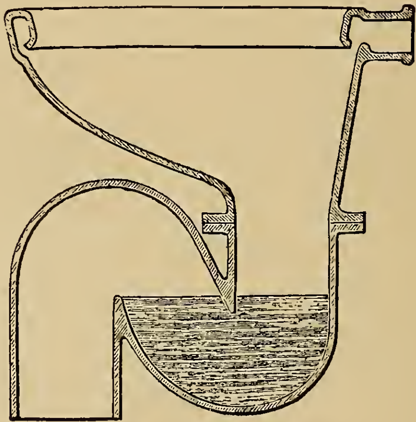

Fig. 36. "Hopper" closet.

was there a closet of this type on the market which was free from the defect before mentioned, and they remained filthy to the last, notwithstanding the best of care.

Up to the time when "washout" closets were made with ornamental exteriors, water closets of all kinds were, as a rule, almost entirely concealed from view by wooden enclosures, usually screwed together, and an inspection of the floor beneath the fixture would often reveal a very filthy condition, particularly where it was the custom to throw slops into the bowl.

In passing it should be mentioned that with the advent of the ornamental "washout" closet it was

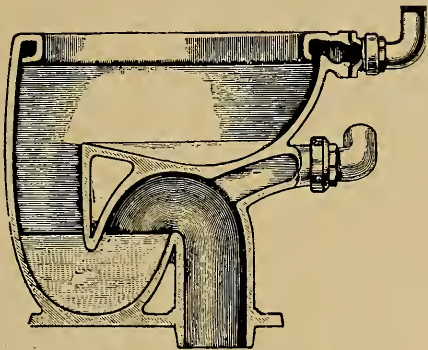

Fig. 37. "Washout" closet.

demonstrated that wooden inclosures were unnecessary not only for water closets but for sinks, washbasins and bathtubs, and a complete reformation in the construction and installation of plumbing fixtures was inaugurated.

The "siphon" closet is made in many styles and with many different methods of starting the siphonic action, but the general principle in all is the same, and it is really the only water closet which has been produced which fulfils the requirements before mentioned. Its popularity may be seen by an inspection of the stock of any plumbing store, or by a glance through the catalogues of the makers of water closets or the advertising columns

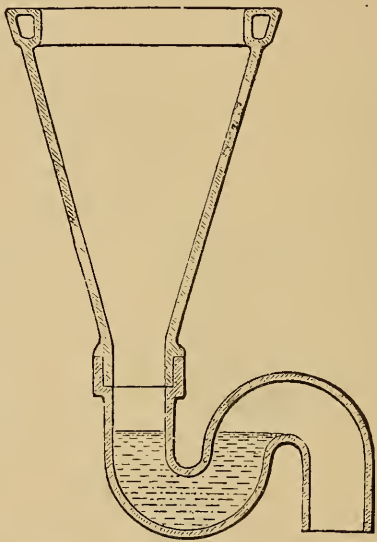

Fig. 38. "Long Hopper" closet.

of any of the plumbing or engineering journals. Man's ingenuity may yet devise a better type of closet, but, from present indications, the "siphon" closet is destined to have a lengthy stay. Changes in the types of flushing apparatus for these closets will appear from time to time, and such apparatus will occasionally get out of order, notwithstanding the most careful usage.

There are two important points to be observed in the setting of a water closet—the floor connection and the back venting of the soil pipe beneath the fixture. The latter point will be discussed in Chapter VII. under the heading "Traps—Back Venting."

In view of the fact that the trap of the modern water closet is above the floor, a defective connection between the fixture and the soil pipe will mean the entrance to the room in which the fixture is placed of air from the sewer. Notwithstanding that this connection may be made air-tight in the beginning, unless the work has been properly done, there will be a constant danger from a possible break in the joint, due either to the expansion and contraction of the soil pipe, or to a movement of the fixture.

To overcome the danger from the movement of the soil pipe, a lead bend should always be used to connect the fixture with the iron soil pipe; and to prevent fracture of the joint by the movement of the fixture, the latter should be made as rigid as possible, and the gasket between the outlet of the fixture and the lead bend should be sufficiently elastic to permit of considerable vibration.

In the case of fixtures not provided with special floor connections, a rubber, asbestos graphite, or asbestos string gasket will adapt itself to every ordinary movement of the fixture, and preserve the joint intact with any reasonable usage of the fixture.

To secure an even surface upon which the underside of the gasket may rest, and to do away with the necessity for a thick gasket, a brass flange, about three-sixteenths of an inch thick, should be soldered to the lead bend and screwed to the floor.

If the gasket and brass flange are of the proper thickness, and the fixture properly set up and firmly screwed to the floor, a comparatively firm and, at the same time, elastic joint will be the result.

Where the water closet is to rest upon a cement, stone, tile, marble or granite floor, the base of the fixture should be fastened to the floor by means of bolts set in the floor. Special expansion bolts may be obtained for this purpose, and are superior to the ordinary lead calked bolts which sometimes break the floor and render the making of an air-tight joint difficult.

In making these floor connections, the brass, flange and gasket are often dispensed with and putty is used in their place. A putty joint may be made air-tight for a time, but when the putty has hardened, and there is a movement of the lead bend or fixture, the putty will be very liable to crack, and, for this reason, it should not be used for the purpose.

Figure 39 shows a type of closet provided with a threaded floor connection, the threaded thimble being soldered to the lead bend and the closet sim-

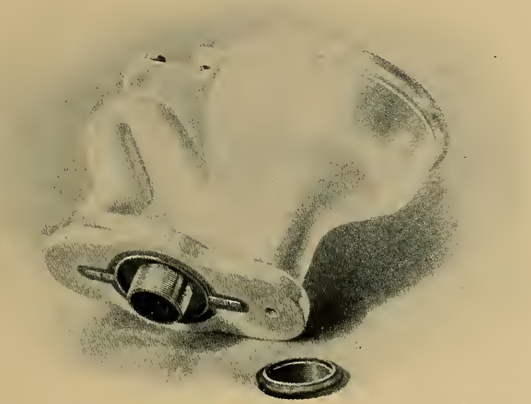

Fig. 39.

ply screwed into the thimble. The usual screws or bolts for fastening the closet to the floor are dispensed with, and the fixture can be removed at any time by simply unscrewing it from the thimble. Absolute security against leakage of water, or the passage into the room of air from the soil pipe, through the floor connection, are claimed for this attachment.

Bath tubs—Like the water closet, the bath tub has undergone a wonderful change in recent years, from the unsightly zinc lined affair, with its wooden enclosure, to the sanitary porcelain or porcelain enameled fixture of today, with its pleasing interior and exterior—a thing of beauty and a joy to the lover of cleanliness.

The modern bath tub is set up with plated fittings above the floor, and the connection of the fixture with the trap and waste pipe should not be a difficult matter, at least in so far as relates to the security and permanency of the connection. The waste pipe should be not less than one and one-half inches in diameter, and should be of lead to a point beyond the trap to allow for a possible movement of the vertical soil or waste pipe into which it discharges. It should not be connected with the trap of any water closet or slop sink, but should have a separate connection with the vertical stack. The common method of making this connection is through a "Bottle" or "Pot" trap, with a removable top, set level with the floor, for the purpose of cleansing the trap.

Of the modern plumbing fixtures, the bath tub is the only one which has a concealed trap, and while these traps are usually provided with access openings above the floors, a bath tub with a trap entirely above the floor would be a great improvement over the present construction.

Wash basins—Wash basins are usually constructed of porcelain, or porcelain enameled iron, in a great variety of styles, and are set up with plated fittings all in plain sight. The connection with the vertical stacks into which they discharge is a very simple process, but the insertion of a piece of lead pipe between the fixture and the vertical stack, to allow for a possible movement of the latter, should not be overlooked.

The waste pipes of wash basins should not be less than one and one-quarter inches in diameter, and the connections with the iron pipes, or fittings, should be made by means of brass ferrules, calked or screwed into the iron pipes, or fittings, and soldered to the lead pipes by what is commonly known as plumber's wiped joints. *This method of connecting iron and lead pipes should be followed throughout the entire soil and waste pipe construction.*

An overflow is a necessary part of a wash basin, and yet may become a source of offensive odors from the accumulation of organic matter upon its sides. For this reason, the overflow should not, as in many instances, be a part of the basin, but should be easily removed for the purpose of cleansing. A standing overflow, set in a recess at the rear of the basin and properly supported, may be made to serve the double purpose of waste plug and overflow, and is recommended as a sanitary arrangement of the outlet of such a fixture.

Slop sinks—Slop sinks are not considered necessary for ordinary sized dwellings, but they are necessary for large buildings, apartment houses, hotels, many public buildings, and the dormitories of educational institutions, where the slops from many rooms, or the dirty water from the washing of many floors, will have to be taken care of by the sewers. They should, in every case, be of porcelain, or of iron with a good porcelain enamel, both inside and outside. They should properly be furnished with flushing rims and flushing tanks for the purpose of cleansing the sides after use; and should always be furnished with removable strainers, of fine mesh, for the purpose of keeping out of the sewer matches, hair, broom straws, and other substances usually found in slops and in water which has been used for the washing of floors. The trap should be above the floor, and the connection with the soil pipe made in the same manner as for water closets.

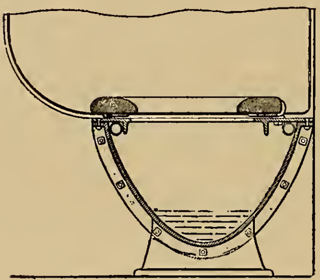

Fig. 40.

Public toliet rooms may be said to include the toilet rooms of all buildings to which the general public, or many people not of the same family, have access, as hotels; department stores; office buildings; schools; halls of assembly; hospitals; state, county and local government buildings; charitable, penal and reformatory institutions; factories; club houses; railroad stations, etc.

The plumbing fixtures which will usually be found singly or *en suite,* in the toilet rooms of buildings such as I have enumerated are water closets, trough closets, latrines, urinals, wash basins, sinks, and baths (stationary tub and shower).

The *water closets, wash basins, sinks,* and *bath tubs* of public toilet rooms will not differ materially from those designed for use in private toilet rooms, to which reference has already been made. In some instances, particularly where the fixtures would be liable to rough usage, porcelain enameled iron may very properly be used in place of all porcelain, and the fixtures in such locations may require to be made stronger and set more firmly than would be required for the toilet rooms of dwellings.

In the choice of water closets for a public toilet room, preference should be given to individual closets, of the siphon type, with seat action flush. In schools, and in other buildings where very small children congregate, closets which depend for their flushing upon the depression of the seats for a given length of time, have not always given satisfactory results, and for such buildings, where water is plentiful, automatic flushing of the closets may be resorted to.

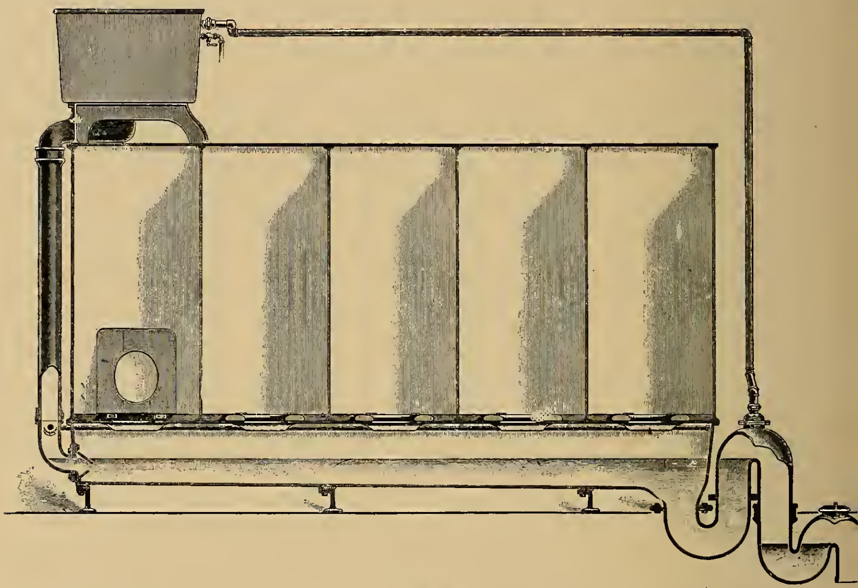

Fig. 41.

Trough closets—so named by reason of their shape—are often made use of in public buildings, particularly in school houses, and are made in various styles, one form of which is shown in Figure 40 and a cross section of the same in Figure 41.

The trough is usually made of cast iron, and sometimes of glazed stoneware, is trapped at the outlet, and has an automatic flush.

In comparison with a range of substantial siphon closets, with seat action flush, as a rule, the trough closet is considered inferior, and for the following reasons:

1. A considerable quantity of excreta may accumulate in the trough, and give rise to offensive odors, between the times of flushing, and at such times as the flushing apparatus may be out of order.

2. The sides of the trough may become fouled above the water standing in the trough, and the fouling may be too high or too dry to be reached or removed by subsequent flushings.

3. Notwithstanding the usual attention given to these closets, the inside of the trough will become discolored, and finally rough, and a permanent coating of foul smelling filth is the result. This is true particularly of closets in which the troughs are made of iron with inferior coatings of enamel.

In addition to the foregoing objections, the unnecessary waste of water, and the time and labor for supervision and cleansing, which such fixtures entail, may be considered valid objections to their general use.

Perforated pipes, for maintaining a clean condition of the sides of the trough, are provided in some makes of this type of closet, but the extent of the surface to be flushed is very great and necessitates a considerable increase in the already large amount of water required for the periodical flushing of the trough. Further, unless the flushing is continuous, or nearly so, and the sides of the trough should become fouled between the times of flushing, it is doubtful if the auxiliary flushing would be sufficient to detach the dry, or partly dry, excreta from the sides of the trough.

Where the amount of water used would not be a consideration, and providing the most careful and constant attention could be given to them, trough closets, of the best types, well ventilated, and frequently flushed, might be considered permissible for some buildings where water closets would be subject to rough usage.

The ventilation of trough closets will be referred to in a subsequent part of this chapter, under the heading of "Local Vents."

Latrines.—Properly speaking, the term latrine may be applied to almost any privy or water closet, but more particularly to the privies or water closets usually found in camps and in some hospitals. For our purpose, it will be taken to mean the type of fixtures represented by Figure 42, designed for use in the toilet rooms of buildings of a public or *quasi public* character.

Like the trough closet, the latrine has been subjected to much criticism in recent years, and the makers of latrines have endeavored to keep pace with the criticisms, by changes and improvements in their wares, until now there are in the market latrines which, when set up, in general appearance

Fig. 42.*

and in some important features, do not differ materially from ranges of individual closets.

In some makes of latrines we have an all porcelain bowl, and in some of these the top is molded to form a seat and thus dispense with the usual wooden

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seat. From a sanitary standpoint, this may be considered commendable, but as a latrine may often be used as a urinal, the porcelain seat may become fouled and rendered unfit for the purpose for which it was designed. Wooden seats are liable to be fouled in the same manner, but the people, especially the traveling public, have received considerable training as to the proper methods of using water closets, and it is believed the wooden seats would be less likely to be put out of commission, in the manner indicated, than would the porcelain seats. Another objection which may properly be made to the porcelain seat is that in cold weather, particularly where the room in which the latrine might be located was not very warm, the seat would be a source of discomfort to those using the fixture.

There is another type of latrine in which the whole of the water for flushing is made to pass through the bowls, in much the same manner as in ordinary water closets, and thus secure a more efficient flushing and cleansing of the bowls than could be obtained by the usual under flush, or by a division of the flush, partly beneath and partly through the bowls, as in some makes.

There is still another type of latrine in which the base of the fixture is concealed by a raised wooden floor, upon which the bowls are set, giving the appearance of a range of individual water closets.

In the endeavor to meet the objection relative to foul odors which may arise from the retention of excreta in the bowls between the times of flushing, many latrines are provided with local vents, and the methods of terminating these vents are many and are very varied. This phase of the subject will be referred to in a subsequent part of this chapter, under the heading, "Local Vents."

Placed in comparison with a range of substantial water closets, with seat action flush, the latrine does not possess any advantage over the former, and is open to the following objections:

1. The base of the fixture is unsightly, a dirt collector, and renders cleansing of the floor beneath the fixture difficult. As previously stated, in at least one make of latrine, this objection has been met by the concealing of the base of the fixture under a raised wooden floor, but this method is open to the more serious objection of providing a space for the collection of water and filth and which cannot be cleansed without removing the fixture.

2. In the absence of thorough ventilation of the bowls, the retention of filth in the bowls between the times of flushing will give rise to foul odors in the toilet room; and even where the bowls are well ventilated, the presence of filth in the bowls for any length of time would be disgusting to persons using the fixture.

3. To overcome the objection relative to the retention of filth in the bowls, nearly constant flushing of the fixture would be necessary, and this would entail a considerable waste of water, which, in many instances, would be a serious objection.

4. In latrines where the bowls are provided with flushing rims, the sudden and unlooked for discharge of a considerable quantity of water into bowls which might be in use at the time would, for obvious reasons, be considered an objection.

Like the trough closet, the latrine was at one time considered a very suitable fixture for the toilet room of a public building, but the advent of a really sanitary water closet, which will stand considerable rough usage, which is as nearly self-cleansing as can be expected, and which does not consume a large amount of water, has placed the two fixtures in question at a disadvantage.

Where a latrine might be considered a necessity, it would be well to choose a fixture in which the water for flushing is made to pass through the bowls, and to place the base of the fixture beneath an impervious floor, so that there would be no interference with the cleansing of the floor beneath the fixture.

Urinals.—Of the foul odors commonly found in the toilet rooms of public buildings, by far the greater portion may be charged up to the urinals; and the evolution of odors from a urinal is usually continuous and very difficult to prevent. For these reasons, much care should be exercised in the choice of such fixtures and in the care of the same when set up.

Urinals are usually constructed of porcelain, enameled iron, soapstone, slate, stone, and cement. Except in schools, and in other buildings where they would be subject to rough usage, preference should always be given to the porcelain fixture. Where iron is used, it should have a substantial porcelain enamel. For stall urinals, and for the backs and partitions of urinals set in a range, the best grades of soapstone may be considered permissible. It is scarcely necessary to state that materials having a rough surface, or which are porous in character, as stone and cement, are entirely unsuited for the construction of urinals, and could not be kept free from odors.

The three principal types of urinals are represented by Figures 43, 44 and 45, that shown in Figure 43 being suitable for almost every location and easily kept clean. There are many different methods of trapping urinals of this type, some having a metal trap, in plain sight, others a concealed trap behind or within the fixture, and other a trap beneath the floor. In the latter case, the one trap is usually made to serve the double purpose of trapping the urinal and floor drain. As in the case of other modern plumbing fixtures, the trap of this or any other type of urinal should be in plain sight, and provided with means for cleansing the same. Urinals of this type should be provided with auto-

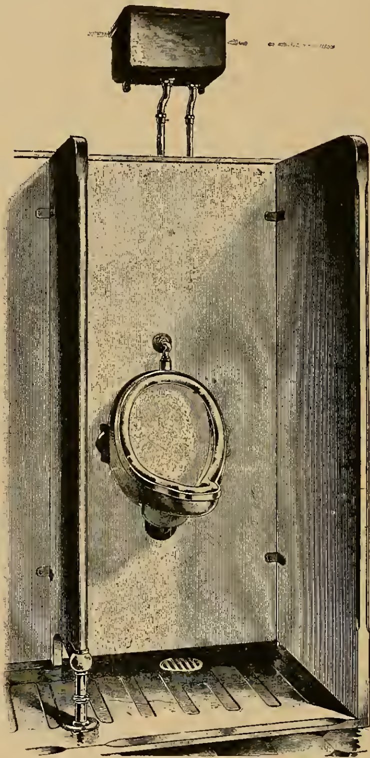

Fig. 43.*

matic flushing tanks, of small capacity, and the

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flushing should be frequent, or otherwise, according to the number of times the fixtures are likely to be used.

The urinal shown in Figure 44 is often preferred for the toilet rooms of railroad stations, public parks

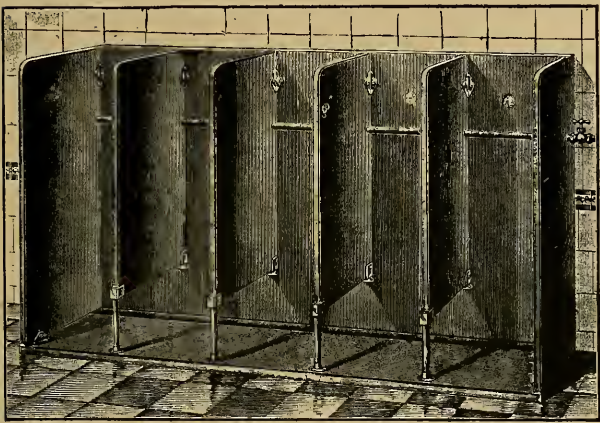

Fig. 44.

and places of a similar character, and many public buildings. They are usually made of slate, and sometimes of soapstone or imperial porcelain. Of the three materials, by reason of its smooth, white glaze, porcelain is by far the most suitable in the points of cleanliness and durability. The best grades of soapstone are considered superior to slate for this purpose, are much less expensive than porcelain, and with proper care may be maintained in a sanitary condition. Urinals of this type should be constantly flushed by means of a perforated pipe, or by a "Spreader" in each stall.

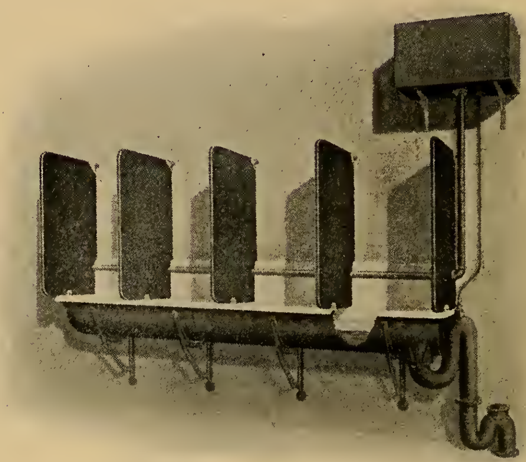

Fig. 45.

The type of urinal shown in Figure 45 is best suited for the toilet rooms of school buildings, or of any building where it would be subject to rough usage. For schools frequented by young boys, the trough should not be more than sixteen inches above the floor, and flushing should be frequent, particularly during recess.

The ventilation of urinals will be considered in a subsequent part of this chapter, under the heading, "Local Vents."

Shower baths.—Shower baths, or as they are sometimes termed "rain baths," are usually found in connection with the toilet rooms of gymnasiums, hospitals, penal institutions, public bath houses, and in some factories and schoolhouses.

Placed in comparison with the common bath tub, the shower bath possesses several advantages over the former, chief among which may be mentioned its tonic effect upon the human system, economy in the amount of water consumed, and thorough cleansing of the body.

It is scarcely necessary to state that every portion of the walls, partitions and floors in the immediate vicinity of the shower should be constructed of smooth and impervious materials, and the drainage from the shower arranged in a sanitary manner.

Where a number of showers are in a row, or adjacent to each other, and the appearance of flow gutters would not be an objection, the entire floor of the toilet room could be drained by flow gutters, all converging to one common trap, in which case the floor drain shown in Figure 20, Chapter III., or other equally good trap, should be used. Bell traps are frequently used for this purpose but, for reasons given in Chapter III., are not considered suitable or safe.

Local vents.—Local vents are intended for the removal of foul odors from water closets, trough closets, latrines, urinals and slop sinks, and should not be confounded with the vents provided for preventing the siphonage of the traps of fixtures.

Where local venting is to be carried out, the fixtures are usually provided with special openings for the purpose. In water closets, and in fixtures having bowls of corresponding shape, the vent openings are usually made at the rear of and near to the tops of the bowls; in trough closets, at some point near to the tops of the troughs; and in urinals, they are usually at or near to the outlets of the fixtures. To be of service, the vent pipes leading from the fixtures should be devoid of sharp turns, and should be connected with heated flues, constructed or suitable for that purpose and extended above the roofs. They should never be connected with the smoke flue of any stove, fireplace or furnace, nor with the ventilating flue of any inhabited room.

Local vents are not considered necessary for the water closets, or other fixtures, in well ventilated toilet rooms of dwellings, and no water closet, or other fixture, should be placed in any part of a dwelling which cannot be properly ventilated without the aid of local vents. In toilet rooms frequented by many people, particularly where such rooms are located in the basements of buildings, the local venting of water closets, and the slop sinks, if any, may be considered an advantage. Trough closets, latrines and stall urinals should always be provided with local vents, of ample size, and having an *upward* inclination from the points where they join the fixtures.

In one type of latrine, provision is made for carrying the local vents *downward* to the floor before they are connected with the vertical flues, and one reason given for so doing is that "foul odors are heavier than air and naturally go down." The difference in the weights of a very short column of ordinary air and a corresponding column of air such as would be found in the bowl of a latrine, during or immediately after use, would be extremely small, and could not be considered as an auxiliary to the draft in the vertical flue. Further, in carrying the vent pipe downward, the air would have to make at least one unnecessary square turn in its passage to the vertical flue, and each square turn means a loss of about fifty per cent in the draft.

Where steam heat is available, a coil of steam pipe in each vertical flue to which the local vents are connected would ensure a good draft. In warm weather and at such times as steam heat might not be available, the vertical flues should be heated by a stove or gas jet. In the absence of either steam or gas, or where a stove might be considered too expensive for the purpose, a small exhaust fan might be made to serve the purpose of securing a positive draft.

Where the local vent of a stall urinal is made sufficiently large, and begins at the floor level, the usual vent register for the ventilation of the toilet room may be dispensed with.

Arrangement, lighting and ventilation of toilet rooms.—The arrangement of the fixtures in a toilet room will not materially affect its sanitary condition, but there is one point which is often overlooked and which may incommode the occupants of a dwelling, particularly where a number of people may be likely to use the toilet room, viz., the location of the bath tub and water closet. Wherever possible, these fixtures should be located in separate rooms, or screened off in such a manner that the fixtures may each be used at the same time, if necessary.

That a toilet room should be well lighted and ventilated goes without saying, and yet there are very many such rooms in which both light and the necessary changes of air are woefully lacking. Whenever possible, these rooms should have at least one outside wall so that light and *summer* ventilation can be obtained by means of windows. Where this is not possible, and the toilet room is on the top floor of a building, such lighting and ventilation may be secured by means of a skylight, or, better still, where the roof is flat, by means of a lantern light. Where the toilet room is not located on the top floor of a building, a special light and vent shaft, terminating in a lantern light, is deemed necessary.

For the proper ventilation of a toilet room in *winter,* and at such times as the windows could not be open, a special vent flue, of ample dimensions, and extended above the roof, should be provided. Where steam heat is available, a few feet of steam pipe placed at the base of such a flue would ensure a positive draft. As previously stated, where a stall urinal is used, the ventilation of the toilet room in which it is located may be accomplished by means of the local vent, provided the same is made large enough for this purpose.

CHAPTER VII.

Traps.

IN a general sense, the word "trap" is intended to mean a snare, an ambush, a strategem, or any device by which animals, birds or human beings may be caught unawares. Used in connection with the well-known and useful appendage to plumbing fixtures of all kinds, the word "trap" is a misnomer, and should be abandoned in favor of a better name, as *interceptor, barrier,* or *water seal.* Either of these would correctly describe the functions of a trap, viz., the prevention of the passage of air from a sewer through the outlets of plumbing fixtures or other openings in the sewer, without materially affecting the flow of sewage into or in the sewer. One of the principal requirements of a trap is that it shall be self-cleansing, and hence it is not intended for the purpose of "catching unawares" any part of the sewage which may pass through it; neither is there anything in the air of a sewer which could or should be "caught" by a trap in the manner indicated. Long usage of the word "trap" will probably act as a deterrent to any such change as suggested, nevertheless the suggestion is worthy of consideration, and might at some time accomplish the end for which it is made.

Traps are, to a considerable extent, unnecessary evils, but there has not been discovered any device which can take their place. The necessity for a trap in connection with each plumbing fixture has never been questioned; the necessity for or the wisdom of the placing of a main trap in a house sewer has been the subject of much controversy, to which reference was made in Chapter II; but the use of a trap at the foot of a soil pipe, a vertical waste pipe stack, or at any point in a sewer between the main trap

Fig. 46.

and the traps of plumbing fixtures, has long since and almost universally been condemned, for the reason that it is entirely unnecessary, a serious hindrance to the flow of sewage, and an obstacle to the proper ventilation of the sewer.

Forms of Traps.—Traps may be divided into three principal classes: Main traps, fixture traps, and floor traps, the various forms of which are based upon the principle of a sag in a pipe, as illustrated by Figure 46.

Main traps have already been considered in Chapter II, and floor traps in Chapter III, therefore the following remarks on traps will have special reference to the traps of fixtures.

The number of traps, of different types, which have been and are at the present time upon the market is legion. There are, however, but few traps which can lay claim to the term *sanitary*, and these

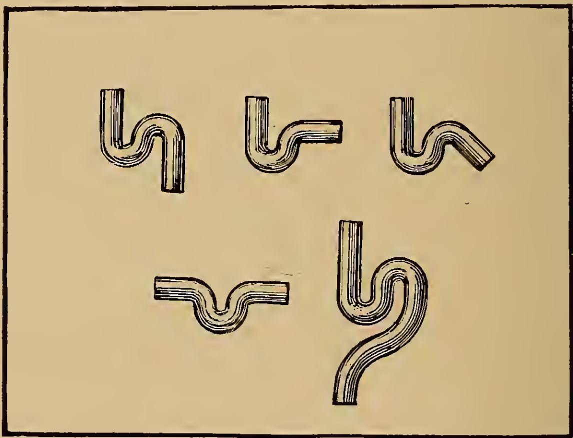

Fig. 47.

are limited almost entirely to those traps which have a uniform circular cross sectional area throughout, five forms of which are shown in Figure 47.

Without adequate protection, however, the water seals of this class of traps are easily destroyed, and it was for this reason, principally, that so many different types of traps have been introduced. In almost every instance, however, the attempt to overcome this defect in the round pipe traps, so-called, has resulted in the production of a trap which was defective in some other particular, notably in respect to its self-cleansing quality, examples of which

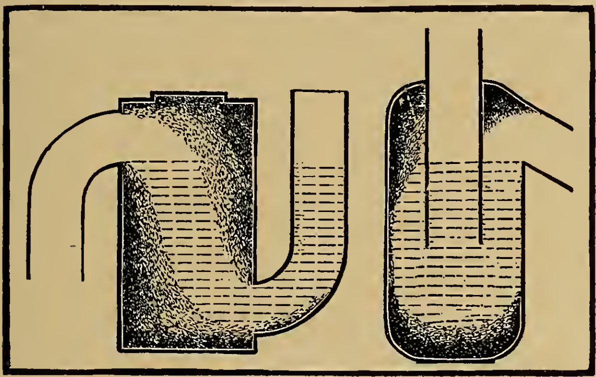

Fig. 48.

are shown in Figure 48. Many traps designed to overcome the defect in the round pipe traps before mentioned are prohibited in the most recent plumbing codes, of which the following extract from the Cleveland code is a sample:

"Every trap on a drainage or plumbing system shall be self-cleaning. No bell, bottle, or D trap shall be used. No form of trap which depends upon the action of movable parts for its seal shall be used. No trap which depends upon concealed interior partitions or deflectors for its seal or re-seal, or which has an interior partition that, in case of defect, would allow the passage of sewer air, shall be used, except for earthenware fixtures where the seal of the trap is plainly visible."

In this code, however, in addition to the class of traps shown in Figure 47, certain resealing traps—modifications and combinations of plain and drum traps—together with anti-siphon traps are permitted, provided they will stand the tests provided in the code. These tests relate, principally, to the ability of traps to resist siphonic action such as they would be subject to in actual practice.

For the purpose of securing the greatest possible cleanliness in every portion of the sewerage system of building, in the selection of traps preference should usually be given to the class of traps shown in Figure 47, and precautions taken to prevent the reduction or destruction of their water seals by siphonic action, etc., as described in a subsequent part of this chapter.

Notwithstanding that a trap may be considered self-cleansing, it will sooner or later become a receptacle for accumulations of grease and other solids which may give rise to foul odors or form the nucleus of a stoppage, and, for this reason, every such trap should be provided with a clean-out, but the latter should always be placed below the water line of the seal so that a leak will be detected.

Loss of Seal in Traps.—The reduction or destruction of the water seal in a trap may be due to one of four principal causes: siphonage, back pressure, evaporation, or capillary attraction. It is sometimes due to the momentum of the water passing through a trap. The most common cause, and that to which special attention is directed, is that of *siphonage,* or the suction produced by the flow of sewage in a pipe in quantity sufficient to fill the pipe at some point in the form of a piston or plug. The mass of water drives before it the air contained in the pipes and leaves behind it a partial vacuum, greater or less according to the rapidity with which air may enter the pipe to restore the normal pressure. If such a pipe was of uniform size throughout, and open at both ends—as in the case of a well ventilated soil pipe of moderate height—the normal pressure of air in the pipe would be restored without undue influence upon the water seals of any traps which might be connected with it; but if the pipe was closed or reduced in size at its upper end, or of such a height that air could not pass down it with sufficient rapidity, the greater pressure of air on the house side of the water seals of the traps would force air through the traps and with it some of the water, and thus weaken or destroy the seals.

Many experiments have been made to determine the conditions under which the siphonage of traps is possible, and *vice versa,* and it has been found that very much depends upon the depth of the water seals of the traps; the relative sizes of the traps and the vertical stacks with which they are connected; the horizontal distance between the traps and the vertical stacks; and the sizes of extensions of the vertical stacks above the roofs.

Among the earliest recorded experiments in relation to trap siphonage are those made by S. Stevens Hellyer, of London,** by which he demonstrated *that round pipe traps, properly constructed and ventilated, are free from injurious effects from siphonage, for if they could not be unsealed when connected to pipes of the same diameter as themselves, nor of smaller diameter, they are more certain to hold their seals when connected to pipes of larger diameter, where the friction, and therefore the suction power of a corresponding discharge of water, would be much less.*

From experiments conducted for the Boston City Board of Health, by J. Pickering Putnam and L. Frederick Rice, and recorded in "The American Architect and Building News," June 7, 1884, it was learned:

1. * * * * *"that the siphonic action which may be produced by a trapped plunger water closet*

**"The Science and Art of Sanitary Plumbing," by S. S. Hellyer, 1882.

under certain simple conditions which are likely to be encountered in plumbing, is sufficient to unseal small S traps, such as are ordinarily used for lavatories, though they be ventilated either at or below the crown in the manner prescribed by the plumbing regulations with vent pipes of the full size of the trap, and that it makes no material difference as to siphonage whether the vent pipe be applied at the crown or at a considerable distance below it. This action takes place even when the pipes are clean and new. When partially closed or clogged with sediment the results would be even more serious.

2. * * * * *"that the power of resistance of 'pot-traps' depends upon their size and more particularly upon the diameter of the body.*

3. That *"* * * * the resisting power of pot-traps of equal depth of seal is in direct proportion to the diameter of the body.*

4. That *"no pot-trap whose body does not exceed in sectional area fifteen times that of each of its arms or connecting pipes can be accepted as anti-siphonic under all conditions likely to be encountered in plumbing.*

5. That *"pot-traps having bodies 6" in diameter and having 1½" or 1¼" connections may, however, be considered safe when they are not exposed to the repeated action of plunger water-closets of the largest water capacity.*

By reason of a conflict of opinions and deductions of authorities who had, up to the year 1885, made experiments in relation to trap siphonage, it was impossible to form a definite conclusion upon the subject, and this led to a series of experiments, in that year, at the Museum of Hygiene, United States Navy Department, Washington, D. C., by Glenn Brown, an architect of that city. These experiments were said to have been "conducted to get at the real facts," the apparatus at the Museum being arranged "more nearly in accordance with the methods in ordinary use, than has been the case in other experimental plants." The principal deductions from these experiments were:

1. *That the seals of ventilated traps are safe against siphonage.*

2. *That, as a rule, the seals of unventilated traps are never safe from siphon action.*

3. *That traps connected on a horizontal pipe and fixtures discharging on the same level into horizontal pipe apparently have no effect on unventilated traps.*

These experiments led to a wordy and public discussion between Mr. Brown and Mr. J. P. Putnam, in which Mr. Brown seems to have had the last word.

More recently a series of experiments on this subject was made under the auspices of the Municipal Building Department by Herr Unna, a sanitary engineer, of Cologne, Germany, for the translation of the record of which we are indebted to W. P. Gerhard, C. E., of New York. So far as can be learned these experiments were confined to the common round pipe type of traps. From a summary of the experiments it is learned:

1. *That the greatest depth of water seal at which traps of from 1¾" to 2½" diameter will be self-cleansing is four inches, and that, other things being equal, this depth is necessary to render traps of the sizes given safe against loss of seal by siphonage. For the traps of water closets a depth of seal of at least two inches was found to be necessary to prevent siphonage.*

2. *That siphonage does not readily take place where the cross sectional area of a soil or waste pipe is one size larger than that of a trap discharging into it, as, for instance, a 2" waste pipe for a 1½" trap, a 2½" pipe for a 2" trap, and so on.*

3. *That where a trap is not more than* 3.3 *feet distant from the vertical soil or waste pipe, siphonage does not readily take place.*

4. *That in order to prevent the siphonage of traps which may be connected with them the vertical soil or waste pipes should be continued in full size, and with as few offsets as possible, to a point above the roof, and that it would be still better to*

enlarge the upper ends of such pipes two inches from a point twenty inches below the roof.

With respect to the requirement in the preceding paragraph, it should be stated that in the various plumbing codes in the United States it is generally specified that the vertical soil pipes shall be continued their full calibre above the roof, and the vertical waste and vent pipes enlarged to at least four inches in diameter before they pass through the roof. To prevent a serious reduction, by frost, in the bore of such extensions, in the most recent codes provision is made for the enlargement of all soil, waste and vent pipes before they pass through the roof, with a minimum size of four inches for the waste and vent pipes.

In 1889-90 extensive experiments in trap siphonage were made at the Stevens Institute of Technology, Hoboken, N. J., by James E. Denton, M. E., having for their special object the determination of the ability of a certain patented Anti-Siphon Trap Vent "to protect simple S traps against the disturbing influences due to the downward flow of water in waste pipes, such as are common to plumbing construction." The results of these experiments were published in Vol. XVI of the Transactions of the American Public Health Association and contribute some new data upon the subject, chief among which may be mentioned the following:

1. *That, contrary to the general impression, the greatest vacuum or suction is not produced when a waste pipe is supplied with a jet of water of the same diameter as the pipe.* Thus, when a 2″ waste pipe received the flow of water from a tank through a 1½″ opening a mercury pressure gauge attached to the pipe at a certain point showed 24″ of vacuum; but when a 2″ orifice supplied the 2″ waste pipe only 18¾″ of vacuum was recorded. The cause of the superior vacuum with the smaller stream was attributed to "the greater friction of the larger stream, resulting in a less velocity of flow, and hence a less intensity of vacuum," and to the fact that "the smaller stream causes an induced current of air to accompany it, which increases the volume of displacement, and may have considerable effect in rarefying the air in the branches of the waste pipe leading to the mercury column." It was also learned "that either a 1½ or 2-inch stream delivered into a 4-inch waste pipe will produce greater siphonage effect than the same stream in a 2-inch waste pipe, and yet the vacuum registered by a gauge will not exceed three-eighth inches of mercury." It was further learned that "a 2-inch stream in a 4-inch pipe does not * * * * produce as great a siphonage influence as the same quantity of water discharged through a 4-inch opening into a 4-inch pipe."

2. *That, contrary to the frequent assumption,* the greatest vacuum with a given stream of water does not occur at the lowest fixture on a line of waste pipe, but decreases as the mercury gauge is applied nearer to the bottom of the waste pipe.* This was said to be "directly traceable to the dynamic principle controlling the pressure of a column of descending water," i. e., "that pressure of such a column shall vary at different levels, by amounts representing the weight of the column above the point of observation, just as though the water was at rest, or the pipe plugged at the bottom. Hence, the nearer to the bottom a fixture is attached the greater the pressure from the superincumbent column above, and hence the less the vacuum."

3. *That a 1½" wrought iron vent pipe, not more than 13½ feet long, and having not more than two elbows, will safely protect the seal of a simple S trap, having only 1½" depth of seal, against the greatest suction siphonage influence which can be produced by any flow of water into a 2" waste pipe of any height.*

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*The popular idea relative to the action of a falling body of water in a long vertical line of soil or waste pipe is substantially as stated in the following extract from "Hygiene and Public Health," by Louis Parkes, M.D., 1889:

"Where one soil pipe receives the discharges of several water closets on different floors the passage of the contents of one of the *upper* closets down the soil pipe may cause the water in the trap of one of the *lower* closets to be drawn off, owing to the suctional force of the downward current of air caused by the descent of the liquid in the soil pipe." [The italics are mine. T. S. A.]

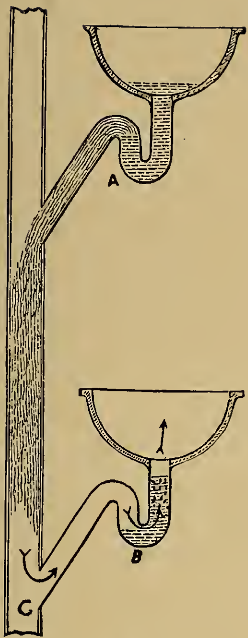


Fig. 49.

In a well designed house sewer the danger from the loss of seal in the traps of fixtures by *back pressure* should not be great. Under certain conditions, however, it may become a source of considerable danger, as may be seen by reference to Figure 49, in which the column of air in the lower part of the soil pipe C is retarded in its descent, causing a compression of the air and a rise of water on the house side of the trap B. Air will be forced through the trap, as shown by the arrows, and, if the falling body of water from the trap A is considerable, the water in the trap B may be forced completely out of the trap. After the pressure of air on the water in the trap B is relieved the water in the trap will fall and, in regaining its normal level, some of the water will escape from the outlet of the trap, thus reducing the seal. In a shallow trap this would mean a considerable weakening of the seal. The circumstances under which such a condition as that just described may occur may be found in many buildings in which the sewerage is believed to be danger proof. A sudden bend at the foot of a soil or waste pipe; a long line of horizontal sewer, of small dimensions, between the foot of a soil or waste pipe and the fresh air opening; or the clogging, or partial clogging, of the fresh air opening or of the vent pipe of a fixture trap, may, singly or together, cause a serious retardation of the air moving before a descending column of water in the soil or waste pipe, and a serious disturbance of the water in the traps of fixtures on the lower floors.

In the experiments on trap siphonage, previously referred to, many interesting points and diverse opinions were brought out relative to the influence of back pressure on traps, the most important of which are as follows:

[From the report of Glenn Brown.]

"Back pressure seems, from the experiments, to be a more important feature in plumbing than is generally supposed. Although the fresh air inlet was open the air confined in the pipes almost invariably found egress more easily through traps on second and first floors than through the opening near the foot of the soil pipe. No trap withstood back pressure better than the others."

[From the reply of J. Pickering Putnam to the report of Glenn Brown.]

"Back pressure may be easily guarded against by simpler methods than by trap-venting, one of which methods is to connect the waste pipe of the trap with the soil pipe at a point *beyond* the bend which causes the back pressure. This can always be very easily done in practice. Another method is to set the trap far enough below the fixture to permit of the formation in the waste pipe, above the trap, of a column of water long enough and heavy enough to resist the greatest pressure of air likely ever to be encountered in good plumbing. The trap must then be constructed with sufficient water capacity to fill such a pipe. In the experiments for the Boston Board of Health the length of pipe required in the worst cases which could be encountered in good plumbing was found to be from fourteen to eighteen inches. This method could always be easily applied in practice in places where back pressure was expected and the other method was not convenient."

[From the reply of Glenn Brown to J. Pickering Putnam.]

"I have found that sewer air is driven into the house by back pressure from friction in the pipes, and that no special bend can be located at the point of such friction. The sides of a straight pipe seem to cause all the friction that is required for such back pressure. If the assumed objectionable bend could be located and the waste pipe attached below the bend, in some cases if not in most cases, the waste pipe would approximate the length of the soil pipe. For instance, wash basin in third story, assumed frictional bend near the fresh air inlet outside the house, the waste pipe would necessarily run through three stories and cellar. Back pressure of this character does not force the water up as a mass into the pipe between the fixture and trap, but the sewer air is forced through the seal in the form of bubbles, as I have stated in my experiments. No matter how far below the fixture a trap was placed the sewer air would be forced through the trap."

[From the report of James E. Denton.]

"The general conclusion is therefore warranted that with a waste system constructed in accordance with the accepted rules of good plumbing practice the amount of back pressure liable to be developed at the foot of vertical lines, while small, may abstract water from a three-quarter S trap by the upward current of gas, due to back pressure, so as to destroy a 1½-inch seal if protected by a vent pipe."

Under ordinary conditions, the reduction of the water seal of a trap by *evaporation* need not, usually, be taken into consideration.

Where plumbing fixtures are not often used, the water seals of the traps may become considerably weakened by evaporation, and, for this reason, the depth of seal of fixture traps should be as great as would be consistent with the rule that every such trap should be self-cleansing. This rule may be ignored, however, in the case of the traps of floor drains, which, as shown in Chapter III, should be constructed with large and deep water seals, with the view of retaining the solid matters which may gain access to them and of preventing a serious loss of seal, by evaporation, during the time they are not in use.

The rapidity with which evaporation of water from a trap will take place will depend largely upon the presence, or otherwise, of a constant current of air in the vicinity of the outlet of the trap, such as would be produced by a trap vent; and, in a lesser degree, upon the humidity of the air in the room in which the trap may be placed or in the soil or waste pipe with which it may be connected.

From a report of experiments made by J. P. Putnam and L. Frederick Rice,* relative to the evaporation of the water seals of traps, it is learned:

* * * "(1) *that a rapid evaporation of the water-seal of traps takes place when they are ventilated at or near the crown, and that evaporation goes on both in winter and in summer, and in ordi-*

*"American Architect and Building News," June 7, 1884.

nary unheated flues, as well as in flues artificially heated. The evaporation is most rapid in winter or with flues artificially heated, and slowest in summer, especially in damp weather. * * *

"(2) *That in winter the evaporation produced by ventilation is so rapid as to destroy the seal of an ordinary 1½" machine made S-trap in from four to eleven days, according to the nature of the current.*

"(3) *That without ventilation, or with the ventilating-flue taken from a considerable distance below the crown, the evaporation of the water-seals of traps is exceedingly slow, and that unventilated traps having a considerable water capacity may be considered perfectly secure against this danger unless they are left unused for years at a time."* (The italics are mine.—T. S. A.)

According to the report in question, under the ordinary conditions met with in a dwelling, and with the usual trap ventilation, on an average, the seal of an unused 1½" S trap may be expected to lose about one-eighth of an inch in depth *per diem,* the daily loss beginning with about one-fourth of an inch on the first day and decreasing as the depth of water in the trap decreases. In the absence of trap ventilation, however, the rate of decrease may not average more than one-thirty-second to one-sixteenth of an inch in ten days.

The loss of depth of water seal in a trap by *capillary attraction* will depend, largely, upon the shape of the trap and upon the accidental, careless or wilful discharge into the trap of a foreign porous substance, as hair, lint, jute, sponge, rag or twine. In a self-cleansing and frequently flushed trap, the danger from this source will be very small, because the shape of the trap will not permit of the retention within it, for any length of time, of any substance capable of producing capillarity. In a trap having an interior partition around which the sewage must pass in its passage to the outlet, the probability of the lodgment of foreign substances in the trap will be considerable. But the lodgment in the trap of any of the substances mentioned will not, necessarily, produce capillarity of any consequence. The capillaries must be in quantity and of sufficient length to dip into the water at one end and extend over the outlet of the trap at the other end. Even then, so we are informed by J. Pickering Putnam, who made experiments along these lines, capillarity will not take place if the outlet of the trap is more than 3½ inches above the level of the water when at rest in the trap.

Of the several means described, whereby the water seals of traps may become weakened or destroyed, *siphonage* and *back pressure* are paramount in importance and demand the most careful consideration by those entrusted with the design and installation of the sewerage of buildings.

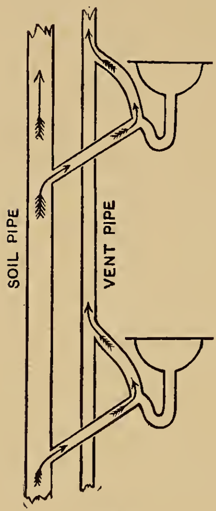


Fig. 50.

As a rule, the usual methods for the prevention of siphonage may also be relied upon for the prevention of serious back pressure, and *vice versa,* therefore a separate consideration of these questions will not be necessary.

There are two principal methods by which the water seal of a trap may be protected against siphonage, viz., back venting of the trap, or the attachment to the trap, or to the waste pipe near to the trap, of an Anti-Siphon Trap Vent.

The general plan of trap ventilation is illustrated in Fig. 50, which is self-explanatory.

Where two or more traps, on different floors, are connected with one main vent pipe, the latter should be connected, obliquely, with the vertical soil or waste pipe below the branch pipe from the lowest fixture on the stack, so as to remove particles of scale and the water of condensation; and should be continued to a point above the roof, or connected with the vertical soil or waste pipe above the highest fixture, in manner similar to that shown in Fig. 22, in a preceding chapter.

The proper materials and weights of vent pipes are described in Chapter IV, and too much care cannot be exercised in their selection. It is of the first importance that the friction due to the passage of air through the pipes be reduced to the minimum, and that corrosion of the insides of the pipes, to any extent, be rendered impossible. For these reasons, only pipes of smooth bore and of non-corrosive material, or which have been permanently protected against corrosion, should be used. Lead comes the nearest to being an ideal material for this purpose, and is recommended for the branch vents. For the vertical vents, cast iron pipes, which have been rendered rust proof, are preferred.

Some idea of the danger to be apprehended from rust in a vent pipe may be gathered from the following extract from "Trap-Siphonage and Trap-Seal Protection," by Prof. J. B. Denton:

"If rust to the thickness of one-hundredth of an inch from the internal surface of 10 *feet of* 1½-*inch vent-pipe should accumulate in an elbow, it would more than fill the latter, as it would occupy about six cubic inches."* (The italics are mine.—T. S. A.)

The size of vent pipes will depend largely upon their length and upon the number of traps which they are expected to take care of.

The usual minimum sizes of back vent pipes, i. e., the branch pipes extending from the traps to the branch or main vertical vent pipes, are as follows:

1¼″ pipe for		1¼″	traps.
1½″ pipe for	1½″	to 2½″	traps.
2″ pipe for	3″	to 4″	traps.

There is a certain length of pipe, of each of the sizes commonly used for the venting of traps, which will protect a trap of a certain size, but these lengths can only be determined, with any degree of accuracy, by experiment, and the known experiments along this line are very few, and, in many instances, unreliable. As previously stated, it has been found that 13½ feet of 1½″ vent pipe, with two elbows, will safely protect the seal of a ¾″ S trap, having only a 1½″ seal, against the greatest siphonage influence which can be produced by any flow of water in a 2-inch pipe of any practical height, even if the waste pipe is closed at the top. It has been further demonstrated that the friction produced by the passage of air through one square 1½″ elbow is equivalent to the friction produced in the same manner by 1.8 feet of pipe of the same diameter. These statements cannot, however, be taken as indicating the probable necessary lengths of vent pipes of the different sizes because the conditions in almost every building will be different.

In the determination of the sizes governing the construction of vent pipes, the same difficulty seems to have been experienced as in the determination of the sizes of soil and waste pipes, described in Chapter IV. An analysis of the provisions of the plumbing codes of twenty-seven of the principal cities in the United States reveals the fact that but five of the codes have provisions practically alike in respect to the general sizes of trap vents. There are three other groups, of two cities each, in which the codes are similar to each other in this particular, but different in each case from the codes in any other group. The similarity of the codes in any two or more cities is due to the copying by one city of the code of another city, and not as the result of scientific calculations, which, as before stated, cannot be made, with any degree of accuracy, for the various conditions met with in practice, except by experiment. Probably the latest contribution to the literature upon this subject is contained in a table in the new plumbing code of the city of Cleveland, Ohio, of which the following is a copy:

Size of pipe.	Maximum developed length in feet. Mains.	Number of traps vented. Branch.	Main vertical.
1¼ inch vent............	10	1	....
1½ inch vent............	20	2 or less	....
2 inch vent............	40	16 or less	32 or less
2½ inch vent............	65	30 or less	60 or less
3 inch vent............	100	60 or less	120 or less
4 inch vent............	150	136 or less	272 or less
5 inch vent............	200	240 or less	480 or less
6 inch vent............	250	360 or less	720 or less

In the table the following notation of traps and equivalents is used:

Traps 2 inches or less in diameter=1 trap.
Traps 2½ inches in diameter=2 traps.
Traps 3 inches in diameter=3 traps.
Traps 4 inches in diameter=4 traps.
Traps over 4 inches in diameter=5 traps.

If the length of a branch or main vent pipe is to exceed the given maximum, the diameters shown in the table are to be increased to the tabulated size opposite the length required, irrespective of the number of traps vented, but in no case are the main back vent pipes to be less than one-half the diameters of the adjoining soil pipes.

The table has been prepared by men of ability and experience in this work, and is probably as nearly correct as anything yet published upon this subject.

Objections, valid and otherwise, have been made to the use of trap vents, and there is a general tendency toward the adoption of safer and less complicated methods of protecting the water seals of traps against siphonage and back pressure.

As long ago as the year 1886, the late Col. George E. Waring, Jr., summarized the principal objections to trap vents in a work on "How to Drain a House," from which the following extracts are made:

"While a sufficient vent-hole at the crown of a trap will prevent its contents from being withdrawn by siphonage (suction), insufficiency in such an opening defeats the purpose for which it was made. Insufficiency may be due to several things:

(a) The opening may originally be made too small.

(b) It may, and very often does, become reduced in size, or entirely closed by the accumulation of foul matter thrown into it during the use of the trap.

(c) As its efficiency is due entirely to the admission of air fast enough to supply the demand for air to fill the vacuum caused by water flowing through some portion of the pipe beyond the trap, it is not only a question of having an opening large enough to admit the air, but of having an adequate current led freely to the opening.

"As the opening is into a portion of the drainage system that is unprotected by a trap, it cannot, of course, communicate with the interior atmosphere of the house; it must be connected by a pipe either with the open air outside of the house, or with the air of the upper part of the soil-pipe, above all fixtures. The ability of this pipe to transmit air in the volume required depends on its size and its directness. A one-inch pipe, one foot long, for example, may admit air fast enough, while a longer pipe of the same diameter, or a smaller pipe of the same length, would not do so.

"One or other of the defects above indicated may very easily defeat the object, and in so far as the opening may be decreased by the accumulation of waste matters, the object which is fully secured while the work is new, may be permanently defeated by a condition that occurs after a little use. What seemed originally to be adequate security may become untrustworthy in time."

Ten years later, in the St. Paul Pioneer Press of January 5, 1896, under the caption, "Danger in Houses," appeared a copy of the report of W. J. Freaney, plumbing inspector of that city, relative to the danger to be apprehended from the use of trap vents. While some of the conditions described in the report may not be fully representative of plumbing in many other cities, the following extracts from the report confirm the statements of Col. Waring, quoted above, relative to the noneffectiveness of trap vents after they have been in use for some time:

"* * * I have made a somewhat limited examination of the practical effect and desirability of the present system of so-called trap ventilation. My investigations confirm the opinion I have held for some time, that the crown and back-venting of traps, as now practiced, is worse than useless. * * * The most serious objection, however, to this pernicious custom is the sense of false security given to the owner or tenant of a house provided with so-called modern plumbing.

"I made examinations in twenty-three houses, the plumbing work in which was done in the very best and most workmanlike manner, all of them having been constructed within the last seven years, in conformity with the ordinance governing plumbing. In twelve of the houses examined I found all of the vent pipes from traps under kitchen sinks completely stopped by congealed grease and particles of vegetable matter for a space of three inches to a foot above the crown of the traps they were supposed to 'ventilate.' In most cases a strong wire was required to dislodge the obstruction.

"Of the other eleven kitchen sink traps examined I found only one that was perfectly clear.

* * * In seven of the houses I found a soft slimy substance adhering to the interior surface of the vent pipes for two or three inches above the crown of the traps. While the stoppage was not complete, there was every indication that an entire obstruction would soon result. The remaining three examined were partially stopped up; but in the case of these the vent was placed below the crown of the trap and so fashioned that the lower line followed the descent of the waste pipe. I also found that where couplings were used at the foot of wrought iron vent pipes, that the dislodged particles of rust form an accumulation sufficient in most cases to stop the opening in the bend."

In the closing paragraph of the report, the inspector calls for the remodeling of the city ordinance so it shall "conform to modern practice," pending which he recommends that publicity be given to the subject, so that the people may "take individual precautions against the evils involved."

Rather more than ten years later, in an article on "Re-Sealing and Anti-Siphon Traps Versus Back Venting,"* H. J. Luff, sanitary engineer, Cleveland, Ohio, advanced additional reasons

* Domestic Engineering, March 2, 1907.

why the back venting of traps is not absolutely reliable:

"First, back venting, though the greatest care may be taken to make the connection to the waste pipe in the most approved manner, viz., taken off at an angle of 45 degrees beyond the crown of the trap, in its installation, is liable to be rendered non-efficient from the following causes: Where galvanized iron pipe is used the galvanizing may form a film which would completely stop the pipe. In the use of lead or cast iron, the molten metal may enter the pipe through the joint when it is being made, and partially or completely fill it. Oakum placed in the pipe to prevent building material from falling into it may be forgotten and allowed to remain, thus completely stopping the pipe, and if the ends of vents are not protected during construction, building material may fall into them, and, lodging in the elbows, completely stop them. All this presupposes carelessness on the part of the plumber, but constitutes a factor which cannot be ignored, as it too often exists. After the vents have been installed, there are conditions over which the plumber has no control that operate to render the vent pipe non-efficient, viz., the freezing of the roof outlets in protracted cold weather, the building of nests by the birds, and the falling of leaves into roof outlets."

After enumerating the danger from clogging of the vents by greasy vapor from kitchen sinks, he goes on to say:

"* * * Also, there is the proposition of the average plumber clearing the sink waste pipe by means of an opening into the waste pipe and leaving the vent untouched, or of trying to force the obstruction from the waste pipe and forcing what might be in the vent pipe up against an elbow beyond the point of accessibility, or of using a blind washer on the back vent union and forgetting to take it out. Then there is the added danger of piping through which no water passes to indicate a leak, should one exist, and those of us who have made smoke tests of buildings that have been in use for a few years know to what an alarming extent this danger exists; and it is the part of wisdom to reduce it to a minimum.

Eliminating from the objections named those which have reference to conditions which might result from badly planned work, or from the carelessness of the plumber in the construction of the work, or in the removal of stoppages, and which should not be advanced as arguments against the use of trap vents, we have left the one chief objection, viz., the possible stoppage of the vents by grease from sinks and by rust or scale from the vent pipes.

The stoppage of vents by grease may, to a considerable extent, be obviated, and the removal of such stoppages, should they occur, be rendered easy, by the connection of the vent with the trap in the manner shown at A, Figure 51. The

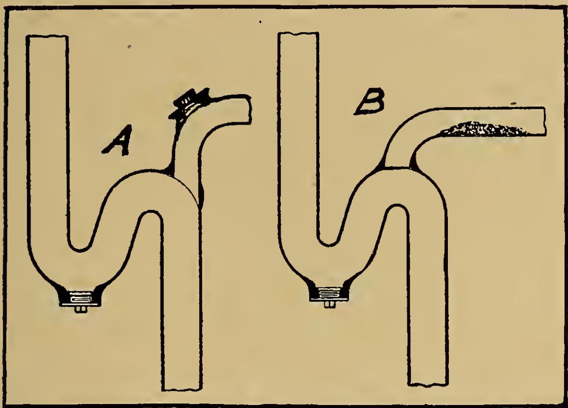


Fig. 51.

usual, and very objectionable, method is to place the vent at the crown of the trap, as shown at B, in the figure.

There are many locations where a long line of vent pipe may be dispensed with, notably where the trap to be vented is on a lower floor, by the use of what is known as an anti-siphon trap vent, a sectional view of which is shown in Figure 52.

The cup "B" is lifted by the air pressure against its under surface, and admitting a free inflow of air, as indicated by the arrows. As soon as the demand for air is satisfied, and the equality of pressure re-established between the air of the room and the air of the pipe, the cup will drop back, by gravity, into the mercury seal L.

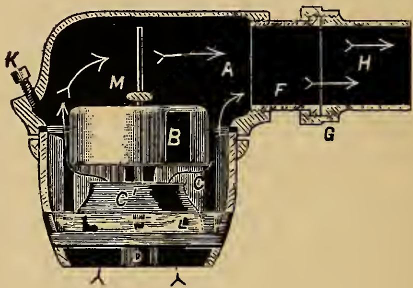


Fig. 52.

For some reason not stated, the use of this form of trap vent is prohibited by the plumbing codes of some cities in the United States. It has stood the test of years, and has been endorsed by many prominent engineers, among whom may be mentioned the late Col. George E. Waring, Jr., and is a much better method of preventing siphonage in traps than the more expensive and uncertain vent pipes extended above the roofs; but, as will be seen by a study of its construction, it would be useless as a preventive of serious back pressure. As a rule, one large sized trap vent of this kind may be made to protect the seals of all the traps in an ordinary toilet room.

Where it is preferred to sacrifice the self-cleansing properties of a trap for the purpose of securing safety against siphonage without the use of trap vents of any kind, and there is a growing tendency in this direction, anti-siphon or, as they are often termed, re-sealing traps may be used for all fixtures other than water closets and slop sinks.

In the absence of reliable tests, the conditions under which the various traps for which non-siphoning qualities are claimed may or may not be used, without back venting, with absolute safety against siphonage, will be, largely, a matter of conjecture. The only tests, of an official nature, of which we have knowledge, are those prescribed in the Cleveland plumbing code. The tests are arranged in three classes:

1. For re-sealing traps, the developed length of the waste pipes which are not more than five feet, measured from the traps to the horizontal soil or waste pipe branches of circuit or loop systems.

2. For re-sealing traps, located horizontally or vertically, not to exceed ten feet from a soil or waste pipe stack or house drain.

3. For anti-siphon traps, located horizontally or vertically, not to exceed ten feet from a soil or waste pipe stack or house drain.

For class one (1), a bell shaped tank is to be used, with a capacity equal to the cubical contents of eight feet of pipe of the same diameter as the trap to be tested. The tank is to have a five foot vertical arm, and when the contents of the tank has been discharged through the trap, the depth of seal retained shall not be less than the one and one-quarter inch seal in a plain trap.

For class two (2), the same kind of apparatus is specified as for class one (1), but the capacity of the tank is to be equal to the cubical contents of thirteen feet of pipe of the same diameter as the trap to be tested, and the vertical arm is to be ten feet. After the test, the seal retained shall not be less than the two and one-half inches seal in a plain trap.

For class three (3), a fifty gallon tank is to be placed ten feet above the trap connection, and the trap connected, by a Y connection, to a vertical pipe no smaller than the trap outlet and forty feet long over all. The entire contents of the tank is to be discharged through the vertical pipe, by the opening of a quick opening valve every five seconds, after which test the seal retained shall not be less than one inch in depth, and the volume of water not less than two and one-half inches seal in a plain trap.

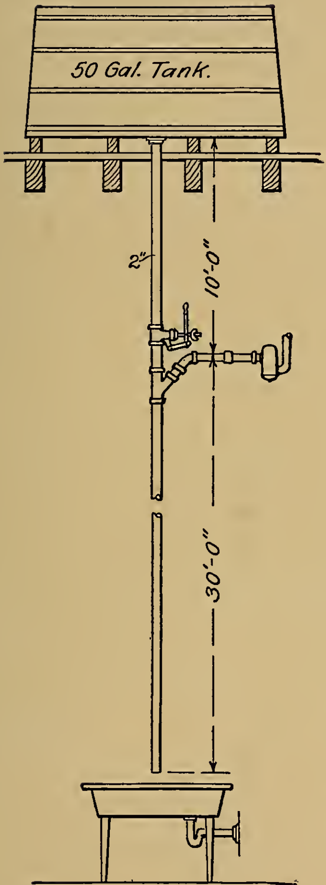


Fig. 53.

A suitable apparatus for this test is shown in Figure 53, the cut for which was kindly furnished by the publishers of "Modern Sanitation."

It is to be regretted that the code under consideration was not so framed as to place the re-sealing and anti-siphon traps in one class, under the general title of anti-siphon traps, and to provide one standard test for all such traps, because a multiplicity of standards must lead to confusion, and necessitates the carrying in stock, by the dealers in plumbing goods, of different kinds of traps for the different conditions under which they may be used.

CHAPTER VIII.

Final Test and Inspection—Subsequent Test and Inspection, Official and Unofficial.

Final Test and Inspection.—In localities having up-to-date plumbing codes, a final test and an official inspection will be required at the completion of the work.

In localities where plumbing work is not under local supervision, a final test of the work should be insisted upon by the owner of the building, and should be carried out under the supervision of some person familiar with but not directly interested in such work.

It should be a matter of pride with every plumber to execute his work in such a manner that it will stand any and every test which may be required. Such work cannot fail to commend itself and secure an increasing and continued patronage.

There are two ways in which the final test may be made:

1. By the peppermint test.
2. By the smoke test.

The peppermint test is made by pouring into one or more soil pipe extensions on the roof a quantity of oil (not essence) of peppermint, varying in amount from two to five ounces, according to the amount of piping to be tested, followed by a small pailful of very hot water, the fresh-air opening and all other untrapped openings in the pipes having previously been tightly closed. The openings into which the peppermint was poured should then be tightly closed, and the person who handles the peppermint should remain on the roof until sufficient time has elapsed to enable someone to go through every part of the building to ascertain if there is any odor of peppermint and to locate possible leaks. Toilet rooms on the upper floors should be first visited, and from thence the course should be downward, through the toilet rooms, kitchen, and pantry (if it contains a sink), on the lower floors, finishing in the basement. The bottle containing the peppermint should not be carried through any part of the house; and, while the test is being made, all windows, and all doors, both inside and outside, should be kept closed. It is scarcely necessary to state that fixtures should not be flushed at any time during the test. If hot water is laid on to the fixtures, the volatilization of the peppermint will be more complete if the soil and waste pipes are warmed up by running hot water through them for a short time prior to the insertion of the peppermint.

The principal objection to the peppermint test is that, owing to the rapid diffusion of peppermint in a room into which it may escape, the location of the leak will usually be difficult, and recourse must then be had to the smoke test. It would therefore be better to make use of the smoke test, whenever this can be done, and the piping is not so concealed as to render impossible the escape of smoke from possible defects into the building.

The smoke test is usually made by forcing into the sewer the smoke from burning oily waste, and sometimes from tar paper and oakum, under a pressure of not more than one inch of water column. Many forms of machines for this purpose are on the market, one of the best of which is shown in Figure 30, Chapter V. In making the test, the smoke should preferably be pumped into the sewer at the fresh-air opening, but where this is not practicable, it may be pumped into the extension of a soil pipe on the roof, provided a level spot can be found on which to place the machine. All pipes on the roof, and all other openings in the sewer, excepting that to which the smoke machine is attached, should be left open until smoke escapes from them in quantity, and then be tightly closed. Doors and windows in the vicinity of the smoke machine should be closed during the test. When the floating drum of the smoke machine shows the sewerage system to be full of smoke, and under the required pressure, the pumping should be stopped, the drum watched for from five to twenty minutes, according to the extent of the work to be tested, and the entire system inspected for possible smoke leaks, through defects in the materials or joints or through traps which have not sufficient water seals. If, at the expiration of the time stated, the drum continues to float at the same height, and there is no appearance of smoke escaping from the pipes, etc., at any point, the work may be considered satisfactory.

If the final test is made under the supervision of a plumbing inspector, he will usually make a thorough inspection of the completed work at this time, noting, particularly, the kind of traps used; the methods of connecting the traps with the branch pipes; the sufficiency, or otherwise, of the measures taken for the prevention of the loss of seal in traps; the methods of connecting the back vents with the traps and with the main vent pipes; and any other details which may not have been ready for inspection at the time the roughing-in test and the preliminary inspection were made.

Subsequent Test and Inspection, Official and Unofficial.—Unless complaint is made relative to the insanitary condition of the sewerage of a building, or there is reason to suspect the sewerage of any building as the source of an outbreak of a dangerous disease, official tests and inspections of the sewerage of buildings, other than those made at the time of construction or reconstruction of the sewers, will not, usually, be made.

Wherever carried out, regular or occasional tests and inspections of the sewerage of buildings have been productive of much good, but the cost of making such inspections upon an extensive scale would probably be considered a serious objection from the standpoint of the taxpayer. There are, however, certain classes of buildings which should receive at least one visit each year by an inspector, acting under the direction of the health department of every locality which has a public water supply and a system of sewers, viz.: public buildings, tenement houses, the older classes of buildings, buildings in the congested portions of cities, hotels, restaurants, bakehouses, factories and buildings of every description where the sewerage would be subject to rough or improper usage or neglect.

The failure of local health authorities to make periodical inspections of the sewerage of buildings in any locality does not, however, relieve the owners of buildings of personal responsibility in the matter. It is not expected, however, that every owner of a building will be competent to make tests and inspections of the sewerage, and to pass judgment upon its condition from a sanitary standpoint. This work should be done by a competent and reliable plumber, or, better still, by a sanitary engineer who is not directly interested in any plumbing business in the locality.

A marked improvement in the condition of the sewerage of buildings would result from a demand, by every prospective tenant of a building, for the production, by the owner, of a certificate, or other statement in writing, that the sewerage of the building was in a sanitary condition at the time of letting.

Notwithstanding that the sewerage of a building was originally well planned and constructed, buildings will settle and possibly result in fractures in the sewer pipes; alternate expansion and contraction of the vertical soil and waste pipes may result in defective joints in the branches, which are usually concealed; vent pipes may become clogged to such an extent as to render them ineffective, or nearly so; and yet many owners of buildings seemingly act upon the presumption that the sewerage of their buildings is in proper condition until a defect may be accidentally revealed, or a stoppage takes place in some part of the system, causing inconvenience.

CHAPTER IX.

THE DISPOSAL OF SEWAGE IN UNSEWERED LOCALITIES.

IN the smaller cities, and in many villages, the mistake is frequently made of insta ling a public water supply without any provision for the removal of sewage and waste water, and as a result the inhabitants are compelled to resort to the use of cesspools, thus endangering the water in the private wells—of which there are usually quite a number—and creating an unwholesome condition of the subsoil in the immediate vicinity of buildings. Such a condition is inexcusable, yet is often permitted to continue for years, and as soon as one cesspool refuses longer to do its work another is dug, until the ground is often honeycombed with these pestiferous pits.

In some such localities advantage is sometimes taken of a system of storm drains for the disposal of sewage, with the result that stoppages are frequent and the subsoil is seriously contaminated by leakages through imperfect joints.

In other such localities, where a natural watercourse is within easy distance, the sewers of many buildings are made to discharge, individually or collectively, into what in dry weather may be but a trickling stream, resulting in a foul condition of the bed of the watercourse for a considerable distance. Even where the flow of water is sufficient to effect a considerable dilution of the sewage and its removal without offense to the senses of sight and smell, the practice of discharging crude and often infected sewage into a natural watercourse, which may be used for the watering of stock or as a source of water supply for some other locality, is reprehensible and should be prohibited by law.

A very dangerous, though not very common, practice is the discharge of the sewage of isolated buildings into wells which have become dry or unfit for use as sources of water supply, or into deep borings in the subsoil. In either case the underground streams of water from which the water supplies of other buildings might be obtained would be in serious danger of contamination and infection.

For isolated buildings, where a public sewer is not available for an outlet, the sewage may be disposed of in a sanitary manner:

1. By irrigation.

2. By the use of a septic tank, with or without subsequent filtration.

IRRIGATION, as applied to sewage disposal, may be divided into two principal classes, viz., surface and sub-surface.

Surface irrigation, as its name implies, consists in the discharge of sewage on the surface of the ground, necessarily at some considerable distance from occupied buildings and from any well or other source of domestic water supply. For the proper working of this method of disposal the land to be irrigated should be comparatively dry and porous in character, and in area sufficient to provide for two or more beds, of equal size, so that the sewage may be diverted from one bed to another at frequent intervals to allow the land last irrigated to rest and regain its normal condition. The beds should be level and banked with earth on the outside so that they may be flooded to an equal depth. To accomplish the uniform flooding of every portion of the beds the sewage should be delivered in quantity and within a short space of time. This would necessitate the collection and storage of sewage at some point above the bed, and its sudden liberation at stated intervals into the sewer leading to the beds. As any arrangement for this purpose which depends upon personal attention would be very likely to be forgotten at some time or other, an automatic flushing tank should be installed in the line of the main sewer, at a point where it cannot become a source of offense to any person, and placed at such a depth as will render freezing of the contents impossible.

Where a considerable quantity of sewage is to be disposed of in this manner, to prevent saturation of the subsoil it will usually be necessary to place under-drains, made of common field tile, beneath the irrigation beds, at a depth of from four to six feet beneath the surface of the ground, and with an outlet into a ditch or other watercourse.

In sewage disposal plants of this character it is customary to effect the separation of the bulky solids from the sewage by a grating, usually in the collecting and storage chamber, from whence they are removed by hand and spread on or spaded into the ground.

While the cropping of the irrigation areas is not necessary to the purification of the sewage, vegetation will use up a large portion of the available organic matter and a considerable amount of water; will relieve the beds of much of the work they would otherwise have to perform, and, in the case of large areas, might be made to yield a fair return for the labor involved.

Where properly planned and cared for, sewage plants of this character should not be a source of danger or offense to any person, and will accomplish the purification of the sewage with the minimum of expense both for installation and maintenance.

Sub-surface irrigation, which is also known as "intermittent downward filtration," does not differ materially from irrigation proper save in the manner of applying the sewage to the land and in the

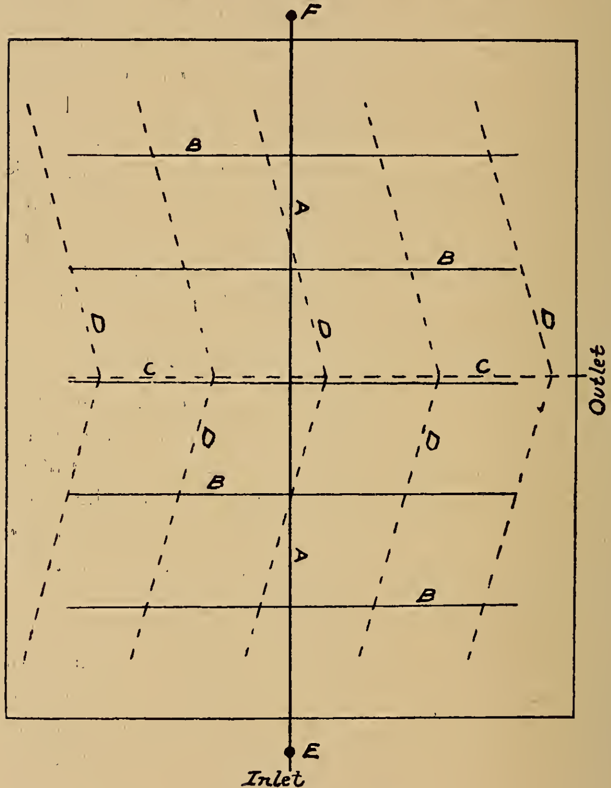


Fig. 54.

greater depth at which purification may be accomplished. In surface irrigation the purification of the sewage is said to be effected by aerobic or nitrifying bacteria, which swarm in innumerable myriads near to the surface of the earth; while in sub-surface irrigation, with a porous soil and free under-drainage, the depth at which the bacteria may be induced to perform their functions will be limited only by the depth of the under-drains. By increasing the depth of the purification beds we may limit their surface area—a very important consideration where land is expensive or limited in amount.

The general plan of a sub-surface irrigation bed is shown in Figure 54.

The main feeder A may be constructed of almost any kind of earthenware pipes, providing the joints of same can be made watertight. They should usually be 4 inches in diameter and have a fall of about 1 to 1½ inches in 50 feet.

The branch feeders B should be of porous field tile, 2 inches in diameter, and laid at about 8 inches below the surface of the beds at their highest points. The capacity of the feeders need not be greater than that of the storage tank, measured by the space occupied by the sewage just before its discharge into the feeders. The joints of the branch feeders should be open, i. e., the ends of the pipes should be about ¼ inch apart, and the upper part of the opening thus formed should be covered with some imperishable material to prevent dirt from falling into the pipes.

For the purpose of maintaining the proper grade and alignment of the main and branch feeders both sets of pipes should be laid on a board or other suitable foundation.

In order that the main feeder may be entirely emptied by the branches the inverts of both sets of pipes should be on a level, to accomplish which specially designed branch pieces should be used. Where the latter cannot readily be obtained a number of perforations in the bottom of the main feeders may be made to serve the purpose.

The main and branch under-drains, shown by the dotted lines C and D, may be of similar materials and of the same general construction as the feeders, save that they need not usually be laid on an artificial foundation. The branch drains should have a gradual fall toward the main drain, and the fall of the latter will be regulated by the difference between its depth near the bed and at its outfall. The main drain may be laid immediately under and parallel to the main feeder, or at right angles to the same, as shown in the figure.

In the event of a stoppage in the feeders it will be necessary to take up the branch feeders, but the main need not be disturbed if clean-outs are provided at the points E and F. The clean-out F should be provided with a tight-fitting stopper, but the clean-out E should be kept open at all times to assist in the aeration of the beds. As grease is one of the most common causes of stoppage in such plants, it should not be allowed to pass into the sewer, but should be intercepted by a grease trap, an illustration of a good form of which may be found in a preceding chapter.

Where only the waste water from a sink is to be taken care of, under favorable conditions the automatic flushing tank and the under-drains may be dispensed with, and a single line of sewer, with open joints at its lower end, would usually be sufficient to properly dispose of the same.

LEACHING CESSPOOLS.

Notwithstanding that much has been written upon this subject, there is still a somewhat prevalent misunderstanding relative to the inefficiency of and the danger to be apprehended from the disposal of sewage by means of leaching cesspools. That this is so, is evidenced by the fact that the boards of health of some localities endorse their use, subject to certain restrictions, as a makeshift method for disposing of the sewage of the unsewered portions of such localities.

A leaching cesspool, built in a sandy or other porous formation, will usually take care of the sewage from a dwelling, in many instances for an indefinite period, but, under the best conditions, this method of disposal cannot be considered *sanitary* and for the following reasons:

1. The leakage of sewage into the subsoil would be very variable, both as to time and amount, and the regular periods of rest, so essential for the proper working of any filtration (oxygenation) area, could not be secured.

2. The leakage of sewage from the cesspool would take place at a considerable distance below the surface of the ground, and would thus render the access to that portion of the subsoil of the proper amount of oxygen for the maintenance of the nitrifying (aerobic) bacteria practically impossible.

3. A lack of oxygenation of the sewage would result in the deposition of organic impurities in the interstices of the soil and this, in turn, in the creation of an unwholesome condition in the vicinity of the cesspool and, possibly, in the clogging of the voids in the soil.

4. Notwithstanding that a leaching cesspool may be located at what may be considered a safe distance from a well, there is always a possibility of the unpurified, and possibly infected, sewage finding its way into and contaminating an underground body of water from which wells, even at a considerable distance, derive their supplies.

The expense which would be incurred in the construction of sewers in the outlying and sparsely settled portions of many cities and villages would be very considerable and would operate to prevent the adoption of any such measures for the relief of the inhabitants thereof. Hence, resort is usually had to cesspools, and in some cities tight and leaching cesspools are used in combination. To properly construct these receptacles, especially where used in combination, as mentioned above, would entail no small expense, and, in many instances, the money expended for such expedients would go a long way toward defraying the cost of sanitary sewers.

THE SEPTIC TANK METHOD OF DISPOSAL.

Up to within a short time ago, the use of septic tanks was confined, almost exclusively, to the disposal of the sewage of cities and large villages, and of buildings of a public or quasi public character. In many parts of the country, they are now being used and installed for the disposal of the sewage of isolated dwellings, and, it is claimed, with much success.

Although the septic tank method of disposal is yet in the experimental stage, in its present imperfect condition, it is vastly superior to any other method yet devised, and there are no apparent reasons why this method, which has been successfully used in many parts of this country and in Europe, for the disposal of sewage on a large scale, should not, subject to proper control, be provided with cleanout openings above the water universally adopted for the disposal of the sewage of isolated dwellings.

The success, or failure, of a septic tank will depend, to a considerable extent, upon the correctness, or otherwise, of its design and, for this reason, the construction of such tanks should not be attempted without the aid of plans prepared by an engineer who has had much experience in this line of work.

The component parts of a purification plant of this character are:

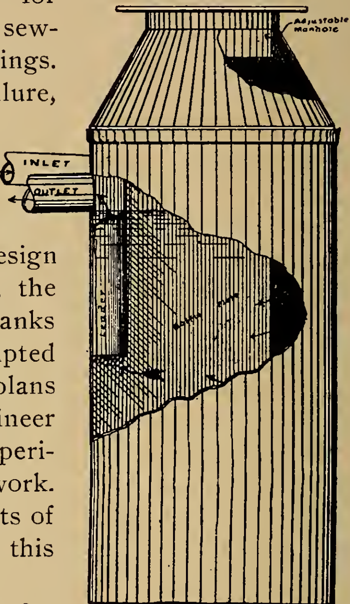
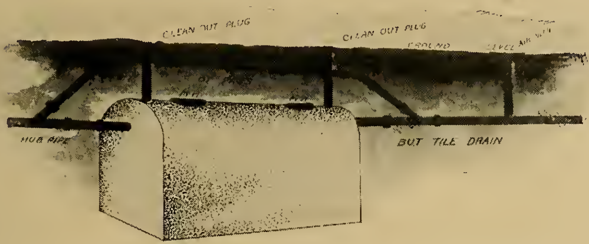


Fig. 55.

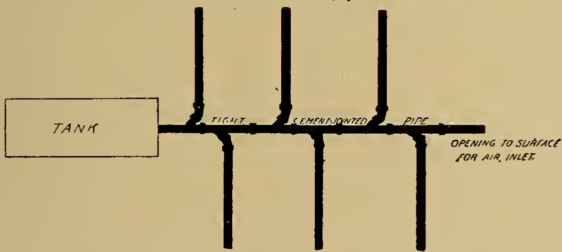
1. A septic tank, for the liquefaction and gasification of the solid matters in the sewage which can be so reduced.

2. A filtration area, for the nitrification (oxidation) of the organic constituents in the liquid sewage.

In the treatment of sewage by this process on a large scale, it is customary to install a settling basin for the removal of the coarser constituents of the sewage before it enters the septic tank. In the disposal of the sewage of a single dwelling,



- TANK:— showing detail of connection and filter appliance —



System of drain tile for Sub-soil Irrigation —

Fig. 56.

however, if the outlets of the sinks, bath tubs, and wash basins are properly protected by strainers, the cellar drains provided with proper gratings and silt chambers, and proper care is exercised in the discharge of slops into water-closets, there would be little, if any, need for this weeding out process.

Examples of domestic septic tanks in general use in certain sections of this country are shown in Figures 55, 56 and 57.

The tank shown in Figure 55 is of cast iron, is circular in cross-section and has an internal partition, or baffle, around which the sewage must travel in its passage through the tank. The effluent from this type of tank is usually discharged into an underground filter, termed a "Nitrification Duct."

The types of tank and irrigation pipes shown in Figures 56 and 57, the cuts for which were prepared by Herbert F. Shade, Plumbing Inspector, Victoria, B. C., have been used quite extensively in the locality just named. The cuts are nearly self-explanatory. It should be explained, however, that the by-pass in the sewer, extending over the tank, shown in Figure 56, is for the purpose of encouraging a draft down the openings and through the tile drain, thus aerating the sewage. It should also be explained that the partitions in the tank, shown in Figure 57, are for the purpose of insuring proper septic action with small as well as large quantities of sewage. The size of the tank is based upon a daily consumption of water equal to forty gallons per person and is 12x4x6 feet in dimensions. The first compartment is capable of treating the sewage of ten persons, and when this amount is exceeded, the sewage would pass under the first divisional board to the next compartment, and so on.

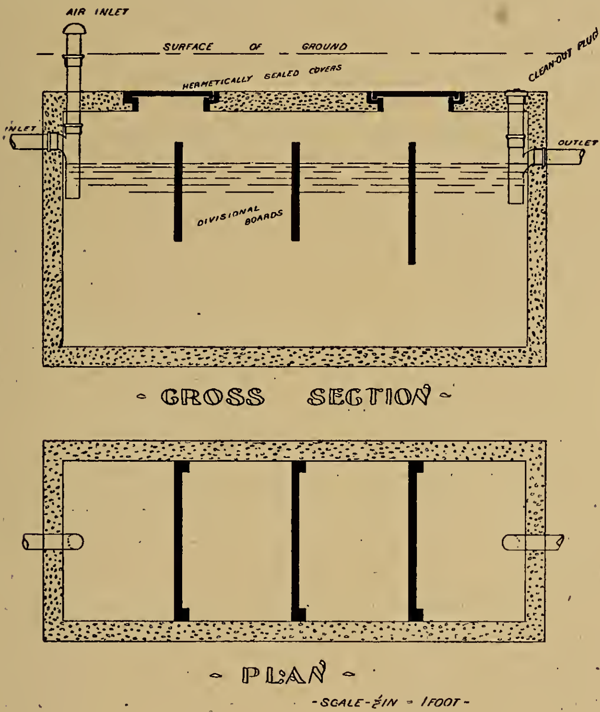


Fig. 57.

Mr. Shade states that he has personally supervised the construction of at least two hundred of such tanks and that he has yet to hear the first complaint of their not working satisfactorily.

The forms of septic tanks shown in Figures 55 and 56 do not provide for the intermittent discharge into the subsoil drains of the septicized sewage; hence, the sewage will usually pass out of the tanks in small quantities and at very irregular periods, and will not reach every part of the filtration areas, except at such times as there may be a considerable discharge from the house fixtures. The addition to such tanks of automatic flushing chambers, by which definite quantities of sewage would be discharged at regular and not too frequent intervals, would be a great improvement and would afford the filtration areas the periods of rest so essential to their proper working.

As before stated, the septic tank method of sewage purification is yet in the experimental stage, and it is claimed that, with this method of purification, it is difficult to obtain an effluent free from disease-breeding germs. For this reason, great care should be exercised in the location and construction of such plants, and it is safe to say that they should never be located where the effluents could readily percolate to underground bodies of water from which domestic supplies are or may be obtained. For the same reason, conclusions relative to the amount of purification effected by any such plants can only be drawn, with any degree of accuracy, after repeated chemical and bacteriological tests of the final effluents have been made. Where the effluent from a septic tank is discharged into leaching pipes below the surface of the ground, as in Figure 56, the determination of the purity of the effluent from the pipes will be a matter of conjecture.

Where a septic tank is used, the main trap may be omitted, and the air inlet may be placed in the sewer near to and on the house side of the tank.

With any method of treatment of sewage, to obviate pumping of the sewage, a natural slope of the land towards the outfall of the sewer will be necessary. Except in the case of large buildings, where expense might not be a serious consideration, the raising of the sewage from one level to another would be out of the question.

If the outfall of a purification plant is into a natural watercourse, to prevent interference with the working of the plant and the probable flooding of the filtration area, the invert of the main drain, at the point of outfall, should be above the high water mark of the watercourse.

To reduce the quantity of sewage to be purified to the minimum, wherever possible, the rain and surface water should be excluded from the sewers leading to the filtration plants.

CHAPTER X.

The Care of Private Sewers—Responsibilities of Owners and Occupiers of Buildings.

AS PREVIOUSLY indicated, the sewerage of a building may be well planned and constructed, and the owner of the building thereby filled with a sense of security against the common dangers and tribulations incident to house sewerage, yet, from the time the sewer and its adjuncts are first used, the seeds of trouble will be ever present and they will remain dormant only so long as the conditions are not favorable to their growth.

THE SOUNDNESS OF SEWERS—RESPONSIBILITY OF OWNER.

The responsibility for the maintenance of a sound condition of the sewerage of a building, in so far as relates to fractures in the pipes or to defective joints, resulting from a settlement of the building or from the alternate expansion and contraction of the pipes, should, very properly, rest with the house owner.

For the purpose of ascertaining what, if any, defects may have occurred in the sewerage of a building since its installation, particularly at the expiration of the first twelve months, when the building will have ceased to settle, a peppermint test should be carried out by, or at the expense of the owner, in the manner described in Chapter VII., and this test should be repeated annually.

THE PROPER WORKING OF SEWERS—RESPONSIBILITY OF OCCUPIER.

The responsibility for the proper working of the sewerage system of a building will, to a great extent, rest with the occupier. This implies, principally, a two-fold duty, viz.:

1. The prevention of the entrance to the sewer of such solid matter as would tend to stoppages in the sewer; and,

2. The maintenance of the normal level of the water seals of all traps.

Where a sewer is well constructed, the several openings to the sewer well protected by strainers, and proper care exercised in the discharge of slops into water closets, and of greasy water into sinks, the possibility of the accumulation of solid matter in the sewer to such an extent as to cause a stoppage will be very remote.

Where the outlets of the several plumbing fixtures, and the surface openings in the floors of basements, toilet rooms, etc., are properly trapped, and the traps protected against loss of seal by siphonage, back pressure, or evaporation, the possibility of sewer air entering the building at these openings will be slight.

In ordinary dwellings, the care of the sewerage should not be difficult, and the exteriors and visible surfaces of the plumbing fixtures will often be found to be all that could be desired in point of cleanliness, but, on examination, there will frequently be found a very foul condition of the traps and, in the case of cellar drains, a considerable reduction of the water seals, or an entire absence of water in the various devices for preventing the entrance to the buildings of sewer air at such points.

Care of traps.—A periodical examination and cleansing of the fixture, refrigerator and floor traps, and the occasional discharge into the floor drains of a pailful of water, would, ordinarily, serve to maintain the sewerage of a building in a sanitary condition for a long time.

Where the traps in a building are numerous, and in any case where the person responsible for the care of the plumbing is not familiar with such work, the taking apart and replacing of the trap screws should be done by a plumber. This is particularly important in the case of traps of large diameter and provided with clean out openings above the water seals, as the improper closing of such openings might result in the leakage of water or in the passage of air from the sewer to the interior of the building.

In buildings of a public, or quasi public, character; in hotels; in residence buildings occupied by many persons, as tenements; and in any building where the plumbing fixtures and accessories would be liable to rough or improper usage, the care of the sewerage will be no small task, and will require regular and systematic attention. Nevertheless, these are the very classes of buildings in which such work will, usually, be neglected until some fixture, trap, or other portion of the sewerage system ceases to perform its proper function.

Placarding in Toilet Rooms.—In these days of enlightenment, the placarding of the walls of a toilet room with notices for the guidance of the uninitiated or the restraint of careless persons who make use of the room, would seem to be unnecesary, yet this plan would prove to be a good educator and would often save considerable trouble as the result of stoppages. The following are suggested as suitable for the placarding of walls in the vicinity of wash basins and water closets:

TO USERS OF THIS WASH BASIN.

Hair, lint, matches, or any other solid substance, should not be put into the basin, as they tend to stoppages in the trap or in some other part of the sewerage system.

TO USERS OF THIS WATER CLOSET.

Matches, Apple Cores or Parings, pieces of hard paper, cloths, or any other foreign substance, should not be thrown into the bowl as they tend to stoppages in the trap or in some other part of the sewerage system.

Grease Traps.—In buildings where grease traps are used, they should be cleaned out as often as a considerable scum forms upon the surface of the water in the traps. Where no grease trap has been provided, very greasy water should not be thrown in the sink, but should be thrown on a piece of land, if the same is available, and not too often in the same place. Occasional spading of the land where such slops are thrown would be advisable.

Flushing of Sewers.—Where a sewer has not a sufficient fall and a flushing tank has been provided for the purpose of keeping the sewer free from deposits, the tank should be examined frequently to ascertain whether it is performing its proper function. Where no special means of flushing are provided for such a sewer, and there is a trap in the floor of a basement room, a powerful stream of water, from a hose inserted in the trap at least once in each week, would be of considerable service in keeping the sewer clean.

Air Inlets.—When placed on a level with or but slightly above the surface of the ground, the air inlets of sewers may become defective, or choked with dirt, leaves, snow, etc., and they should be examined at frequent intervals to ascertain whether they are in working order.

Purification Plants.—In the case of buildings not connected with a public sewer, but which are provided with purification plants, the latter should receive frequent and regular inspection, with special reference to the rapidity with which the sewage is escaping from the filtration areas. If sewage remains for any length of time in the drains from which it is supposed to leach into the filtering medium,—as can be ascertained by means of the grade openings provided for the ingress of air to the drains—clogging of the pores of the filtering medium would be indicated.

Sewerage in Unoccupied Buildings.—There are two principal dangers to be apprehended from the sewerage of unoccupied buildings, viz., in the mild and warm weather, the evaporation of the water seals of fixtures and floor drains, and, in winter, the freezing of the water in the several traps. For the prevention of the evaporation of the water seals, oil, of one of the heavier, non-drying kinds, should be carefully poured into the traps, in quantity sufficient to form a thick layer on the water; or, if the building is to be vacant for a considerable time, the water may be removed and the trap filled with the oil. The latter method will also be suitable for the protection of the traps of such buildings during freezing weather. When the buildings are again occupied, the oil should not be allowed to enter the sewer, but should be carefully removed from the traps and the traps cleansed with a hot solution of common soda, or other suitable alkali.

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