Lancelot Newton
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HOUSE DRAINAGE.

HOUSE DRAINAGE MANUAL:

A GUIDE TO THE

DESIGN AND CONSTRUCTION OF SYSTEMS OF DRAINAGE AND SEWAGE DISPOSAL FROM HOUSES.

BY

WM. SPINKS,

ASSOC.M.INST.C.E.; MEM.SAN.INST.; MEMBER OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS; PRESIDENT INSTITUTE OF SANITARY ENGINEERS; LECTURER ON SANITARY ENGINEERING, YORKSHIRE COLLEGE (VICTORIA UNIVERSITY); PRESIDENT OF SANITARY ENGINEERING SECTION OF CONGRESS OF BRITISH INSTITUTE OF PUBLIC HEALTH, 1895. AUTHOR OF "PAVING AND MAKING GOOD PRIVATE STREETS," "VILLAGE DRAINAGE," ETC., ETC.

WITH

TABLES, ILLUSTRATIONS, EXTRACTS FROM THE PUBLIC HEALTH ACTS, METROPOLIS MANAGEMENT ACTS, AND MODEL BY-LAWS RELATING TO HOUSE DRAINAGE.

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PREFACE.

A complete treatise on drainage would be of the nature of a trilogy, in that it would have to discuss phenomena at the entrant end of the system, in the connecting ducts, and at the exit end. Each of these divisions can, however, with advantage be treated separately, and this book is the outcome of an effort to consider in the light of modern knowledge more especially the principles to be followed in the proper designing and the apparatus connected with the due construction of the entrant end of a drainage system. Reference has necessarily been made to the other parts of a system in order to obtain a better understanding of that which has been treated more fully. The preparation of even a short work of this kind takes considerable time, and in these days of rapid progress there must necessarily be apparatus that remains undescribed. The great point to be aimed at is a clear conception of the principles to be followed. The reader having obtained such knowledge will be able to discriminate between the various apparatus as to which is most suitable for any specific purpose.

In order to make the work of greater service to property owners and leaseholders, comprehensive chapters have been added on the law relating to house drainage.

The author is indebted to a large number of manufacturers for description of special apparatus and for drawings from which to prepare the illustrations used in the book, and hereby tenders to each of them his best thanks for the assistance thus rendered.

W. SPINKS.

Prudential Assurance Buildings, Leeds,
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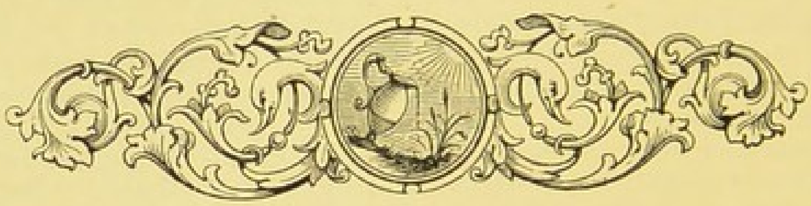

HOUSE DRAINAGE.

INTRODUCTORY.

At the present time vast sums of money are being spent by sanitary authorities in providing new and complete systems of sewerage and sewage disposal for the districts under their control, but if the work stops short here the improvements which should be effected in the general sanitary condition will only be partial. To be a thorough success, the scheme must be completed by a general overhauling of the house drains that require to be connected to the new sewers, and their reconstruction undertaken upon a sound basis so as to ensure the speedy removal from about the dwelling of all the sewage and waste water, with proper provision against the escape of sewer gas and for ventilation and flushing of the drains. The principles of house drainage should now be well understood, and the methods prescribed in the model code of by-laws can no longer be dubbed new-fangled, seeing that they have been practised for something like twenty years with but slight variations. It is unnecessary to enlarge upon the evils and disasters which invariably follow badly designed and executed drainage work, as they have been pointed out in so many treatises, and recorded by the Press, as to be well known to all students of sanitary science. The percentage of houses which have satisfactory sanitary arrangements is, unfortunately, exceedingly low, nor is the number confined to any particular class of dwelling, as those engaged in making sanitary surveys well know. My own experience as a householder and house-hunter has taught me also that this condition of things is not confined either to one locality or one county. Apart from the danger of living in a house where the sanitary arrangements are imperfect, there is likewise the inconvenience and discomfort experienced from such a condition of things, and for which there is no excuse; their origination and conception may have been either due to ignorance or greed, but their maintenance is intolerable in these days of inspection and super-inspection, with all the powers and machinery that the law provides for the abatement of nuisances. The ordinary householder or houseowner is generally indifferent to these things. Drains, being out of sight, are probably out of mind, and conveniently kept so: and it is only when drain-begotten diseases arise in a house that attention is given to them, and then in great haste the services of an expert are requisitioned. It is gross folly to rely implicitly upon the builder and his staff in the designing and execution of house drainage work. The "practical man," with his rule-of-thumb, and his lord high executioner, the "odd man" who is set to do the work, have sown the seeds for many a harvest that death has gathered in. A complete system of house drainage is a hydraulic machine, and requires as good materials for its construction as good labour to piece them together, and as skilled brains to devise and supervise, as any other class of machine; and it is a machine which ought to have the foremost consideration in the designing of a house, and not be left to be engrafted on after the plans are all settled. For this purpose the services of an expert are required—

one who is familiar with the requirements of a habitation, with the designing of drainage systems, and the hydraulic laws and principles governing them, experienced in the various classes of materials required and the labour and workmanship which is necessary.

I have endeavoured in the following chapters to point out how house drainage systems should be conceived, designed, constructed, and kept in good working order. In the first place, I deal with the general defects, etc., met with, and the requirements of houses; having arrived at the latter, the next stage is the preparation of the plan showing the course of the drains, then the consideration of the laws and conditions which govern their size, and after that the means to be taken to ensure perfect ventilation and cleanliness in the system. The methods of construction, with the various details, will to some extent differ according to the experience and custom of the designer, but these do not in any way affect the principles. For the purpose of assisting students and those engaged in designing this class of work, and making the explanations clear, drawings or diagrams are inserted, showing the types of appliances referred to. It is quite impossible in a work of this character to reproduce all the good things known in sanitary practice, and I have no doubt overlooked some of unexceptional merit.

The method of disposing of sewage in cesspools as ordinarily practised is a most insanitary one, filthy, and extremely dangerous to health, due to inadequate capacity, bad design, improper construction, the direct connection of drain thereto, want of attention, failure to remove contents and to cleanse at proper intervals. Cesspools hold highly putrescent solid filth, and many of them are also provided with overflows, so that the liquid flowing out is more concentrated than the sewage flowing in. There are also the faults due to position, whereby percolation from them causes contamination of the surrounding subsoil, and very frequently the sources of water supply also.

The slovenly and haphazard way in which sewage purification is so frequently done, especially at farm-houses, cannot be too severely condemned. "Rough irrigation" it is sometimes called—certainly rough, and likewise very nasty. A close examination reveals the fact that the drain is made up, joints have been forced, and the sewage is flowing unchecked into a watercourse from which grazing cattle drink; or, may be the pipe delivers only on to one spot in the field, very often quite close to house or garden, and the immediately contiguous ground is supersaturated and impregnated with filth, and because it was there when the farmer was a boy, and he has heard his father speak of the antiquity of the system, it is regarded with admiration. Giles and his brood may, from living altogether in the open air, be hardened to its noxiousness, but many a casual visitor who has come into the country to spend a happy day has returned in company with the typhoid germ locked in his bosom, or other part of the body that it prefers for its propagating propensities. Improvements upon these crude arrangements may be effected by adopting any one of the systems mentioned in the chapter on "Sewage Disposal" which is best suited to the special conditions prevalent.

CHAPTER I.

SANITARY SURVEYS.

Examination.—In making an examination of existing property for the purpose of ascertaining its general sanitary condition, the first stage on the part of the examiner is to procure a plan showing the course of the drains, which must be carefully traced, and all deviations and rearrangements recorded. Failing this, a sketch plan must be made, but in noting the course and position of the drains too much reliance must not be placed on the oral evidence tendered. The source of this evidence is usually the gardener or plumber who is accustomed to execute repairs about the house. The information they have to offer may be respectfully received, but the inspector must rely on his own observation, and take such measurements and have whatever openings made as are necessary in his judgment. He should mark on the plan the position of all gullies, waste, soil, and down pipes, both external and internal, examine all cellar areas to see if there are any gullies in the floor or pipes emptying at the sides, and trace the route of such pipes, their origin, and the purpose they serve. He must trace the course through the house of all waste or rain pipes, whether in casings or not, and note where they terminate. The point of discharge of the various branch drains may be ascertained by pouring down each waste or soil pipe and each gully separately a quantity of whitened water, and noticing whether it appears in the main drain at an opening which, failing an intercepting chamber, should be made for the purpose at the lowest point in the drain contiguous to its connection to the main sewer. The object of this test is to ascertain that all the branches are free and unobstructed in their course to the main drain, and are not connected to any disused or subsoil drain. In the basements of many houses will be found subsoil drains which the builder may have put in to clear off a wet spot in his excavations during the erection. From time to time fresh sanitary appliances are added in houses, such as an extra bath or lavatory, and the plumber may have carried his waste-pipes directly into such a drain, deeming that as it is only soapy water that has to be carried away it is of no importance. It must also be remembered that these casual alterations are very seldom made under the supervision of either architect or engineer. In my own experience I have come across large mansions literally honeycombed with stone subsoil drains and having all waste-pipes from lavatories, sinks, and baths, and even soil-pipes, connected directly into them. The course of these subsoil drains must be carefully noted, as well as the purpose which they serve, and their point of discharge ascertained. The position of the outside closet must also be noted, as well as its character and condition. If it should be a privy midden, then the floor and sides must be examined to ascertain whether there is any percolation into the surrounding subsoil. If the house is not connected to any system of public sewerage, then the outfall of the drain must be found and its position with regard to the house recorded, as well as the condition of the place where it discharges. If it should discharge into a cesspool, the shape, dimensions, and capacity of the cesspool must be taken, and the periods of cleansing ascertained. Note if there is any overflow pipe, and, if so, trace it to its ultimate destination, and record its position. Examine the quality of the brickwork throughout the cesspool, and see if there is any leakage or percolation. Note the position of any well, and record it; measure the distance from any privy midden, cesspool, gully, or drain, and test for leakage from drains into well. In many old houses, before a public water supply was available, the roof water was frequently collected in storage tanks placed under the floor of the back kitchen or wash cellar. These must be traced, as well as the possibility of there being any connections from rain-pipes still remaining. One very important point relating to these soft-water tanks and wells must not be overlooked, and that is the diversion of sewage into them caused by rat runs. Where rats frequent a drain they often make a burrow from it to a well, through which the sewage becomes diverted, thus contaminating what may possibly be the only source of water for drinking supply. My father, who is an old medical practitioner, once related a case to me that came within his own knowledge of a serious and fatal outbreak of typhoid fever amongst the occupants of some country cottages, where, on pumping the well dry, not only the decomposing carcases but the skeletons of rats were found at the bottom, and further exploration revealed a burrow from the drain.

In all modern systems of public water-supply service, the cisterns, either for storage or flushing, are required to have overflows acting as warning pipes, so that there is no fear of these being connected to the drains. Still they must not be overlooked. Even in town houses large disused storage cisterns remain, and the overflow and scour-out pipes must be traced, as they are sometimes found to be connected to the drain by way of the soil-pipe.

An external sanitary survey cannot be complete without an examination of the subsoil, the levels of the surrounding ground and the dip of the strata noted, and the possibility of any drainage finding its way thereto from contiguous property. The ground should be opened on the highest side, and the depth of the water-bearing strata ascertained and the level noted, with its relation to the levels of the basement floor recorded.

For the purpose of testing the soundness of these drains outside, a water test should be applied. The drain being stopped at its lower point by a screw stopper (of which there are many satisfactory kinds in the market) and filled with water from the higher end, the action of the water must be carefully noted, and if subsidence takes place, or if quiescence is unattainable, it is a sure sign of defective joints, and the drain must be condemned. All the exposed pipes and drains in the interior of the house should be tested by smoke, or by the insertion of a tube containing some pungent odours, at the lowest point, care being taken to stop up with wet cloths all vent or other pipes having communication with the open air, so that the escape, if any, may be confined to the interior of the house. Sometimes a combination of the odour and smoke test may be used with advantage. These are very powerful tests on account of their penetrating properties, for wherever smoke will issue, so will sewer gas also. In addition to its value in disclosing defective joints and fittings in the plumber's work, there is also the possibility of discovering disused and faulty drains by means of the smoke finding its way into them—that is, drains which for some reason or other have been allowed to remain connected, and which may extend underneath the house. It also discloses leaks into cavities in the walls, from which the smoke may issue in unexpected places, and otherwise assists in tracing the course of the drains under the basement floors. The smoke test is applied either by the insertion of suitable rockets or by the pumping in of smoke from a small hand machine. The odour test is usually applied in the interior of the house by inserting past the highest trap of the suspected pipe a sealed glass tube containing a pungent drug attached to a ball float, secured by a convenient length of string. The discharge of a flush of water from the cistern will dash the tube against the side of the pipe, and, by smashing it, liberate the odours it contains; these are extremely penetrating and easily detected. The method of pouring oil of peppermint down the pipe is apt to fail, on account of the chance of some portion being spilt over the clothes or hands of the operator, who will thus carry the odour about with him; on this account the glass tube system is the better one.

CHAPTER II.

Defective Drainage.

The Old Style.—Our ancestors, judging by the works they have left behind them, seemed to have the crudest ideas as to the best means of conveying sewage from habitable buildings. The ancient Briton, and his successor for many centuries, was content to allow his filth to soak into the surrounding ground, but then he had not a daily paper on his breakfast table bristling with the returns of the Registrar-General's Department to rouse him with its tables of vital statistics. It is only within comparatively recent years that engineering science has applied itself to the modest function of designing conduits for conveying sewage, and the highly-glazed stoneware pipe which is now so common was evolved from the egg-shaped pipe, whose existence was unknown half a century ago. The brick culvert at that time was in general use, except in the northern part of the country, where they had their "stone age" in the form of a culvert of rough ashlar, and which ought now to be as extinct as the "dodo," but unfortunately is not, as it is very common indeed in those parts of Lancashire and Yorkshire adjacent to the Pennine Range to find many public sewers and house drains of this type.

Stone and Brick Drains.—It should be evident to everyone, even to the merest tyro of a nuisance inspector, that by no possibility can such drains be suitable for conveying sewage, and their very existence is always a standing source of danger to the health of the inhabitants. They are invariably full, or nearly so, of a deposit of putrefying sewage slime, which can only be removed by spade labour. Flushing would be of no avail, inasmuch as both the sides and bottom of the drain have open joints. The form of such a drain is opposed to all known laws of hydraulics, and the flow of the liquid is most erratic, and the matter carried along in suspension settles rapidly. The size, too, seems to have been designed (not calculated) so

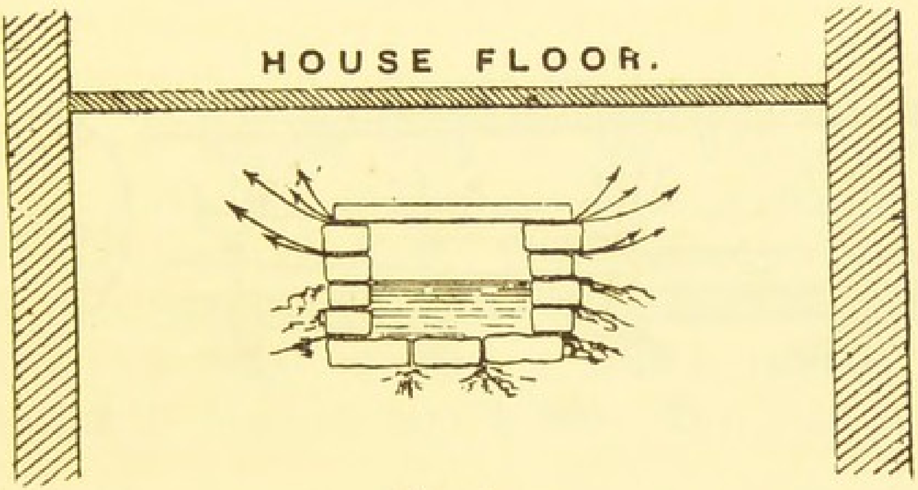

Fig. 1.

that the sewer could be traversed by a man along its entire length, perhaps for the purpose of repair, and thus we have a huge underground reservoir of foul air, tapped at various points by the inlets that have been made into it from the several branch drains. The accompanying Fig. 1 well illustrates the condition of things which is invariably found whenever these stone drains are examined.

Pipe Drains.—The earliest form of the salt-glazed stoneware pipe was an ovaloid, but not of the proportions as are now commonly applied in the construction of brick sewers—viz., 3 by 2—the radius of the invert being $\frac{1}{2}$. The invert of the egg-shaped pipe came almost to a point at the intersection of the side arcs, consequently the excessive friction set up materially reduced the velocity of the sewage and caused deposit. Nor had the pipes any sockets, so that the joints are open, and floating matters, such as bits of sticks or clothes' pegs, frequently get fast in these joints, and lying across the pipe arrest other objects, such as pieces of cloth, etc. Thus a stopped drain is very frequently caused. In some northern towns that I am acquainted with there are still many thousands of yards of these

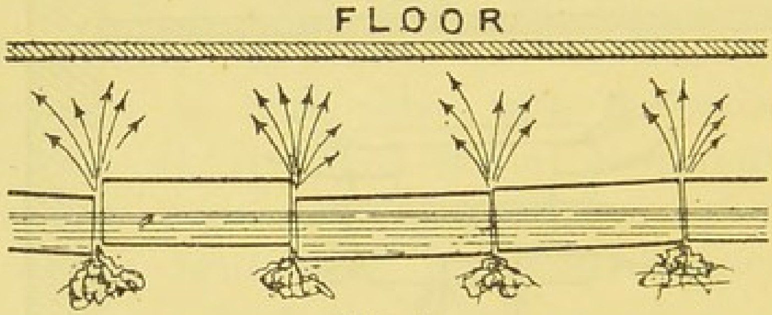

Fig. 2.

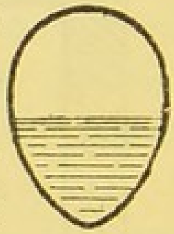

Fig. 3.

egg-shaped pipe drains, and whenever they are examined there is invariably found a great amount of deposit in them, and their condition is such as is shown by Figs. 2 and 3.

Many people there are who imagine because a drain is formed of circular socketed pipes it cannot be amiss, and how common it is to hear an assurance, "Oh, the drains are all right; they are all pot pipes." Yes, there are pipes and pipes, and even in the very best pipe yards accidents will happen. A pipe may get slightly damaged in the green state when drying; it may miss the glaze when in the kiln, or get cracked or twisted by sudden extreme rises in the firing. All such pipes when the kiln is unpacked are put on one side, and are known in the trade as "seconds." It is these that our friend the "jerry" builder is so "sweet on," and with the help of his odd man, who is considered quite good enough to lay a drain, he lays the seeds of a fine crop of nuisances, to be subsequently taken

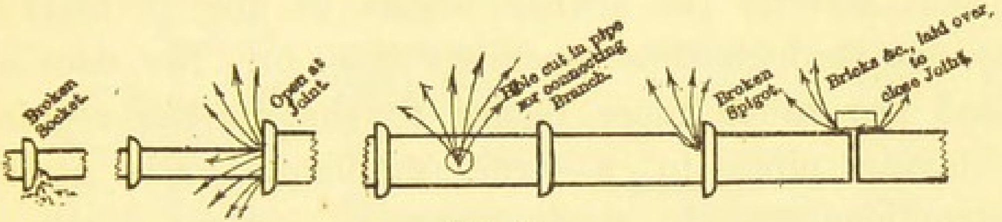

FIG. 4.

in hand by the very people who ought to have prevented his scamped work in the first instance. Fig. 4 is a very fair illustration of the way in which this kind of work is done. There is no pretence at jointing, and should they happen to run short of a particular size, say of 6in., a 4in. is rammed in, or the 6in. is rammed into a 9in. The same style

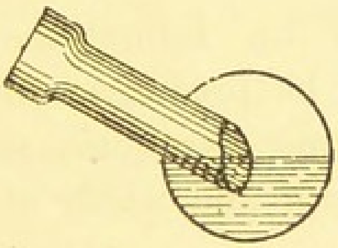

FIG. 5.

of work is found in the making of junctions or in connecting to the main sewer. It would involve too much labour and expense to take out three pipes and insert a bevel junction pipe, so a hole is knocked in the main and a straight pipe shot through, often projecting so far across it as to cause a stoppage (as shown in Fig. 5), and the unfilled-up part of the hole is made-up with pieces of slate or broken bricks. The laying of drains in straight lines is a practice carefully avoided by the odd man, who has an artist's eye for graceful sweeping curves, which he invariably makes with straight pipes by chopping a piece off one side of the spigot end, thus leaving a great gap in each joint at the outer edge of the curve, so that directly the sewage begins to flow it finds its way out through these openings (Fig. 6). Nor does our friend pay much more regard to the niceties required in laying pipes to a true gradient. His general instructions are to work up to a certain depth at the far end, "to be sure to give it plenty of fall,

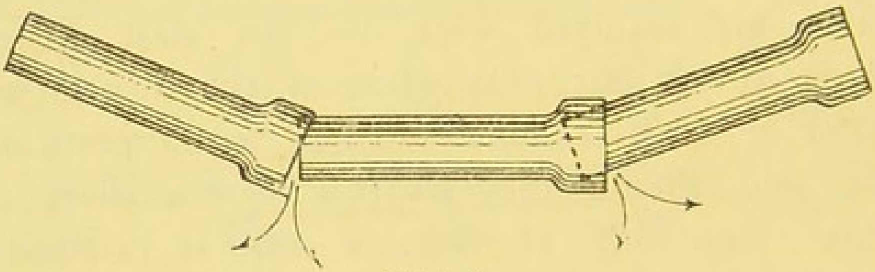

Fig. 6.

and get it covered up before the surveyor catches you." Consequently he produces a delightfully fantastic line making serpentine gyrations, seemingly only held in check by the depth and width of his cutting.

Gullies.—Many houses are riddled on the basement level with gullies to carry off nothing but the water which is used for washing the floors, and as this is perhaps only done at wide intervals of time, there is always a great danger, even in the best types of gullies, of their losing the water seal by evaporation. There is no occasion for any drain to be brought inside a house except under certain unavoidable conditions, and it is surprising how many houses there are that are directly connected to the main sewer by cellar drains, the only check against the inroad of sewer gas being the gully trap (when it has one); but the traps are so frequently of such a bad shape or so badly laid that they serve no preventive purpose. Those shown in Figs. 7, 8, and 9 are only instances of which hundreds similar might be adduced.

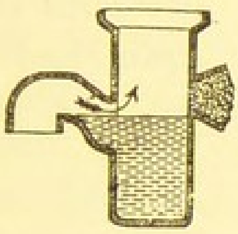

Fig. 7.

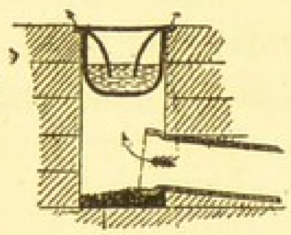

Fig. 8.

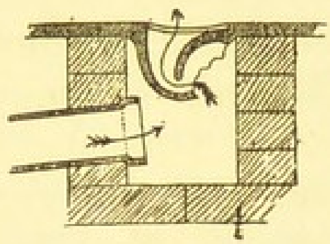

Fig. 9.

Traps.—The drains we are often assured are well trapped, the idea presumably being that a trap has marvellous powers of preventing the inroads of sewer gas, regardless altogether of its form, size, the position in which it is placed, or the method of laying it. A covered trap is altogether useless and a source of danger, as the sewer gas will impregnate the water

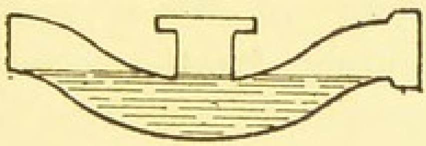

Fig. 10.

standing in the trap, and be given off on the house side and pass on up the drain and its branches. A particularly foul and objectionable type of trap is that shape known as the "manhole" trap (Fig. 10), in which the filth and slime accumulate at the sides of the handhole; and if there should be a shaft carried up to the surface with open cover, there will always be an escape of foul air from this standing and immovable filth.

Soil-Pipe Connection.—The connection of the soil-pipe to the drain is often another source of mischief, and very carelessly executed. It frequently is made to a 6in. drain, the joint being completed with clay. I remember one case being pointed out to me with pride by the sanitary inspector under whose directions it had been executed, where this 6in. branch drain had been inserted into a 9in. pipe without the use of a proper

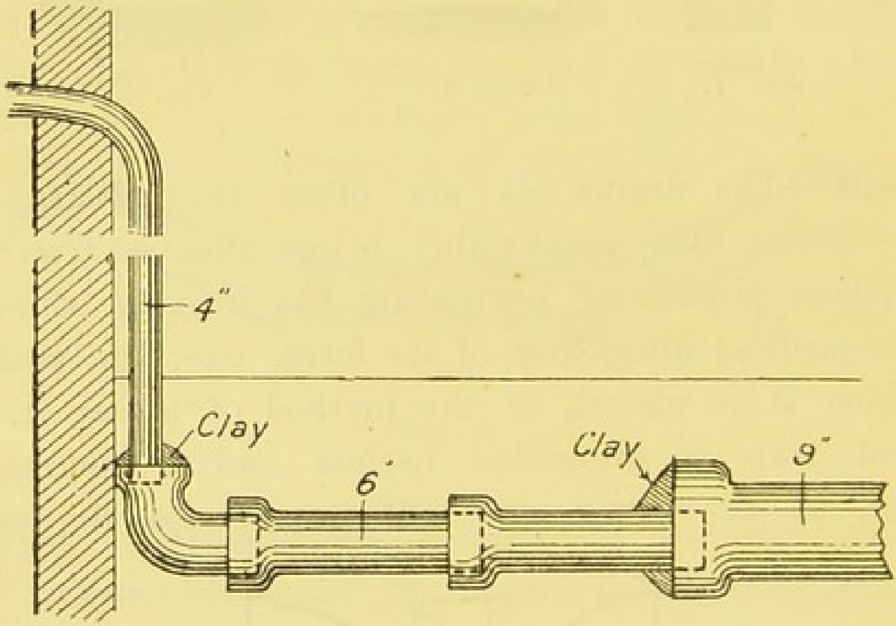

Fig. 11.

taper, and the filling being made up with clay puddle; the sketch (Fig. 11) will illustrate this little piece of official sanitation.

Rainwater Pipes.—In many districts the rain-water down pipes are connected directly to the drains, and very often in much the same method as described above for the soil-pipe. There is no doubt that this is a very mischievous practice, and one that is fraught with much danger to the public health, and should be avoided by all sanitarians. The joints being made of inferior materials allow the escape of sewer gas in the neighbourhood of windows and doors, and it also travels from the spout-heads under the eaves and so into the house. At the very time when the pipe should be of the most service as a ventilator—that is, when the air in the sewer is being displaced by the sudden influx of rainwater—it is of the least service owing to its capacity being reduced by the descending column of water from the eaves' spouting. Another dangerous feature is the connection of the gutters from bay-window heads into the down spouts. In the majority of instances there is a bedroom window immediately over the bay, and when this is thrown open to air the room, sewer gas will find its way in through this small connecting pipe.

These are typical illustrations of perhaps the most common and universal defects in drainage work, and those accustomed to the making of sanitary surveys can no doubt call to mind hundreds of others of the species.

One great disadvantage in this class of work is the absence of any means for inspection; and the difficulty in finding the exact position of the drain or the junctions, and the consequent cost which is entailed in tracing them out by excavation. There is also little chance of making satisfactory amendments, and the best course is to root everything out and begin again *de novo* on right lines.

CHAPTER III.

Requirements of Houses.

Consumption of Water.—The amount of sewage which has to be drained away from every house depends entirely upon the consumption of water by the household, because sewage, after all, is the clean water taken into the house for dietetic and domestic purposes, and which, being fouled in those operations, is afterwards poured away as waste. It is very difficult to gauge exactly the amount so consumed, as everything depends upon the personal habits of the occupants, and the amount may vary anywhere between seven gallons per head for the occupants of the town slum to seventy gallons per head for the occupants of "villadom," where the daily tub is in general use. Probably about sixteen gallons per head per day will be found to be a fair average to allow all round. Dr. Parkes says that he found twelve gallons to be the amount used by a clean, healthy man of the middle class belonging to a fairly clean household, which he sub-divided as follows:

Cooking	·75
Fluids as drink (water, tea, coffee)	·33
Ablution, including a daily sponge, bath taking two and a half to three gallons	5
Share of utensil and house washing	3
Share of clothes' (laundry) washing, estimated	3
	12

And where water-closets are in use in the house another four gallons may be added, giving a total of sixteen gallons per head per day. This must not be confounded with the amount of water allowed per head of the population per day, as there are in that case other considerations, such as trade use, waste, public uses, fire, and so on; but the sixteen gallons may be taken as the amount of sewage per head per day flowing from each house in the shape of waste water from cleansing, cooking, ablution, washing of clothes, and the flushing of soil-pipes, and which finds its way into the drains. Mixed with the above there are the evacuations of the occupants of the house, which, to again quote Parkes, can be put at two and a half ounces of fœces.

Composition of Sewage.—The whole of this, when combined, as will be readily understood, forms a most complex liquid containing a high percentage of nitrogen and ammonia. Decomposition sets up directly it passes into the drain, and may be said to reach its most active stage after the lapse of from three to four days, though in some states of the atmosphere the time is longer. Often very fœtid substances are given out, and the following gases have been traced: Sulphuretted hydrogen, bicarburetted hydrogen, carbonic acid gas in excessive quantities, marsh gas, and ammoniacal gas.

It is a popular idea that where water-closets are not in use the sewage is comparatively harmless, and not liable even to cause pollution of streams. The least amount of reasoning will soon prove the fallacy of this line of argument. Supposing the solid fœces are abstracted from this complex liquid, there still remains the bulk of the urine in the sewage, a large proportion of which comes in in the form of chamber slops. One would have thought this question was finally determined and set at rest a quarter of a century since by the report of the Rivers Pollution Commission, where the analyses of the two classes of sewage were shown to be as under:

TABLE I.—AVERAGE COMPOSITION OF SEWAGE.

In Parts per 100,000.

Description.	Total S lid Matters in Solution.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Total Combined Nitrogen.	Chlorine.	Suspended Matters.		
							Mineral	Organic	Total.
Midden towns	82·4	4·181	1·975	5·435	6·451	11·54	17·81	21·30	39·11
Water - closet towns	72 2	4·696	2·205	6·703	7·728	10·66	24·18	20·51	44 69
In Grains per Gallon									
Midden towns	57·68	2·926	1·382	3·804	4·515	8·078	12·467	14·910	27·377
Water - closet towns	50 54	3·287	1·543	4·692	5·410	7·462	16·926	14·357	31·283

In addition to sewage as above described, where there are stables, cowhouses, and piggeries there will be the sewage from them to be conveyed away, as well as the water used in washing carriages, etc.

Essential Conditions.—In addition to the domestic sewage created in and about a house and its offices, the drain has also to serve as a conduit for conveying away the rainwater which falls upon the roof and paved and flagged surfaces of the yards, courts, and areas. These areas will, of course, vary in extent according to the size and character of the house, ranging from fifty square yards in the case of town cottages to something like a thousand in the suburban detached villa. The quantity which flows from these surfaces, and the speed at which it reaches the drain depends of course upon the rainfall and the amount of evaporation and absorption taking place. Some authorities assume that one half the rain that falls finds its way into the drain during the time occupied by the fall. It must not be forgotten, however, that the whole of the surfaces about a house are practically impervious, that vitrified tiles and paving bricks, asphalte, cement, or other non-absorbent materials are used in the yards and courts, and that the joints of sett paving are grouted with pitch or cement, so that it will be more prudent to discard any loss by evaporation and absorption, and to provide for carrying off the greatest quantity which is likely to fall even in extreme and unusual storms, and which may be put down at four-hundredths of an inch per minute continuing for half an hour, producing in that time 1·20in. in depth.

If, then, the house is to be healthy, a drainage system must be devised that will remove immediately from its precincts both the sewage and rainfall in a perfect manner, so that the site may be dry and unpolluted. The air in and about the house must not be contaminated from excreta or decomposing sewage, nor the water supply fouled by either direct or indirect contact with the sewage or its emanations.

These, then, are the functions of a perfect drainage system; and its conception must be influenced by certain essential conditions which form the only basis upon which a successful and complete workable scheme can be devised, and which may be classified as follows:

1. *Removal of Sewage.*—That the sewage must be rapidly removed from the building and its precincts, and the drains be "self-cleansing," so that there is no stagnation or collection of deposit in them.

2. *Surface and Subsoil Water.*—That, wherever practicable, the surface and subsoil water shall be conveyed away in separate drains.

3. *Line of Drains.*—That all drains shall be laid out in straight lines with true gradients from point to point.

4. *Turning.*—That all turning shall be done in manholes or inspection shafts, which must be placed at every change of direction or gradient.

5. *Drains to Terminate outside House.*—That drains shall not pass from sewers to the inside of houses, but end at an outside wall.

6. *Drains under Houses.*—That drains shall never pass under buildings where it can possibly be avoided, and in towns where drains have to be carried through the house from back to front special precautions must be taken.

7. *Separation of Branches.*—That all important branches must be independent and concentrated in a turning chamber, and all branches be as short as practicable.

8. *Inspection Chambers.*—That the drains shal in ali parts be readily accessible for the purposes of examination, testing, and cleansing.

9. *Watertightness.*—That the best materials be used and skilled labour employed to ensure the drains being watertight, so as to avoid pollution of the soil.

10. *Size.*—That drains shall not be larger than necessary for the maximum duty they may have to discharge, as the larger the drain in proportion to the quantity of sewage passing through it, the less the power of the sewage to carry solid matters along, and *vice versâ*.

11. *Falls.*—That the falls of drains shall, wherever possible, be sufficient to produce a self-cleansing velocity for the small amount of sewage that is usually discharged through them, apart from rainfall.

12. *Depths.* — That excessive and unnecessary depths must be avoided. Special means must be taken to effect the change of levels in drains.

13. *Disconnection of Main Drain.*—That the air communication between the public sewer and the house drain shall be severed by means of an intercepting manhole or shaft.

14. *Disconnection of Long Branches.*—That all exceptionally long branches shall in like manner be severed from the main house drain.

15. *Ventilation.*—That the drains must not terminate in a dead end, but be amply ventilated by openings, so as to create an undiminished current of air through them.

16. *Inlets to be Trapped.*—That all inlets to drains shall be properly trapped, with the exception of those used for the purpose of ventilation.

17. *Wastes to Discharge in Open Air.*—That all waste-pipes from sinks of every kind, baths, lavatories, and other appliances from which foul matter is discharged, and rainwater-pipes, must discharge over a gully placed in an accessible position, and connected with the drain outside the house.

18. *Flushing.*—If the available fall is not sufficient to produce a self-cleansing velocity in the drains, provision must be made for regular and frequent flushing.

Where the discharge of sewage into drains is only intermittent, and not sufficient to prevent deposit in drains that may be laid to a satisfactory gradient, an automatic flush tank should be fixed at the head of such drains.

CHAPTER IV.

The Planning and Arrangement of Drains.

Before ever a ground plan of a house is inked in by the draughtsman, the position of all the sanitary arrangements and fittings, their waste-pipes, and the drains to which they are to be connected should be finally determined. This can only be done successfully by a careful study of the proposed elevation, so as to select such a position for the soil, vent, and waste pipes, as will allow them to be carried down without unnecessary bends. It frequently happens after a house is erected that the position shown upon the plan for a waste, gully, or soil pipe is out of the question, as to bring it straight down would mean the cutting of a window sill or the running through an area or coal shoot; hence it has to be carried across by means of bends to a more convenient and accessible position. These, it is true, are only little details, and perhaps of minor importance compared to the *tout ensemble* of the elevation; but whatever effect the elevation may have upon the beholder, it can have none upon the health of the occupants of the house, and a badly arranged waste or vent pipe may. It is often the custom in house drainage work to "make the punishment fit the crime" by preparing, after all is completed, a plan showing as much as can be remembered of the course of the drain and its branches, but which for future reference and guidance is of very little value, owing to the difficulty of locating the exact positions of the turns and junctions. In arranging the lines of a drainage system for the necessary waste - pipes, etc., the main drains must always be in straight lines, turning being done in chambers; and the branch drains should always be as short as possible and gathered into a chamber, so that each branch should be controllable and get-at-able. For rainwater drains this last arrangement is not essential. At changes of gradients, also, there should be a lampeye, and at the outlet end of the drain—at some convenient point within the curtilage—there should be placed the disconnecting chamber, and at the head of all long drains a flushing chamber. The advantages of the right line arrangement are manifest—the position of any drain can be accurately traced, as well as the exact point of junction of any branch. Generally speaking, these rules can be easily followed, and the only cases where they present much difficulty, and where ingenuity is required, is in dealing with the remodelling of the drainage of the irregularly-built courts and alleys which are so frequently met with in the old parts of town property. To make the application of this system clear, the author proposes to illustrate it by specimen plans of the various types of property which are commonly met with, leaving out of consideration large public buildings and institutions, which require to be dealt with on special lines.

Town Courts.—Fig. 12 shows a block of miscellaneous town property, consisting of some through houses with separate backyards, single houses without backyards, and stables and workshops, etc. In this class of property the closets are usually arranged in blocks at some convenient point, and the only sanitary appliances and fittings in the houses are the sinkstones in the kitchen; the drainage from these and the roof and surface water gullies is all that will require collecting. The intercepting manhole is shown at the junction of the drain for the side court, a lampeye being fixed at the first turn, a manhole at the T junction, and a flushing chamber and manhole at the head of the drain, with a vent-pipe from the manhole. Another vent-pipe is also carried up at the end of

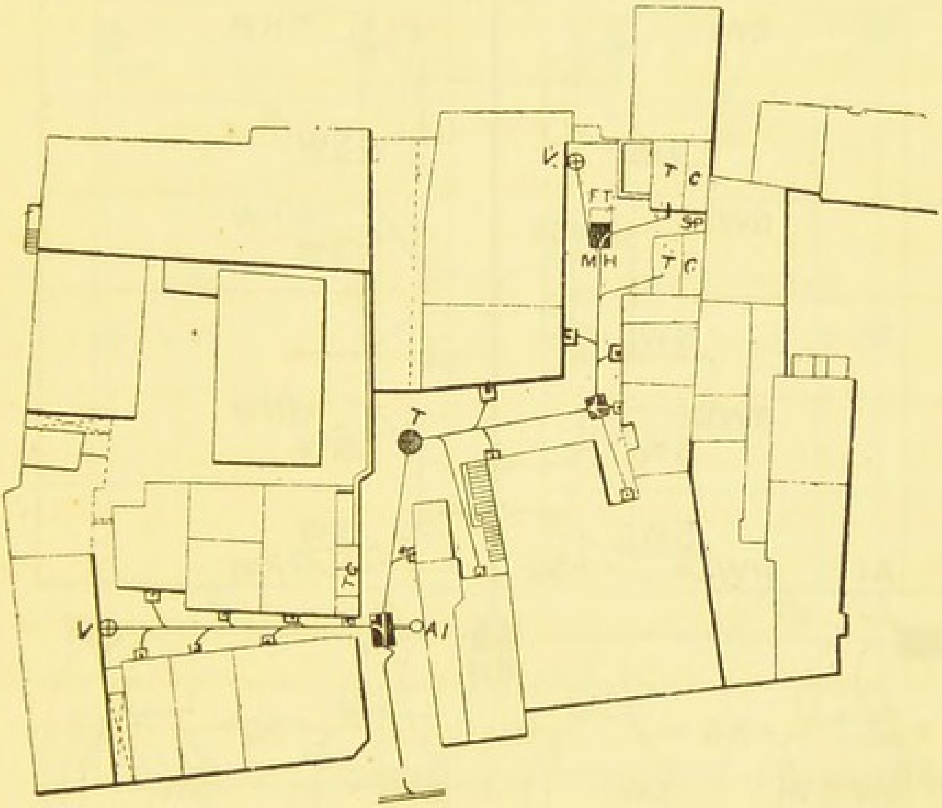

Fig 12.

drain in side court. In narrow courts like this one all the covers of manholes and lampeyes should be airtight. The air inlet to the intercepting manhole is by a side drain and vertical pipe.

Blocks of Cottage Property.—Fig. 13 shows a rectangular plot of land laid out to contain four blocks of cottages, built to conform to the Model By-laws, each house having a separate backyard containing a closet,

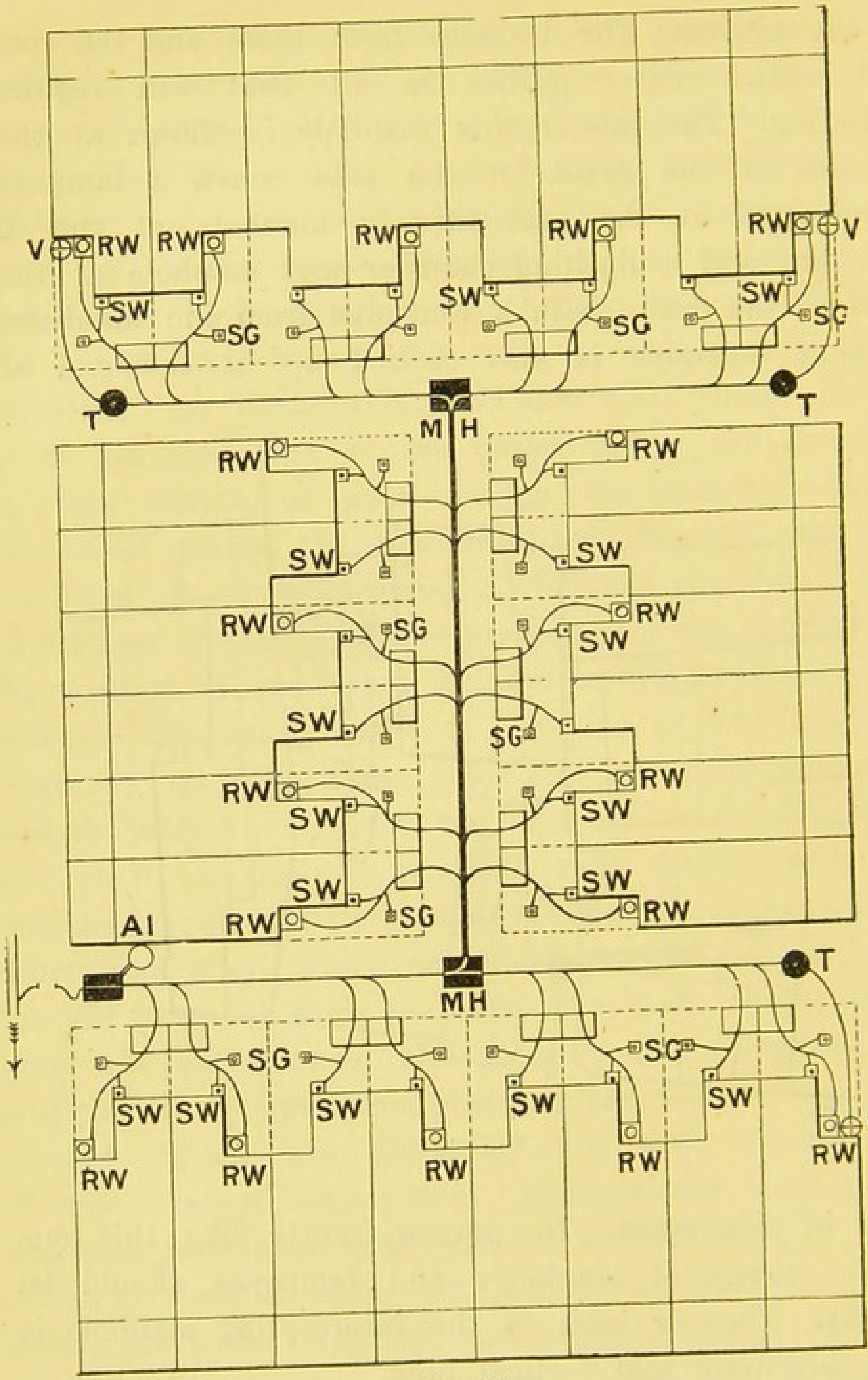

Fig. 13.

and there are through passages, say, 10ft. wide between each block. The main drains are shown to be laid in the passages, and the house drains are each separately connected therewith. This system, although slightly more expensive in the initial cost, is the best in the long run, and steers clear of any legal difficulties which might and do arise when two or more houses are connected to a drain which passes within the curtilage of each, and possibly each house belonging to a different owner. Supposing the drain from one house

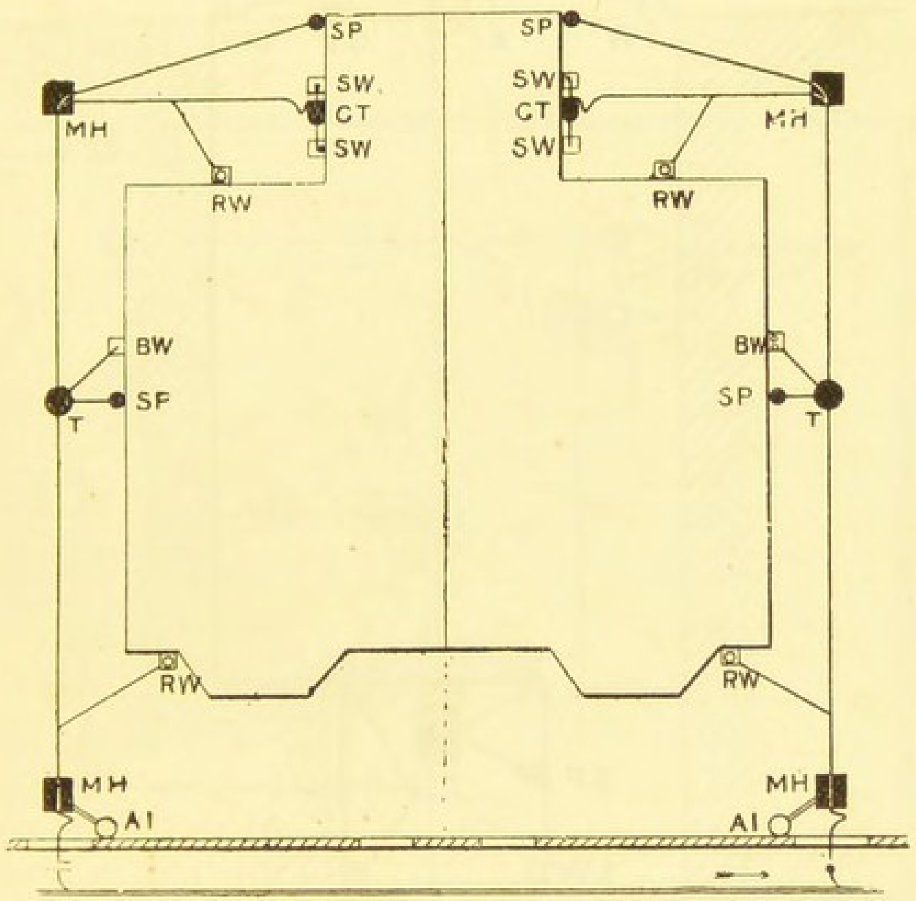

FIG. 14.

was connected to that in the yard adjoining, and that each was owned by different persons, a stoppage taking place within the premises of the adjoining house would cause a nuisance in the one above, and the owner is unable to proceed to remedy it without a great deal of circumlocution. This plan shows an arrangement of waste-water closets—a system which is largely adopted in Northern and Midland towns—so that all the drains must pass through the closets. A manhole is required at each junction, and a lampeye

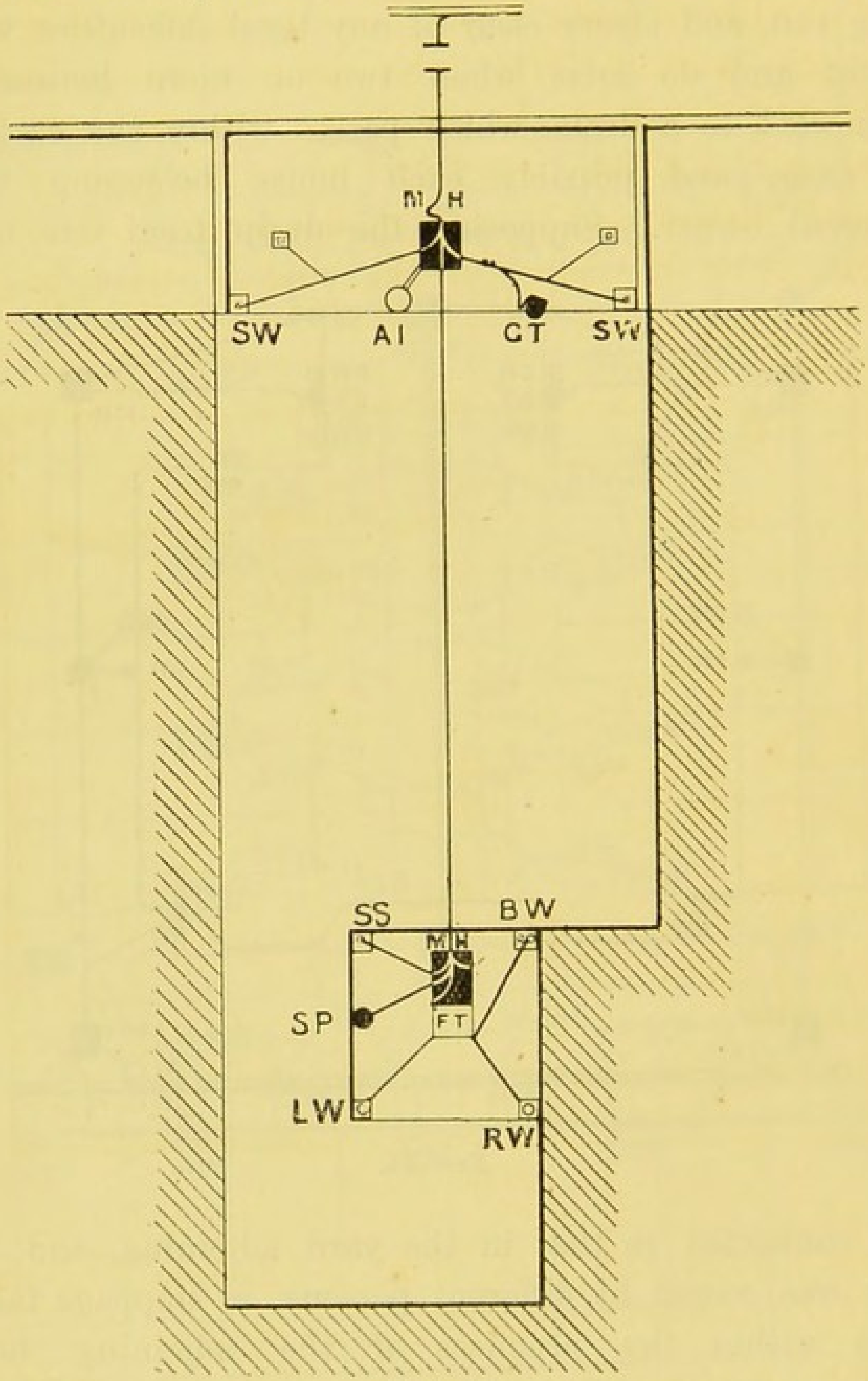

Fig 15.

will serve at the heads of drains from which a ventilator is carried.

Semi-Detached Houses.—Fig. 14 shows a pair of small semi-detached houses. The sanitary appliances usually found in this class of property are kitchen sink and wash-up sink on the ground floor, with outside servants' closet; on the first floor a w.c., bath, and lavatory. The intercepting chamber and air inlet are just within the curtilage. The drains to bath waste and w.c. are connected to a lampeye of the "Tron" pattern, and those from the servants' closet and kitchen sinks in another at the head of drain, so that

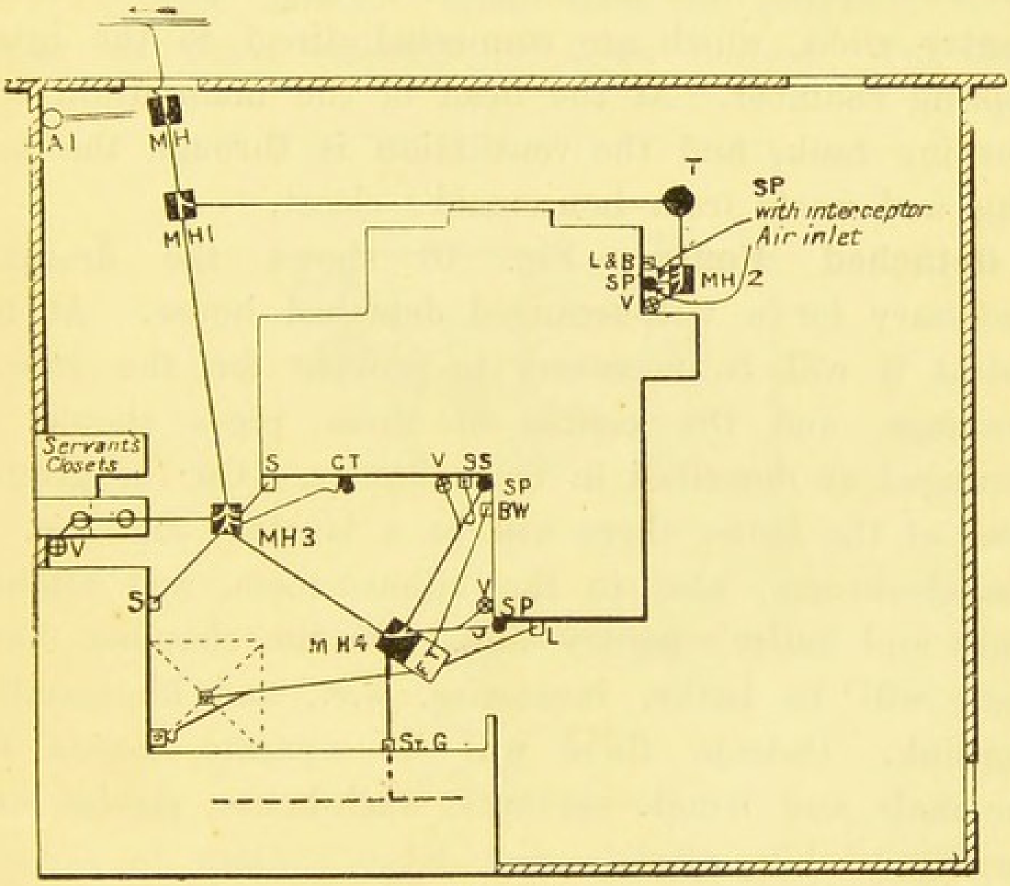

FIG. 16.

the main drain and each branch delivering foul water can be inspected at any time.

Town House.—Fig. 15 shows the arrangement for a town house, and in this case, as there is no frontage or access to a back street, for lighting and ventiiation the plot has to be cut up by the insertion of a small well or area; and there is the usual area in front, with corridor connecting the front and back blocks. There will be the servants' closets on the basement level, with closet and lavatory on the ground and other floors. The baths' waste-pipes will also discharge into this area, and waste-pipe from house maid's closet. All these branches are connected to a manhole, and the drain from this area must necessarily pass under the house. In the front area there will be the waste-pipes from the kitchen and wash-up and butler's pantry sinks, which are connected direct to the intercepting chamber. At the head of the main drain is a flushing tank, and the ventilation is through the soil-pipe and waste from housemaid's closet.

Detached House.—Fig. 16 shows the drainage necessary for a well-arranged detached house. At the outset it will be necessary to provide for the subsoil drainage, and the course of these pipes should be arranged as described in next chapter. On the ground floor of the house there will be a lavatory and w.c. in the cloakroom, also in the billiard-room, and kitchen sinks and butler's pantry sink. On the chamber floors there will be baths, lavatories, w.c., and housemaid's slopsink. Outside there will be separate closets for the male and female servants, wash-house, stables, and carriage-washing shed.

The main drain will be laid in the back road to the house, the intercepting chamber being just inside the gateway. Manhole No. 1 is at the junction with drain from cloakroom, and at the end of this drain No. 2 is fixed, receiving the branches from lavatory and w.c. Manhole No. 3 is inside the courtyard, and will receive the branches from outside closets, laundry, kitchen, and butler's pantry sink. Manhole No. 4 will be at the head of the drain, and receive branches from soil-pipes from chamber floor and billiard-room closets, housemaid's slopsink, and stable drainage. At the end of this manhole will be a flushing tank, into which the drains from bath waste, billiard-room, lavatory, and carriage-washing place will deliver. As the branches to soil-pipes are of considerable length, they will be intercepted at foot and independent ventilation provided.

Office Blocks. — Fig. 17 shows an arrangement for town office blocks. These sites are generally very similar to those selected for town houses. For the

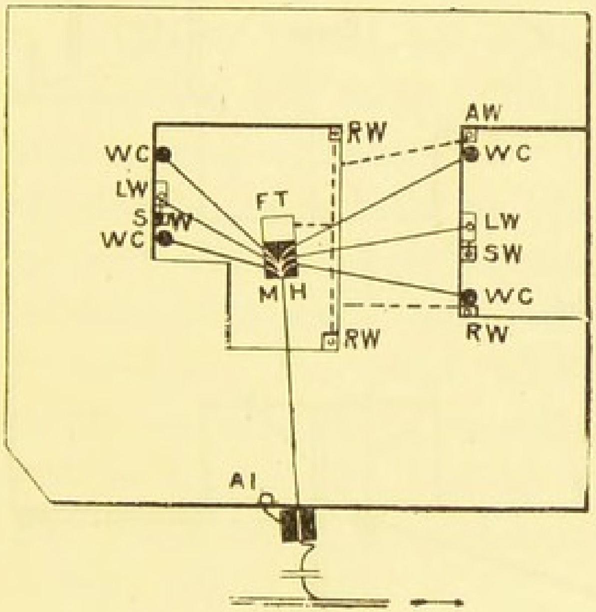

Fig. 17.

purposes of getting light and air for the corridors, areas or wells are left unbuilt upon at suitable points, and abutting on these areas on each floor are the closets and lavatories and sink for receiving dirty water used in washing the floors. Since the introduction of hinged lift-up seats to water-closet basins, urinals inside are gradually being discarded in the best type of building. As in the case of a town house, the main drain must pass under the basement floor; but owing to all the land being covered up to the building line of the street, the intercepting chamber must be fixed in the form of a covered area in the footway. The manhole at the head of the main drain receives the branches from each range of closets and lavatories, and the waste-pipe from sinks discharges over the gully for the latter. If a flushing tank is to be fixed at the head of the drain, it is not desirable to use the lavatory water for this purpose, as ink - bottles are generally

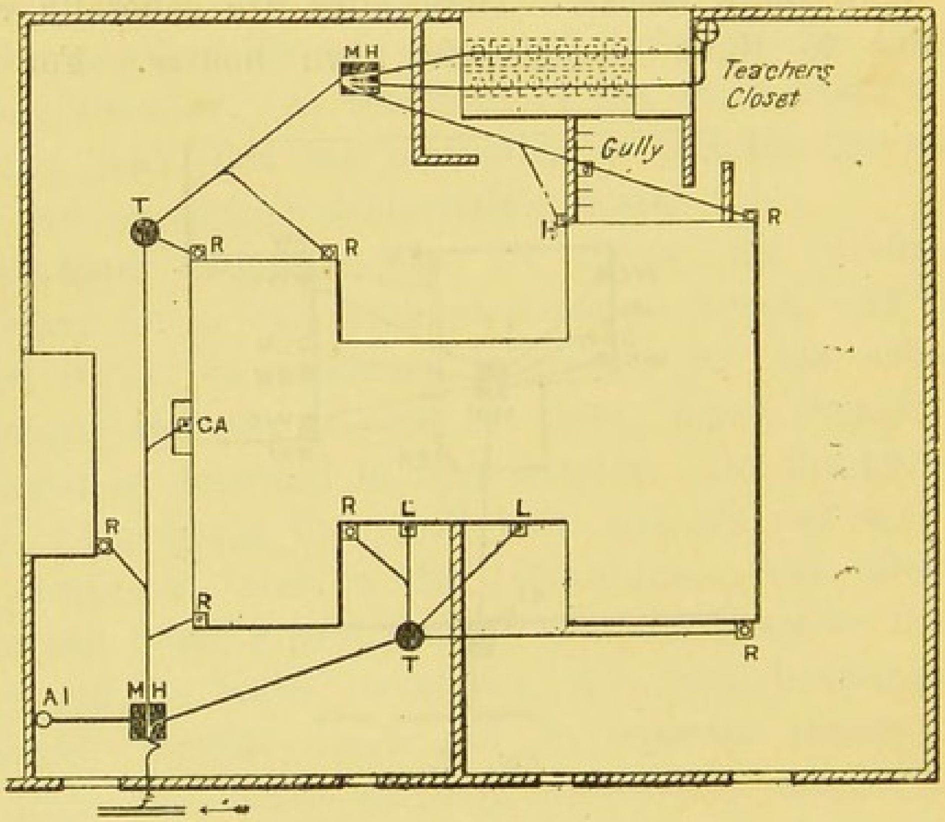

Fig. 18.

emptied into them, as well as a variety of other deleterious liquids of a character known only to the gentle office boys who frequent the corridors. A similar arrangement to this may be devised for clubs and hotels and buildings of a like character.

Elementary Schools.—Fig. 18 shows an arrangement for public elementary schools. In some of the older types it is not usual to find any sanitary fittings inside the school buildings for lavatory purposes, a water-tap and sinkstone fixed in the closet block being made to serve the purpose; but in modern schools a cloakroom is provided, adjacent to the principal entrance, containing a range of lavatory basins.

Outside we have on the girls' side a range of trough closets, with teachers' closet at end. There is a similar arrangement for the boys, and a range of urinals also. The heating apparatus is fixed in a special basement chamber, and to receive the water when the boiler is emptied a gully must be placed in an outside area. The intercepting chamber will receive drain from lavatories, these branches being collected in a "Tron" inspection eye. There will also be another at bend at end of school buildings, and the manhole at head of drain will receive branches from each range of closets and from the boys' urinals. In towns where sites are valuable and schools are carried up several storeys, the same arrangement as here shown can be adopted. In some instances the playgrounds are constructed on the roof, and the sanitary offices also.

Large schools, hospitals, workhouses, and asylums require dealing with on special lines following the arrangements prescribed by Mr. Rogers Field in his memorandum prepared in 1892 for the Commissioners of Lunacy, and which can be obtained from Eyre and Spottiswoode.

CHAPTER V.

Subsoil Drainage.

To insure healthy habitations one of the essential conditions is to secure a site dry and not malarious. This is, of course, not always possible, so that steps are needed to prevent the excess of water and organic emanations contained in soils from passing into the house. The two agents, therefore, with which we have to deal are ground air and ground water. The former may be prevented entering the house by concreting the whole of the site as prescribed by By-law 10, and the latter by the provision of a system of subsoil drains as prescribed by By-law 60. But before considering in detail the methods to be followed, it will be well to point out certain conditions of soil affecting health.

The Air in Soils.—All rocks, except the hardest, contain air, and the amount is in loose sand often 40 to 50 per cent.; in soft sandstones, 20 to 40 per cent.; while surface soil may contain as much as two to ten times its own volume of air — which is mostly very rich in carbon dioxide,* is very moist, and Parkes says probably contains effluvia and organic substances derived from the animal or vegetable constituents. In some districts there are a great many building sites formed of made soils, that is, every available kind of material has been dumped down, such as ashes, nightsoil, trade refuse, builders' rubbish, etc. This

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* At a depth of a few yards the carbonic acid may rise to as much as 8 per cent., or 200 times more than atmospheric air.

conglomeration is necessarily an impure soil, and although in time the organic matter gradually disappears by oxidation and the action of rain, if proper provision were made for the draining away the polluted water from these soils, their recovery would be considerably accelerated ; but when we consider that, as a general rule, the tipping at such places is not subject to supervision, and that often slaughter-house offal and other garbage is deposited there, such sites should be carefully avoided, especially when we remember that the heat which is generated in the house draws the air through the soil into the house, and often from a very considerable distance. Loose, porous soils, because they quickly dry, are, as a rule, considered healthy, provided steps are taken to prevent the emanations from noxious effluvia arising from animal or vegetable contamination.

The Water in the Soil.—The water present in soils may be divided into moisture and ground water, the latter defined by Pettenkofer "as that condition in which all the interstices are filled with water, so that except in so far as its particles are separated by solid portions of soil there is a continuity of water." The amount of moisture present in soil will depend, in the first place, upon the amount of rain, or the supply of ground water (which is dependent upon geological conditions); and in the second place, upon the power of the soil to retain water.

Schübler gives the following table showing the retentiveness of soils:

Sand takes up 25 per cent. of its own weight of water.

Fine precipitated chalk takes up 88 per cent. of its own weight of water.

Pure clay takes up 70 per cent. of its own weight of water.

Garden earth takes up 181 per cent. of its own weight of water.

These may be compared with sandstone rocks taking up 8 per cent., and limestones from 8 to 17 per cent.

The subterraneous continuous water is found to be at different depths; while at some cases it is only 2ft. or 3ft. from the surface, in others it may be hundreds. This will depend upon the configuration of the impermeable stratum and the compactness of the soil overlying it. The surface of saturation is not horizontal, but will have an inclination towards the nearest watercourse or sea, and its rise or fall is governed by the rainfall and the pressure exerted by the rivers. This will vary according to the surface velocity, tides, etc.

The absorbing power of soils has been determined by Schübler as follows:

POWER OF RETAINING HEAT, 100 BEING ASSUMED AS STANDARD.

Sand with some lime	100	Clayey earth	68·4
Pure sand	95·6	Pure clay	66·7
Light clay	76·9	Fine chalk	61·8
Gypsum	72·2	Humus	49·0
Heavy clay	71·11		

The Relation of Soils to Diseases.—The relation of soils to diseases has for some time formed the subject of research and investigation all over the world, and not only is it proved that a cold, moist soil predisposes to rheumatism, catarrh, and neuralgia, and produces an unfavourable effect upon the lungs, but also that it has a relative effect upon such diseases as enteric fever, diarrhœa, diphtheria, etc. Those of us who have the misfortune to live on a cold, moist soil are well aware how much our health improves when we are transferred to a dry soil, which has an even greater effect than the change of air.

The healthiness of a soil depends upon these four factors, according to Parkes, from whom also the annexed table is taken:

(1). Considerable slope, so that water runs off regularly, and the air is dry.

(2). Vegetation not excessive.

(3). Absence of organic emanations.

(4). Purity of water supply.

SOILS IN ORDER OF HEALTHINESS.

—	Slope	Permeability to Water.	Emanations into Air.	Substances into Water.
Primitive and metamorphic rocks (when unweathered).	Great usually.	Slight.	None.	Few.
Clay, slate........	Ditto.	Ditto.	Ditto.	Ditto.
Millstone grit, hard oolite formations.	Moderate.	Ditto.	Ditto.	Ditto.
Gravels and loose sands, without impermeable subsoils.	Slight.	Great.	Slight.	Variable.
Chalk (not marly)	Moderate.	Ditto.	Ditto.	Lime salts, a little magnesia.
Sandstones (old and new).	Ditto.	Variable, but usually considerable.	Ditto.	Variable, often great: alkaline and earthy salts, organic matter.
Limestones (old and new).	Considerable.	Moderate.	Ditto.	Rather considerable lime salts.
Magnesian limestone, dolomite, etc.	Moderate.	Ditto.	Ditto.	Considerable lime, magnesia.
Sand, with impermeable subsoils.	Slight.	Arrested by subsoil	Considerable	Variable, often great: alkaline salts, some lime.
Clays, marls, mixtures of sand and clay, most alluvial soils.	Ditto.	Slight.	Ditto.	Often great: alkaline and earthy salts, organic matter.
Marshes (when not peaty).	Ditto.	Ditto.	Ditto.	Great: salts, organic matter.

Drying the Ground.—Sufficient has been said as to the relative effects of ground air and water; and although we are not able to pick and choose a subsoil for our habitations, we cannot, unfortunately, turn to the table and instruct our architects to provide us with either No. 1 or any of the succeeding ones, so we must make the best of the geological formation as we happen to find it. Undoubtedly, a very great deal can be done to lessen the evils of ground water by careful drainage of the subsoil, under intelligent supervision. The builder, frequently, in getting out his foundation, and finding water present, lays rough drains on lines which best suit his purpose, and connects them into what will be, when the house is finished, the main sewage drain, or, perhaps, to some old drain which he comes across without paying any heed to its condition, nor taking any thought of such things as disconnection and ventilation. Sometimes, also, to assist in drying the ground, these drains are constructed of dry stone walls, and from time to time various waste-pipes get connected to them; and the author has even found soil-pipes so connected. It is unnecessary to enlarge upon the certain dangers which arise from such grossly careless work. Wherever possible, it is an advantage to have separate drains for subsoil and surface water, that is to say, if an entirely independent outlet can be obtained into a watercourse or pond; but where no such provision can be made, then the subsoil water should be drained into the disconnecting chamber. Where the subsoil drain must of necessity discharge into the same sewer as the sewage drain, a second chamber is entirely superfluous. This class of drainage requires ventilation and aeration just as much as sewage drains. The lowering of the subsoil water requires consideration, and the system determined upon before the site is disturbed, as the depth of the basement, and consequently the levels of the other floors, depend upon the depth of the sewer into which this drain has to be connected. The subsoil drain should be laid below the footings of the foundations, and it is a good arrangement in getting out the ground for the foundations to excavate a little wider and to lay the drain outside and below the footings all round the house, making a connection into the disconnecting chamber, as shown upon the plan in Fig. 19. The method of laying a drain through the centre of the site with lateral branches is not to be

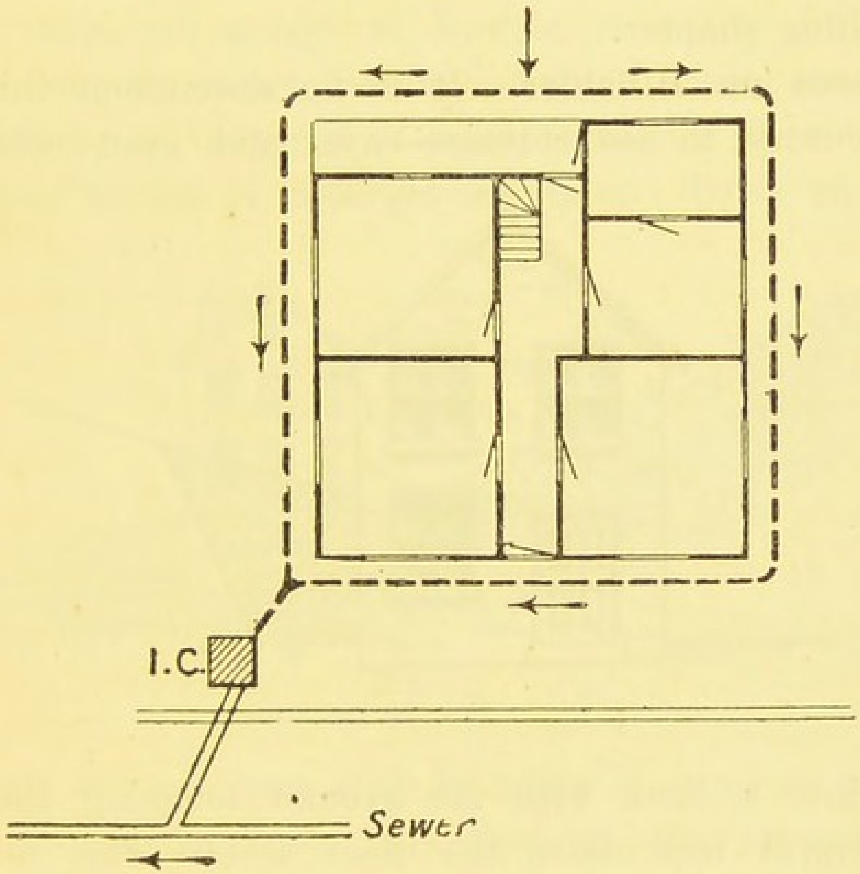


Fig. 19.

commended, for the reasons already pointed out. The drain may be of suitable earthenware field pipes with open joints, packed round with stone scapplings, broken bricks, or clinkers, and the trench should be refilled with hard, dry materials—never with clay. The ventilation opening may be on the surface, but care must be taken in dry seasons to see that the intercepting trap is kept fully charged with water, so as not to lose its seal by evaporation. The provision of subsoil drainage will necessitate a deep intercepting chamber, which might not be occasioned by the branches from the various waste-pipes, provided none of them were in the basement; but it does not follow that this will cause additional excavation for the trench of the sewage drain, because the change of level can be effected at the chamber in the manner described in a succeeding chapter.

Houses on Hillsides.—It is no uncommon thing in the country to see cottages—aye, and even schools—

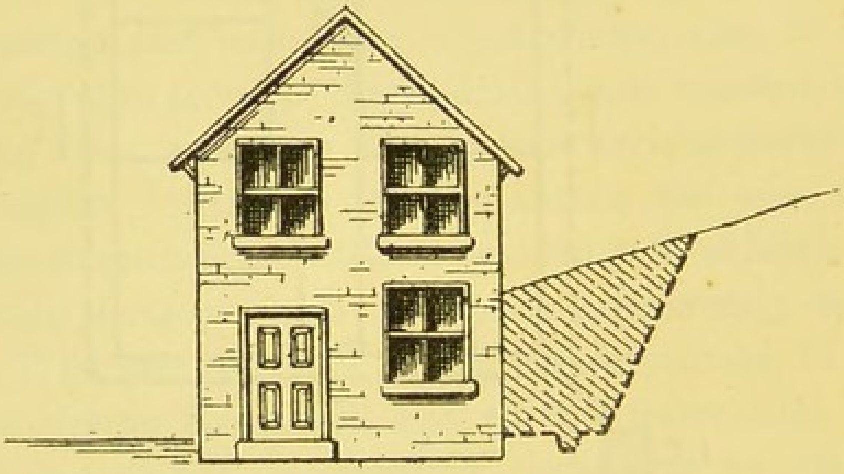


FIG. 20.

built into a bank with the ground touching the wall for several feet above the floor level. This may be picturesque, but it is not healthy—not even if the bank is sandstone or limestone rock. I have frequently been asked for remedies against the dampness which always strikes through, and have been told that this and the other have been tried on the inside, but with no effect. Nearly all these walls are built either without damp-proof courses or cavities. There is only one real remedy, and that is to excavate the bank away from the house, as shown by the hatched lines in Fig. 20, and to cut a gutter at the toe of the bank; or, better still, lay a paved channel to the nearest drain. If the land is in another ownership and cannot be obtained for this purpose, then there is nothing for it but for the medical officer of health to condemn the house as unfit for habitation.

The subsoil drainage of houses built on hillsides requires careful consideration; and if no provision is made for intercepting the subsoil water on the higher side of the house there will always be trouble, especially if the soil be pervious for a few feet and then suddenly change to impervious, as in times of heavy rainfalls there will be a regular stream of underground water. Even with clay

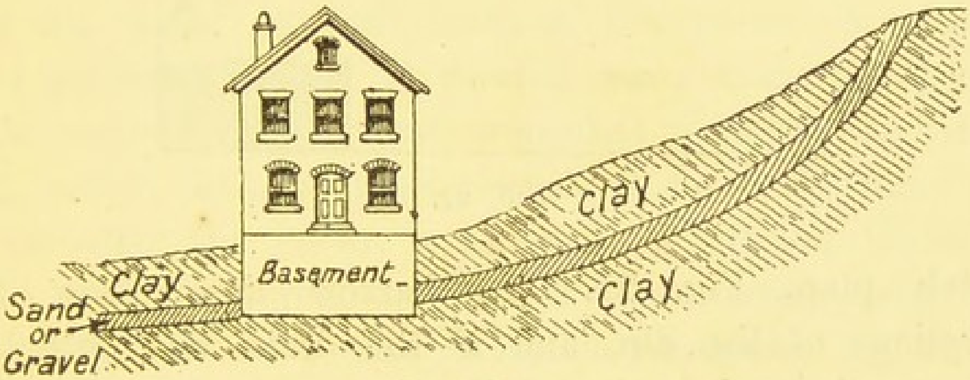


Fig. 21.

or loamy subsoil there may be veins of sand or gravel; and although the rain may flow off the surface near the house, still surface water will find its way through the pervious stratum, entering at the outcrop, as shown in Fig. 21.

The excavation for the foundation will bare any such formation about the house itself, but it is advisable before building operations commence to sink trial holes in various spots above the house, to observe carefully the surface of saturation, and notes should be taken of its fluctuations in dry and wet periods. The only effectual remedy for dealing with this subsoil water is to cut a drain well above the house down to about 2ft. below the level of the basement floor, following the contour of the dip of the strata, as shown in the

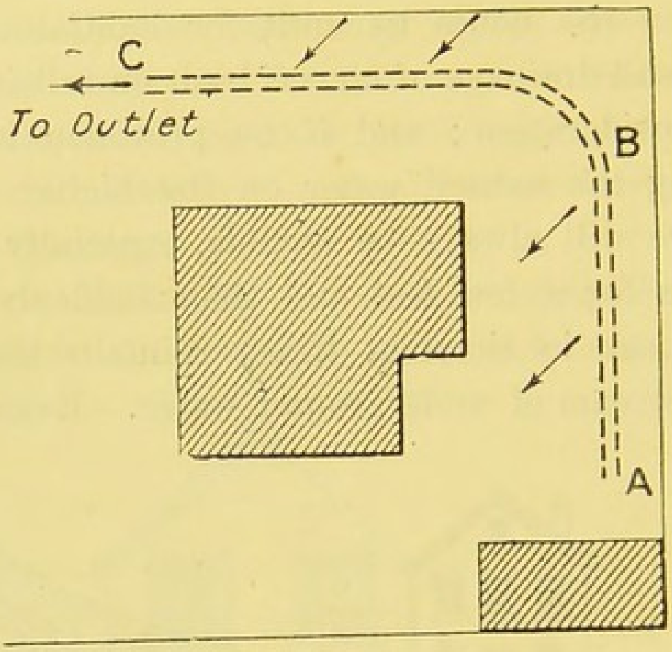


Fig. 22.

sketch plan, Fig. 22. The arrow lines show the directions of the dip, and if the drain was only laid between the points A and B, the water would still be unchecked beyond, and would flow towards the house;

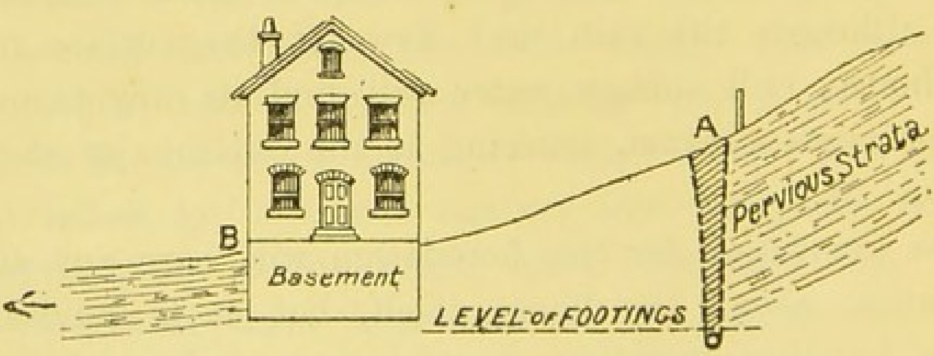


Fig. 23.

so that to be thoroughly effectual the drain must be carried clear past the house, say, as far as C, and from that point it can be gradually brought out to the surface at some convenient point, unless the intervening space between the house and this intercepting drain is paved—that is to say, if it is garden or has a surface through which water can percolate — then provision must also be made for carrying away the water from about the foundations. Fig. 23 is a cross-section showing the relative levels of this intercepting drain and the footings of the basement. The excavated material should not be put back into the trench, which should be refilled with rock scapplings, brick rubbish, or clinkers, so that the water which drains through the hillside will fall down into the pipes. The intervening space to the house will thus be rendered dry, and all water cut off between the points A and B that gathered beyond B flowing away from the house. This method may appear somewhat expensive to carry out, but in this, as in all else, it is no use locking the stable after the horse is stolen. After the house is built and the levels fixed it is more often than not impossible to carry out thorough measures for intercepting subsoil water; and it is clear from the testimony gathered on all hands that it plays a very important part in the sanitary conditions of the house, and its effects upon health are so manifest that it is essential for its treatment to be considered in the conception of all schemes of house drainage.

CHAPTER VI.

Inclination of House Drains.

Velocity.—It is the practice in this country to fix the inclination of house drains so as to produce a minimum velocity of 3ft. per second to keep them self-cleansing; this standard being deduced from the experiments conducted by Wicksteed and Beardmore, while an American engineer, Julius W. Adams, recommends not less than 5ft. In determining with accuracy the size and inclination of drains, it is necessary to consider not only the character of the ordinary sewage which will flow through them, but also the amount of water and solid matter in addition. The properties of a sewage flow are; (1) its viscidity, which may be taken to be the same as that of water; (2) its velocity; and (3) the scouring action of the stream upon the bottom of the channel.

(2) The velocity depends upon the inclination and the hydraulic mean depth, which is the cross-sectional area of the stream divided by the wetted perimeter—*i.e.*, the length of the pipe surface in contact with the stream. When the inclination remains the same, the greater the hydraulic mean depth the greater is the velocity. The friction between the flowing liquid and the surface of the channel with which it is in contact influences the flow. Should this surface be large and the depth of stream slight, its velocity is reduced; and if the surface is small and the depth increased, the friction is lessened and the velocity

increased. The quantity of liquid passing through a pipe is ascertained by multiplying the sectional area of the stream by its velocity.

(3) *Deposit.*—In order that stoppages may not take place in a drain through the accumulation of solid matter, it is necessary to consider the third property. Wicksteed found that a mean velocity of 137½ft. per minute would suffice for the removal of heavy sewage matter when the sewer was running full and half full; and in Beardmore's "Manual of Hydrology" it is stated that the velocities enumerated below have these effects:

30ft. per minute will not disturb clay with sand and stone.

40ft. per minute will sweep along coarse sand.

60ft. per minute will sweep along fine gravel.

120ft. per minute will sweep along rounded pebbles.

180ft. per minute will sweep along angular stones.

Bottom velocity, which imparts the greater motion, differs from mean velocity in the ratio of ·80 to 1, or four-fifths. The greatest discharge from a circular pipe is when it is not quite full—that is, when rather better than fifteen-sixteenths full, and the greatest velocity occurs when it is thirteen-sixteenths full.

The Fall for Drains.—The depth of the sewer into which the house drain is to be branched is the controlling factor in determining the inclination; and in the erection of new property the level of the lowest point from which water or sewage has to be conveyed should be so adjusted to the level of the sewer as to allow of an inclination that will produce a self-cleansing velocity in the drain through its whole length. In many instances, considerably quicker gradients than this can be obtained, and builders and contractors frequently instruct their men to give the drains "all the fall you can," not having taken the trouble, perhaps, to prepare sections, nor to lay down the gradients after proper consideration; and where they are a little doubtful about the fall, judging by the eye only they increase the size, consoling themselves that as drains must get stopped up sooner or later they have staved off the evil day to "later" and obtained salvation for themselves. Drains laid upon these principles can never be satisfactory nor fulfil the first of the essential conditions laid down on page 20. And we are assuming now that in all cases the joints will be made watertight, and the drain laid true to line and grade under proper supervision; is it then desirable to have a rapid fall in house drains? The drain only requires such a rate of fall as will carry off the sewage and the greatest quantity of rainwater coming into it: and for the sewage alone a moderate fall is better than a rapid one. It must be remembered that the house drain in most instances is comparatively short, and if it is well laid it is impossible for the waste waters and sewage to remain long in the pipe. The liquid should carry the solid along with it and not run away from it, and the velocity should be sufficient to maintain an equable condition, so as to prevent deposit. The discharges from a house into a drain are irregular both as regards intervals of time and quantity of liquid, etc., so that with a very rapid fall, liquid would be liable to leave a solid deposit, and it might be some considerable time before a sufficient volume of liquid passed through the drain to carry it on. And at certain times of the day, generally in the forenoon and evening, the discharge of waste water from houses is greatly in excess of the general average during the time domestic operations are being carried on, and at these times the discharge is sufficient to maintain a depth of water along a drain laid to an inclination to produce a self-cleansing velocity that will not only carry the sewage along with it, but also free the drain from deposit which has been previously left there. As illustrating the deposit that is left in drains by intermittent small streams of water, the results obtained from several hundred tests made in 1893 by a special committee of the Sanitary Institute show that with a two-gallon flush from a w.c. in a drain 50ft. long, 6in. diameter, at a gradient of 1 in 40, the retention is 14 per cent., and with a three-gallon flush 4 per cent.; and in the case of a 4in. drain 26ft. long, the retention is 4 per cent. with a two-gallon flush, and 0 per cent. with a three-gallon flush.

It will be noted that the length of 50ft. is a common length for a main drain from the back of the house to the intercepting chamber in front, but that the gradient is considerably more than usually given, and that the length of 4in. drain is an average one for branch drains from soil-pipes.

Assuming a 6in. drain to be laid at 1 in 60, and that the depth of flow is 1½in., then the velocity will be 2·8ft. per second; that depth we have seen is sufficient, and it is much better to maintain that rather than to acquire a greater velocity by means of a greater rate of fall. And there is also another advantage which will appeal to property owners and builders, that there is a saving in the depth of the trench. The difficulty of the change of level before branching into the main sewer can be got over by following the directions already given.

The following small table, extracted from the more complete one, shows the rate of flow at various depths for a 6in. pipe at 1 in 60 and a 4in. at 1 in 40.

	Depth.	Velocity in feet.	Discharge in gallons per minute.
6in.	$1\frac{1}{2}$in.	168	40
6in.	3in.	240	147
6in.	$4\frac{1}{2}$in.	272	268
4in.	1in.	157	17
4in.	2in.	224	61
4in.	3in.	254	111

Amount of Sewage and Rainfall.—The quantity of waste water and sewage that has to be carried off from each house may be determined upon the lines set out on preceding pages 18 and 19; but, in addition to this, regard must also be had to the proportion and quantity of rainfall. The separation of rainfall from sewage, to lessen the difficulties of dealing with the sewage at the disposal works, should be effected to the fullest possible extent. So far as the back portions of town property is concerned, it may be assumed that the whole of the rainwater which falls upon the back part of the roof, upon the yard and area, and the back roads or passages will find its way into the drains. In many text-books, the following table is often quoted as showing the depth of rainfall per hour flowing off various surfaces, for which provision should be made in sewers.

	Inches in depth.
From roofs	·5
,, flagged surfaces	·2
,, paved surfaces	·1
,, gravel surfaces, clay subsoil	·05
,, gravel surfaces, gravel or chalk subsoil	·01
,, meadows or grass plots	·02

On page 128 of Symons's "British Rainfall, 1884," the following extremes of rainfall in the British Isles are recorded.

0·55in. in 5 minutes	1·50in. in 45 minutes
1·10in. „ 15 „	1·80in. „ 60 „
1·25in. „ 30 „	2·20in. „ 120 „

While some of the falls recorded in the mountainous districts of Wales and Cumberland are phenomenal, it is by no means rare to have a fall of 1in. in half an hour during heavy thunderstorms. So that it will be safe to take an extreme case of, say, 2in. falling in one hour. Some small part of this may by soakage and evaporation not reach the drain; but having regard to the impervious character of the surfaces of the roofs and yards, and the rapidity with which the rain falls during violent storms, this portion may be neglected.

The majority of building plans submitted to local authorities are not prepared by architects, and those for cottages, which form the bulk of inhabited houses, are usually drawn by some builder or joiner whose knowledge of rules and calculations for determining the size of drains is either very limited or is allowed to lapse; and for the guidance of not only this class of tradesman, but for all engaged in house drainage work, I have prepared a table showing the maximum discharges of sewage and rainwater from houses of a universally prevalent type. The maximum discharge of sewage may be taken, say, at the time of letting off the bath waste, and for rainfall 2in. per hour is taken. The yard space is taken upon the basis of distances across the backs as prescribed by the model by-laws. These figures may be proportionally applied to all classes of houses, and will form a reliable basis to determine the sizes of the drains.

The most common diameter of pipe for a main drain is 6in., but in many instances a 4in. would be preferable. It is certainly, when laid, insignificant-looking, and appears hardly worth the labour necessary to make the joints watertight and sound. Yet if proper care is taken in adhering to straight lines and in laying true to the gradient, they often make the better drain for the purpose, because the frequent discharges of waste water, some of which are but small in quantity, but produce the desired depth, and solid deposits will remain unwashed away for shorter periods of time.

A reference to the following table will show how far a 4in. pipe may be used for a main to carry off both sewage and rainfall.

Table showing Maximum Quantity of Sewage to be removed per minute from various types of houses, and also Rainfall flowing off back portions to determine size of drain.

6in. Drain.

Class of House, showing number of rooms on ground floor.	Approximate Number per acre[1].	Frontage, in feet.	Area of Back Portion, in square yards[2].	Maximum Flow of Sewage per minute, in cubic feet.	Rainfall, calculated at 2in. per hour, in cubic feet.	Total, in cubic feet.	Gallons, approximately.	Di-charge from 6in. Pipe running full, at inclination of 1 in 60.	Number of Houses which 6in. will serve.
Two	46	12	52	2	1·3	3·3	21	294	14
Two (with lobby)...	38	15	65	2	1·62	3·62	23	294	13
Three	38	15	65	2	1·62	3 62	23	294	13
Three	32	18	75	2	1·87	3·87	24·5	294	12
Four[3]	20	21	130	2	3·25	5·25	33	294	9

4in. Drain.

Class of House	Approximate Number per acre	Frontage, in feet	Area of Back Portion, in square yards	Maximum Flow of Sewage per minute, in cubic feet	Rainfall, in cubic feet	Total, in cubic feet	Gallons, approximately	4in. drain running full at 1 in 40.	Number of Houses
Two	46	12	52	2	1·3	3·3	21	122	6
Two (with lobby)...	38	15	65	2	1·62	3·62	23	122	5
Three	38	15	65	2	1·62	3·62	23	122	5
Three	32	18	75	2	1·87	3·87	24·5	122	5
Four	20	21	130	2	3·25	5·25	33	122	4

[1] Inclusive of share of front and end street, and allowing 5ft. for half of back street. [2] Inclusive of roof from ridge, yard, and portion of back street. [3] This may also be taken as typical size for ordinary suburban semi-detached houses as portion of ground at sides and back will be garden surface.

What is called Maguire's rule for gradients for house drains to produce a self-cleansing velocity is easily remembered—

4in.	1 in 40
6in.	1 in 60
9in.	1 in 90

Formulas to Ascertain Discharge.—The discharge from drains at any particular depth of flow can be calculated by multiplying the sectional area of stream by the velocity. The velocity may be determined by the use of formulas, of which there are many available, but the one most commonly used is that known as Eytelwein's—viz.:

$$Q = A \times V. \qquad V = 55 \sqrt{R \times 2\,H}.$$

Q = discharge;
V = velocity;
A = sectional area of stream, in feet;
R = hydraulic mean depth, in feet;
H = fall per mile;
55 = a constant.

For some years past engineers have adopted the formula of Kutter, which introduces a coefficient for roughness, as it is known that the roughness has a material effect on the velocity. The formula is extremely cumbersome and intricate, and Mr. Santo Crimp, M.I.C.E., has recently devised and published a simple formula, the outcome of a long series of experiments, which in the results approximates closely to Kutter's when the coefficient of roughness in that formula lies between ·012 and ·013. As compared with Eytelwein's formula, the results in small sizes are on an average about 10 per cent. less.

CRIMP'S FORMULA.*

$V = 124 \sqrt[3]{r^2} \sqrt{s}$;
V = velocity in feet per second;
r = hydraulic mean depth in feet;
s = fall divided by the length.

For circular pipes running full or half full this is equivalent to

V = velocity in feet per minute;
D = diameter in inches = $48\,r$;
I = inclination, or the length divided by the fall = $\frac{1}{s}$;
Q = cubic feet per minute delivered when running full;

$$V = \frac{563 \sqrt[3]{D^2}}{\sqrt{I}};$$

$$Q = \frac{3{\cdot}072 \sqrt[3]{D^8}}{\sqrt{I}}.$$

To Find Area of Sewage Flow.—The area of the segment of a circle formed by the portion of the pipe taken up by the stream may be calculated in the following way:

A B C = segment;
A B = chord;
C E = versed sine;
A D = radius of arc;
A C = chord of half arc.

To two-thirds of product of chord and height of

* "Tables and Diagrams for Use in Designing Sewers and Water-Mains," by W. Santo Crimp, M.I.C.E., and C. E. Bruges, A.M.I.C.E.

segment add cube of height (or versed sine) divided by twice chord, and sum will be area of segment.

To find length of chord A B: From square of A D subtract square of E D, and square root of remainder will be length of A E = $\frac{1}{2}$ A B.

N.B.—When segment, is greater than a semi-circle find area of remaining segment, which subtract from arc of the whole circle, and remainder will be area required.

Area of circle = diameter^2 × ·7854.

To find length of wetted perimeter A C B: From

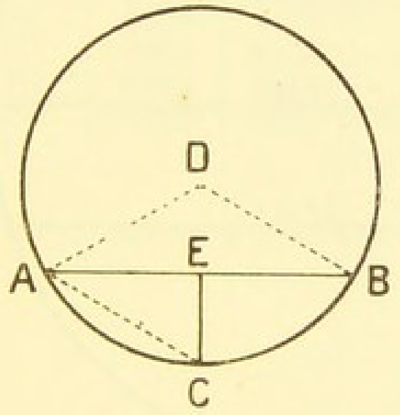


Fig. 24.

eight times the chord of half the arc A C subtract the chord of the whole arc, and one-third of remainder will be length of A C B nearly. Length of chord A C will be found by preceding rule.

By the use of the foregoing rules the sectional area of stream at any depth and the hydraulic mean depth may be ascertained. To save tedious calculations, the author has prepared a table giving the discharge from 6in. drains at 1 in 60 and 4in. at 1 in 40, for various depths of flow, with the corresponding values of the hydraulic mean depths, sectional areas, and velocities.

In Slagg's "Sanitary Work," page 150, the following useful diagram (Fig. 25), showing the proportional values at varying depths, is given. The various arithmetical values of details usually required can easily be found from the formulæ given at the side of the diagram.

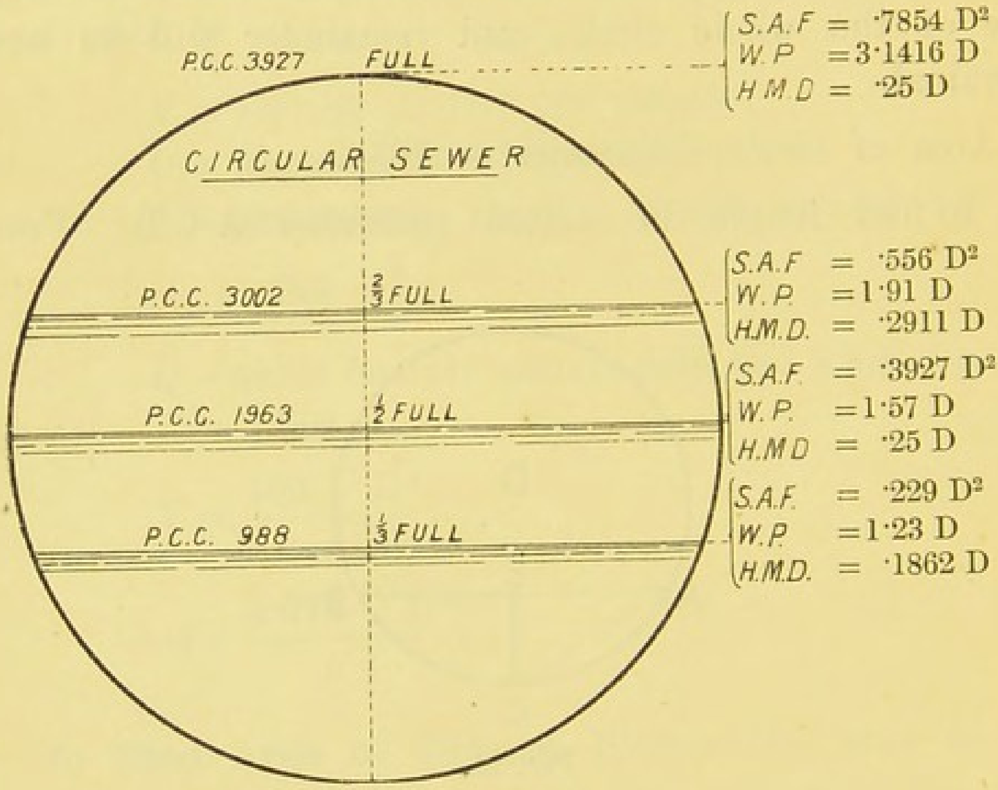


FIG. 25.

⅔ C.C. occurs at ·61 H.
½ C.C. occurs at ·5 H.
⅓ C.C. occurs at ·39 H.

C.C. = Carrying capacity; H. = Height; D. = Diameter or width at springing; P.C.C. = Proportional carrying capacity (the width, D, at springing of the arch = 1 in each case); S.A.F. = Sectional area of flow; W.P. = Wetted Perimeter; H.M.D. = Hydraulic mean depth.

In the following table all the quantities in each column are calculated from Crimp's formula.

6in. Drain, Inclination 1 in 60 = 88ft. per mile.

—	Depth of flow, in inches.	Hydraulic Mean Depth.	Sectional Area, in square feet.	Velocity.	Discharge, in cubic feet.	Discharge, in gallons.
Full	—	·125	·19634	240	47·1	294
Three-quarters ...	$4\frac{1}{2}$	·1508	·158	272	42·4	268
Two-thirds	$3\frac{3}{5}$	·1456	·139	265	35·4	221
One-half	3	·125	·09817	240	23·5	147
One-third	$2\frac{2}{5}$	·0931	·0573	196	11·0	69
One-quarter...... ..	$1\frac{1}{2}$	·0733	·0384	168	6·4	40

4in. Drain, Inclination 1 in 40 = 132ft. per mile.

—	Depth of flow, in inches.	Hydraulic Mean Depth.	Sectional Area, in square feet.	Velocity.	Discharge, in cubic feet.	Discharge, in gallons.
Full	—	·0835	·0873	224	19·6	122
Three-quarters ...	3	·1006	·0762	254	17·8	111
Two-thirds	$2\frac{2}{5}$	·0970	·0618	247	15·1	94
One-half	2	·0835	·0436	224	9·8	61
One-third	$1\frac{3}{5}$	·0621	·0255	183	4·6	29
One-quarter.........	1	·0489	·017	157	2·7	17

CHAPTER VII.

PIPES AND JOINTING.

Manufacture of Pipes. — The clays from which suitable pipes are usually made are those obtained from the beds lying in the coal measures, and known as "fireclays." These vary very much in their tenacity, porosity, and ductility, all of which qualities are severely tested in the various processes of pipe manufacture. The mixture should be so prepared and pugged as to be able, when dried and fired, to retain, with only a slight deviation, the shapes imparted to it in moulding. The most essential features to be obtained in the raw material are toughness, tightness, impermeability, durability, and strength; and the clay should be so finely ground that, when finished, the pipe shall possess a perfectly smooth surface throughout, the crust being thoroughly homogeneous, and capable of resisting intense heat.

It is not necessary to here describe the various stages in the manufacture of pipes, as the process can be seen by those desirous of becoming acquainted with it.

The stoneware pipes are manufactured from clays obtained from Dorsetshire, which are more tenacious than the fireclay, so that an equally durable and strong pipe is obtained with a relatively thinner crust. They are consequently lighter, which effects a small saving in carriage and in handling of the larger pipes. The analysis shows that the composition of the clays from which the stoneware pipes are made, and the Wortley clays from which the Leeds pipes are made, is much about the same, but the latter possess a mechanical condition which renders them less brittle. The stoneware pipes, when finished, are of a pale buff colour, and the fireclay pipes are of various shades of reddy-brown, and sometimes bluey-grey.

Glazing.—In consequence of the silt which is conveyed with the sewage, there would be constant abrasion of the surface of the pipe, which would reduce its hydraulic efficiency, and would in time, from this action, be entirely worn away unless preventive measures were taken ; for this purpose, when the kiln is being fired, salt is thrown in, and this imparts a highly-glazed surface to the pipe. The value of this glaze cannot be over-estimated, especially to small pipes, as all the liquid portion of the sewage is needed during the dry-weather flow to aid the current in its self-cleansing action ; therefore the higher the glaze, the better will be the discharging capacity of the pipe. The glaze also makes the pipe impermeable (except under extraordinary high pressure), and enables it to resist the action of whatever acids are present in the sewage, and also the abrasion that would be caused by the silt and other bodies which, from carelessness and a variety of accidental causes, find their way into drains.

A good pipe, therefore, should be well burnt throughout its entire body, straight in the barrel, and truly cylindrical when cut die square, highly glazed over the whole surface, and the interior free from blisters, clinkers, and other defects, and should ring sound when rapped with a hammer.

Thickness and other Dimensions.—It is customary for the crust of stoneware pipes above 6in. diameter to be one-twelfth of the diameter in thickness and for fireclay pipes to be one-tenth. The following table of the various dimensions of pipes will be found useful for reference.

		Size of Pipe.			
		4in.	6in.	9in.	
Thickness of crust.	Stoneware	$\frac{9}{16}$in.	$\frac{11}{16}$in.	$\frac{3}{4}$in.	
	Fireclay	$\frac{9}{16}$in.	$\frac{11}{16}$in.	$\frac{15}{16}$in.	
Depth of socket		$1\frac{3}{4}$in.	$2\frac{1}{2}$in.	$2\frac{1}{2}$in.	
Weight of pipes	one-twelfth	—	—	$59\frac{1}{2}$	lbs.
,, ,,	one-tenth	17	30	54	
Number per ton	one-twelfth	—	—	25	lineal yards.
,, ,,	one-tenth	88	50	$23\frac{1}{5}$	

Strains.—Pipes when laid in position are subject to the following strains: (*a*) crushing, (*b*) internal pressure, (*c*) abrasion. Crushing is caused by the weight of the superimposed materials in the refilled trenches; internal pressure is only exerted when there should happen to be a complete stoppage that would fill the bore of the pipe, and thus dam up the sewage. In consequence of the shallow depths at which house drains are laid and the numerous openings to the surface, the head of water is never likely to be very high, only a few feet at most. The causes of abrasion have already been explained. The ability of the pipe to resist these various forces may be tested in the following ways:

(*a*) *Crushing.*—Cut socket holes and bed the pipe horizontally and evenly, then pack and fill up with sand and apply a weight uniformly along the top. For breaking, support the pipe on blocks, and apply weight at centre.

(*b*) *Internal Pressure.*—Use the ordinary hydraulic press; great care must be exercised in screwing up the plates to close the ends of pipes, so as not to strain or fracture the metal. The pipe must be set plumb up and level, and the plates travel in parallel planes.

If very accurate results are desired, this adjustment is a delicate operation.

Some fireclays are exceptionally strong, and I have frequently tested them up to 160lb. on the square inch when one-twelfth thick, and probably one-tenth could be made to stand 200lb. Some pipes are advertised as being stamped tested, but I fail to see the value of this as a guarantee, as it is obvious that the imprint could only be sunk in the pipe when the clay was "green," and, therefore, before the test can have been applied. The weakest part of a pipe is at the closing up of the shoulder of the socket to the barrel; and at many works the sockets are put in by hand after the pipes are moulded. Pipes thus made must necessarily be weaker than those made complete in one mould. Bearing in mind, also, the strain to which pipes are subject in transit from the kiln to the trench, if a breaking test is desired, then the proper place to apply it is at the spot where they are delivered for laying.

(c) *Abrasion.*—To test for this, apply a loaded small section of the pipe to a revolving grindstone kept wet and clean, and let the number of revolutions (with diameter) of grindstone required to remove glazing be recorded, or the number of revolutions required to wear away a definite thickness of the pipe may be recorded.

Impermeability may be tested by the capacity of the pipe for absorbing water.

Jointing.—It is essential that the joints of pipes must be absolutely watertight, otherwise the evils from percolation, which have been pointed out in a previous chapter, will be sure to arise. It must not be forgotten that the drains immediately about the house are frequently situated not more than a few feet from the walls and at a shallow depth, so that in case of leakage the soil gradually becomes impregnated with the filth which has escaped from the drains, and the vitiated air is drawn into the house through the walls by the heat which is created in the house. So much sickness is directly due to this cause, that too much care cannot be exercised in the making of the joints.

Clay Joints.—For many years after the introduction of socketed pipes, clay was the only material used for the purpose, and is now in a great many places. So long ago as 1878, Mr. Baldwin Latham drew attention to the danger of using this material as being one of the worst that could be found for the purpose. In his well-known work on "Sanitary Engineering" he says: "We seek the most impervious materials wherewith to construct our sewers, and often spoil their effect by the indifferent manner in which we put the materials together. A soft, yielding substance like clay is about the worst possible material that can be used for jointing pipes, as it must be clear that clay is liable to get washed out of the joints, both from the action of the water escaping from the pipe or of water flowing from the subsoil into the pipe. Apart from this, a soft, yielding material when used for jointing, notwithstanding however perfectly the work may be performed, will lead to failure, as the weight of the earth covering the pipes causes the clay to be squeezed out of the lower part of the socket of the pipe, leaving an aperture in the upper part through which sewer air and sewage may escape, or water and sand be carried from the subsoil into the sewer. These serious defects in jointing not infrequently lead to the disturbance of the line of pipes and destroy the regularity of their bed."

Mr. de Courcy Meade, the city surveyor of Manchester, in 1893, when he was the surveyor of the Hornsey Local Board, in a report upon "Intercepting Traps and Watertight Drains," likewise called attention to the dangers arising from the use of this material, especially from the "cracks which will almost invariably appear when clay filling is used, as it becomes dry and shrinks." Much of this class of work is done by contract, or the labour is performed piecework, and it is hardly to be expected that drains so laid will continue watertight, especially where the puddle band has not been carried completely round the pipe; the cutting of socket holes for the purpose being a duty seldom performed, except under the very closest supervision.

Cement Joints.—A joint made from Portland cement and sand is a right one subject to certain conditions, but as ordinarily made is quite as objectionable as the clay joint. The greatest care requires to be exercised to see that the whole space completely round the spigot is evenly filled; generally speaking, the labourer entrusted with this work takes care to plaster plenty of cement on the top of the pipe, where it can be seen, but a close examination will reveal that the invert is entirely bare. Another great objection to joints made in this way is that the cement is applied in too moist a condition, and there being nothing to resist its progress, it travels down to the invert, is forced up through the joint, and there sets in a ridge, forming an obstruction to the flow of sewage. I had occasion once to take out some drains which had been newly laid, under the supervision of an architect, and almost every pipe when displaced was found to have a ridge of this character. Jointing by this method is not to be commended; but if it is adopted, then care must be bestowed upon the proper mixing of the cement to get it into such a condition as will enable it to combine and set easily without displacement, which may be caused by blows from the men working in the trench or in the refilling of the earth. The pipelayer should always be provided with a tool, known to the men as a "badger," with which to wipe out the inside of the joint after it is run; this may be formed of a disc of wood of rather less diameter than the pipe, having on its edge a narrow strip of indiarubber; the disc should be secured to a haft of a length equal to the length of a pipe and a half. The disc should lie in the barrel of the pipe last laid, and the pipe about to be laid should be passed over the handle and properly centered; to do this, the pipelayer should insert his arm into the barrel so that he can feel with his fingers whether there is any projection of the inverts at the joint, and the pipe should be gradually turned until a true invert is obtained, and should he fail to accomplish this, the pipe should be withdrawn and a fresh one procured that will fit. Then after the joint is made, the badger should be pulled forward across the joint, from which it wipes away any protruding cement which has projected through in the interstice. Quite recently a "badger" has been introduced by Mr. Fred Lynde, A.M.I.C.E., which is formed of hard woods, and consists of two discs edged with indiarubber connected together by a spiral steel spring which enables the tool to be drawn through bends (see Fig. 26).

There is one great objection to this class of joint, and that is, that the invert spigot lying in contact with the socket leaves a large opening at the top of the pipe, so that very little, if any, cement is forced into the invert unless it be raised for the purpose and properly adjusted, an operation which I fear is but seldom performed, except under the closest supervision. Fig. 27 illustrates the evil here pointed out.

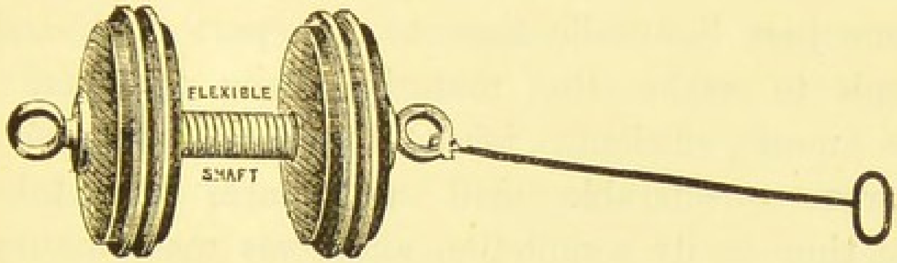


Fig. 26.

Where an ordinary pipe is used, the best method of making a joint is by first of all caulking the pipe with strands of tarred gaskin inserted all round the spigot and driven home to the rebate of the socket, and the annular space completely filled; the work being done with a proper caulking tool, cranked for hand hold with a flat face, $1\frac{1}{8}$in. by $\frac{5}{16}$in., of the

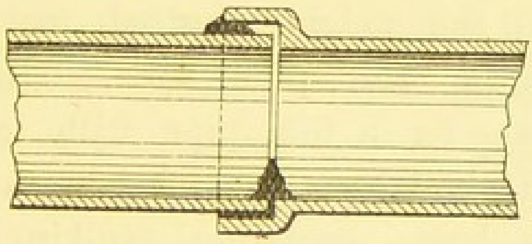


Fig. 27.

hardest steel. This band of tarred gaskin will prevent any of the cement from passing through the joint, and being impervious is not liable to rot through contact with the moist cement. To make the joint properly, a hole in the bottom of the trench is necessary to be made in front of each socket to give the joint-maker room to work in. The joints should be completed by a mixture in the proportion of four parts Portland cement to one part of clean, sharp sand, and should form a fillet projecting beyond the socket to a distance equal to the thickness of the socket, and neatly bevelled off to an angle of 45deg. Some engineers, instead of Portland cement, prefer to use a composition of one part hydraulic lime to one part sand, and hair enough to make the material hang together. This is a most efficient joint, but, as will be seen, requires considerable skill and care, and takes up some time in its completion and costs more money than the somewhat loose and unsatisfactory method first

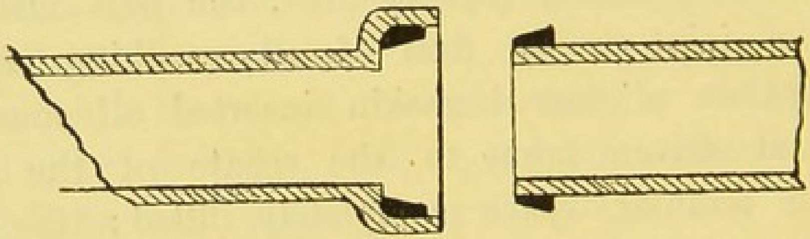


FIG. 28.

described. The cost of the tarred gaskin is about 4d. per pound, and the weight required for a 6in. pipe is $4\frac{1}{2}$oz., and for a 4in. pipe $2\frac{1}{2}$oz.; the amount of cement used is—for a 6in. pipe $2\frac{1}{3}$lb, and for a 4in. pipe $1\frac{1}{3}$lb.; and the labour expended by the pipe-layer in laying, driving home, centering, caulking, and pointing the pipe is found to be—for a 4in. pipe $2\frac{1}{3}$ minutes, and for a 6in. $5\frac{2}{3}$ minutes. These times do not include lowering the pipes or any other work about the trench, which would, of course, be common to all types of pipes.

Stanford Joint.—There are many inventions for making the joints of pipes watertight, and almost every pipe-maker turns out some special form of joint. The oldest, and perhaps best known of all, is the "Stanford" joint, and which is shown in Fig. 28. It will be noticed that on the socket is cast a ring of asphaltic composition, and a collar upon the spigot end. In laying the pipe, both the ring and collar require greasing so as to get the joint to fit more readily, and to prevent stripping of the composition when they are being forced home. The collar is slightly cambered, which allows a little play at this stage. As the patent has run out, any person can make this joint on ordinary pipes: the composition being formed of one part of clean, sharp sand, one

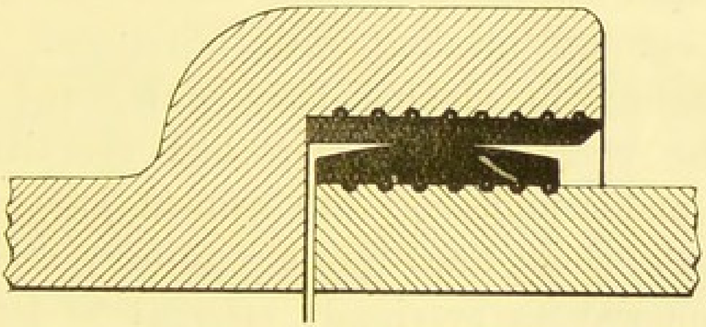


FIG. 29.

part of boiled tar, and one part and a half of sulphur.

Doulton's Joint.—Messrs. Doulton make a somewhat similar joint on the ball-and-socket principle, and is called by them the "Self-adjusting Joint." As will be seen by Fig. 29, it is one that can be very easily and rapidly applied.

Hassall's Single-Lined Joint.—The single-lined pipe of Hassall's patent is somewhat similar to the Stanford, except that the sockets are much deeper. In my opinion, for ordinary house-drainage work, this is the best type of pipe to use, and for some years now I have specified nothing else. In making this joint, the ring and collar are first coated with the specially prepared plastic cement (which is sent out with the pipes), and then the pipes are pushed home until the joint is set flush, the plastic cement filling up all the interstice between the spigot and abutting edge of socket.

Among the many advantages in using a special form of joint are: the certainty of always getting a perfectly sound, straight, well-glazed, and truly cylindrical pipe, as the dies and moulds used in putting on the castings cannot be inserted in or over an irregularly-shaped pipe. It is obvious that the labour involved in turning over and selecting the best pipes for this purpose must be paid for, but this extra cost is certainly recouped by the annoyance saved on the works in sorting out and dealing with rejections. There is also the facility in making the joints, and the time saved in the operation. I have had the times noted in making and completing with cement joints 4in. and 6in. Hassall's single-lined pipes (ordinary sockets) just in the same way as previously referred to for caulked joint, and found them to be—for 4in. $1\frac{1}{3}$ minutes, and for 6in. $2\frac{1}{4}$ minutes; and the quantities of cement used were—for a 4in. $\frac{1}{2}$lb. per joint, and for a 6in. pipe $1\frac{1}{3}$lb. The following table shows at a glance the details of costs of jointing ordinary pipes and Hassall's single-lined.

Cost of Labour, Material, etc.,

	Time.	Gaskin.	Cement.	Establishment Charges, 10 per cent.	Profit at 10 per cent.	Total. d.
4in. O.	·23	·80	·20	·12	·13	1·58
4in. H.	·16	—	·12	·03	03	·34
6in. O.	·65	1·12	·57	·23	25	2·82
6in. H.	·26	—	·32	·05	·06	69

For 4in., it will be noticed that, in round numbers, the cost of the joint for labour and materials is at the rate of 1¾d. per yard less in the Hassall's pipe than in the ordinary; and for the 6in. pipe, the rate is 3¼d. per yard in favour of Hassall's.

Sykes's Joint.—There are also a great many other types of special jointed pipes more or less well known, such as the Archer, the Paragon, Double Seal, and others. One that has recently been introduced by Mr. Sykes, and which is manufactured by the Albion Clay Company, is of quite another form than those previously noticed, inasmuch as the composition is cast on the pipes with a male and female thread to form a screw joint; and in making the joint a cement composition is used, which is forced into all the

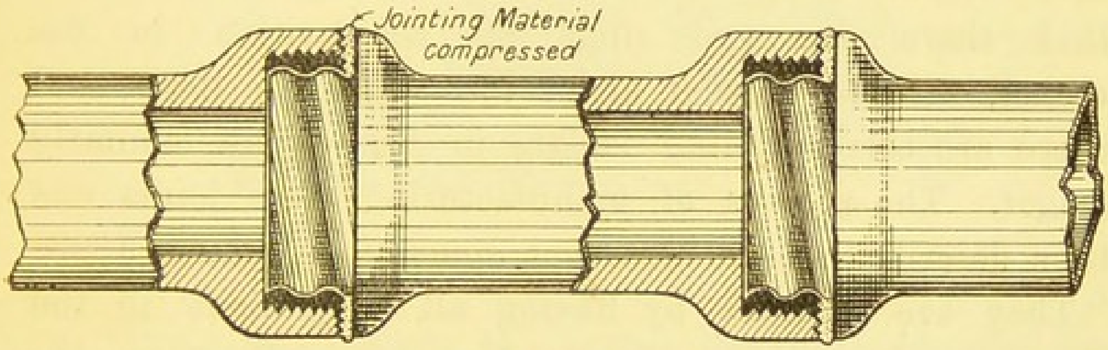


Fig. 30.

interstices by the pressure exerted in screwing up. Fig. 30 sufficiently explains the principles and method of making this joint.

Hassall's Double-Lined Joint.—In running sand or ground where subsoil water is likely to be met with, or where the drain is laid close to a watercourse or follows the course of one removed, Hassall's patent safety joint (double-lined) can be used with advantage, as it can be readily and rapidly made in water; and wherever thoroughly first-class and reliable work is desired, it is undoubtedly the best pipe to use. I quite coincide with the opinion expressed by Mr. H. Percy Boulnois, M.I.C.E., city engineer, Liverpool, on page 295 of his "Municipal and Sanitary Engineer's Handbook," that "Hassall's pipe is the best at present known to engineers and surveyors." Mr. Mawbey, borough engineer of Leicester, speaking in a discussion on pipe jointing at the Sanitary Institute Congress at Newcastle-on-Tyne in September, 1896, said, "His predecessor, the late Mr. Joseph Gordon, M.I.C.E., engineer to the London County Council, dissatisfied with ordinary socketed pipes, got the Corporation to put an end to their use for all ordinary purposes, and now they did not allow anyone to lay them. Mr. Gordon found Hassall's joints the best in the market, and they have been used exclusively ever since." It will be seen from the sketches that there are two rings of composition in the socket, with a space of about 1½in. between them, and there are corresponding collars in the spigot similarly spigot. The process of manufacturing these joints was thus described in the *Contract Journal* of June 7, 1893: "They are dressed by having all projections in the barrel removed, and preparatory to casting on the patent asphaltic composition, the spigots and sockets are pared with a sharp chisel, and the glazed surface removed, in order that there may be a firm adhesion of this patent 'metal' to the pipes. The lower or rebated collar is then cast on the spigot, a steel moulded collar is slipped over the spigot and carefully adjusted and centred, a luting of clay being fixed below it all round the pipe, and the hot 'metal' is then run in. The same process takes place with the collar at the end of the spigot. In putting the corresponding hoops on the inside of the socket, a steel circular die is centred and adjusted, and the hot 'metal' poured in. After the 'metal' has cooled, the collars and hoops are carefully pared off with a sharp tool, and the pipes are then ready for packing. It will thus be seen, the collars and hoops being cast on each pipe from the same moulds and dies, that there is no uncertainty about getting a close fit, as they all come together as truly as if they were turned and bored. Another point to be noticed is the care that is taken to ensure the recess from the cement between the hoops being of a uniform thickness all round."

The mode of making the joint in the trench is as follows :

Lay a band of plastic cement marked A in Fig. 31, a sixteenth of an inch in thickness on the whole face of

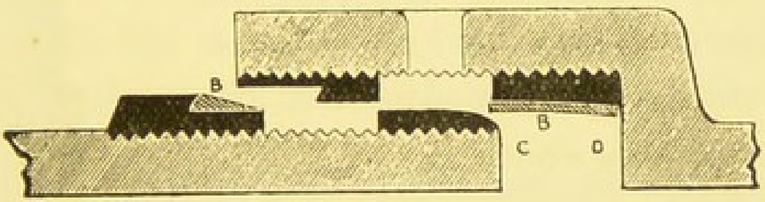


Fig. 31.

the lining cast inside the socket, in the manner shown in Fig. 31. Also lay in the groove of the collar cast round the spigot a band of plastic cement, marked B. Then place this spigot end inside the socket of the pipe lined with plastic cement, and press the same home with an iron bar or other suitable appliance until the external end of the spigot of the one pipe, marked C, abuts against the inner shoulder within the socket of the other pipe, marked D. The two bands of plastic cement will thus be compressed, as shown in Fig. 32, thereby closing the space between the castings of the two pipes, but leaving an annular space or groove between the inside of the socket of one pipe and the outside of the spigot of the other pipe. This annular space is filled with a mixture of five and a half parts of neat Portland cement and three parts of water. Before pouring this cement into the annular groove through the opening, F, a piece of plastic cement must be put under the bridge, E, in Fig. 33 (which divides the two holes, F and G), to block up the space underneath this bridge, so as to compel the Portland cement to run in one direction round the whole of the annular space, until it appears again at the opening, G; unless it does so appear, it will prove that the space between the castings has not been properly closed with plastic

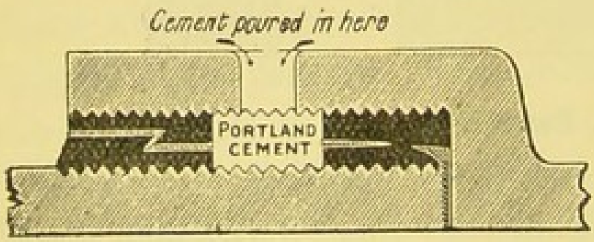


Fig. 32.

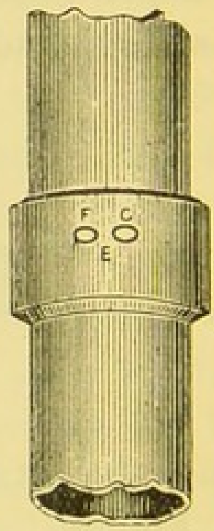


Fig. 33.

cement; should this happen, the joint must be remade according to instructions given. The Portland cement should be poured through a tun-dish or funnel, which is placed in the opening, F, so as to run round the groove under pressure, and drive out all air or water that may be in it. The plastic cement is supplied with the pipes.

The Portland cement should be well mixed and perfectly free from lumps. The cement should not be mixed until it is required for use, and should be well stirred up before pouring in.

If pipes are jointed and the Portland cement is not poured in at once, the two openings, F and G, should be covered by a flat piece of clay, so as to keep the annular space free from grit, etc., until such time as it is filled with Portland cement.

The advantages of this joint are obvious to those having any experience of sewerage and drainage, and, to mention them briefly, are: (1) an airtight and watertight joint; (2) the joints are the strongest parts of the sewer; (3) a true invert secured by the pipes being centred properly when the bituminous bands are cast on; (4) the pipes can be laid in water; (5) in consequence of the joints being watertight, the sizes of the pipes may be reduced; (6) the joints cannot be washed out; (7) the sewage can be passed through the pipes directly they are laid without affecting the joint.

Iron Pipes.—Cast-iron drains may under certain circumstances be preferably used to any form of special jointed stoneware pipe, as they present fewer joints and are more durable and capable of withstanding heavier superincumbent loads, so that in cases where the drain is very near to a surface that is traversed by specially heavy traffic, iron pipes should always be used. They should in all cases be constructed of heavy cast-iron socket pipes, and be of the following dimensions and weights.

Length.	Diameter.	Thickness.	Weight.	Depth of Lead.	Weight of Lead in lbs.	Space in Sockets.
9ft.	4in.	$\frac{3}{8}$in.	1cwt. 2qr.	$1\frac{1}{2}$in.	2·14	$\frac{3}{8}$in.
9ft.	6in.	$\frac{3}{8}$in.	2cwt.	2in.	5·6	$\frac{3}{8}$in.
9ft.	9in.	$\frac{1}{2}$in.	4cwt.	2in.	$10\frac{1}{2}$	$\frac{3}{8}$in.

Iron pipes must be free from rough projections, and coated with a solution to prevent oxidation by contact with the sewage. The best known of these compositions is that of the late Dr. Angus Smith's, and consists of four parts coal tar or pitch, three parts prepared oil, and one part paranaphthaline. The paranaphthaline gives solidity, the oil fluidity, and the tar adhesiveness. The pipes should not be exposed to the weather or allowed to rust before being coated, but immediately after proving should be heated to a temperature of 600deg. F. in a stove, and then dipped into the solution at a temperature of 300deg. F.

The depth of sockets should be 4in., the inner 2in. caulked with white spun yarn, and the outer 2in. filled with lead, care being taken to use sufficient lead in one running to complete each joint (as

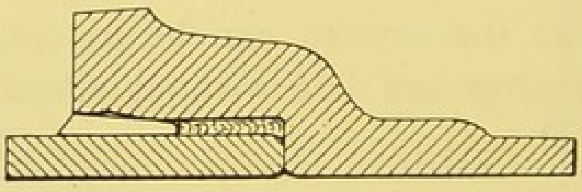


Fig. 33a.

shown in Fig. 33a); which, when cool, is "set up" within the socket nearly an eighth of an inch to fill the space more perfectly with lead, which contracts on cooling. Under a great pressure of water there would be leakage if the lead were not set up. In the case of a drain, there would be hardly likely to be any pressure except by an accidental stoppage, and then only slight. It is advisable not to depart from the usual method of making a lead joint, for though there may be no leakage of sewage, there might be an escape of air above the water-line.

CHAPTER VIII.

Ventilation of Drains.

Before proceeding to point out in detail the methods for the proper ventilation of the house drain — the necessity for which is, of course, admitted by all—it would be well to consider how it arises. It may be urged that, if the drain has been constructed upon the principles here laid down, the sewage will have passed off the premises in such a short time that decomposition cannot have set up. That will be perfectly true, but it does not follow at all that the same conditions will prevail in the sewer, as a little attention to the subject will show. In a system of sewers the flow is very intermittent, the bulk of the house sewage being discharged in eight hours, and for the remaining sixteen it is often not more than a mere dribble, quite insufficient to keep them self-cleansing during that period when sewage gases are largely generated. Town sewage is a much more complex mixture than ordinary domestic sewage, as there is the addition of drainage from slaughter-houses, stables, cowhouses, etc., and very frequently of trade effluents of varying character and rapidly-changing constituents and temperature, which are constantly transforming the gases generated. It is a duty imposed upon all sanitary authorities by Section 19 of the Public Health Act, 1875 "to cause all sewers belonging to them to be constructed, covered, ventilated, and kept so as not to be a nuisance or injurious to health, and to be properly cleansed and emptied." How far this section is complied with, it is impossible to say generally; but we do know that in many places there is either an ignorance of its existence or a determination to take the risk attendant upon its non-observance. It is not the place here to point out the attempts, partial or otherwise, that are made to ventilate and cleanse town sewers, but simply to state that, owing to the varying conditions, construction, age, and other circumstances, the generation of sewage gases in them cannot be entirely avoided, and that under the most favourable conditions the velocity of air in sewers is much less than is usually found in house drains, and the air in them, although more impure, is less diluted with fresh air.

Dangers of Free Connections to Sewer. — The danger of free communication with the sewer, and dead ends to the house drain and its branches has already been pointed out in Chapter II., and to remedy this an opening to the external air is necessary. There are very few instances, even on old property, where this is not attempted; but to be effective, this opening must in no case be of less diameter than the main house drain. On page 16 I have pointed out what is very commonly done in making a connection from a soil-pipe to the main drain. In these cases may be often observed, leading from the soil-pipe to the eaves, a 2in. pipe to act as a so-called ventilator, and which is the sole means of ventilating the 9in. drain—that is, by a pipe which is about one-twentieth of its capacity. What, then, becomes of the remaining nineteen-twentieths? It is clear there is not sufficient pressure behind it to drive it through a 2in. tube, and we are forced to the conclusion that it will find its way into the house wherever openings present themselves. In addition to the objection to a free connection with the sewer on account of the conditions there prevailing, one must also remember that in towns the dejections from patients suffering from various forms of zymotic diseases are frequently passed into the sewers without sterilization; and that as sewer air is not always moving in one direction, being subject to the temperature, velocity, and the course of the atmospheric air, as well as to the velocity, bulk, and temperature of the stream, these disease germs are liable to be carried up any branch drain, and so into the houses connected thereto. Some twenty years ago the late Sir George Buchanan, when at the Local Government Board, examined into an outbreak of enteric fever at Croydon, at a time when the soil-pipes of the houses were ventilated above the eaves and were in free communication with the sewers. In his report this gentleman states: "The air of the sewers is, as it were, 'laid on' to houses; it is arranged that every house drain and every house soil-pipe shall contain, up to the very wall of the house, and up to the very trap of the water-closet, the common air of the Croydon sewers, not simply charged with impurities it may receive from the particular house, but charged also with any dangerous quality that it may have brought from other houses; for hardly anywhere in Croydon can there be found an arrangement for severing the sewer air from the air of the house drain; so that wherever drain air has entered the house, no matter by how inconspicuous a defect, and no matter whether it has given rise to stink or not, it has been the air of the common sewer."

Drain to be Intercepted.—To prevent this free communication with the sewer and to cut off the house from the dangers pointed out as likely to arise therefrom, it is necessary to interpose some resisting body, and the one usually selected as being the most effective for the purpose is a water-trap. The flap-valve which is used to prevent backwatering is not reliable, as while sewage is passing it must necessarily be open above the stream, and so admit sewer air into the drain. The particular form of trap will be considered later on, but its position should be as near to the sewer as possible; and as the necessary works in connection therewith are part of the house drain and the maintenance thereof belongs to the owner, this must be within the curtilage of the premises (except under such exceptional conditions as will be hereafter pointed out) as close to the building line of the street or road as possible.

Through Ventilation. — It is a sound axiom that "you cannot have too much fresh air in drains," and for the purpose of effecting through ventilation there must be an uninterrupted current through an undiminished passage-way from end to end. There must be no dead end, but the drain must terminate in an opening to the air. One opening only would simply cause the air to be shut up and to stagnate in the drain and to become exceedingly foul by reason of the contact with the sewage. To counteract the effects that are caused by the insertion on the drain of the water-trap, there must be placed immediately alongside of it, upon the house side, a clear way opening from the air to the drain in such manner as shall comply with the provisions of Model By-law 65, which also stipulates for the second opening at the head of the drain. By

By-law 62 it is further provided that all other inlets upon the drain shall be properly trapped—that is to say, that all branch drains of every kind shall terminate at and be connected to a water-trap. The accompanying section (Fig. 34) shows the first of the methods

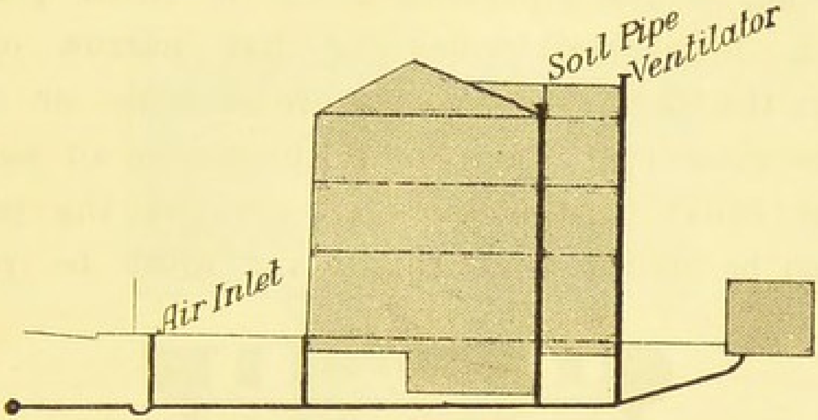


FIG. 34.

prescribed by the Model By-laws. The alternative method may be effected by carrying the outlet pipe up the front of the house clear of the eaves, and the inlet may be fixed against the wall of the outside closet, thus reversing the current of air.

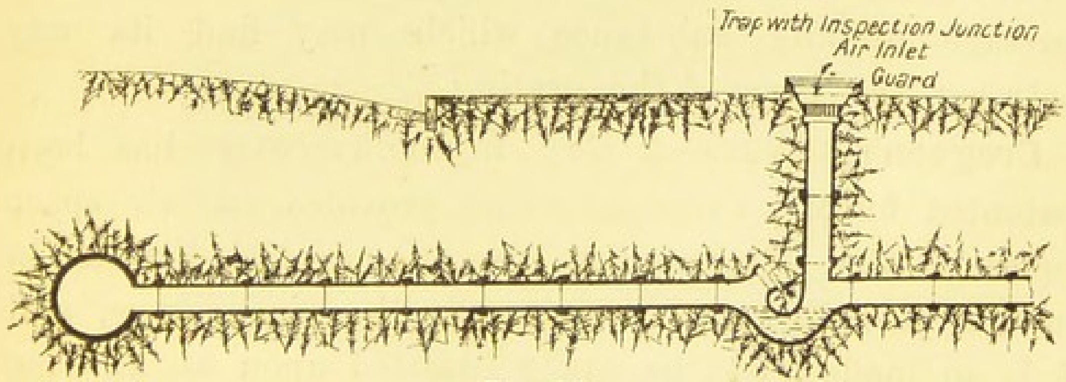


FIG. 35.

Disconnecting the Drain.—Fig. 35 is an enlarged drawing showing the details of the method of disconnecting the house drain and providing the air inlet. There are, of course, a great variety of ways for executing this work, dependent on and controlled by the special circumstances of each case, but the provisions contained in Clauses II., III., and IV. of By-law 65 must be carefully observed.

Air-Inlet Covers.—It is a very usual thing to see these air inlets covered with a cast-iron grating let into the socket of the pipe, and which is either perforated with a few small holes or has narrow openings between the bars; such covers are of little or no use, as it is clear that there is nothing like an aggregate opening equal to the sectional area of the pipe. It will also be noted that this cover must be provided

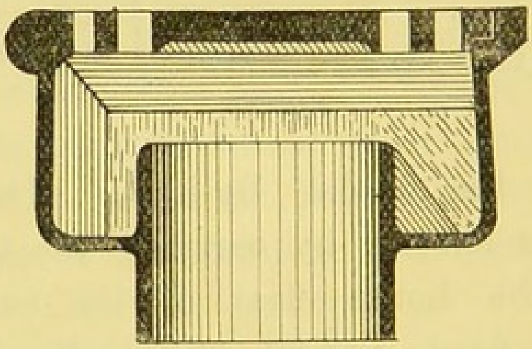


FIG. 36.

with a dirt-box or some other provision to arrest the passage of any substance which may find its way between the bars of the grating.

Cregeen's Cover.—A very ingenious cover has been patented by Mr. Cregeen, which provides an air space equal to the air-pipe, and also a suitable dirt-box in such a position as not to impede the air passage, and it is so made as to be easily inserted upon an air-pipe and securely fitted to the socket, as will be seen on reference to Fig. 36. This cover is made of cast iron of heavy section for use in situations traversed by vehicular traffic; but in other places, one having the dirt-box made of stoneware with a loose iron cover is quite suitable.

Ham, Baker, and Co.'s Cover.—Another form of cover having a loose-dirt box is shown in Figs. 37 and 38; this is made by Messrs. Ham, Baker, and Co., of Westminster, and will be found to answer the purpose admirably, and has a very smart appearance when set.

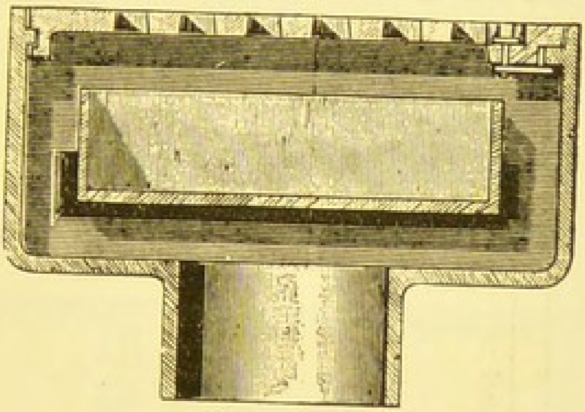


FIG. 37.

Air Inlet by Side of Wall.—There are frequently certain positions in which it is not, from a variety of surrounding circumstances, advisable to place an air inlet grating on the surface. There may be also

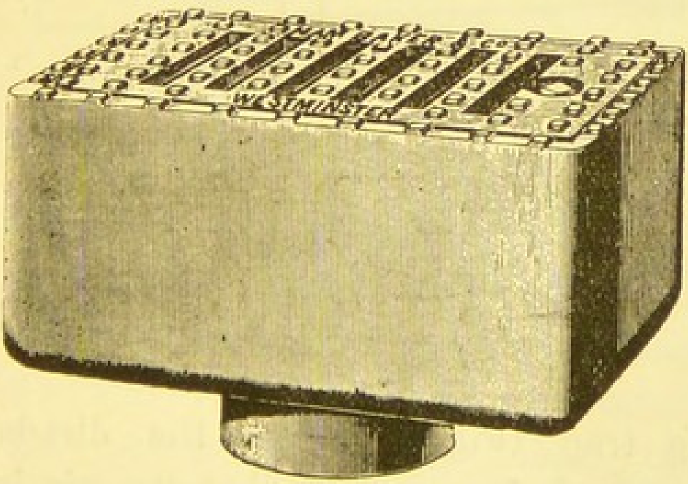


FIG. 38.

the scruples to be met of people who have a horror of seeing any opening to a drain, and who are always positive that in passing over such contrivances they can detect foul air, so keen is their power of scent;

it is idle to try and persuade such people that they are the victims either of sentiment or imagination. In these cases, the air inlet may be fixed on the face of the wall of some contiguous building, and having an induct pipe of cast iron (this, if preferred, may be inserted in a chase in the wall) connected to stoneware pipes branched into the vertical shaft off the

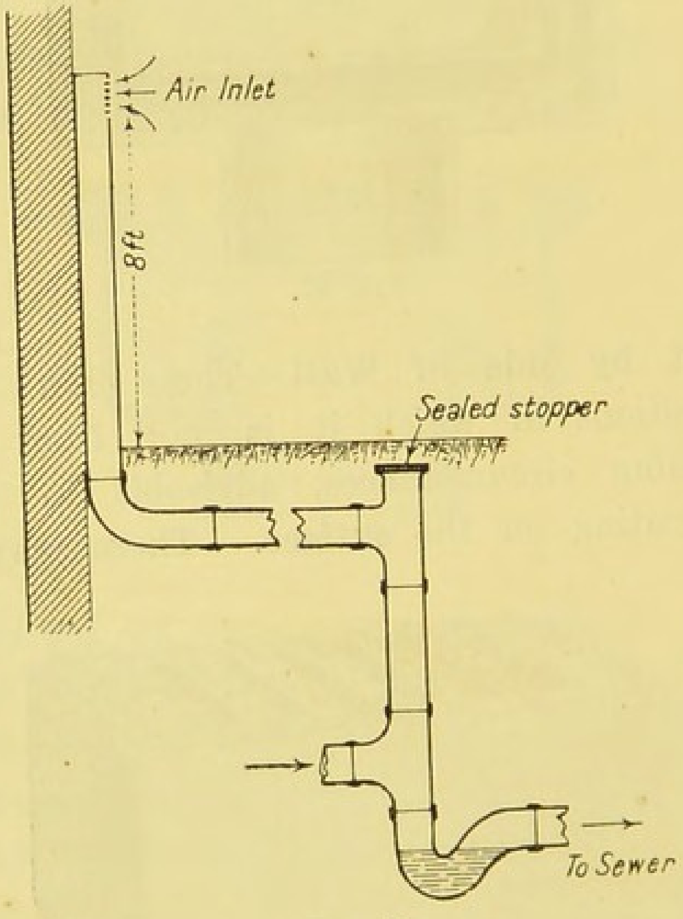


Fig. 39.

intercepting trap (Fig. 39). As the dirt-box will be dispensed with, it is necessary that the air inlet should be fixed out of reach of mischievous personages who might otherwise be fired with a penchant for feeding it with all manner of solids. Care must be taken to provide an inlet having openings between the bars equal to the sectional area of the drain, and for these situations a mica flap-valve may with advantage be used in preference to an open grating. In cases where the house drain passes under the building and the interceptor is below the public footway, then the air inlet should always be constructed in this manner. For the reasons given above, and others which are so obvious as not to require enlarging upon, air inlets fixed either as a special casting in the curb or let into the plinth course of the building are not to be commended.

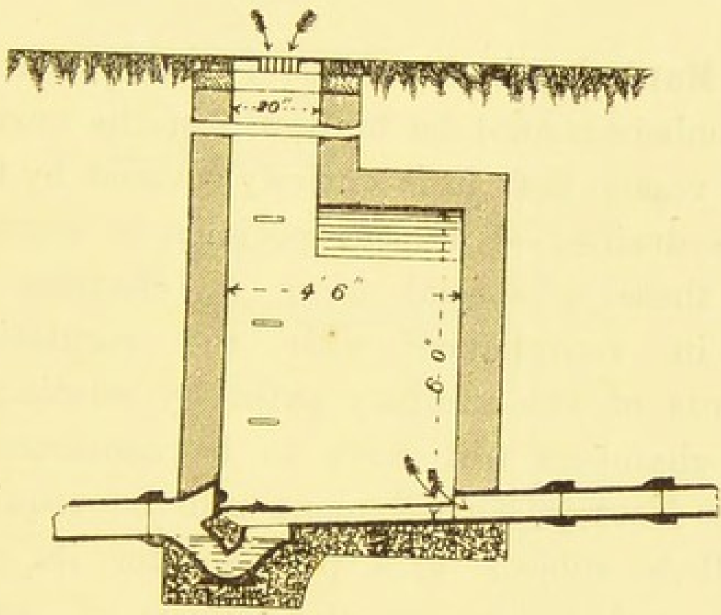


FIG. 40.

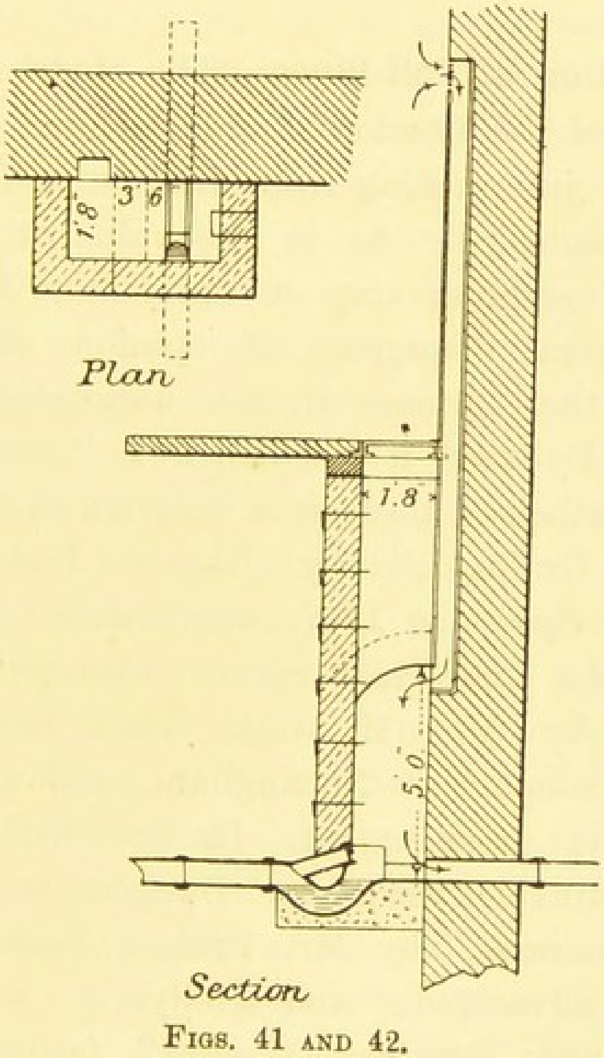
It must also be pointed out that the footway belongs to the district council, and that the owner of a house is not at liberty to insert anything without their consent; and that even before removing the surface to get access to the pipe shaft, permission would have to be obtained from them.

INTERCEPTING MANHOLES.

Ordinary Manholes.—A better arrangement than the pipe-shaft air inlet is to form a disconnection chamber or intercepting manhole (Fig. 40) within the curtilage of the premises, and as near to the main sewer as possible. The manhole should afford plenty of room for access to the trap for inspecting or cleansing purposes, and the cover should have an open grating to serve as an air inlet. Wherever surface openings are objected to, then the air duct may be constructed after the manner shown in last figure, and the manhole closed with an airtight cover. The methods of constructing these chambers will be described in detail in the chapter devoted to manholes.

Special Manholes in Streets.—There are cases where access chambers cannot be built within the curtilage, for the simple reason that it is entirely covered by the buildings to be drained—I refer especially to town blocks; and for these a special form of chamber will be required in compliance with the regulations and requirements of the sanitary authority relating thereto. As these chambers will have to be constructed under the public footway, an easement will be required, and which will be subject to a payment for its grant and conditions probably as to the means of access and the projection of the air-inlet duct. No hard-and-fast line can be laid down for these, as much will depend upon the importance of the thoroughfare, the width of the footway, and the amount of traffic passing over it; and in many towns no projections of any kind other than window cills are allowed beyond the face of the building. For these and similar reasons, therefore, no standard type for this class of chamber can be set up.

Figs. 41 and 42 show a plan and section of one of these chambers, of which I constructed seven for one of the largest banks in Manchester a few years ago, and it is especially interesting as being the first of its kind executed in that city. No greater projection was allowed than 1ft. 8in., and the length was fixed at 3ft. 6in. This size will just allow a man when kneeling to get access to the trap. A bonnet arch was turned over 5ft. above the invert, and a shaft 20in. square carried to the surface.



Figs. 41 and 42.

The cover was an airtight iron cover; but, instead of having a studded plate, ribs were cast across, and it was filled in with concrete, rendered smooth so as to be similar to the pavement. No projection of the air-pipe was allowed, so a chase was cut into the wall and a pipe 8in. by 6in. inserted and secured to the wall by ears screwed into plugs. The grating was 8ft. above the footway. A number of waste-pipes of all kinds discharge into these chambers, and although to comply with the Corporation's conditions was necessarily an expensive piece of work, the chambers were satisfactory to all parties, and they have continued to work well. This system or some modification of it may be adopted in similar situations.

Disconnection of Soil-Pipes.—The Model By-laws and the by-laws of the London County Council prohibit any but the one intercepting trap, and particularly at the foot of the soil-pipe. As to the value or otherwise of fixing an intercepting trap at the foot of the soil-pipe, there is a great divergence of opinion amongst sanitarians. In the footnote in the annotated edition of the Model By-laws it is called a "useless impediment"; nevertheless, there is a diagram in "Regulations for House Drainage," by Rogers Field, M.I.C.E., published by Spon's in 1877, which shows this arrangement. In the same year Spon's also published some regulations by Mr. M. Ogle Tarbottom, M.I.C.E., which were adopted at Nottingham, and which likewise included this arrangement. In the well-known and extremely valuable work on "Dangers to Health from Defective Drainage," by Mr. Pridgin Teale, F.R.S., the system is advocated; and Hellyer's work on the "Plumber and Sanitary Houses" fairly teems with illustrations showing how the system can be adopted under every conceivable variety of circumstances. For a small single house with only one w.c. there is, of course, no need for a second disconnection, but where there are a number of houses side by side communicating with a combined drain, or—as it is to be known in future—sewer, then it has always seemed to me that the arguments urged by Dr. Buchanan, which are quoted on page 77, apply quite as forcibly, and that it is sufficient for each house to deal with the smells created about that house alone, and not to be troubled with the smells of one or more adjoining houses, whether diluted or not. In the case of large houses, too, where there may be long branches from the main to the soil-pipe, it is an advantage to have a disconnection. Again, every sanitary appliance inside the house is doubly trapped—once inside the house, then disconnected outside, then a properly trapped gully. If that is sound construction, then why should the outgo of a w.c. trap communicate directly with a drain and *vice versâ*? If the latter is the right principle, why place gullies under every trapped waste-pipe even when a vent-pipe is carried from the waste from below the lead trap into the open air so as to get perflation? The only possible objection that there can be to an open end of a soil-pipe foot is that the unpleasant smell from the fresh fœces may be driven out of the opening and escape though a window into a lower room. All this is capable of adjustment: the grating should not be fixed upon the surface in any situation where such a condition of things may arise, and the alternative of leading an air-pipe to the interceptor and fixed in a suitable position should be adopted. I have had a great number of soil-pipes disconnected and placed openings upon the surface, and have never heard any objections to them. Mr. Hellyer cites a case which shows conclusively that the system can be adopted without the least possible offence to the most sensitive nostrils, and I venture to give the particulars, which are as follows:

"About the year 1882, I had two stacks of soil-pipes fixed with a large number of valve closets upon each, and they were made to discharge with open ends into open traps. But as the gratings over the tops of the drain 'disconnecting' traps were right in the footway of a narrow public thoroughfare, and as the parties chiefly concerned in the erection of the building would have been too nervous to have sanctioned any such open ventilation, nothing was said about the arrangement of such ventilating traps, and the gratings were supposed by all concerned except myself to be simply covering the ends of rainwater-pipes. As a proof of the safety of such arrangement it may be mentioned that, though the closets upon each of the two stacks of pipes just referred to have been in great use for several years, though thousands of people have walked over the gratings, and though office windows are within 8ft. or 10ft. of them, no one has ever noticed the slightest disagreeable smell from the arrangement. Whenever I have examined these intercepting traps they have been found quite free from any offensive odour, and the atmosphere has been passing freely *into* the discharging end of the soil-pipe at this point, and not *out* of it." Mr. Hellyer also states that he has a similar arrangement within 10ft. of his own office window and that he has never found it in the slightest degree offensive. The soil-pipe at my own house is treated in this manner, and I have never yet found anything in the least degree objectionable emanating from the open grating.

An open trap should never be fixed in a confined space or narrow passage-way where currents of air can blow over them, which might have the effect of drawing the soil-pipe air out through them by removing the atmospheric pressure from the discharging end of the soil-pipe through the wind blowing down over the

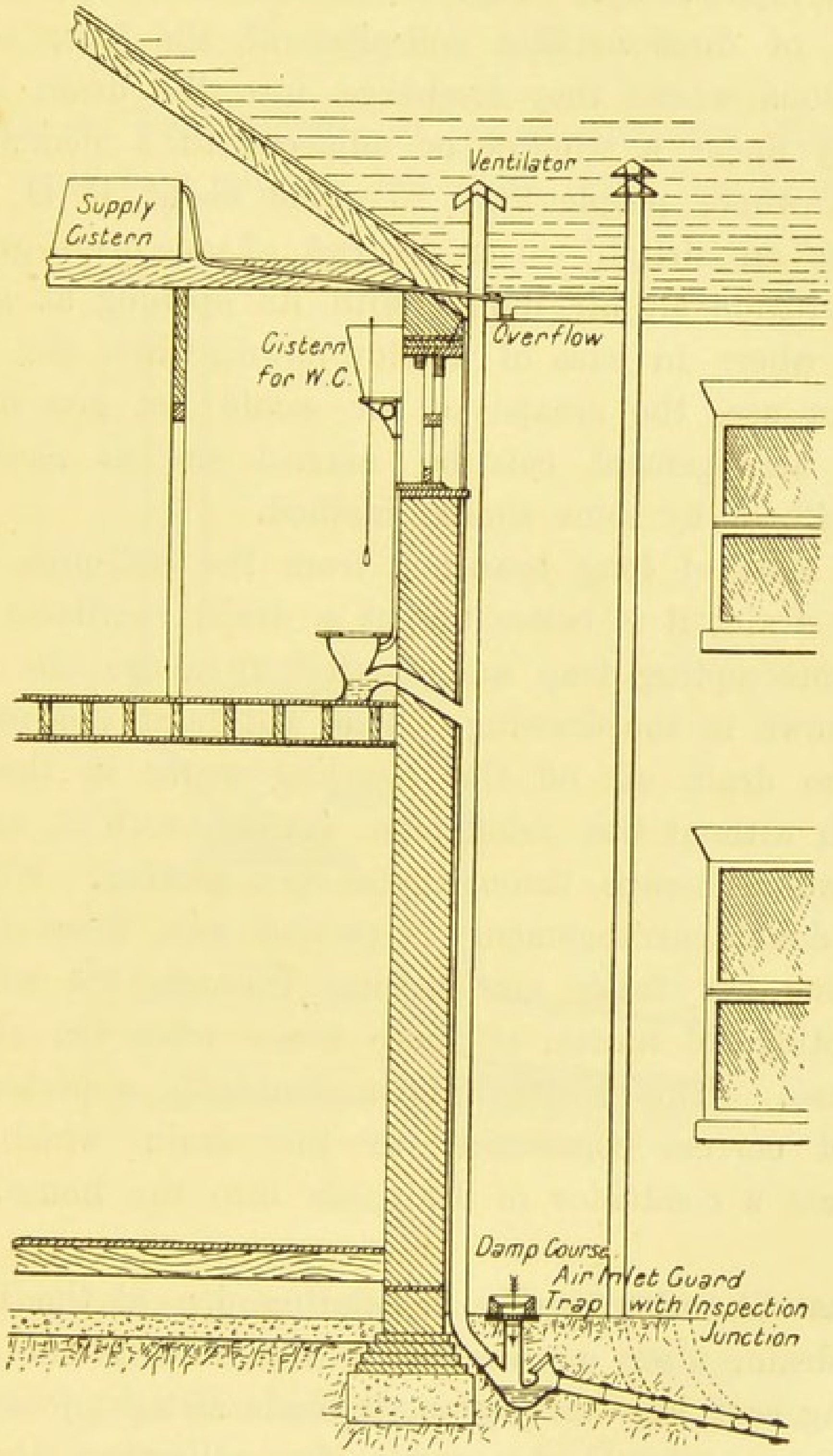


FIG. 43.

top of the trap, and a *blow-down* will take place in the soil-pipe; and when the closets were in use this blow-down would be offensive, while at other times it would be inodorous and could not be detected by the passer-by. Fig. 43 illustrates this arrangement of disconnecting soil-pipes at the foot, but in situations where they discharge into the drain immediately under a window or adjacent to a doorway or porch where people have to stand about, it is better to use an airtight cover instead of an open grating, and provide an air induct with its opening at such a point where in case of a blow-down, when the closet was in use, the escape of air would not give offence. This arrangement can be carried out as shown in Fig. 43, or by some similar method.

In case of long branches from the soil-pipe to the main drain, it is better to put a drain ventilator below the intercepting trap and carried up above the eaves, as shown in the drawing. This will take the pressure of the drain air off the standing water in the trap, which without this relief pipe would absorb it, and the gas would escape through the open grating. Wherever this double arrangement is carried out, there can be nothing but fresh air passing through the soil-pipe, excepting, of course, at those times when the closet is in use. This method is undoubtedly superior to a direct correct connection to the drain which may become a conductor of drain air into the house.

Rust Chambers.—The ventilating-pipe at the head of the drain, when a soil-pipe is not used, should be of strong cast iron with properly-made airtight joints; and provision should be made for collecting the rust which is likely to accumulate in the bend at bottom of the pipe. This rust would gradually diminish the air passage, and very likely in course of time completely intercept it, so that a receptacle for this deposit should be provided. A very simple one made in glazed stoneware is shown in Fig. 44, and is the invention of Mr. Fred Lynde, A.M.I.C.E.

Cowls on Vent-Pipes.—In many instances the head of a ventilation pipe is left quite open, but to prevent

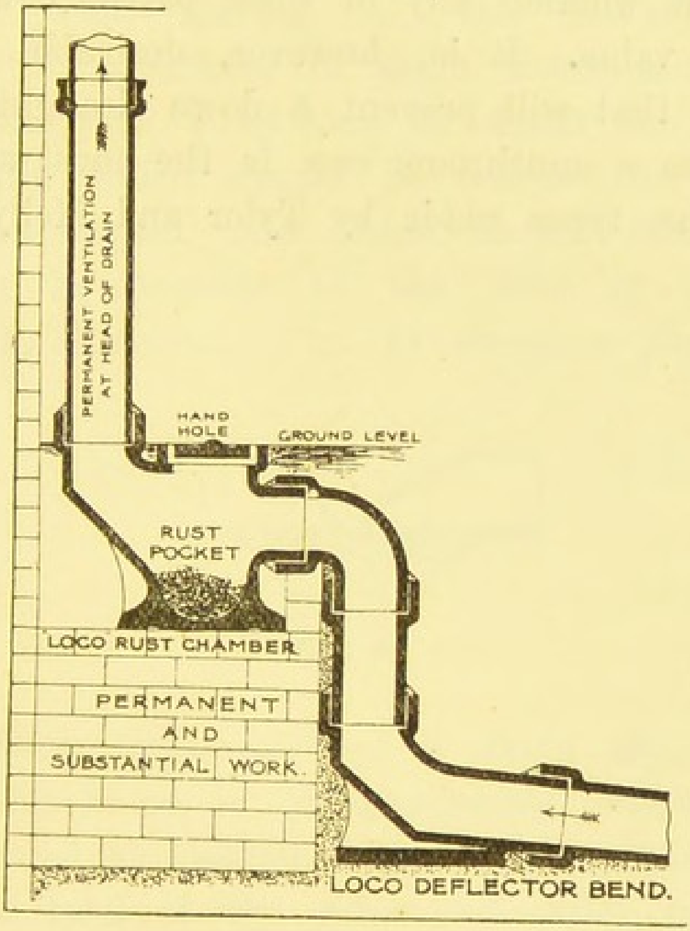


Fig. 44.

access by birds, it is better to finish them off with a galvanised wire balloon. As to the efficacy of cowls for inducing or accelerating a current of air, there is, and must always be, a great variety of opinions, as so much depends upon the position of the terminal, which, if under the shelter of overhanging walls, will be influenced by the rebounding air and the eddies caused by such a position. Some cowls act better than others when the air is light and variable, and *vice versa*; and the power of the best of them to exhaust the air from the drain is really so slight—that is, that the excess of air extracted over what is passed through an open pipe, when measured at the same time and under the same conditions, that on the whole it is questionable whether any of these patent cowls are of any real value. It is, however, desirable to adopt something that will prevent a down draught, and for this purpose a mushroom cap is the most serviceable, such as the types made by Tylor and Hellyer.

CHAPTER IX.

Intercepting Traps.

Syphon Trap.—Having in the previous chapter described the principles of drain disconnection, it is now necessary to point out in detail the particular form of trap which should be selected for use as a foul-air interceptor, and which should offer as little obstruction as possible to the flow of sewage in the opposite direction. Fig. 45 shows a plain syphon

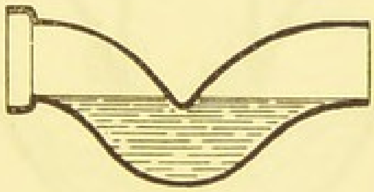


Fig. 45

trap, and this forms part of a drain through which the sewage flows in a continuous stream. This trap is formed by making a dip, which is carried below the invert level of the inlet and outlet end of the pipe; and to guard against loss of seal, which might be caused by evaporation, this dip should never be less than 2in., and in a dry state of the atmosphere this is little enough. The sewage lies dead in the trap when there is no discharge through the drain.

Manhole Trap.—A modification of this form of trap is shown in Fig. 46, and is known as the manhole trap. This is a particularly objectionable type, as grease quickly adheres to the walls of the manhole, and the obstruction causes a rapid accumulation of sediment in the bowl of the trap. The quantity of sewage discharged from a house is often very small and not sufficient to cause much disturbance in the trap; sediment under such circumstances will form, and will increase and harden, and finally result in a complete blockage.

Sanitary Institute Experiments in Flushing of Traps.—From the report of the Committee of the Sanitary Institute on the "Flushing of Water-Closets," issued November 1, 1893, we find that in the case of a drain 50ft. long, laid at a gradient of 1 in 40, that

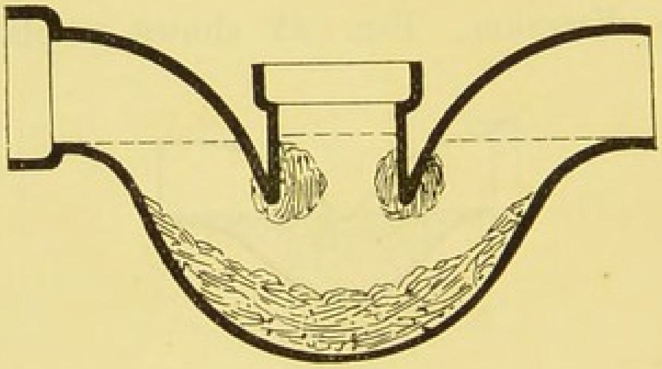


FIG. 46.

the average amount of material remaining in the intercepting trap from 600 experiments was 36 per cent. with a two-gallon flush, and 26 per cent. with a three-gallon flush. Two hundred and forty experiments were made with a drain 26ft. long at a gradient of 1 in 40, and the retention was 26 per cent. with a two-gallon flush, and 19 per cent. with three gallons.

Requirements of Good Traps.—From these experiments it will be seen that intercepting traps are liable to blockage due to insufficiency of flush in the sewage discharged through the drain, which is increased by the accumulation of grease, which ought never to find its way there if the various sink gullies are regularly and properly cleansed: and in dry seasons this conglomeration of grease and sediment will give off a peculiarly foul odour. To overcome these difficulties, it is essential in the first place that the intercepting trap should be of a self-cleansing form, and should not hold more water than the flush of the water-closet, so that it may be frequently changed; and where this flush has a long way to travel, some additional flushing power is required. Care is also required in setting the trap true in every direction. Where these details are intelligently attended to, the interceptor need not be a "miniature cesspool"; and

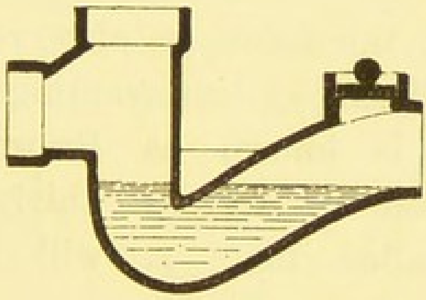


FIG. 47.

where they have been followed out, the traps have been observed to work satisfactorily even after twenty years of use.

A well-known form of trap is that known as the "Buchan," which is shown in Fig. 47, and in which a drop of 2in. is introduced at the inlet, but the straight wall opposite to this is as objectionable here as in the wash-out form of w.c., as the force of the flush is just as apt to get broken up by being banged about from side to side, and then quietly falls into the bowl of the trap and loses its scouring power. It is important, therefore, to make the fullest use of the incoming flush, and not to change its direction, but rather to direct it upon that part of the trap where it is most wanted.

Fig. 48 shows a good, strong, and compact form of trap which fulfils these conditions, and where the seal is 3in. instead of 1½in., as in the "Buchan,"

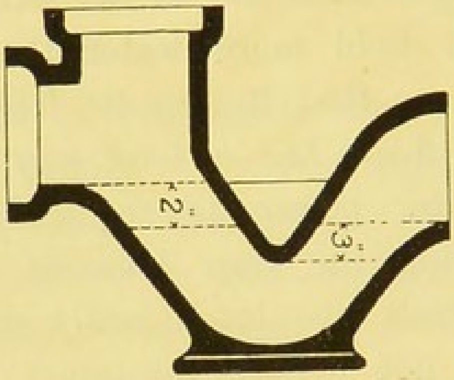


Fig. 48.

and the drop at the inlet is also retained. One of the oldest-made forms of intercepting traps is shown in Fig. 49, and is known as Brown's, and has, I am informed, been in use for thirty years, and is still regularly called for. It will be noticed that

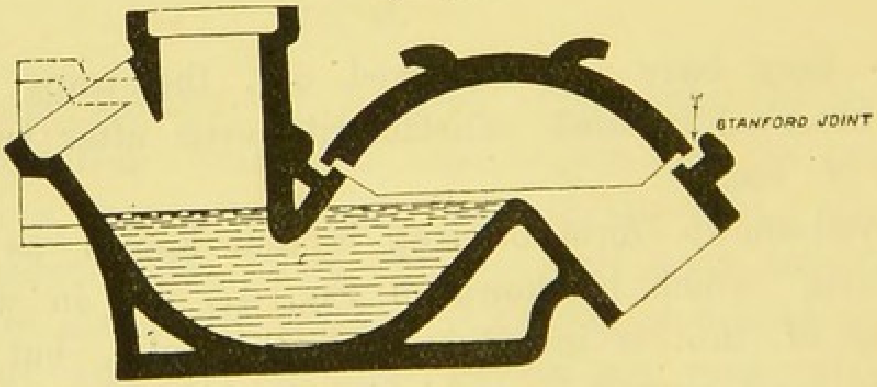


Fig. 49.

not only is the inlet bevelled so as to turn the direction of the flow upon the bottom of the bowl, but the outlet takes the form of a weir, which imparts a cascade motion to the water passing through the trap. The trap is also made with a good strong seat, so that it can be firmly bedded and set true without much labour. Another form of these drop traps with weir outlet is that known as Stidder's, and which is shown in Fig. 50. This trap

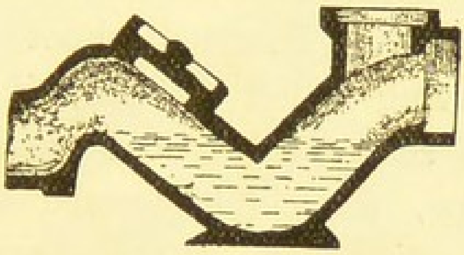


FIG. 50.

is made in a great variety of patterns to suit all kinds of special circumstances. The "Quick-motion" trap of Mr. Slagg, shown in Fig. 51, is of quite another pattern, the throat being contracted to half the cross-section of the drain, and, having a flat

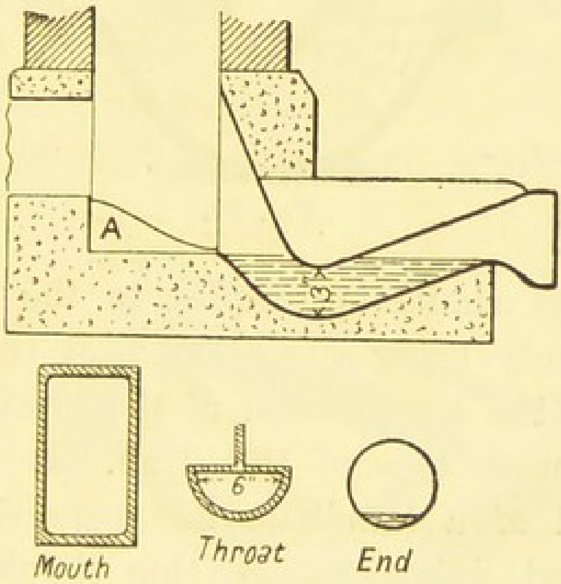


FIG. 51.

roof. It is claimed that the velocity through this trap is twice as much as can take place through the ordinary form, and that its capacity is large enough to pass the greatest quantity of water coming to it, and small enough to compel the water and sewage to pass through with a greater velocity than it can possibly have when the sectional area is the same as the drain-pipe itself. The air inlet is usually formed of brickwork for these traps, and the bottom, with an inverted shoot from the drain to the trap, having a fall of 4in., it will be noticed that where the contracted throat deploys to the full size of the pipe, a weir is formed with a drop on the outgo of 3in., so that there is a cascade motion, as in Brown's and Stidder's traps.

Intercepting Traps for Manholes.—The intercepting traps that are fixed in the outlet to manholes are

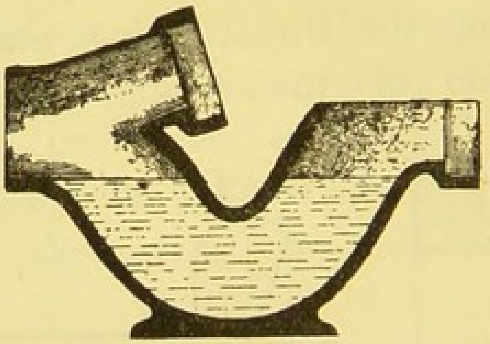


FIG. 52.

designed upon similar principles to the ordinary ones, the shapes only being altered to meet the requirements necessary in the construction of the brickwork. Fig. 52 shows a common type of this trap. It will be noticed that, instead of a handhole for inspection, an arm is projected, and the socket of this should be set flush with the brickwork and closed with a stopper. A relieving arch should always be turned over this arm, otherwise the superincumbent weight of brickwork would fracture the metal.

Fig. 53 shows another shape of this type of trap. It will be noticed this is somewhat stronger than the one in the preceding figure, as the arm and trap are joined; but there is the disadvantage of the straight wall opposite to the inlet, which has been previously

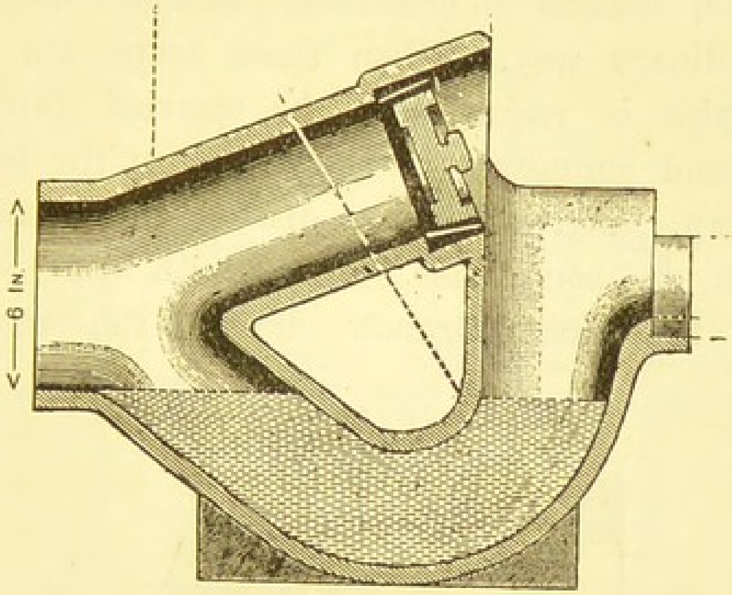


FIG. 53.

pointed out. In Hellyer's "Drain Sentinel," which is constructed in a similar manner, this wall is slanting, as shown by the dotted lines.

Fig. 54 shows another variation, which in principle

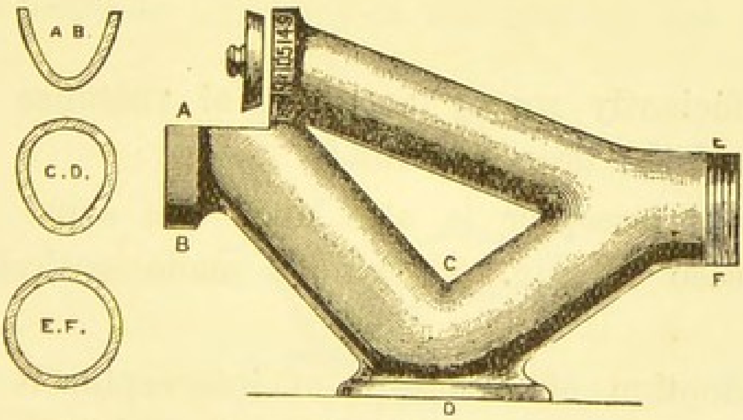


FIG. 54.

is somewhat similar to Slagg's trap, as will be seen from the cross-sections, the shape being changed from circular to ovoid with the object of getting an improved scour from the sewage during its passage through the trap.

Some of the manhole intercepting traps are entirely closed, and, instead of channels, pipes are used, jointed in the ordinary way. When these traps are used, an air-inlet pipe is required to be carried through the manhole and connected to the drain on the house side of the trap. Fig. 55 shows one of these traps. The head-piece is sometimes made with one or more junctions to receive branch drains, the access hole

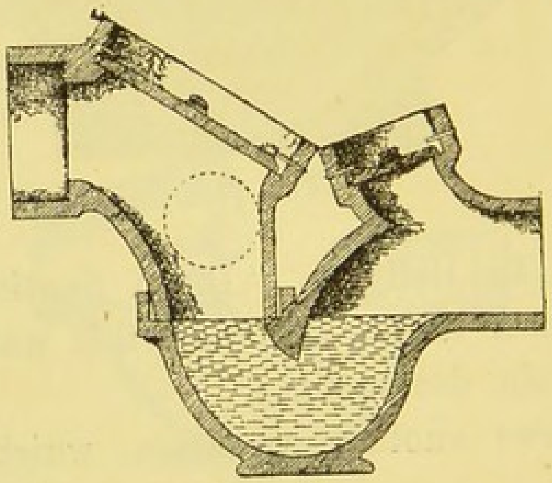


Fig. 55.

being sufficiently roomy to allow of entrance for tools into any of the branched inlets.

Sykes's interceptor is also upon the same lines, as will be seen in Fig. 56, but is made entirely in one piece.

The adoption of this type of interceptor is a sign of weakness and a concession to the "miniature cesspool" school of sanitarians, whose arguments hang entirely upon defective drains, appliances, and want of attention on the house side of the interceptor; and without going over the ground again, I can only repeat that there is no danger from a well-selected, well-arranged, and well-fixed open intercepting trap.

Intercepting Traps for Soil-Pipes.—There are many forms of intercepting traps for use at the foot of soil-

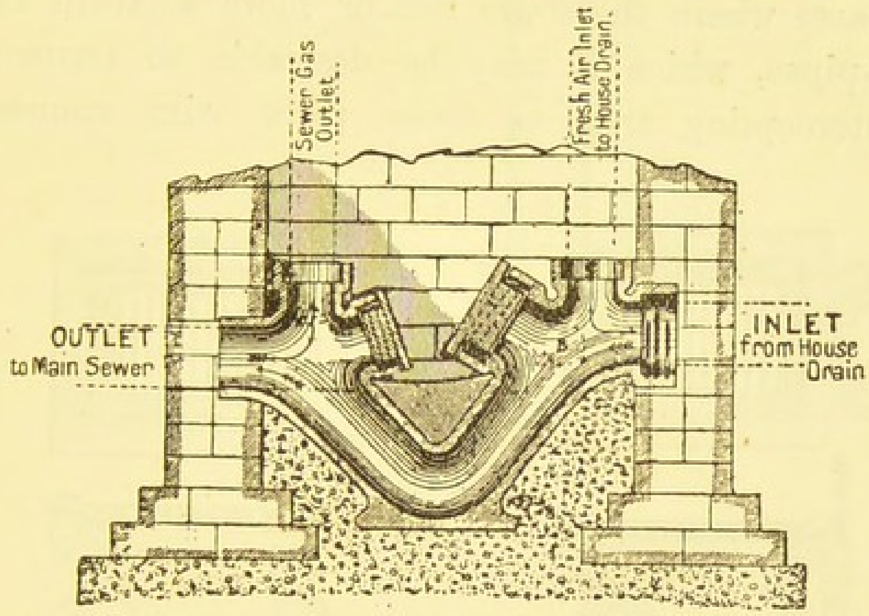


FIG. 56.

pipes. Brown's trap (Fig. 49) or Stidder's (Fig. 50) are very suitable for the purpose, but in fixing this type of trap care should be taken to see that the openings between the bars of the grating are of a total

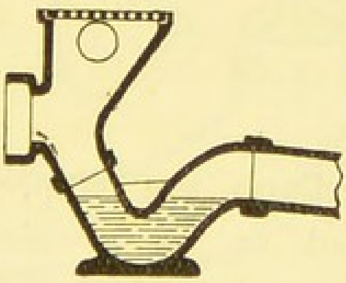


FIG. 57.

capacity slightly in excess of the soil-pipe. This will mean fitting on a short taper pipe to the air-inlet branch. Mr. Hellyer has devised a trap which I have found to be an excellent one for the purpose (shown in

Fig. 57), and which carries out this principle in a very workmanlike manner. The traps shown in Figs. 58 and 59 are also on the same lines, but made in one piece. These are manufactured by Cliff's, at Wortley, Leeds.

In cases where there are two or more adjacent stacks of soil-pipes, which it may be desirable to connect to one intercepting trap, a loose piece with connecting

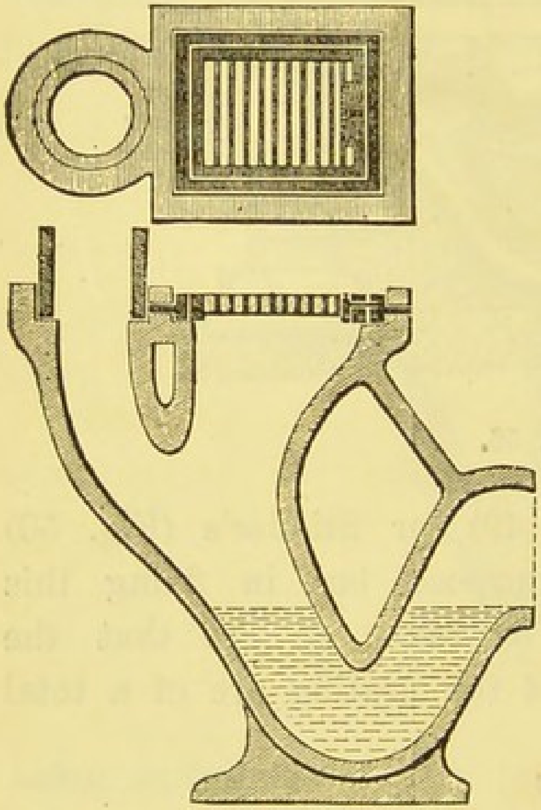


Fig. 58.

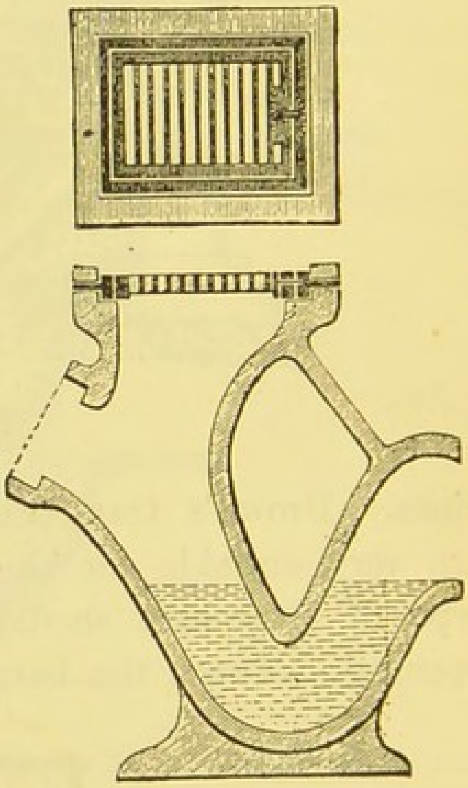


Fig. 59.

arms may be fixed on the trap, or a small brick chamber constructed so as to give more convenient access to the separate branches. Where the depths of the drain is in excess of the depth of these last-mentioned traps, a small brick shaft will have to be brought up to the surface; for the Brown's or Stidder's type of trap a length of pipe will suffice. In situations where there is traffic over the surface, such as in pathways, areas, or courtyards, the air-inlet cover should be of similar pattern to those shown.

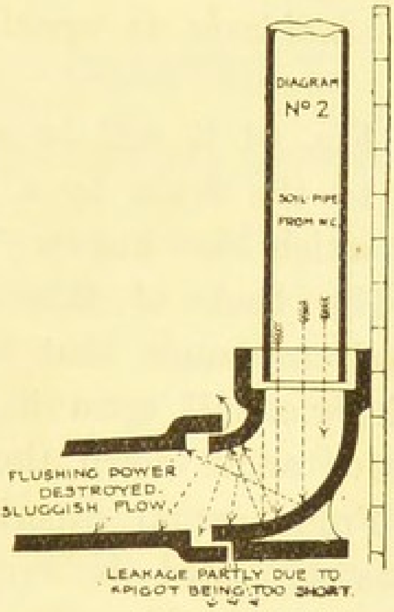


Fig. 60.

Bends in Soil-Pipe Drain.—It is not advisable to use an ordinary bend for a connection from the soil-pipe to the intercepting trap, as the flushing power of

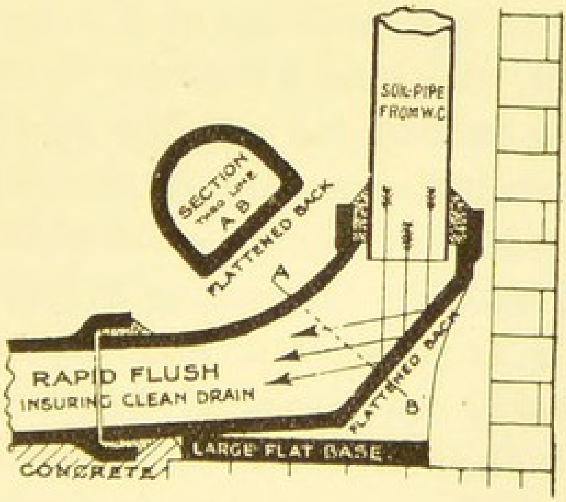


Fig. 61.

the discharge from the w.c. is broken up and diminished by striking the angle of the bend, as will be seen by reference to Fig. 60.

Fig. 61 shows a bend designed for such situations by Mr. Fred Lynde, A.M.I.C.E., by, as he says, "taking an advantage of a well-known natural law, that *the angle of incidence is equal to the angle of deflection.*"

On reference to Fig. 61 it will be seen that the soil-pipe is connected to the drain by a specially designed connecting pipe, which is known as the "Loco." deflector bend. The back of this bend is flattened and formed at such an angle that the flushing water and fœces from the w.c. fall upon it, and are deflected at the most effective angle down the drain, as shown by the arrows. From actual experiment the velocity of the water thus projected is very considerable, so great, in fact, that it could only with difficulty be seen, on its passage down a drain, through an inspection hole made for the purpose.

CHAPTER X.

Setting Out and Construction.

Taking Levels.—In a preceding chapter (IV.) I have referred to the necessity of a good and accurate working plan, but there is still something more required, and that is a section showing the surface levels along the intended line of drain, together with the levels of floors and other surfaces, which will regulate the height of gullies, and from which the wastes will discharge. Taking plan No. V., let us see what levels are necessary, so that the gradients of the main drain and branches can be determined. In addition to the main line, levels will be required at the soil-pipe in the corner, and at the corner of the coach-house and stable, and also for the ground-floor lavatories, etc., in the cloakroom. It is not necessary here to describe the usual type of surveyor's level nor the method of operating it; those who are not familiar with these can find full instructions in various well-known treatises on the subject. All sections should be plotted in relation to some well-defined datum, for although this is sometimes taken from a fixed mark, such as a threshold, it is very much better to adopt the Ordnance datum. From the published maps the level of the nearest convenient benchmark should be ascertained and booked, and the first reading of the staff taken upon it. The next point will be the surface level of the road over the sewer where the junction will be connected; then the channel curb, back of footpath (which will regulate the surface of intercepting chamber), next the ground at point where the junction manhole is to be fixed. If there are any depressions in the ground between the manholes they should be taken. We will assume that from the position in which the instrument is fixed it is impossible to read any sights beyond the second junction manhole, so it must be again set up in a convenient position for covering the greatest number of sights without changing. This will be somewhere about the outside corner of carriage-washing shed, so that the final sight can be read clear of the buildings as we are working back round the front of the house to pick up the lavatory branch drain. From there we go on until we finally complete by taking the reading of the same benchmark from which a start was made; and if the levels have been accurately read, on casting up there should be only a slight variation between the recorded reduced levels. The entries in the level book will appear as shown in the specimen page.

Preparation of Working Section.—The section may be plotted on a convenient scale, say 20ft. to 1in. horizontal and 10ft. vertical. It is not necessary in work of this character to write in the reduced levels of the surface, as about new premises, that is subject to alteration and change, but the reduced levels of the temporary benchmarks should be recorded distinctly in black figures. The value of these benchmarks will be fully pointed out later on. In fixing the depths of the drain for this plan, owing to an absence of cellar drains, we are governed by the necessities of the longest branches. Assume that the outlet of the soil-pipe interceptor, which is at the head of the drain, is 2ft.

SPECIMEN PAGE OF LEVEL BOOK.

Back Sight.	Inter-mediate.	Fore Sight.	Rise.	Fall.	Reduced Level.	Chainage.	Remarks.
2·17					29·30		Ord. B.M. on railway bridge.
5·23		5·00		2·83	26·47		
	5·45			22	26·25	0	Centre of road over sewer invert, 7ft. 8in. below.
	5·19		·26		26·51	12	Channel.
	4·94		·25		26·76	12	Curb.
	4·19		·75		27·51	18	Back of footpath.
	5·71			1·52	25·99	40	M.H. No. 1.
5·76		3·18	2·53		28·52	70	M.H. No. 2.
	4·07		1·69		30·21	94	M.H. No. 3.
	4·93			·86	29·35	132	Kitchen sink, 25ft. from line.
	3·04		1·89		31·24		Soil-pipe, 34ft. from line.
	3·47			·43	30·81		Corner of coach-house, 43ft. from line.
	3·61			·14	30·67		Soil-pipe at corner. 16ft. from line.
	2·86		·75		31·42		Heel-post hinge stable gate.
5·26		4·57		1·71	29·71		
	4·18		1·08		30·79		Threshold of front door.
	5·01			·83	29·96	0	Soil-pipe from cloakroom.
	5·47			·46	29·50	14	Bend in line.
3·38		4·11	1·36		30·86		Top of plinth course.
	6·04			2·66	28·20	54	Junction with M.H. No. 1, 40 on last line.
	6·71			·67	27·53	102	Lower hinge of front gate.
5·43		6·47	·24		27·77		
		3·93	1·50		29·27		Ord. B.M.

below the surface, deducting this from the reduced level we have 29·24 as the level of the drain at this point. Allowing 1ft. of fall in the 34ft., we shall then be 28·24 at the entrance into the manhole—that would be 3ft. 2in. below the surface; but as it is intended to place a flushing tank in connection with this manhole that would not suffice as the depth of the syphon flushing leg, with dome and trapped outlet will be about 4ft., and over that will be the cover, so

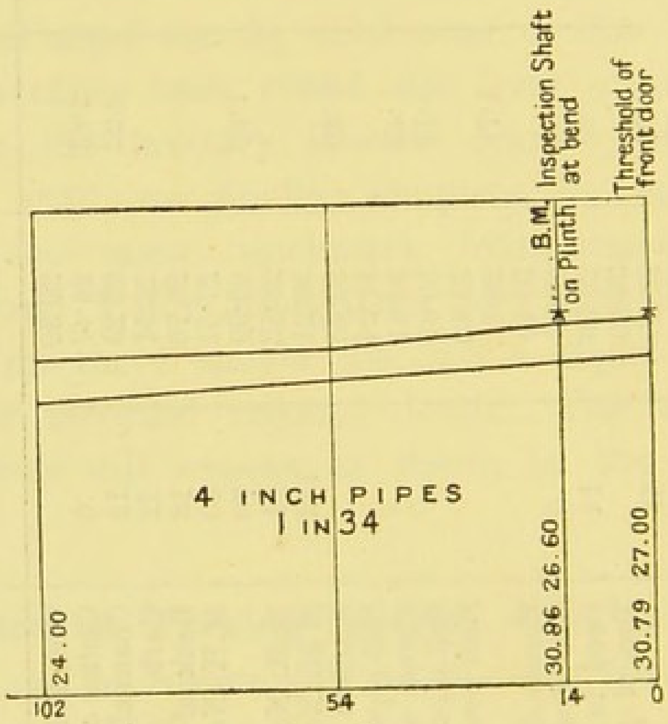


Fig. 62.

we require a depth of about 4ft. 9in., at which it has been fixed upon the section, with a reduced level of 25·50. A reference to the other levels of the sanitary appliances will show that this will permit of ample fall being given to the various branch drains which discharge into that manhole. The next point where the level is regulated is at the junction manhole, where the drain from the front of the house is to be connected. Fixing the depth in the chamber at the far end at about 3ft., we have a reduced level of 27, and if we give 3ft. of fall in the total length of 102ft. it will produce a gradient of 1 in 34, which is satisfactory for a 4in. pipe. This will bring the level at the junction to 24·00; but as it is not advisable to connect to the main drain at the same level, this is dropped to 23·5, which will allow a fall of 1 in 46 between the intercepting manhole and the end of drain: and there is a drop of 3ft. before connecting to the

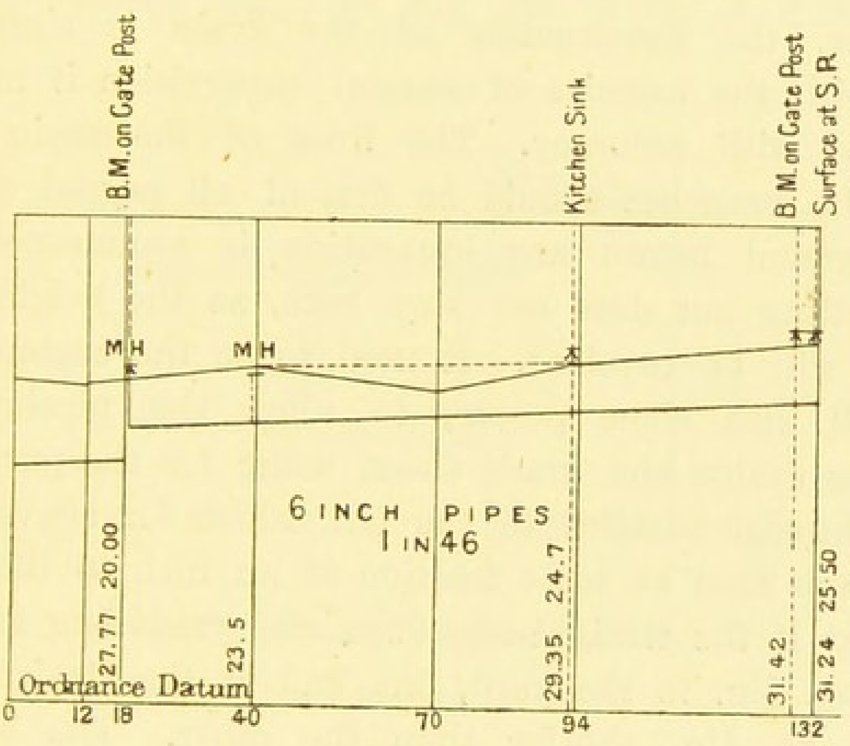


Fig. 63.

sewer (Figs. 62 and 63). This change of level (which may be effected in the manner pointed out in the succeeding chapter) possesses two advantages: first, there is the saving of excavation by lessening the depths of the excavation in all trenches; and secondly, a better working gradient is obtained, which keeps up a more equable flow, and overcomes the difficulties which have been previously pointed out as arising from too rapid falls in drains. The reduced levels of the drains should be written on the section in red figures, and the drains themselves marked in red lines, with the sizes and gradients also. The height of the datum line above Ordnance should be recorded, and the chainage of the various points where manholes are to be fixed, or changes of direction and gradients occur.

Methods of Laying Pipes to the Gradient. — Having prepared a working section in this complete manner, the construction of the drain is simplified, and with the exercise of careful supervision it may be finished with accuracy. The lines of the main drain and the branches should be first of all pegged out on the ground before any excavation is commenced, but the setting out does not stop here, as the heights and levels will be required. It used to be the custom, and is still with some people, to allow the pipelayer to lay the drains and grade them, using for the purpose a straight-edge bevelled to the fall, which for convenience sake was fixed at some fraction of an inch to the yard, so that if the straight-edge was one yard long and the fall was $\frac{3}{4}$in. to the yard, one end of the straight-edge would be $\frac{3}{4}$in. shorter than the other. The bevelled edge being placed along the pipe, a spirit-level is rested on the outer edge and the lie of the bubble noted, and the pipe is then adjusted as required. No one can pretend that this is either an accurate or reliable method of grading pipes, which may or may not reach the required depth at the termination of the drain. I have sometimes come across a pipelayer with a rough piece of railing which he has sawn off to a yard length, and at one end he has secured a small piece of lath with a tin tack, and with that instrument and a level he was flattering himself he would lay a truly graded drain—comment is needless.

Sight-Rail and Boning-Rod Method.—The only accurate method of securing a perfectly regular gradient is by the sight-rail and boning-rod system, by which means an imaginary line is drawn parallel to the intended gradient of the drain, and this can be fixed easily no matter whether the gradient be steep or ever so flat. The boning-rod is a long rod cut off at any convenient length to suit the depth of drain. At

Fig. 64a.

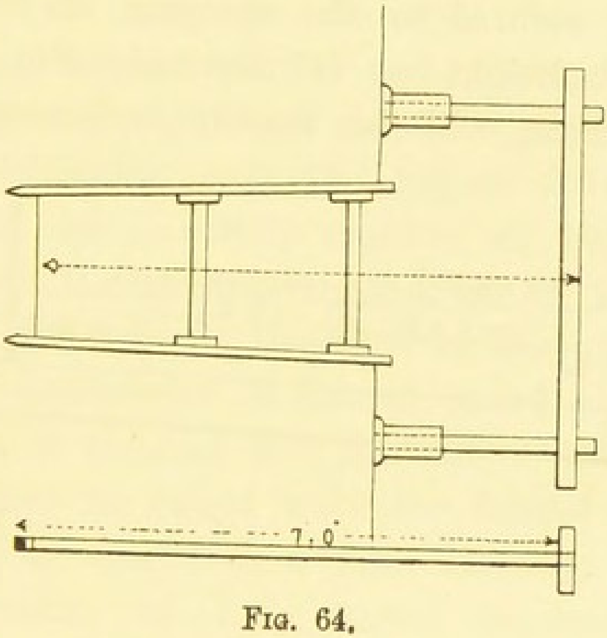


Fig. 64.

one end is accurately fixed at right angles the cross-head or T piece, as shown in Fig. 64, and at the lower end is screwed on a shoe which fits on to the invert of the pipe; thus the shoe should be secured to the rod by angle iron and screwed in, and whenever the rod is required to be shortened, the change is readily made (Fig. 65). Sight rails are always fixed first at the point where the drain commences; next, at all changes of direction and gradient, and at any intermediate point convenient when desired. Two uprights should be placed vertically in two pipes, one on each side of the trench, but well away from the edge, so as to prevent displacement in case of slight "shunts" in the trench. The pipes should be filled round the uprights with

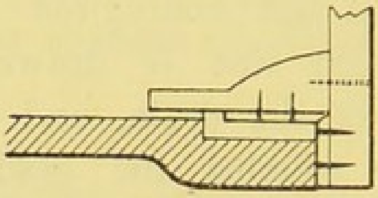


FIG. 65.

sand and tightly packed. The sight rail is an ordinary straight-edge secured to the uprights set level across, and at such height as is required (Fig. 64A). The method of fixing will be readily understood from the

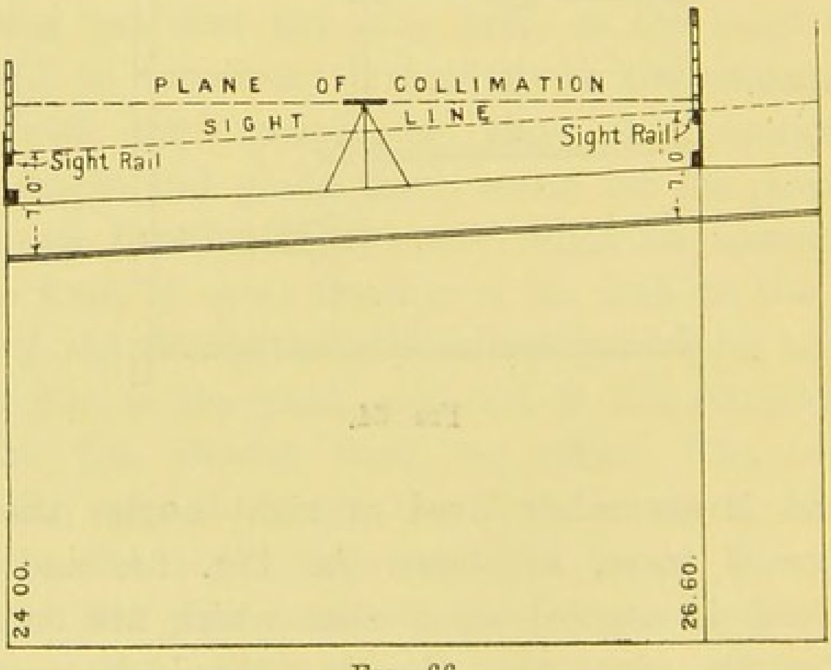


FIG. 66.

following description of the setting out of the line of 4in. pipes shown upon the section (Fig. 62).

Setting-up Sight Rails.—On reference to Fig. 66, it will be seen that the level is set up about midway between the two turning points. It will be seen that as the drain varies in depth from 3ft. to 4ft. below the surface, a convenient length for the boning-rod will be 7ft. The reduced level of invert at the starting manhole is 24·00; the sight rail will be therefore 31·00. At the turning chamber the reduced level of invert is to be 26·60; the sight rail here will have to be 33·60. It will be remembered that a temporary benchmark was left on the lower hinge of the front gate, reading 27·77; the level staff must, therefore, be first held on that and the reading taken, which we will assume to be 6·17. Now, to get the level 31·00, 3·23 must be deducted from 6·17, being the difference between 27·77 and 31·00, so the staff when held on the sight rail must be raised until the plane of collimation cuts the figures 2·94, when the upright must be carefully marked at the bottom of the staff, then the same reading must be taken on the opposite upright. To fix the level at the other end, the head of the instrument is turned round and the same reading, 2·94, is secured, and the fall of 2·60 is added; or the staff may be raised until the figures ·34 are cut. Before removing the level, a final reading of the staff should be taken on the second benchmark, which should record 3·08 if the level has been accurately set, the benchmark being 30·86. These figures may be recorded also in this way:

	27·77	height of temporary B.M. above datum.
add	6·17	staff reading (back sight) on above.
	33·94	height of plane of collimation above datum.
	31·00	height of starting sight rail—zero.
	2·94	reading on staff to secure last level (31·00).
	33 94	as above.
	33·60	height of first sight rail.
	·34	reading on staff to secure level of 33·60.

Another method of fixing sight rails is to first of all work out in feet and inches the difference in level between the inverts of the drain and the temporary benchmarks that were fixed opposite or near to the positions for the sight rails; this method allows the clerk of works discretion in fixing the length of the boning-rod. To fix the height of sight rail, he levels across from the B. M. with straight-edge and spirit-level to the upright, upon which he marks the level of the B.M., and measures up the requisite height, being the difference between the B.M. level and intended level of sight rail. This method should not be followed unless the accuracy of the clerk of works can be implicity relied on; it has the advantage certainly of saving a great deal of time, as when the surveyor is on his visit he can take all the necessary readings; and after working out in the office the necessary calculations, they can be furnished to the clerk of works whenever required without leaving the office. Taking the same section again, such a schedule of levels would be made up in the following manner:

Position of B.M.	Chainage between Sight Rail.	Reduced Level of B.M.	Reduced Level of Inverts.	Depth of Invert below B.M.	Height of Sight Rail above B.M.	Remarks.
On hinge of gate post.	0	27·77	24·00	3ft. $9\frac{1}{8}$in.	3ft. $2\frac{7}{8}$in.	gradient 1 in 34
Plinth at angle	88	30·86	26·60	4ft. 3in.	2ft. 9in.	
Threshold of door	102	30·79	27·00	3ft. $9\frac{1}{2}$in.	2ft. $2\frac{1}{2}$in.	

Excavating Trenches.—The levels being obtained and sight rails set up, the excavation of trench should be proceeded with. So far as the portion in the road is concerned, that will have to be done in all respects in compliance with the regulations of the local authority, and which are referred to fully in a subsequent chapter. The trench should not be got out wider than necessary to allow sufficient room for the pipe-layer to work at the bottom. The length opened out will be governed by the number of men kept constantly at work, the nature of the ground, and the interference with the access to the premises; and where the ground is bad from wet sand or other causes, or in passing close to walls and buildings where the foundations may be liable to disturbance by reason of the trench being kept open, it should only be got out in short lengths in special circumstances; and under close supervision tunnelling may be allowed. If rock be met with, it must be hewn out by hand, as blasting is too risky in the neighbourhood of property; but should the trench be, in the opinion of the engineer, at a safe distance from houses, it may be resorted to—the contractor taking all responsibility for accidents both to lives and property. In rock where a good roof may be obtained that is sufficiently strong to support the superincumbent weight, driving headings may be allowed, and also in other cases where the excavation would exceed in depth three lifts—say, 16ft. Up to that depth there is no economy in tunnelling, but before this is resorted to, all the surrounding circumstances must be fully weighed and considered. The excavated material should be neatly and compactly deposited alongside the trench so as to do as little damage and occasion as little inconvenience as possible, and all surplus soil to be removed promptly as the works proceed.

Timbering Trenches.—As the excavation proceeds, the sides of the trench should be supported by proper timbering fixed in a sound and workmanlike manner by "experienced and competent timbermen." Fig. 67 shows a cross-section of trench fully timbered. The walings, of 3in. spruce planks, are first set up and secured by stretchers of good, strong square or round fir or (in narrow trenches) of larch. The poling boards are of spruce or elm, cut into 3ft. 6in. lengths, with

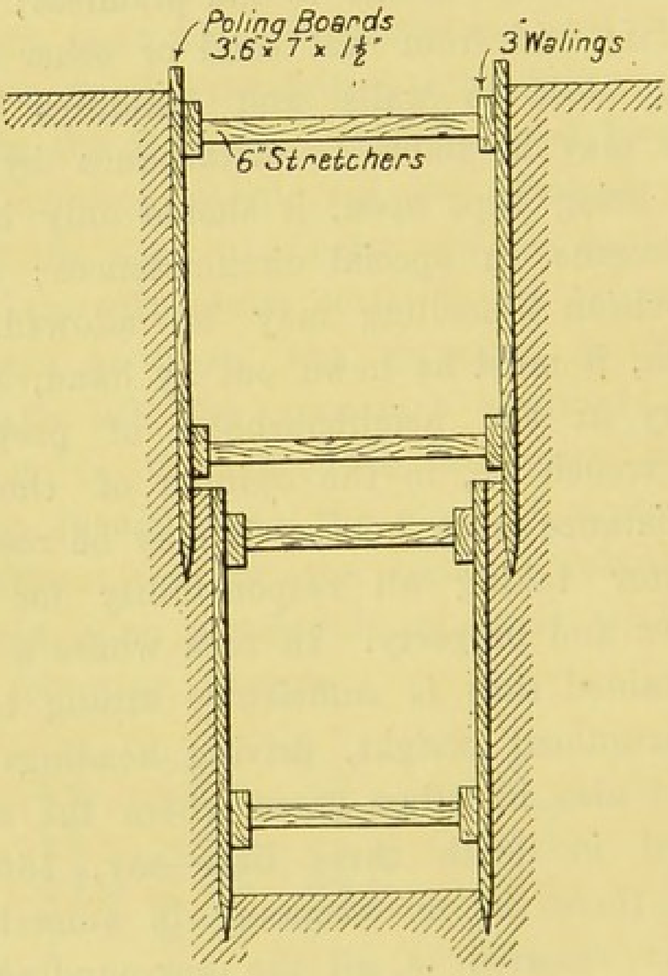


FIG. 67.

the toes sharpened and driven in with a mall behind the walings as close as the nature of the ground requires. The lower timbers are inserted in the same manner as the work proceeds. In case running sand is met with, the poling boards should be wedged close together and additional stretchers inserted, and behind the poling boards, litter, rushes, or bracken should be packed as tightly as possible, and added as required. Occasionally this running sand is so difficult to deal with that a second and inside course of poling boards is required to resist the pressure. The timber within each length of walings is called a "setting," and in difficult ground the work should proceed by settings, one being opened out as the preceding one is being filled in. This is naturally a costly process, but is a safe one. In certain cases, to support property, some of the timber will require to be left in the trench, and where this is done, such timber should be accurately measured and cubed up; but if the necessity for leaving it in has arisen from carelessness or neglect on the part of the contractor, any timber so ordered to be left in should not be paid for. The timbering should be strong enough to carry the staging necessary to hold the weight of material thrown up at each "lift," and the men working upon it, which are usually from 4ft. to 5ft. apart vertically. Water and gas pipes and similar things will require supporting across the trench so as to prevent their fracture. These are sometimes slung to the top stretchers by chains, so that these walings must not be struck as the trench is being refilled. Extra timbering will likewise be required in the shoring up of walls and buildings. If any water is found in the trench, the contractor must at his own expense provide and fix proper and sufficient pumps for abstracting it, forming proper dams and sumps for the purpose, to keep the excavations clear of water during the progress of the works, and where the depth of sump is below the level of the pipes, all the wet and loose "slurry" must be removed and the hole made good with concrete.

Foundation for Pipes.—The trenches must be neatly formed to the shape of the drain to be laid down, and all irregularities resulting from bad workmanship filled up with fine gravel or concrete. Where the foundation is not sufficiently firm to keep the pipes true to the gradient or will cause them to give way when the superincumbent weight of the refilled trench is placed upon them, a foundation of concrete should be formed and carried up at least half the height of the pipe, so that it may be securely bedded in it. The method of mixing this concrete will be found fully described in the chapter on "Manholes, etc." The concrete must be lowered to the bottom of the trench in buckets, and properly placed in position; for if it is shot from the top of the trench, it loses its proper consistency, as the stone, being heavier, parts from the mortar and falls to the bottom first, and, in the act of striking, any mortar which is carried with it is, by the rebounding driven off and adheres to the sides of the trench above and is thus wasted.

Connections to Sewer.—The first stage in laying a new drain is to make the connection to the public sewer, and this must be in accordance with regulations of the council. In the specimen form of regulations will be found various methods of making these connections. Right-angle junctions must never be used, but proper oblique; or, as they are sometimes called, bevel junctions, and the junction piece must not be upon the top of the drain, but the pipe turned over until it rests upon its side at such level as shall be fixed by the surveyor. The next length of pipe may sometimes require to be a bend of suitable curvature, and as these are usually made to varying radii there will be no difficulty in selecting one to fit the special angle created by the connection. Should there be any difficulty in getting detached from the main sewer the three pipes necessary so as to admit of the insertion of a proper junction pipe, such as running sand in the trench or the danger to property or other things in keeping it open or enlarging it, then, if the surveyor sanctions, a hole may be cut in the pipe for the insertion of a properly curved and flanged connecting collar, the spigot of which is of a depth equal to the thickness of the sewer pipe, and the flange is bedded in cement mortar upon the pipe. These collars should have sockets, as shown in Fig. 68.

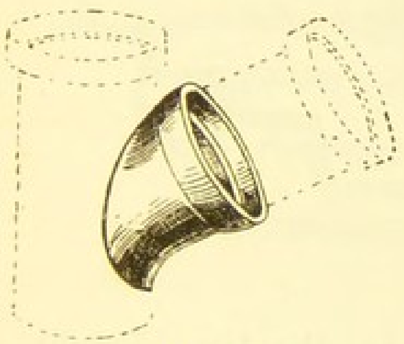


Fig. 68.

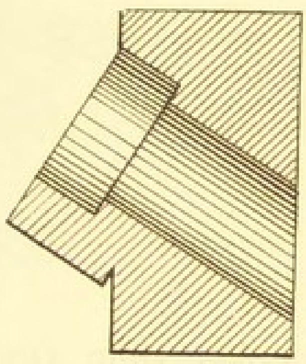


Fig. 69.

When the connection has to be made with a brick sewer, then the brickwork must be cut out sufficiently to allow the insertion of a highly glazed stoneware or fireclay oblique junction block having square bed, sides, and top, as shown in Fig. 69, and which must be set in cement mortar, and the brickwork of the sewer walls made good.

In districts where the sewers are liable to be backwatered from tide locking or the rise of floods, it is essential that these junction blocks should be fitted with a flap-valve that will close with the pressure of the rising sewage in the main sewer. There are also several modifications of this form of valve, which are fully described in the chapter on "Cellar Drainage."

Laying Pipes to Line and Gradient.—In laying the pipes to obtain the exact line, the centre of the trench should be nicked on each sight rail, as shown in Fig. 64A, and a stout cord connected to each mark. From this a "plumb-bob" can be suspended over each pipe. Socket holes must be cut in the foundation and the pipe firmly bedded; its exact level is secured by the pipelayer inserting the shoe of the boning rod upon the invert and keeping the rod upright. The

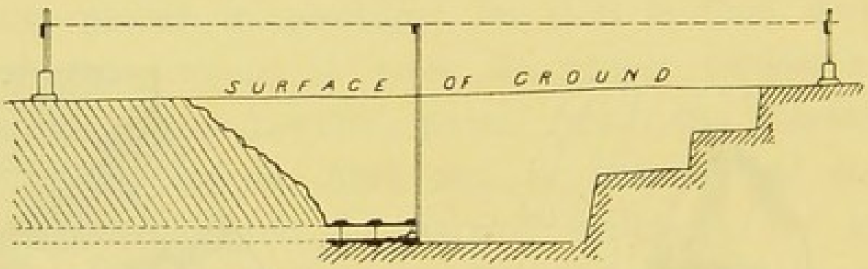


Fig. 70.

overlooker then applies his eye to the lower sight rail to see whether the top edge of the cross-head of boning rod is above or below line of sight between the rails. If it is above, then the ground must be trimmed and the pipe lowered until the trued grade is reached; should it be below, then it must be gently raised and packed with dry, firm material. Small pieces of broken slate will be found the most suitable for this purpose. Fig. 70 shows the process of "ranging" pipes by the method described.

Hydraulic Testing for Soundness of Joints.—When the pipe is finally adjusted to the exact gradient, and the "all right" signal sounded, the jointing must then be proceeded with according to the manner required either for ordinary or special jointed pipes, and must be completed according to the process described in the chapter on "Pipes and Jointing." No pipes should be covered up until they have been examined and tested for water-tightness. This is done by stopping up the lower end of the drain with a plug so as to make it absolutely watertight, and at the extreme end a bend and two lengths of pipe should be placed temporarily, so as to secure a sufficient head of water—say 5ft.—and the drain should then be filled and allowed to stand for, say, two hours, during which time the behaviour of the water in the vertical stand-pipe should

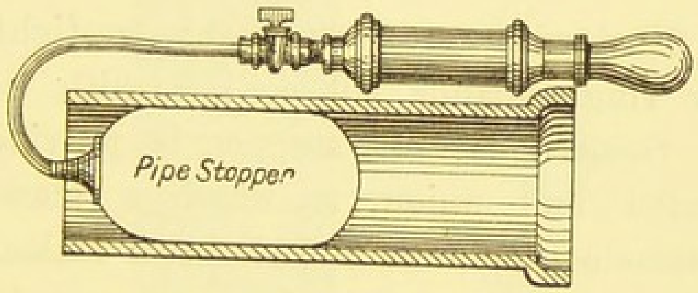


Fig. 71.

be noticed: and if there should be any subsidence a leakage will have taken place at one of the joints, which should be searched for, and, when discovered, made good. There are several forms of these stoppers to be had. Fig. 71 shows Jones's indiarubber bag stopper, which is a very convenient one for carrying about. Attached to the end of the bag is a length of india-rubber tubing, with tap and union for attaching a small force pump. The bag is first inserted in the drain before inflation, and filled with air by working the pump. When the contact between the bag and pipes prevents the escape of water the tap should be closed, and the bag can remain as long as required; by opening the tap the air will escape, causing the bag to collapse and allowing its withdrawal. Mr. Jones is also the patentee of another stopper, called the "Screw-expanding," which is shown in Fig. 72, and consists of a hollow rubber ring between two flat discs, the outer

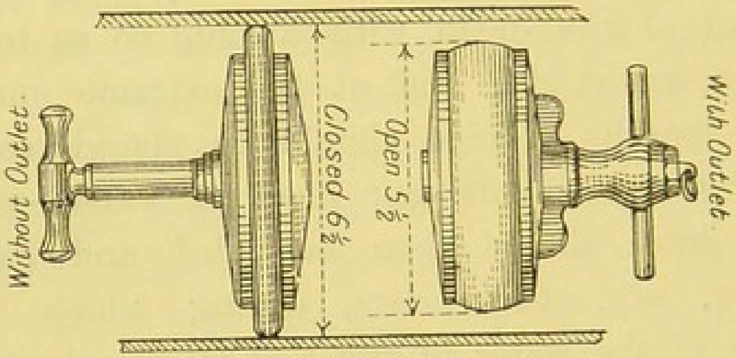


FIG. 72.

one being fitted with screw and key; on tightening up, the rubber ring expands till contact with the pipe is attained. Sometimes this stopper is provided with a central outlet and union, to which a glass pressure gauge is attached, so that the slightest leakage may be detected. Figs. 73 and 74 show a general view and

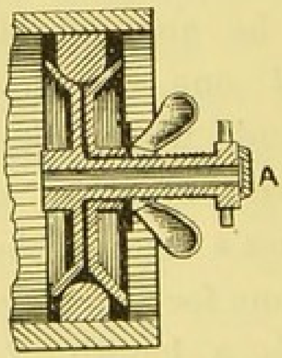


FIG. 73.

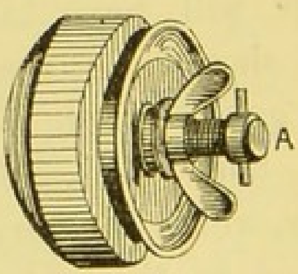


FIG. 74.

section of the "Grip" plug, patented by Mr. Milton Syer, and Fig. 75 shows a section of the "Addison" stopper. The parts are non-corrosive; the disc of galvanised iron; the nipple of gunmetal; the nut and cap of brass. The rubber in contact with the pipe is shown at A A. The lip, C, is made in such a form that the pressure of water acting *upon* it tends to make the joint more secure. The rubber cannot pinch between the two discs, being held in position by the guide, B. These stoppers expand about $\frac{5}{8}$in., thus making them perfectly tight, and allows for variation of size in different makes of pipes. The expanding is *easily* done by screwing the nut which is provided with long wings, E. The stopper is fitted with an inside tube, D, sealed by a screw-cap, F, which, when unscrewed, allows the water to escape after being used for testing.

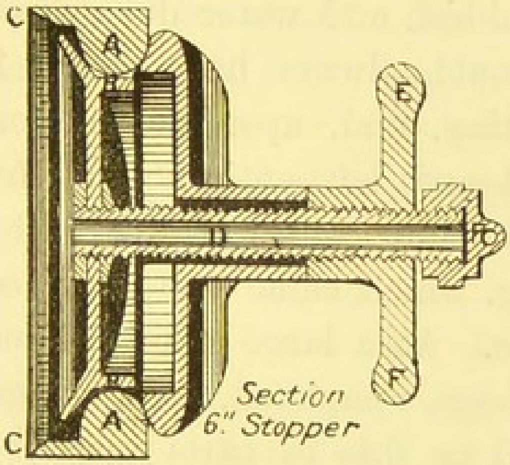


Fig. 75.

Refilling Trenches.—In refilling the trench the best material should be selected to go in first—such as sand or fine gravel—and this must be carefully placed and compactly rammed round the pipe without disturbing the line or fracturing the joint. When there is not less than a foot of cover over the pipes the water may be let off, the discharge being observed in order to be sure that all the pipes were fully charged and that the test was a fair one. The trench can then be refilled in layers not more than 9in. thick, and well punned, two rammers following one filler, but no clay should be brought within 12in. of the surface. The supports for gas and water pipes will require to be left until the trench has become quite consolidated. It is better not to reinstate the surface materials, but to cover off with good ashes or gravel. Settling will probably take place at the rate of 1in. per foot in depth even with the best rammed refilling, and with clay will be even more than that, as it is very difficult to get it compactly together unless it has "fallen." When consolidation appears to have been effected, the surface materials should be reinstated and made good.

The whole length of drains should be kept as free as possible from rubbish and water during construction, and iron drains should always have every length brushed out before jointing, and, upon completion, they should all be cleansed and left entirely free from rubbish of every kind. The importance of this will be appreciated by the following, which came under my own observation a few years ago. At a large country house, a few weeks after all had been completed, a stoppage in the drain took place: and as this in parts was over 20ft. deep, it became a very serious matter. On examination of the intercepting trap it was found to be full of stone scapplings, which were traced to a mason who had been making some alterations to a manhole cover, and being too lazy to carry them away, or, perhaps, because the 5.30 bell had sounded, had swept them into the manhole. After all is entirely completed, the whole of the drains should have the hydraulic test again applied to them.

CHAPTER XI.

Drains Under Houses and the Drainage of Basements.

Requirements of Model By-Laws. — On page 9 of the "Suggestions for Sewerage and Drainage," Sir Robert Rawlinson says: "In towns where houses have to be drained from back to front through the basement, the drain-pipes should have an effectual joint, and be bedded and covered in concrete." He also states in a footnote to page 8 that "iron drains may be used with advantage for this purpose, the joints being made air and water-tight." Mr. Hellyer suggests laying iron drains in a trough of concrete, covered over with a flag. This renders them easy of access, but, of course, adds very much to the cost of the work. In certain cases it is unavoidable to carry drains under houses, and in and about London, where back roads to houses are the exception, such a course is quite common. Model By-law 62, in the third, fourth, and fifth paragraphs, contains provisions for such cases, prescribing that the pipes shall be completely buried in the ground underneath the building, surrounded with 6in. of concrete, and shall likewise be adequately ventilated at each end of the portion that is under the building. This method of laying drains is both clumsy and expensive, especially if the work has to be executed at an existing house, as all materials have to be carried up and down in buckets—a slow and costly process. There is also a certain vagueness about the making of the joint, and there are sure to be many ideas as to what is "good and solid concrete." It will be noticed that the words "Portland cement" are missing; nor is there anything said as to the component proportions, so that it would be quite possible to comply with the wording of the by-laws and still have a very unsatisfactory length of drain. On page 14 of Mr. Meade's report (referred to in Chapter VII.) he says: "I have seen leaky drains taken out of old buildings where concrete had been used, and it was only necessary to observe the filthy condition of the concrete and the ground adjoining to have forcibly impressed upon the mind the necessity of laying all drains with perfectly watertight joints."

To secure this I have invariably laid drains under buildings with Hassall's double-lined pipes, and it is of course much cheaper than either iron or the concrete surround, and is perfectly safe in such a position, seeing that it will bear a pressure of 110lb. on the square inch. I have myself had them put in in towns where the by-laws specify the concrete surround, and have never had the slightest objection on the part of the inspector.

Plans Nos. IV. and VI. show the arrangement of drains when carried from back to front, and where the vent-pipe is so close to the portion under the house a special pipe as prescribed by the by-laws is not necessary. In cases where there is no forecourt or area the waste-pipes from sinks and lavatories, etc., should be conducted into the intercepting chamber, and then disconnected; this may be arranged as shown in Fig. 41.

If iron pipes should be preferred for this class of drain on account of the fewness of the joints, they should be selected and laid in accordance with the descriptions given in Chapter VII., p. 73.

Cellar Drains.—In the chapter (II.) on "Defective Drainage" I referred to the direct communication of the basements of houses with the sewers by the connection of the branch drain from gullies placed therein, and which are commonly found to be laid as in Fig. 76.

Where the only preventive against the inroad from gas from the public sewer is the water seal in the gully, if it has any apart from the question of loss of seal, there is the certainty that sewer gases can be absorbed by the water standing in the trap and

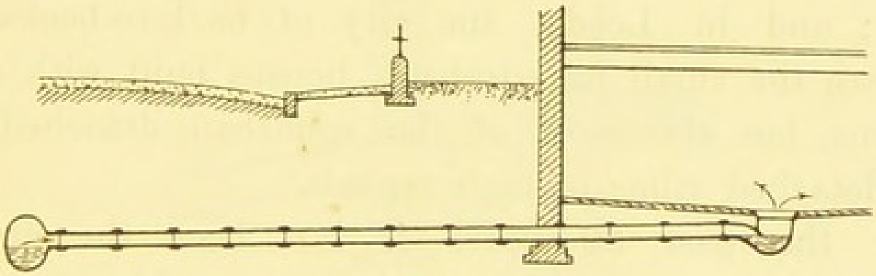


FIG. 76.

given off in the house. The following extract shows how this has been proved with gases usually prevalent in sewers.

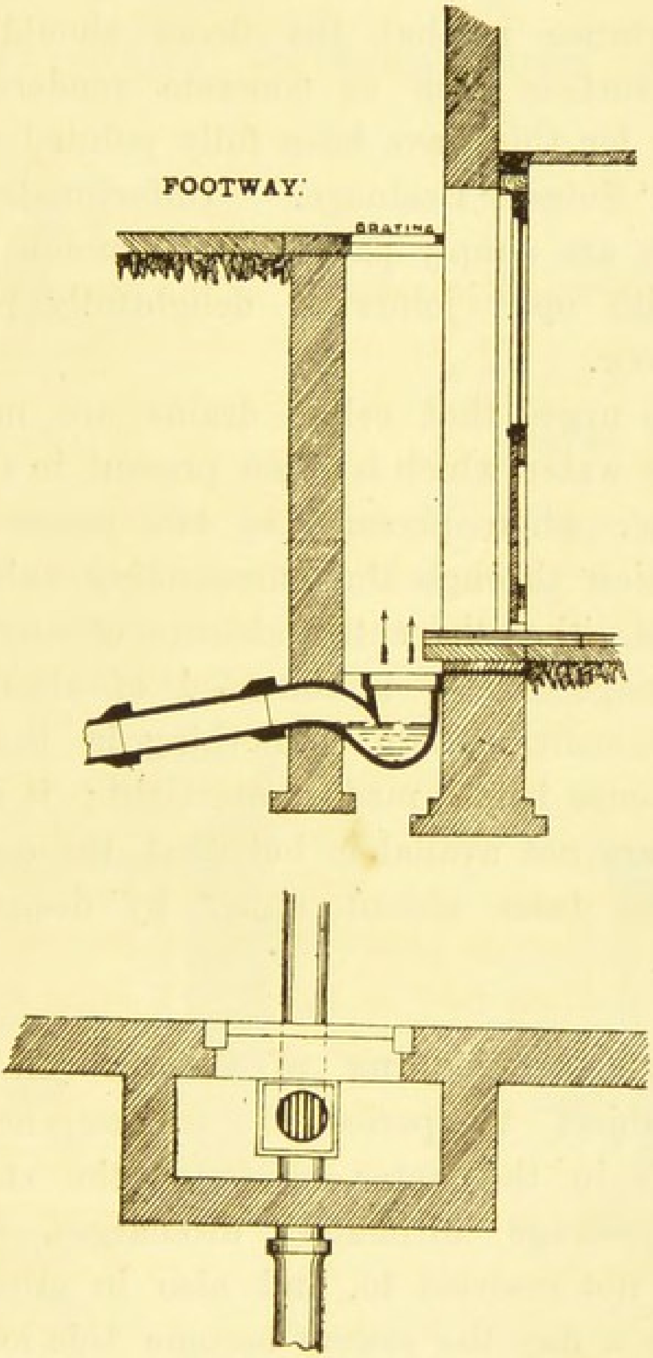
Mr. Joseph Parry, M.Inst.C.E., the water engineer of Liverpool, in his book on "Water," page 129, gives the results of some experiments as follows:

"(1) That sewer gases will pass through water. Some interesting experiments on the passage of gases through traps were made a few years ago by Dr. A. Fergus, of Glasgow. At the outlet end of a trap (a bent tube) he placed a small vessel containing the test solutions, at the bottom of the ഗ trap, and test papers at the top of the ഗ trap, the test papers were suspended. He found that ammonia passed through the water in from 15 to 30 minutes, sulphurous acid in an hour, sulphuretted hydrogen in three to four hours, chlorine in four hours, carbonic acid in three hours.

"(2) That traps may be emptied by evaporation. If traps are placed where the water is not frequently renewed, or if a house is long unoccupied, danger may arise from this cause."

Drains Should Terminate in Areas Outside Cellars. It may be necessary to carry off waste water from cellars, but for this purpose the drain need not be brought inside the house. In many classes of small town houses one of the cellars is used for a wash cellar; and in Leeds, the city of back-to-backs, not only are the small back-to-back houses built with cellar kitchens, but also most of the suburban detached and semi-detached villas of high rentals.

For the past 30 years it has been the practice in Manchester to deepen the area outside the cellar window by carrying it down below the floor level, and placing a gully in the floor of the area; the floor of the cellar is inclined towards a grooved channel formed in the centre, which leads to the area discharging over the gully. In case the water seal in the gully is lost or forced, the gas would escape through the area grating and be diffused in the atmosphere. An access door to the area is fixed below the window cill to allow of the gully pit being readily cleansed. In the case of existing property having cellars drained as in the preceding figure, it would be somewhat expensive to disconnect them by constructing such an area, but an intercepting trap should be fixed and an air inlet brought up to the surface after the manner shown in Fig. 35, page 79. Should there be sinkstones in these cellars, their wastes would be disconnected by discharging into the area or air-inlet



Figs. 77 and 78.

pipe as the case may be. The provision of gullies in cellars for carrying off the water used in washing the floors is a great mistake and a positive danger; the water used in this necessary operation should always be mopped up. It is also very important that there should be no connection to a drain from any larder or keeping cellar for food and milk, etc.; and what is quite of as much importance is that the floors should have an impervious surface such as concrete rendered smooth. The reasons for this have been fully pointed out in the chapter on "Subsoil Drainage." Unfortunately, a great many cellars are simply paved with common bricks laid flat and with open joints—a delightfully porous and absorbent floor.

It may be urged that cellar drains are necessary to carry off the water which is often present in them. This may be due, when present, to two causes: first, to the percolation through the surrounding subsoil, which demonstrates either the entire absence of any system of subsoil drainage or else to the need of attention to it and improvement. There is nothing in the world to prevent a house being made watertight; it is not that the means are not available, but that the consideration of them has been absent either by design or from carelessness.

Prevention of Flooding of Cellars.—In low-lying districts subject to periodical submergence and to sudden rises in the water-levels of the streams into which the sewage ultimately discharges, and where pumping is not resorted to, and also in other districts where twice a day the sewers become tide-locked, there would be an escape of water through the basement gullies during those times—that is, the gullies within the backwater zone would be affected. There are, however, many appliances for cutting off communication between the basement drain and the main sewer at such times, closing when the water in the sewer rises to the level at which they are fixed by the pressure from it being greater than the pressure from the water flowing down the drain.

Flap-Valve.—Where the branch drain is connected

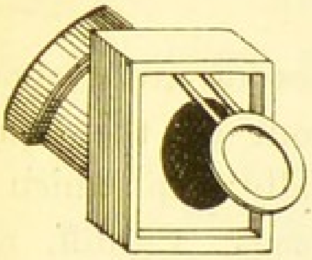
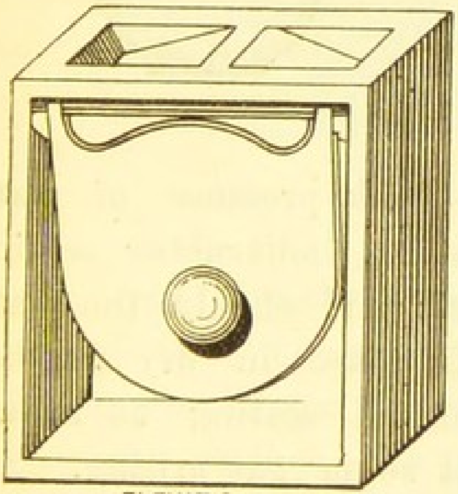


Fig. 79.

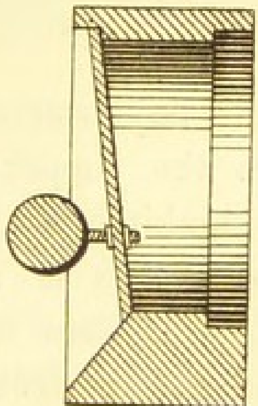
Fig. 80.

to a brick sewer, the junction block should be fitted with a galvanised iron flap-valve hung to swing freely and to close truly. To get this most accurately, a cast-iron ring should be shrunk into the block, having



ELEVATION

Fig. 81.



SECTION

Fig. 82.

its outer face ground; and the face of the meeting portion of the valve should also be ground. The shape of these valves is shown in the cross-section, Fig. 80.

Balance Flap-Valve.—Another form of valve made to secure effectual closing is the balance valve, which is shown in Figs. 81 and 82. This is hung inclining inwards to the branch, and is kept in that position by the counterpoised balance weight. The small amount of water trickling down a cellar drain at ordinary times would hardly be sufficient to keep the valve open, hence a stoppage with accumulation of deposit would take place.

Couzen's Gully Trap.—In the cases of areas shown in Fig. 77, and situated in the front of the house, nothing could be better than the gully trap which is made by Messrs. G. and F. Couzens, Cardiff, and which is shown in Figs. 83 and 84.

The action in each case is automatic. In Fig. 83,

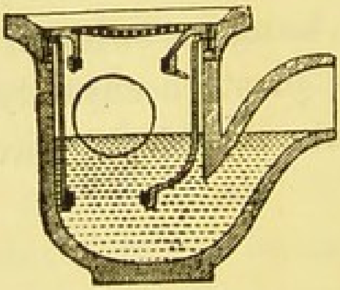


FIG. 83.

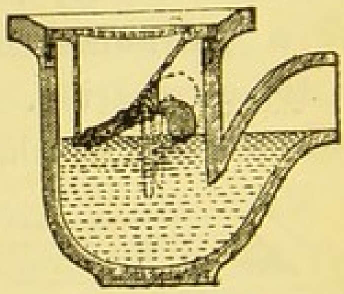


FIG. 84.

it will be observed that any back pressure of water raises the copper ball against an indiarubber seating, thus making an effectual seal; and should the water evaporate, as is sometimes the case in dry weather, the ball lowers on to the bottom seating as shown, forming a perfect seal against sewer gas arising.

With Fig. 84, it will be observed that there is a door with a weighted lever, which allows the water to pass through into the gully, and closes automatically, forming a perfect seal against back flow of water and arising of sewer gas.

Dyer's Valve.—In cases where the whole of the drainage system is below flood or tide level and subject to back-watering, the valve patented and designed by Mr. F. Dyer, London, can be advantageously used, and may be fixed immediately below the intercepting trap. Access may be had to it by lengthening the manhole and forming a small chamber, and it can be arranged for any desired fall or for a dead level. Fig. 85 shows one of these valves fixed in a chamber; the side wall being partly removed, shows the suspended ball.

The tide or flood when breaking up the drain enters the out-go branch, rises in the chamber, and floats the ball, which, as the water rises, approaches the inlet or

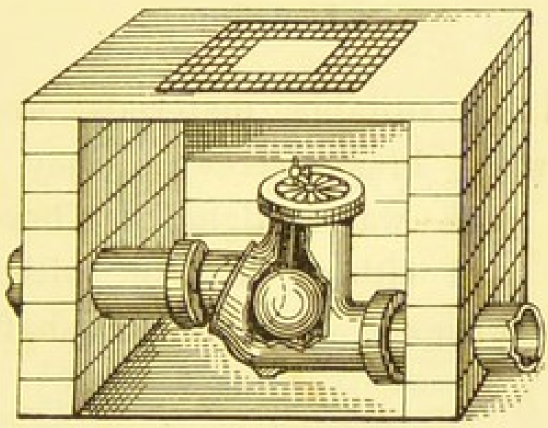


Fig. 85.

house end branch, and finally beds itself upon the seating, thus effectually closing the orifice and preventing the water entering the building. Consequent upon this action, the greater the amount of water pressure there is behind, the more completely trapped or sealed the trap becomes. By reason of the arm being always slightly inclined towards the inlet branch, there is no danger of the ball sticking with the arm vertical, or of its being moved the wrong way. When the water subsides again the ball falls with it, unsealing the inlet and leaving a clear passage.

Ball-Trap Interceptor.—Figs. 86 shows the ordinary ball-trap interceptor, and Fig. 87 the one patented by Messrs. Couzens, of Cardiff. The action is automatic, and any back pressure of water raises the copper ball against an indiarubber seating, thus forming an effectual seal. The access holes are covered with iron

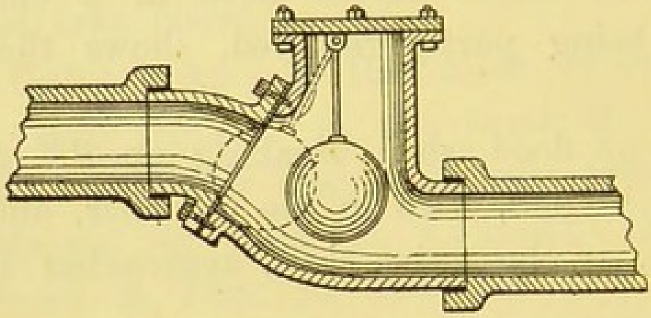


Fig. 86.

covers bedded in suitable materials, and secured to the fireclay with brass screws; they are therefore perfectly gas and water tight. These interceptor traps can be used either with or without inspection chambers; if without, an access shaft should be

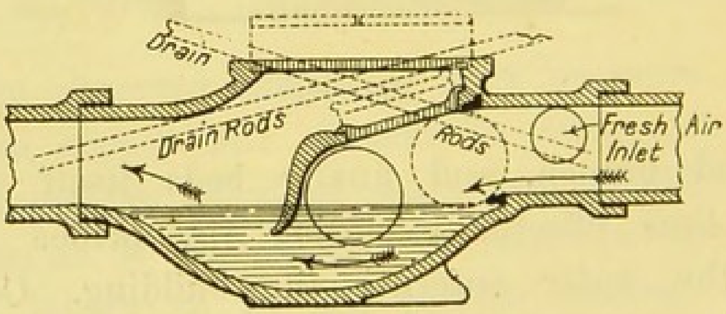


Fig. 87.

carried up from the large opening, as shown by the dotted lines.

Adams's Lift for Raising Sewage from Basements.—There are often basements which are at such a depth relatively to the depth of the sewer that it is next to impossible to drain them satisfactorily by gravitation, or they may even be very much deeper than the sewer. Often this difference in the respective depths, and the consequent inability to provide an outlet for the drainage, prevents the fullest use being made of such basements, and in business premises in towns this is a very serious drawback to their letting value. By the adoption of a very simple arrangement designed by

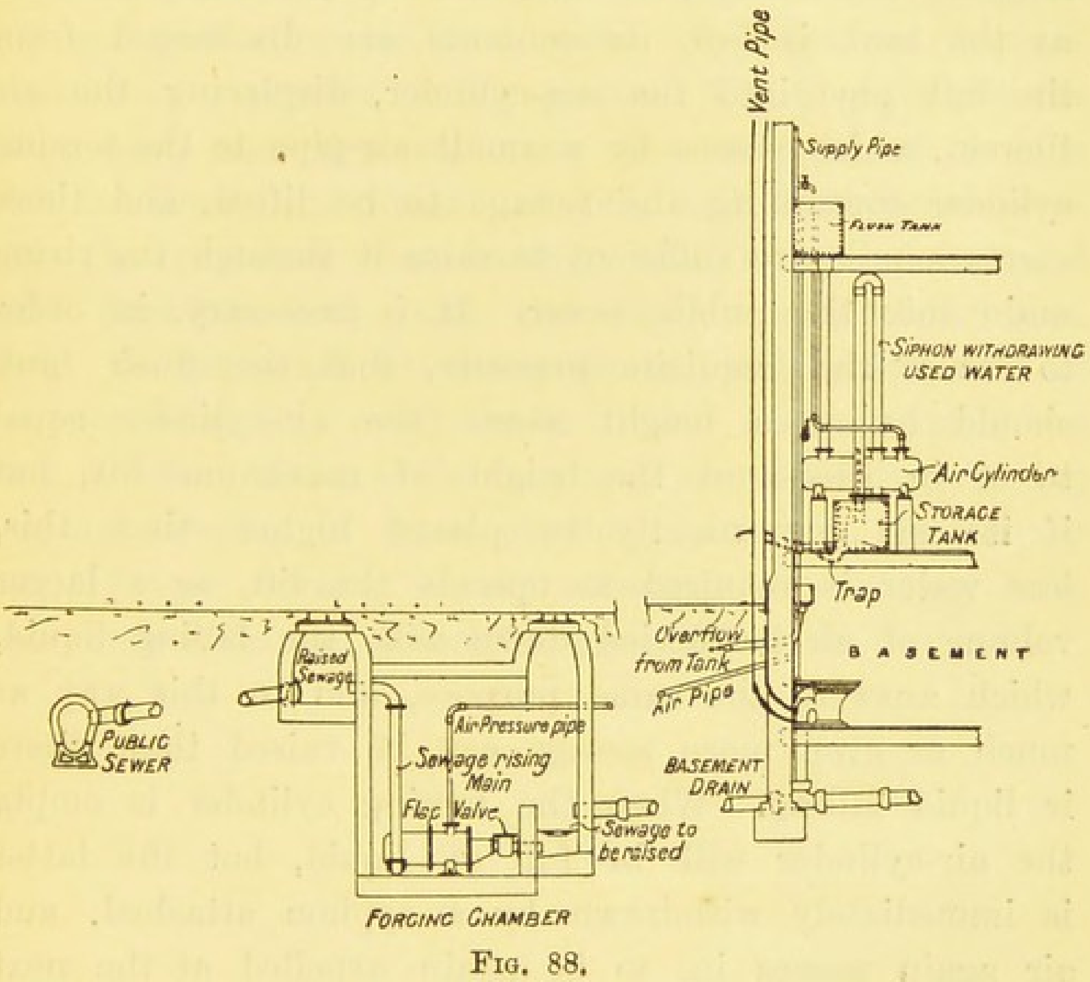


Fig. 88.

the Adams Patent Sewage Lift Company, of York, all basements may be drained, and the sewage lifted from them automatically into the public sewer. This system is shown in Fig. 88, and the working of it is as follows: The low-level sewage passes outside the building into a chamber below ground level (fixed in a convenient position for access), where it enters a cylinder by gravitation, passing a flap-valve, which prevents its return when the air pressure is applied. This pressure is obtained from an air-cylinder placed on a higher level in any convenient position in the same or other building. An automatic flush tank is fixed above the air-cylinder, and is fed by water from the service main or bath waste. The inflow may be regulated by hand, or by a float on the sewage, so that none is wasted. As soon as the tank is full, its contents are discharged from the fall pipe into the air-cylinder, displacing the air therein, which passes by a small air-pipe to the forcing cylinder containing the sewage to be lifted, and there exerts a pressure sufficient to raise it through the rising main into the public sewer. It is necessary, in order to secure the requisite pressure, that the flush tank should be at a height above the air-cylinder equal to or in excess of the height of maximum lift, but if it can conveniently be placed higher than this, less water is required to operate the lift, as a larger volume of air is carried down with the falling liquid, which answers the same purpose, and in this way as much or even more sewage can be raised than there is liquid falling. When the forcing cylinder is empty the air-cylinder will be full of liquid, but the latter is immediately withdrawn by a syphon attached, and air again passes in, to be again expelled at the next discharge. The water thus withdrawn may be stored in a tank as shown, and again used for flushing the closets in the basement or for other purposes, or may be run off by a pipe connected to the overflow from tank which discharges into the chamber for raised sewage. This pipe will require to be disconnected from this chamber by an intercepting trap and air inlet, with a trap below the tank and a vent-pipe to external air. If clean water only be used for flushing, when discharged from the air-cylinder it need not be wasted, but conveyed to any point where required for re-use.

It will thus be seen that sewage may be raised by simple automatic apparatus involving practically no expense in maintenance, in which there are no moving parts, except a flap-valve, nor other mechanism to get out of order, and which requires no manual labour or expensive motive power. The first cost is the last cost, and depends upon the amount of sewage to be lifted, the height of lift, and the convenience of the positions for forcing, and air-cylinders, and the flushing tank, and the amount of labour that will be expended in fixing them, and which will of course vary in every case. But the circumstances which affect these, while they may cause the lengthening or the bending of some of the pipes, will not impair the efficient working of the arrangement, as they have no relation to the principles on which it is designed.

CHAPTER XII.

Manholes and Lampholes.

Sizes and Dimensions.—In a previous chapter on the "Planning of Drains," the right line arrangement was insisted upon, and in carrying out this system it is necessary to have access to the drain for inspection or cleansing purposes at every change of direction and inclination. Where the drains are shallow—say up to 3ft. deep—there is no difficulty in a workman being able to get at them for these purposes from the surface, and in such cases the chamber need not be made larger

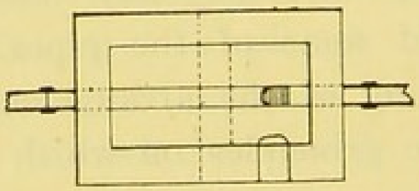


Fig. 89.

than 3ft. by 2ft. 3in., but where the drains are deeper it will be a necessity that the man should be able to turn round comfortably and freely. He will require also to get down on his knees and to have plenty of room to extend his body and legs, in case he should have to insert his arm up the pipe to feel for any object; or in working drain-cleaning rods sometimes two men may be occupied for such manholes: therefore the minimum size should be 4ft. 6in. by 2ft. 3in. For ordinary depths manholes may be of rectangular shape, which, besides being sufficiently strong, is the more readily constructed. Fig. 89 shows a plan, and

Figs. 90 and 91 longitudinal and transverse sections of a manhole constructed to these requirements.

Inverts.—The foundation should be of concrete, properly prepared, and laid at least 6in. thick under the invert, which should be accurately moulded to receive the channel; this should be formed of highly-

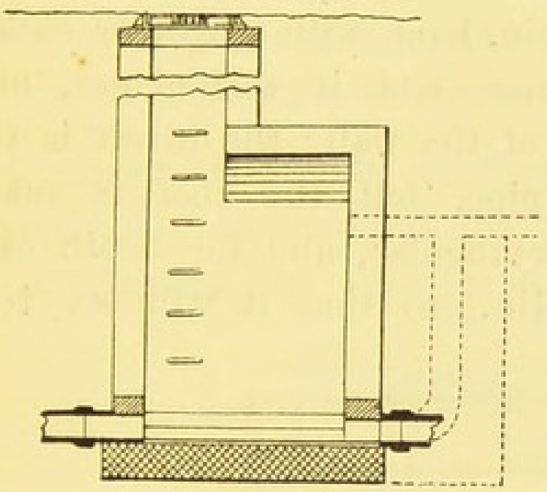


Fig. 90.

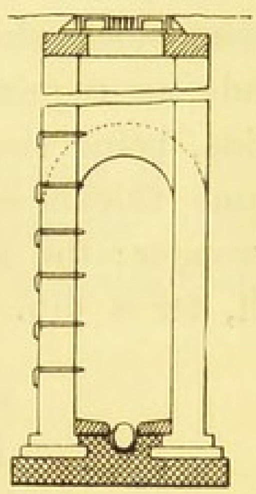


Fig. 91.

glazed ware, radiated to the size of the drain, and may either be socketed or butt-jointed, as shown in Figs. 92 and 93. The joints should be flushed up solid with cement mortar, and neatly pointed. It adds very much to the strength of the inverts to finish them off with

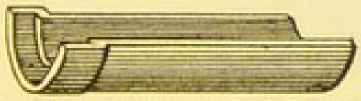


Fig. 92.

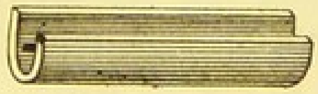


Fig. 93.

a curb of bull-nosed salt-glazed or blue Staffordshire bricks, which not only protects the channel but renders it deeper and better in every way.

Branch Inlets.—All pipes branched into manholes should have relieving arches turned over them to keep the weight of the brickwork off the pipe, the metal of which is not sufficiently strong to carry such loads without fracture. The radius of house drains is so small that there is considerable difficulty in getting suitable purpose-made bricks for these arches, and, besides, the cutting of the courses and the proper closing up is tedious work when properly executed. To meet these objections I have lately introduced a special short block which is 1ft. 6in. long, with spigot or socket ends as required: the inner end is rectangular, 9in. wide, being the thickness of the wall; the invert is the same thickness as the pipe, but the roof is made stronger; the sides are rectangular, and the depth over all, for a 6in. pipe, is $9\frac{1}{2}$in., so that it will set true

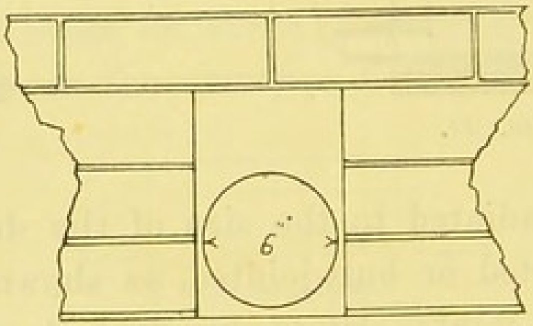


FIG. 94.

in three courses of brickwork. Fig. 94 shows how these blocks are set without breaking the usual horizontal and vertical joints of the bricks.

Chambers.—Where the manholes are 8ft. deep, or less, they should be covered at a depth of 2ft. from the surface with 6in. stone "landings" (as shown in Fig. 95), and the entrance cover fixed on a "landing" holed to the size of the cover. Where the drain exceeds 8ft. in depth, then a chamber should be formed and a shaft carried up to the surface, as in Fig. 90. Remembering that a man will occasionally require to stand erect in the manhole, the height from the channel curb to the soffit of the arch should be 6ft. If there is no great weight of material to be replaced over the chamber, it may be covered with a stone landing instead of a bonnet arch of brickwork. The shaft should be carried up the full width of manhole, but the cross measurement need not exceed 20in., as that is the usual width of the opening of entrance cover. Step-irons should be built in manholes at convenient intervals—say, every fourth or fifth course of brickwork, as shown in Fig. 103.

Changes of Levels at Manholes.—Changes of levels should only be made at the manholes, and the custom of connecting the inlet pipe, when at a considerable

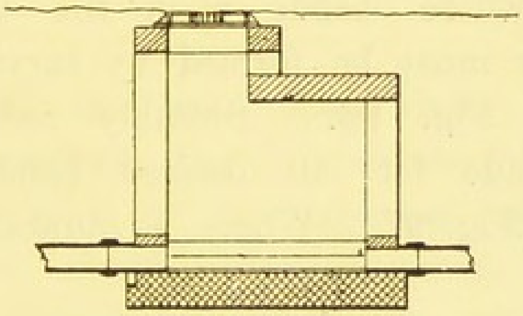


FIG. 95.

height above the outlet, direct into them is not only objectionable on account of the splashing and the rebound leaving portions of the solids on the floor and sides, but also as it destroys the utility of the manhole for inspection purposes, as no man can work efficiently under a constant shower-bath. Where this change of level has to be effected, a pipe shaft should be carried down behind the manhole wall, and a rest bend placed at the invert level into which the shaft should be inserted. For inspection of the higher length of drain the drop-out should be a T-junction, one arm being carried through the manhole wall and covered with an inspection cap. This pipe shaft should be completely enclosed in a concrete collar, and the bend at foot securely bedded in concrete. The dotted lines in Fig. 90 show a change of level carried out as here described.

All Bends to be made in Manholes.—The drain must be perfectly straight from wall to wall of the manhole

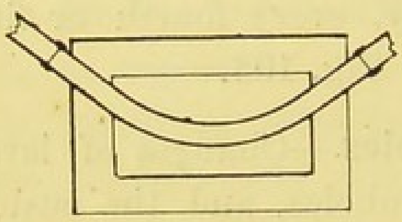


Fig. 96.

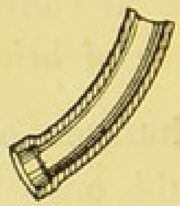


Fig. 97.

in all cases where bends upon the main line are required. They must be formed by curving the invert as shown in Fig. 96. Suitably radiated channel pieces are made for all desired bends, similar to that shown in Fig. 97. Where a number of branches

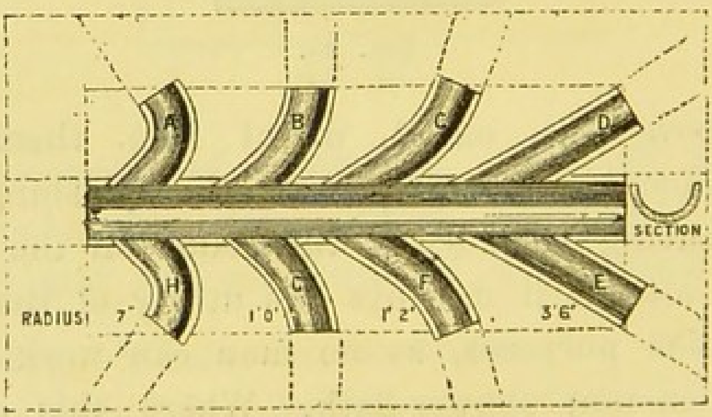


Fig. 98.

are led into the manhole they must be joined to the main invert channel by curved connections after the manner shown in Fig. 98, from which it will be seen that these are usually made to varying radii. Where socketed channels are used, or half pipes, suitable single or double junction pipes may be procured, as shown in Figs. 99 and 100. Figs. 101 and 102 show the well-known channel bends introduced by Mr. Winser, which have an overhang on the outer side to prevent the escape of the sewage on to the floor of the manhole and to confine it to the

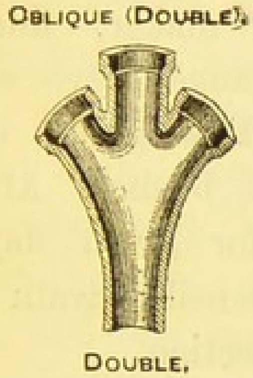


FIG. 99.

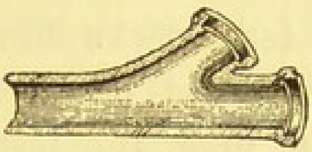


FIG. 100.

channel. It will be seen that where there are a number of junctions in a manhole, the bull-nosed brick curb will have to be dispensed with. In these cases the floor of the channel must be made of concrete, the exposed surfaces being floated up and rendered smooth, and the arrises neatly rounded off.

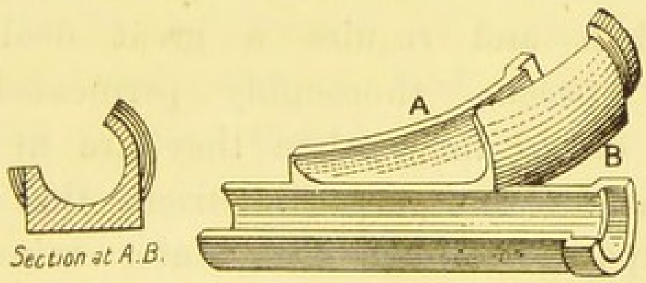


FIG. 102. FIG. 101.

Composition and Mixing of Concrete. — Concrete should be composed of four parts of broken stone or gravel that will pass a 2in. ring, three parts of clean sharp sand to one part of Portland cement. The whole should be mixed on a boarded platform and turned over three times when dry, clean water then added, and the mass turned over three or four times more and thoroughly mixed. When laid in position, it should be thoroughly punned so as to ensure its perfect solidity and freedom from vacuities. The Portland cement should be of the very best quality, obtained from an approved maker, finely ground, so that the residue on a 50-gauge sieve will not be more than 10 per cent., and weighing not less than 112lb. to the imperial striked bushel. After the test blocks have been immersed for seven days, they should be capable of bearing a tensile strain of 400lb. upon the test block of 1in. in section.

Brickwork.—The bricks should be the best hard, square, well-burnt bricks that can be obtained in the district, and as free from limestone as possible. Before use the bricks should be totally immersed, and well saturated, in a large tub of water for not less than half-an-hour. This will have the effect of causing any limestone there may be in the bricks to expand and burst them. Bricks often come fresh from the kiln and require a great deal of water before they become thoroughly permeated, so that throwing it on to them when they are in a heap is not sufficient for the purpose. Bricks that have been standing exposed through the winter rains may not require this immersion. There is necessarily a great deal of moisture in the interior of manholes, therefore all the face bricks should be as hard and impervious as possible. In many districts the ordinary common brick is not suitable for use in facing, and it is an advantage to adopt a brindle or blue Staffordshire brick or a salt-glazed brick; but nothing is gained by using the best white glazed bricks, which usually cost from £12 to £14 per 1,000. The interior of a manhole is not required to be finished like a lady's boudoir. All that is needed is a hard, impervious surface, and this can be obtained with a wire-cut brindle or common brown salt-glazed brick. The mortar should not be made from common lime, but of hydraulic lime, such as that obtained from the blue lias, and which can be procured ground and fresh from such firms as Messrs. J. Ellis and Sons, Loughborough, and sent in bags direct from the kiln to the works. It should be composed of one part lime and one part clean sharp sand, and used as soon as mixed. Any mortar that has been allowed to set should not be reworked, but removed. All joints should be flushed up solid, and should not exceed on the face ¼in. in thickness, and every brick should be hammered down to a solid bed as it is laid, both headers and stretchers, so that every joint may be filled; no filling up the joints from the tops of the course should be permitted. This class of brickwork should be set in Old English bond, and all arches should be formed of suitably radiated bricks turned over centres, and when these are withdrawn the joints should be cleaned off and properly stopped.

Step-Irons.—The step-irons should be 1in. round wrought iron, each leg hooked 4in. deep, the one up and the other down, so that when set each will grip the next course but one of the brickwork. This method of setting is shown in Fig. 103. The steps should project into the manhole about 4in. in the clear and be about 9in. wide, and should always be well coated with hot tar as soon as made. Cast-iron steps are frequently broken after they are fixed by the accidental dropping of heavy objects into the manholes, and are therefore not nearly so serviceable as those made from wrought iron.

Stonework.—The soft ashlar stone ordinarily used in building for cills, heads, and strings, etc., is not suitable for manhole covers, and as these usually are from 12ft. to 16ft. super, the maximum of strength with the minimum of thickness is required. The best

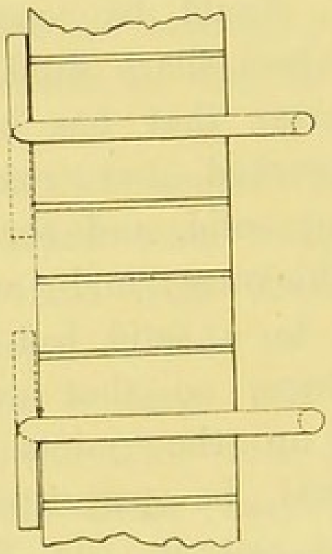


FIG. 103.

stone for this purpose is the flagstone rock, such as is quarried over the Rossendale district, in Lancashire, and Brighouse, in Yorkshire, and which is well known. The material should be uniform in texture, sound throughout, and free from shakes, beds, laminations, iron bands, clay holes, or other imperfections; and always be set so as to lie on its natural bed and have a solid bearing upon the brickwork, all beds and joints being dressed true and square. The bearers for the entrance covers should be holed 20in. diameter, and the face dressed true for the frames to bed evenly on them.

Where the manholes are traversed by heavy loads, the bearers and covers should be of "landings" 6in. thick, but in other situations they may be selected from 4in. flags.

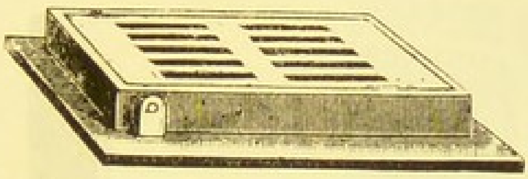
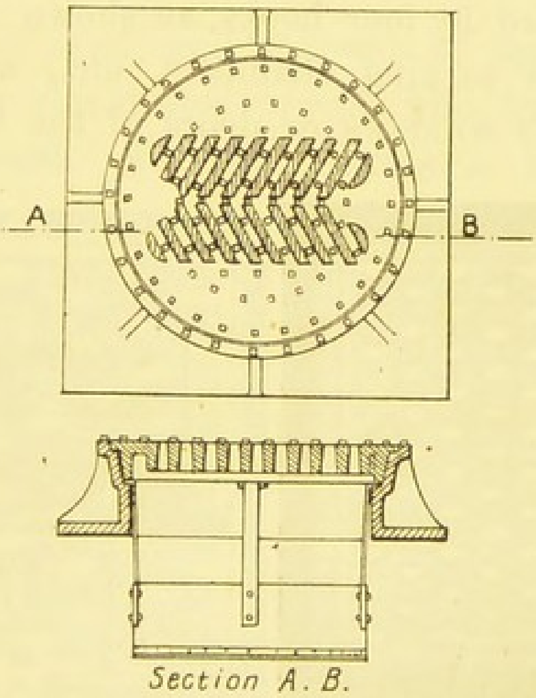


Fig. 104.

Entrance Covers.—The iron entrance covers are made in a seemingly endless variety of patterns and shapes, as may be gathered from an examination of makers' catalogues. Where an open grate ventilating cover is required for situations not traversed by heavy loads, a



Figs. 105 and 106.

light and simple hinged cover may be used, such as shown in Fig. 104; but if the manhole is in the road to stables, or will be crossed by loads of coals, etc., something stronger must be used, such as that shown in

Figs. 105 and 106 (which are patterns I have adopted for main sewers), the frame being 7in. deep so as to allow for bedding without cutting the ordinary 6in. deep setts. The covers are only 3in. deep and loose, being drawn

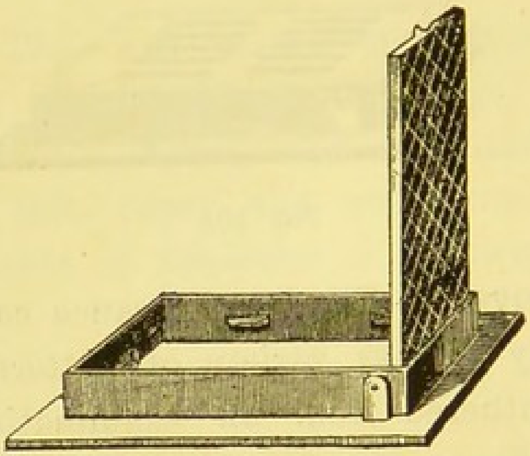


Fig. 107.

out by keys. From the frames a galvanised iron dirt-box is suspended by four hooks, as shown in the section. The covers for turning chambers, etc., where they are not adjacent to windows or doors of the house, may be

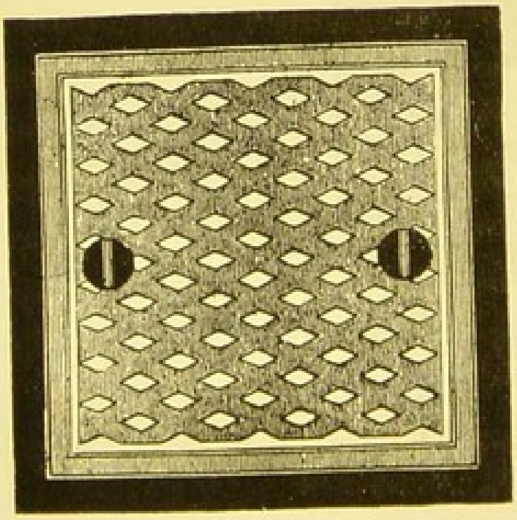


Fig. 108.

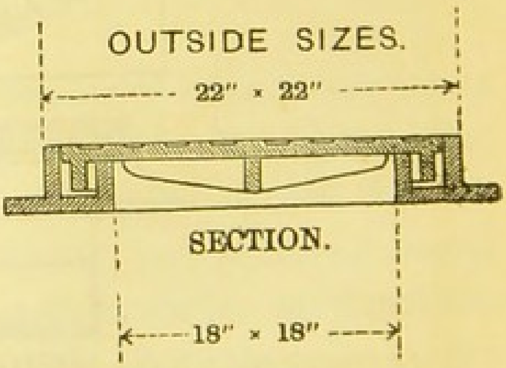


Fig. 109.

similar to the one shown in Fig. 107, which is a plain hinged cast-iron door, resting on projecting lugs. When the manholes are close to the house, or in courtyards or pathways, they should be covered with airtight covers. Figs. 108 and 109 show an ordinary loose cover; the frame has a U-shaped space all round, which is filled with sand. The cover shutting down into this forms an effectual seal. Sometimes a strip of indiarubber is

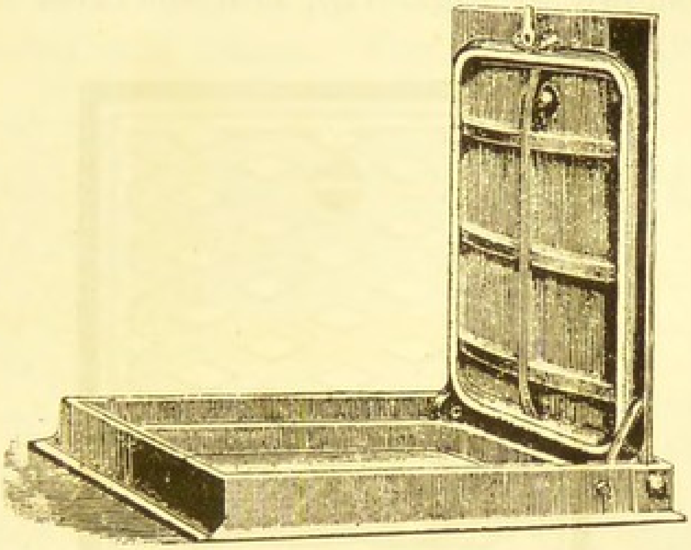


FIG. 110.

used instead of sand, and the web of the cover is dull pointed; when closed this presses into the rubber, thus creating the seal. Fig. 110 shows a hinged airtight

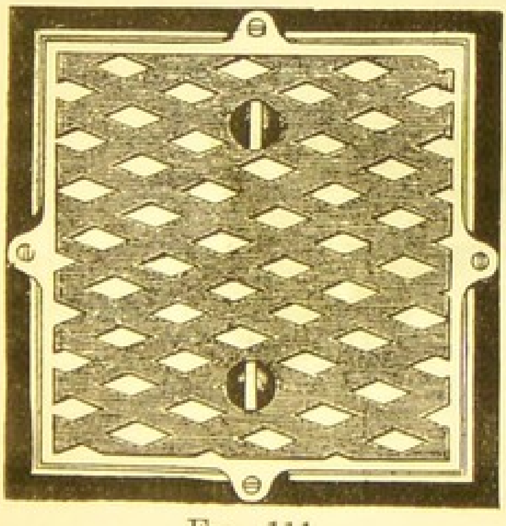


FIG. 111.

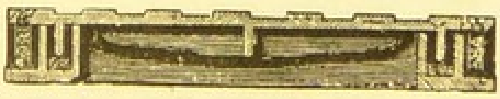


FIG. 112.

cover, in which asbestos packing is used in lieu of indiarubber. In situations outside the premises, such as public thoroughfares, the covers should be screwed down into the frames, as shown in Figs. 111 and 112.

In confined spaces, such as the areas in front or the wells in the rear of town houses, and in middle of office blocks, a double-seal cover should be used, which simply consists of two cover plates let into the one frame, as shown in Figs. 113, 114, and 115.

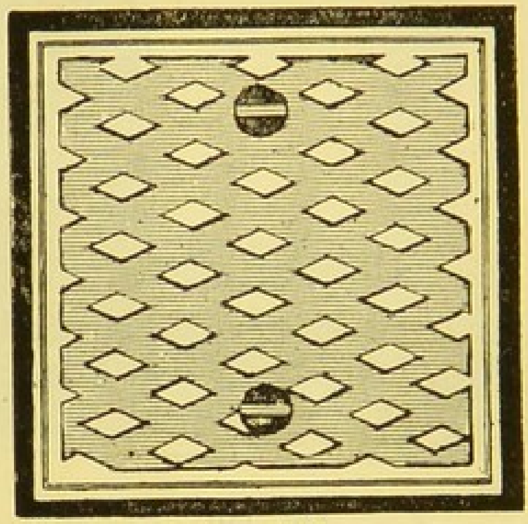
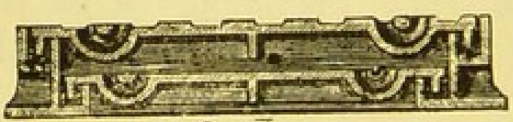


Fig. 113.



Section.

Fig. 114.

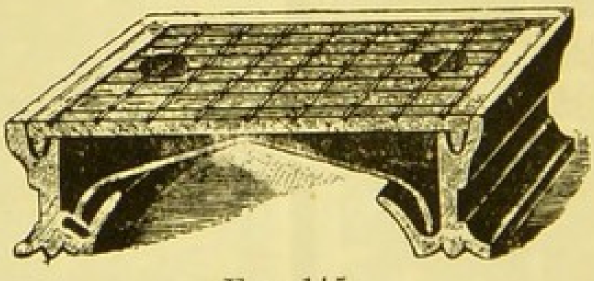


Fig. 115.

Lampholes.—Lampholes should never be fixed at the change of direction or gradient of a drain, but only at intermediate points on straight lengths. It is desirable to have access to a drain about every 80 yards, so that if the length was, say, 100 or 120 yards, it would be more economical to insert a lamphole half-way than to build a manhole. It is a very rare thing, however, to find such a long straight line on a house drain—though it may occur in country houses, or schools, and other public institutions. The lamphole is simply a plain pipe shaft carried up to the surface, covered with an iron cover and frame. Figs. 116 and 117 show plan

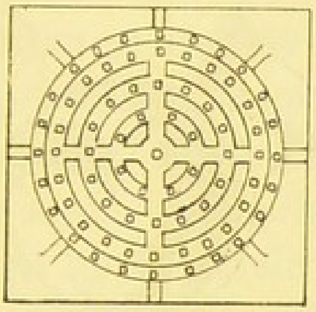


Fig. 116.

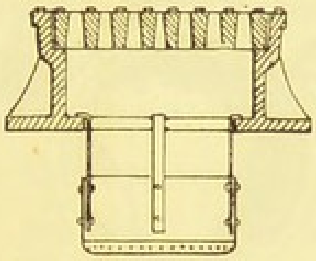


Fig. 117.

and section of ventilating cover, with dirt-box. The frame should be bedded on a holed flag at least 4in. thick, and to support this firmly a concrete collar should be carried up round the lamphole. Where the drains are shallow it is not necessary to go to the expense of constructing manholes at the turns, as equal access may

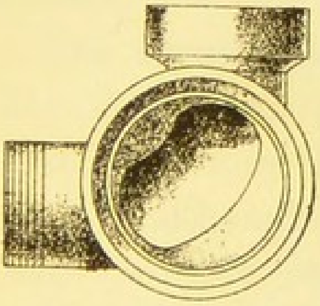


Fig. 118.

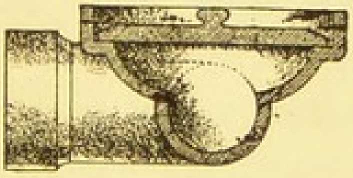


Fig. 119.

be had by using the "Tron" inspection chambers, which have lately been introduced by Messrs. Joseph Cliff and Sons, of Wortley, Leeds. On the bend is a circular socketed eye-piece, 15in. or 18in. diameter, as shown in plan, Fig. 118, and section, Fig. 119. When required to be brought to the surface a straight length of pipe is jointed on, and a lamphole cover fixed in the usual way. Not only are these made to various curves, but they are also made with right and left oblique junctions, double junctions, T junctions, and Y pieces (see Figs. 120 and 121). They can also be fitted with

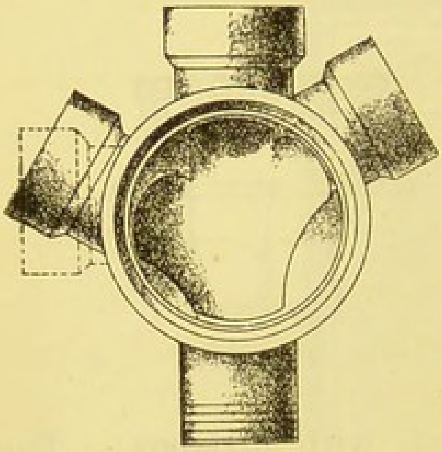


Fig. 120.

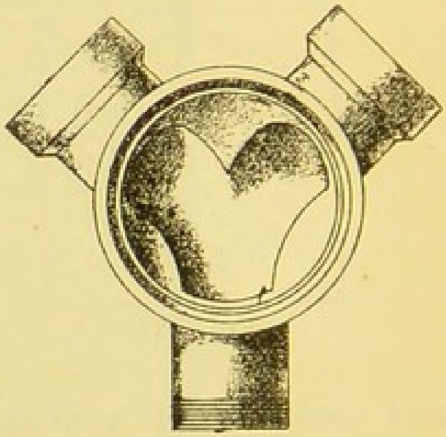


Fig. 121.

Hassall's or any other form of special joint, if required. It is a very great advantage to have a simple and cheap arrangement like this which will facilitate the inspection of branch drains. I have shown in Chapter IV. how they may be introduced.

CHAPTER XIII.

Disconnection of Waste-Pipes and Gully Traps.

Position of Gullies for Waste-Pipes.—It is imperative that all the waste-pipes from the various sanitary appliances in the house should not be directly connected to the drain, but be broken off in the external air, and the inlet to the drain be properly trapped. The fourth paragraph of By-law 66 provides that these waste-pipes (except those from housemaids' slopsinks) must "discharge over a channel leading to a trapped gully grating at least 18in. distant." The reason for fixing arbitrarily a space in the open air between the gully and the end of the waste-pipe does not appear to be generally understood or appreciated. In Chapter II., dealing with "Defective Drainage," a number of bad types of gullies are illustrated, and the consequences of the defects pointed out. The accumulation of filth in gullies is well shown by Fig. 122. The gases and odours from such filth will penetrate into the house by way of the lead waste-pipes; and although there may be traps upon the gullies, we have already seen from Dr. Fergus's experiments (see page 127) that these gases can be absorbed and given off inside. As some people are not convinced by mere laboratory tests, the following extract from a report by Mr. Rogers Field, M.I.C.E., dated 6th January, 1876, on "Uppingham Sewerage and Private Drainage," which gives a striking instance of the passage of sewer gas through water-traps, may perhaps appeal to them more sympathetically. He says: "On my examination of the sanatorium I found that there was a bad smell in two lavatories attached to water-closets situated one above the other. Further investigation showed that this smell did not proceed from the water-closets, but from the lavatory basins, where a decided current of very foul air was coming into the chamber from the unplugged outlet of the basins, and it was found that each basin was connected directly with a pipe which discharged into a partially closed gully

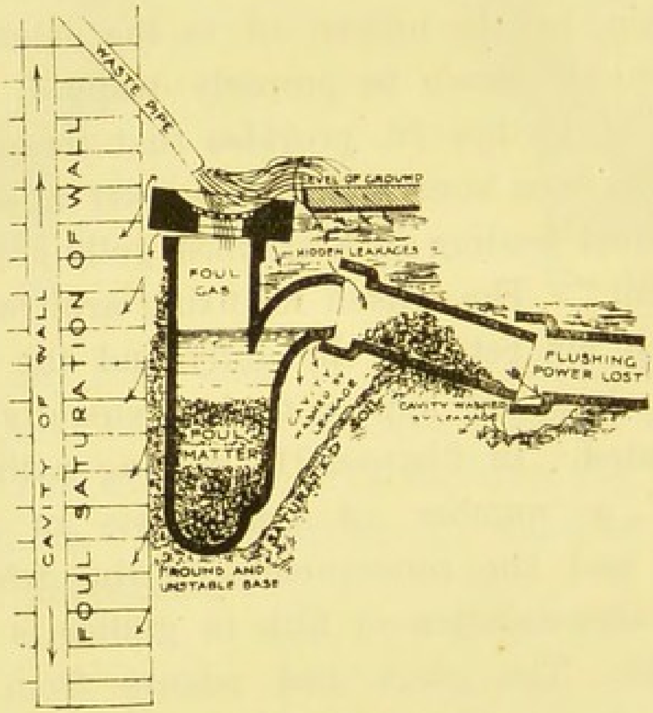


Fig 122.

outside the house covered with snow, and this again into a cesspool. On opening the gully it was ascertained that the outlet was properly trapped, and that there was no apparent escape of foul gas, but that the water in the gully (though clear) had a very bad smell. In order to test whether this arose from any passage of foul gas through the trap, clean water was poured into the gully, and this removed the smell. The gully was then examined again after a few hours, and it was found that the water had assumed a very decided smell. The experiment was repeated with the same result, and it appeared that the longer the water was left after it was changed the fouler it got. Moreover, on closing the gully again after the water had become foul, the foul current of air returned in the lavatory. There could be no question, therefore, but that the smell arose from the passage of foul air from the cesspool *through the water-trap.*"

For the prevention, therefore, of the penetration of these gases into the house this space of 18in. must be provided; the details of the arrangement required will be pointed out further on. There are endless varieties and patterns of traps to be had, many designed for special purposes. Some of them, while evidencing a great amount of ingenuity on the part of the originator, are too fearful and wonderful to be of the slightest utility on the premises of the ordinary householder, and others are constructed in such a manner as to be insanitary appliances owing to their lack of effectual seal, possessing deep pits below the outlet, which become small cesspools, square corners from which dirt and filth cannot be dislodged.

Requirements of a Good Gully.—A well-designed gully should fulfil the following conditions:

1. The shape should be such as will cause it to be self-cleansing and facilitate the passage of the liquids through it, and it must be free from angles or corners.

2. It should have a flat base to ensure its stability and permit of its being firmly set.

3. It should have a seal of not less than 2½in. in depth—that is to say, more than 2½in. in depth of water must evaporate before the water seal would be broken.

4. The entrance to every trap should be provided with a grating opening outwards, to allow the trap to be readily cleansed.

5. The dish, or loose cover, should be designed to deliver the water rapidly into the gully so as to prevent the escape of liquid over the sides. The cover must not be set loose upon the gully, but secured with a properly-made watertight joint.

6. The gully must be set perfectly level and be securely jointed to the drain.

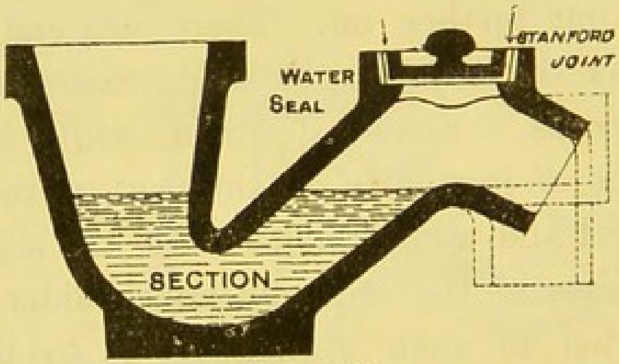


FIG. 123.

Self-Cleansing Gullies.—Many gullies are designed to have the inlets of the waste-pipes connected below the grating. It is obvious that such a gully does not comply with the by-law above referred to. Others are long trench-shaped boxes, with flat bottoms and square corners, and are therefore not self-cleansing; while others are designed with movable receptacles or sludge-boxes, and these, too, are not self-cleansing. The simpler gullies are in design, the more effectual they will be. Most people are familiar with the action of a wash-down w.c., and have, no doubt, noted its efficiency. A good gully should be designed upon the same lines, as shown in Fig. 123.

Figs. 124, 125, and 126 show a type of gully which has been adopted by the War Department. The grating is

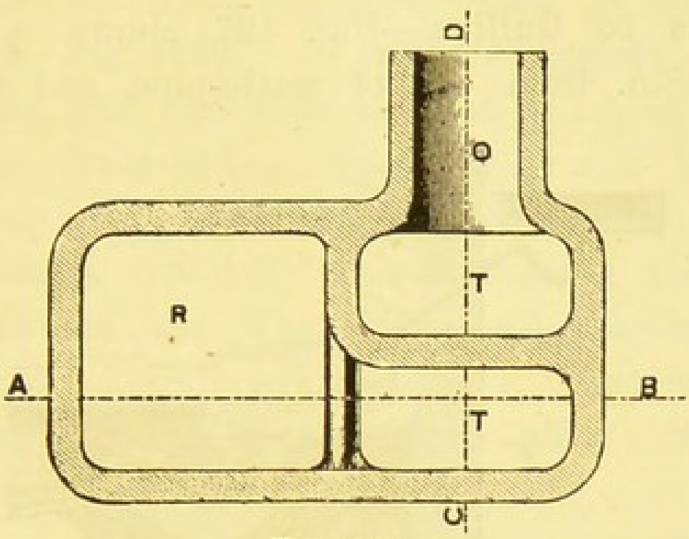


FIG. 124.

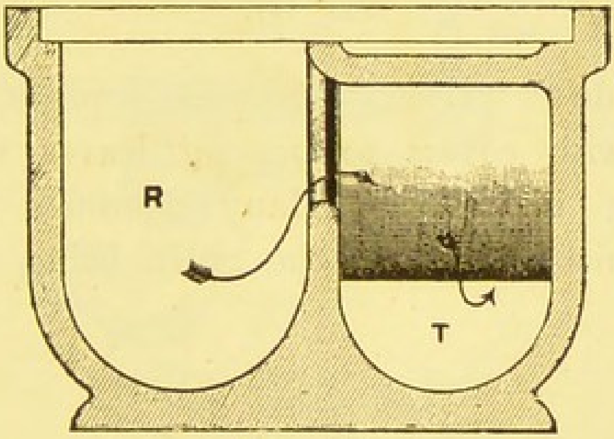


FIG. 125.

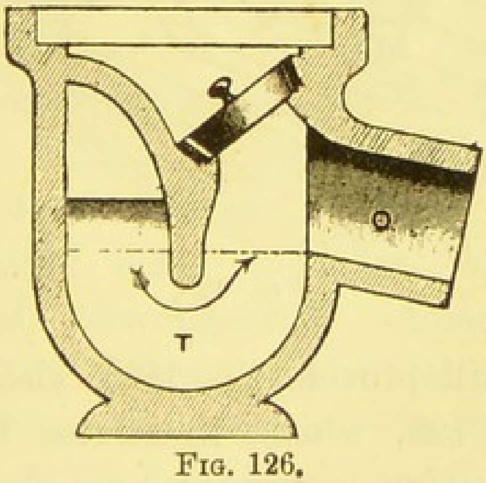


FIG. 126.

over the receiver, R; the water flows over the weir into the compartment, T, and thence out at O. It will be seen that the sludge may be removed from the receiver, R, without untrapping the gully.

Channels to Gullies.—Fig. 127 shows a gully in position, 18in. from end of waste-pipe, and fitted with

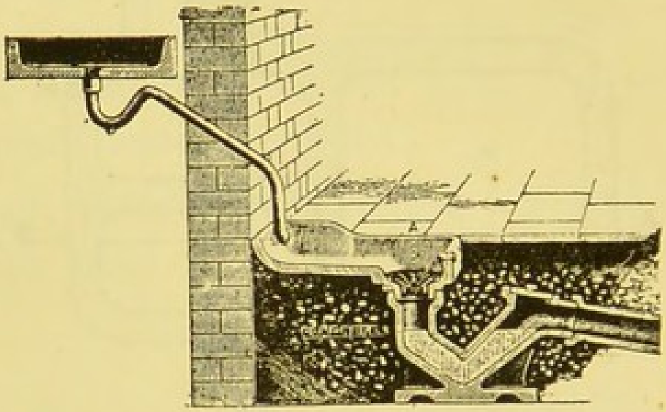


Fig. 127.

one of Lynde's "Loco." channel copings, which are also made with covers to prevent leaves and rubbish accumulating in them. Many channels have been designed which allow of the gully being set close to

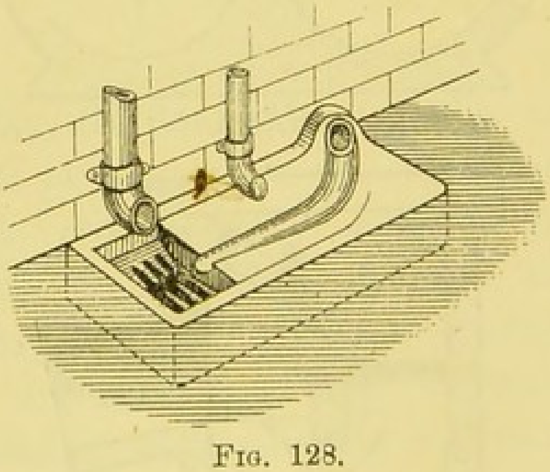
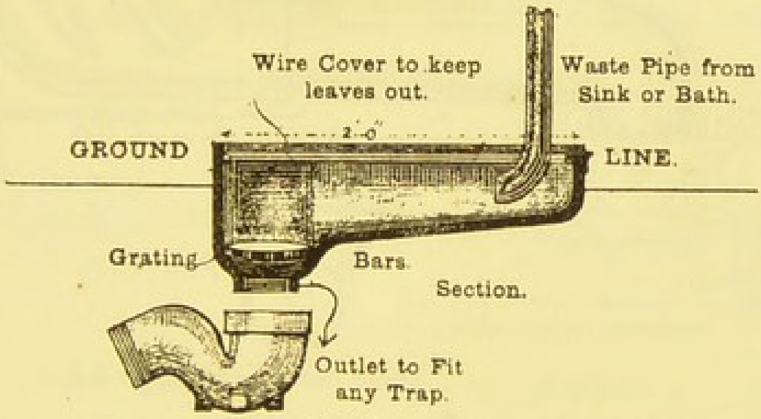


Fig. 128.

the wall and still provide the 18in. clear air space, as shown in Fig. 128, which illustrates Duckett's patent gully channel, which is formed by a groove in a block of highly-glazed fireclay.

A very good form of gully, with channel or slipper, allowing the 18in. air space, and which can be set close to the wall, is manufactured by Doultons to the patent of a Mr. Docking, and which is shown and described in Fig. 129. It will be noticed that the trap is loose, and can thus be readily set in whatever direction the drain takes. There is also a loose wire cover to keep out leaves, etc.; this in certain positions is an advantage, especially in the autumn and winter. Messrs. Wenham and Waters also manufacture a very similar slipper, known as "Stidder's," but which has the channel and trap all in one piece; this being



Channel and Gulley for Waste Pipes. Docking's Patent.

FIG. 129.

immovable requires either one or more bends in making the connection to the drain. In new work this need be no difficulty, but in making up to an existing drain with the position of the waste-pipe fixed, it may entail some obstacles. More recently a greatly improved disconnecting slipper has been introduced by Mr. Sykes, and which is shown in Figs. 130 and 131. The slipper, Fig. 132, covered by a grating, is made in one piece, with spigoted outlet to fit into loose P or S trap as required. The inlet is socketed to receive intake piece, P, which is made with either one, two, or three inlet arms in which the waste-pipes are joined as shown. This is a very clean and effective slipper, and when set and finished off has a very smart and workmanlike appearance.

Disconnection of Waste-Pipes in Streets, etc.—In the West Riding of Yorkshire, as is well known, there are unfortunately a vast number of back-to-back houses. In such houses, when the sinks are placed against

Fig. 131.

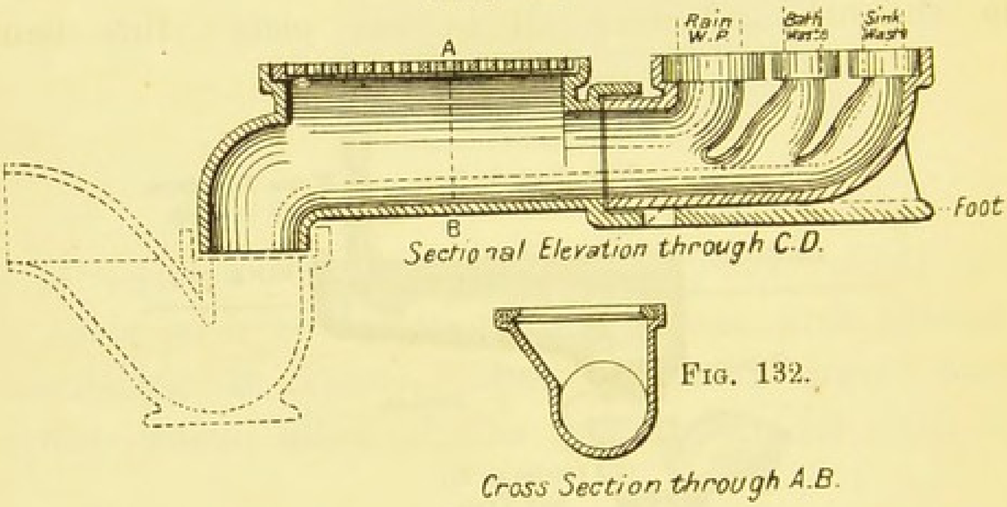


Fig. 132.

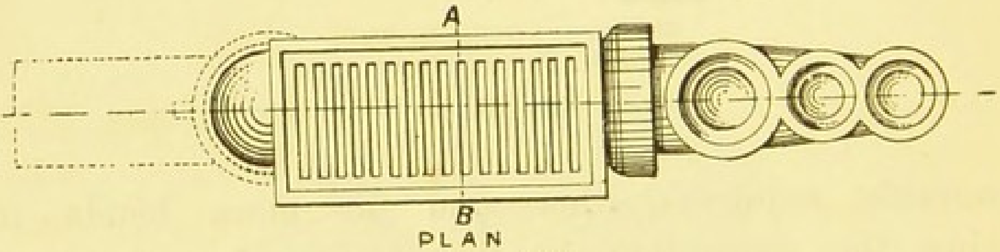


Fig. 130.

the outside wall, the gully traps must necessarily be in the footway; and not only is the splashing over a dished grating an objectionable nuisance, but the practice of fixing a sunk or hollowed stone in the line of traffic also exceedingly dangerous. This is generally admitted, and to place such a gully 18in. away from the wall, as now required, would be going from Scylla into Charybdis. It should be remembered in this connection that these houses are not built under by-laws approved since the inauguration of the Model Code, except in the county boroughs. I have been frequently asked how this apparent poser could be solved, and venture to think the solution may be found by the adoption of a channel and gully for which I have taken out a patent, and which is shown in Figs. 133, 134, and 135. A cast-iron box 18in. long is divided by a short mid-feather, and is covered with a grated opening. Any dirt passing through this lodges in the channel next the wall. The outer channel is fitted at one end with a socketed union to receive waste-pipe, and outlet end is connected

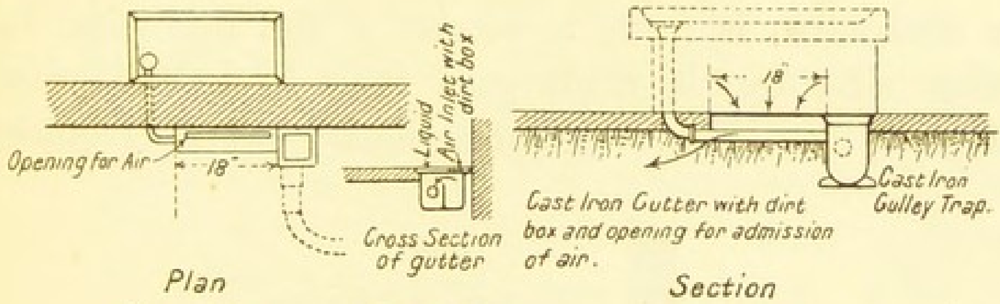


Fig. 133. Fig. 135. Fig. 134.

to a cast-iron gully similar to one shown in Fig. 139. The whole arrangement can be set close to the wall and flush with the surrounding pavement, and is free from any projections. It affords complete disconnection, and is easily accessible for cleansing purposes.

Disconnection of Rainwater-Pipes.—The evils that arise from a free connection of rainwater-pipes to drains have been fully enlarged upon in Chapter II., and it appears clear that under the Model By-laws (Section 62, paragraph 6) they must discharge into a properly-trapped apparatus. A common yard gully will serve very well in most situations, but where neatness of finish and avoidance of splashing is required, one of the purpose-made gullies should be used, such as Hellyer's "Rainwater Interceptor," shown in Fig. 136.

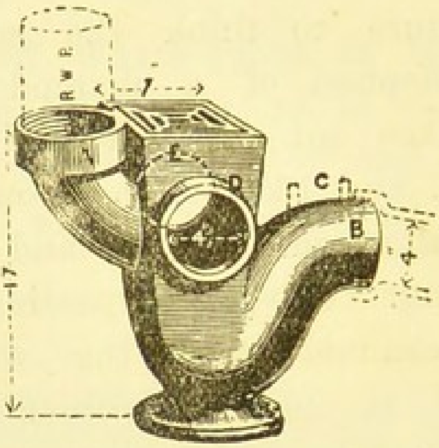


Fig. 136.

The socket, A, is made to receive a 4in. iron pipe, but smaller sizes can be made good to it by a lead union, and this can also be made square when required.

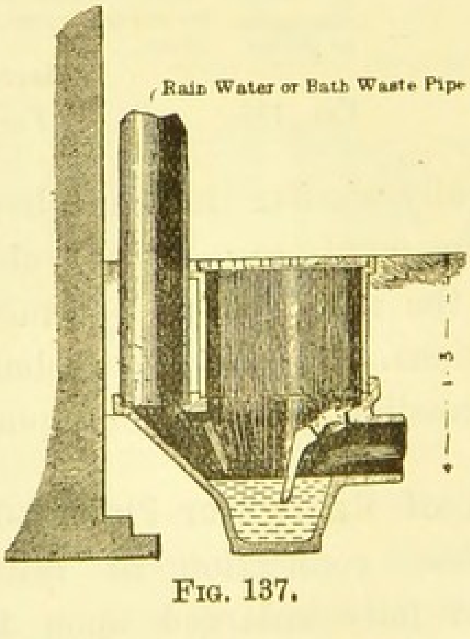


Fig. 137.

Apertures are also provided for connecting branches, as at D and E, which may be stopped when not wanted.

Fig. 137 shows the "Cecil" trap, as made by Messrs. Joseph Cliff and Sons, Leeds. These are fitted with raising piece, reaching to the ground level, and access to the drain can be got from the inside of the gully without opening the ground. This gully is simple in construction, compact, and easy to fix.

Another appliance for fixing to rainwater-pipes is the

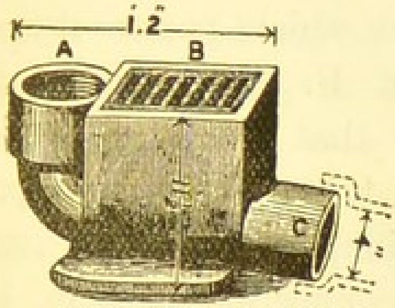


FIG. 138.

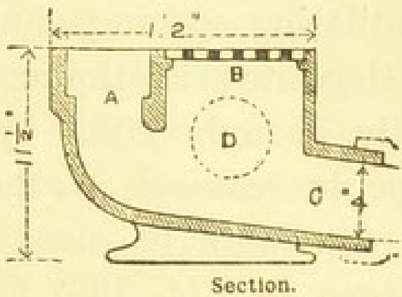


FIG. 139.

"shoe." Figs. 138 and 139 show the well-known one that is made by Hellyer. This is made without a trap; and unless the branch drain has an interceptor on its length before connection to the main drain, a P or S trap should be fixed at C. In the streets of towns a stronger class of gully is required and one that shall take

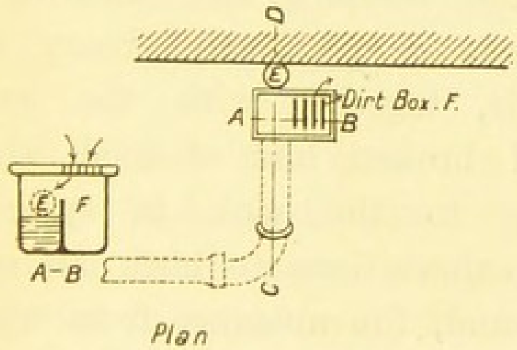


FIG. 141. FIG. 140.

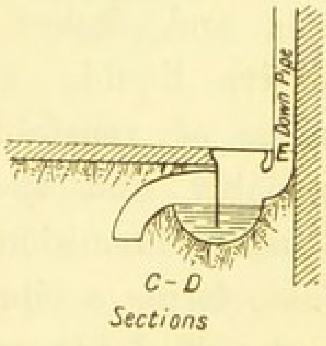


FIG. 142.

up little space, and when set shall be flush with the surrounding pavement and free from projections. Cast iron is the only suitable material for this type of gully.

Figs. 140, 141, and 142 show a rainwater disconnecting gully which I have designed (manufactured by J. Stone and Co., Deptford), and which will be found to meet all these requirements. The gully is divided into two compartments by a mid-feather, the rainwater-pipe being connected to a union, E, which may be either square or round as required. One half the cover is solid, and lies over the water compartment; the other half has ventilating openings, and any dirt which passes through is deposited in the compartment F. The size of this gully is only 10in. by 6in., so that if the rainwater-pipe is recessed in the wall it takes up little space. It can also be used in combination with the gutter (shown in Fig. 133) for the disconnection of sink, etc., wastes in the like situations. In periods of dry weather, rainwater gullies should be frequently inspected to see if the seal has been lost by evaporation, and they should be replenished with fresh water as often as required.

Grease-Traps.—The gullies for the waste-pipes from scullery sinks require to be of a special type. Every householder knows that the scraping and washing of plates and dishes produces a peculiarly greasy and offensive liquid; and this, together with the small parings of vegetables and broken bits of food which invariably find their way to the sink in spite of frequent admonitions and exhortations to burn all such refuse, forms a vile compound, the nuisance from which is intensified not only by the washing-up water, but by the further addition of the water in which vegetables have been boiled and the liquor pressed from them. This horrible mixture is so subtle when in this state that it is as slippery as an eel, and will disappear through the finest grating; and the scullery-maid will take care to press through any obstinate leavings that may be stranded. When this mixture gets into the drain and begins to cool it rapidly congeals and causes an obstruction, and a serious nuisance will arise from it unless speedily removed. Builders and others have been aware of these conditions, and from time to time one comes across either a peculiarly objectionable cesspool gully designed to retain this solid mess and closely covered up, so that the gas penetrates into the house; or else a very large and badly-designed gully, equally offensive. It is obvious that for an ordinary house the common gully is unsuitable, and how much

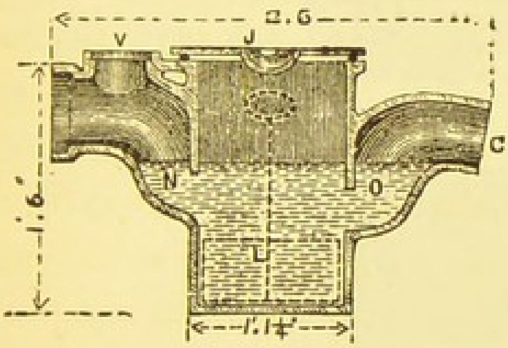


Fig. 143.

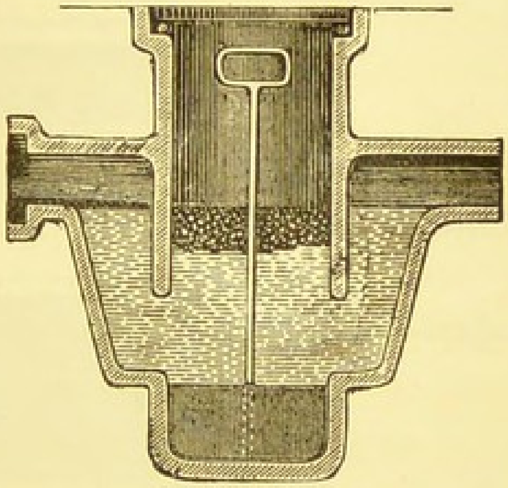
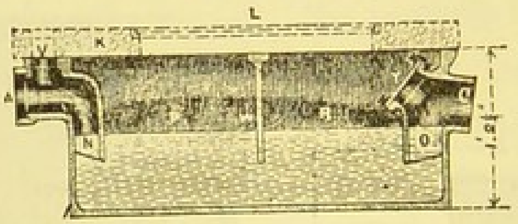


Fig. 144.

more is this the case for hotels, clubs, restaurants, schools, and institutions, where cooking for large numbers takes place every day. The evil can be remedied in two ways—either by adopting an appliance which collects the grease and from which it can be removed by hand, or taking some means to force the liquid clear through the drain before congelation can commence.

Figs. 143 and 144 show types of grease interceptor traps suitable for small houses. They are each fitted with a movable bucket of galvanised iron, in which the sand and solids are collected, the grease rising to the top, as shown in Fig. 144, where it cakes. This requires breaking up and removing periodically. Fig. 144 is Smeaton's grease-trap, made by Cliff, of Leeds; and Fig. 143 is Hellyer's pattern. For moderate-sized houses a large receptacle is required, say not less than 2ft. long if the horizontal pattern is adopted, of which Fig. 145 is a type. Opposite the inlet is a wall, which is carried down almost to the bottom of the box, and opposite the outlet is a similar wall, these forming the

FIG. 146.



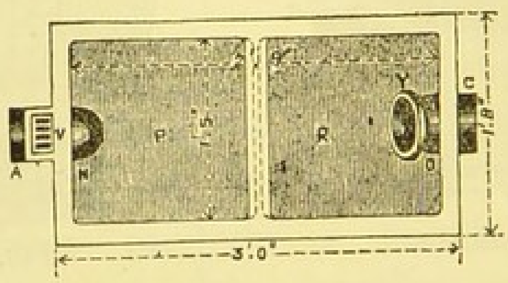


FIG. 145.

grease interceptors. In Adams's pattern (Fig. 147) these are cast on the movable lid, which is galvanised and fitted with a sunk grating. The liquid enters through this, then passes down to the bottom of the box, travels slowly across, rising up to the outlet, the silt and sand being deposited, and the grease coagulating on the top. There are a great variety of traps made on this principle, and for larger houses, hotels, clubs, restaurants, schools, and public institutions, a much larger collecting box is necessary—not less than 3ft.

long. The construction of these is slightly varied by the introduction of a mid-feather, W, in Fig. 146, which shows Hellyer's extra large size grease-trap, which has a vent-pipe, V, on the inlet arm and an

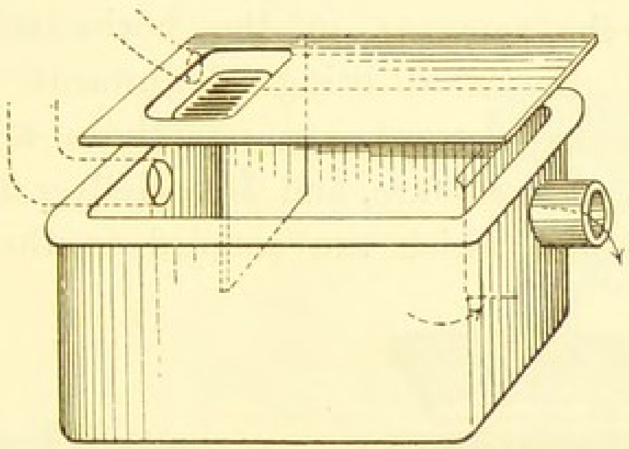


Fig. 147.

access hole for the drain at Y on the outlet arm, and is covered with a holed flag, in which an airtight iron cover is inserted.

Fig. 148 shows Mr. Lynde's "Loco." grease-trap.

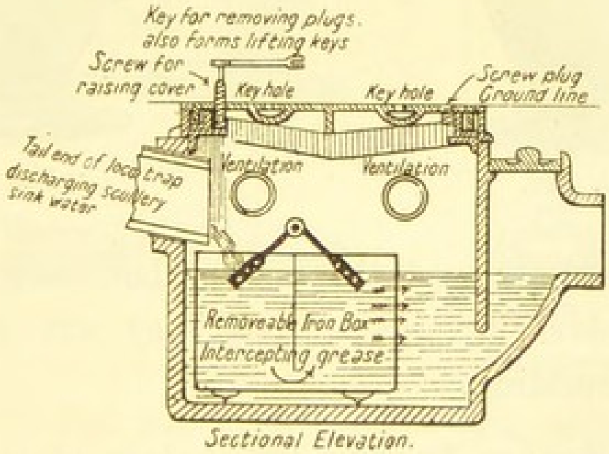


Fig. 148.

This contains a movable galvanised iron bucket divided by a mid-feather, the liquid escaping through perforated holes in the sides, as shown by the arrows. This is also protected by an airtight cover, and ventholes are placed in the side of the box. Access to the drain is from the outside of the box.

Some makers adopt a deep vertical type of grease-trap, such as is shown in Figs. 149 and 150, which are views of Bolding's Simplex grease-trap. The principle is the same as in the horizontal ones, the direction of the flow being downwards instead of horizontal. Grease-traps are sometimes made in cast iron instead of stoneware, and Mr. Hellyer has patterns of movable ones which are coupled to the waste-pipe

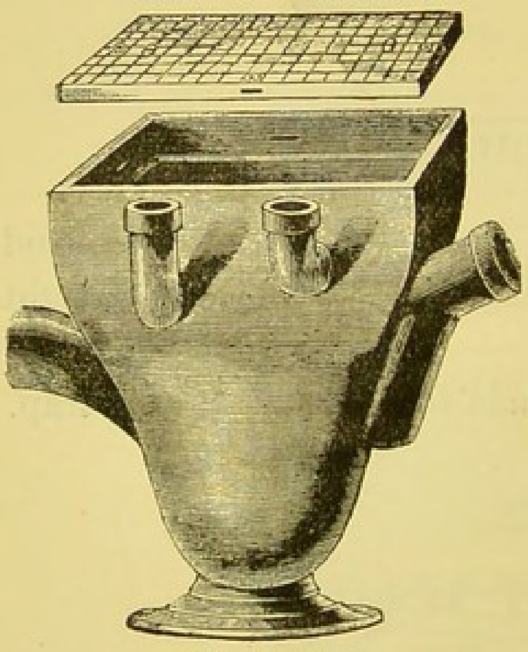


Fig. 149.

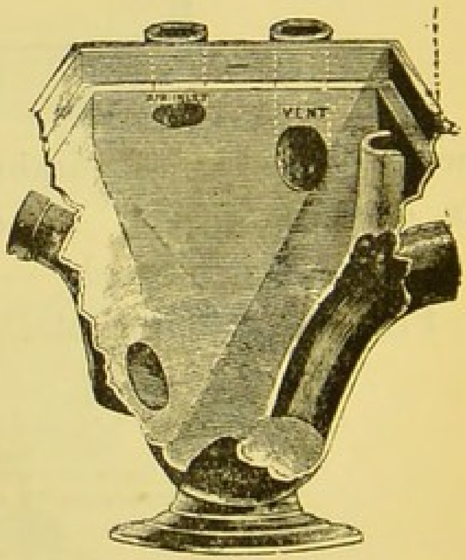


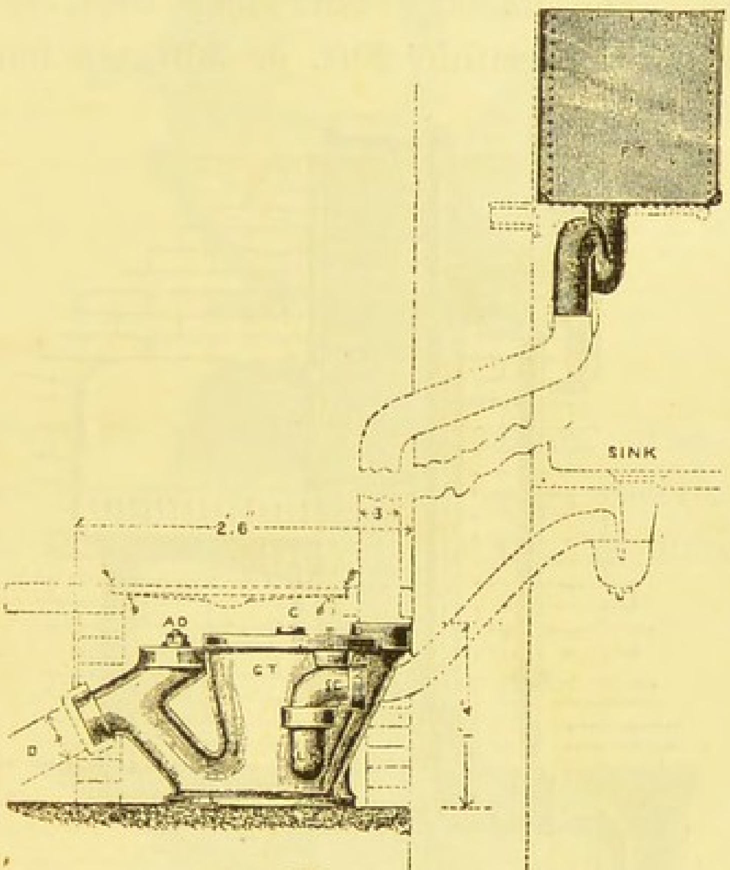
Fig. 150.

by a screw union; and there are also others which can be fitted under the sinks when they are on the upper floors of a building.

Flushing Grease-Traps.—This class of trap, in which the grease is intercepted and collected, require a great deal of attention to keep them clean and in good working order, and to overcome these difficulties a flush-out grease-trap has been devised by different makers so as to despatch the grease, by breaking it up, by the force of the flush through the drains to the sewer as rapidly as possible.

Figs. 151, 152, and 153 show Mr. Hellyer's pattern, which is fixed in a small brick chamber. Just enough water

Fig. 151.



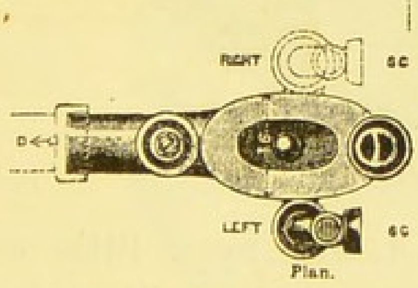
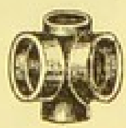


Fig. 152.



DC
Connector with two inlets.

Fig. 153.

being retained in the trap to congeal the grease, the flush from the automatic flushing tank, F T, enters the trap at the back, a portion of the flush passing through a flushing rim with a jet opposite the outlet for breaking up the congealed head into small pieces and floating them through the drain, the remainder of the flush being conducted downwards by a separate waterway to the bottom of the trap for scouring out solid matter. A 20-gallon flushing tank is used, and a head of from 4ft. to 7ft. can be obtained. The flush is 3in. bore, but where the head is less, 4in. The flushing tank may be fixed in any convenient position within 20ft. or 30ft., so long as the

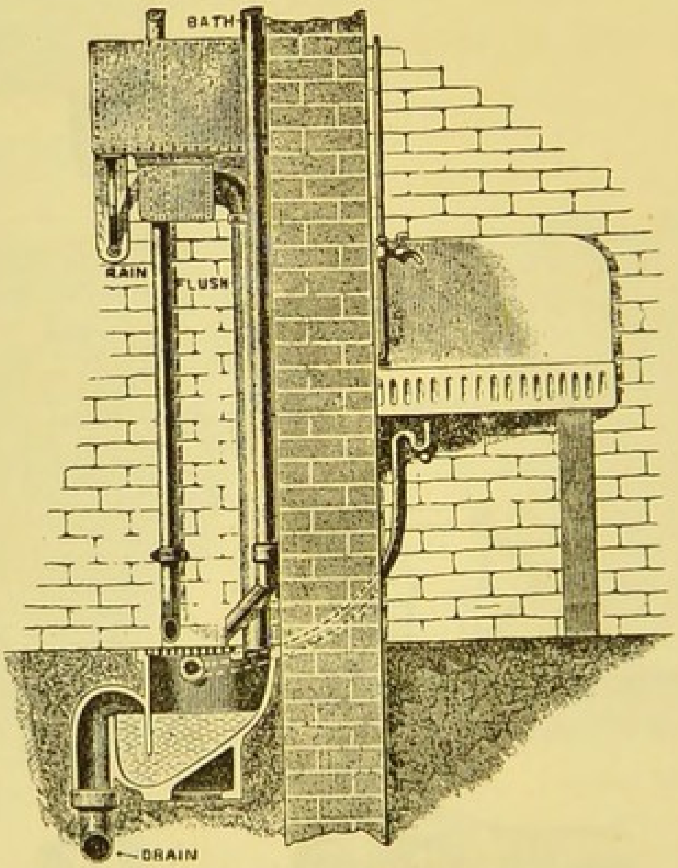


Fig. 154.

necessary head is obtained, and by a little contrivance the waste water from baths may be utilised for flushing purposes, the tank being placed outside. When this position is adopted, special means must be taken to prevent freezing up and to secure its efficient working during the winter; it should also be covered over to keep out leaves and litter.

Fig. 154 shows the arrangement of a very simple form of flushing tank manufactured by Bowes - Scott and Western, of Westminster.

Figs. 155 and 156 show Winser's patent reversible flushing rim grease-gully, made by Cliff and Sons, of

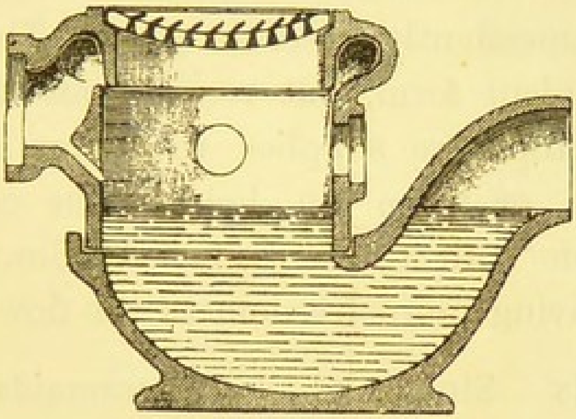


FIG. 155.

Leeds. Fig. 155 is made in two pieces. The trap—the lower portion—can be turned in any direction to suit the drain; the upper portion can also be turned to suit

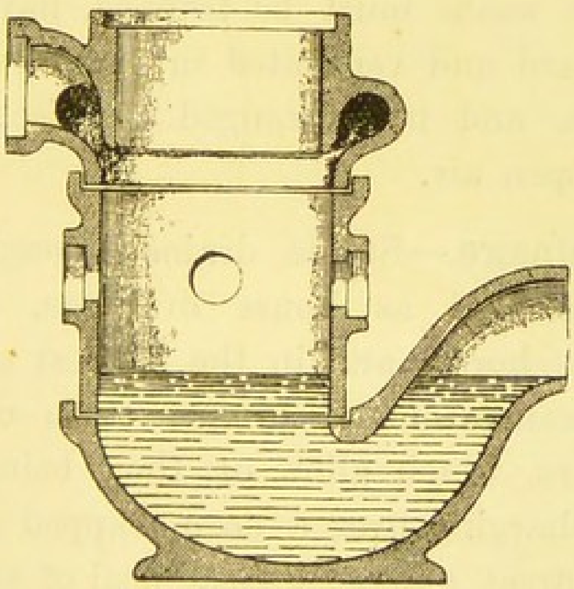


FIG. 156.

the connection from the automatic flushing tank. This meets the now usually adopted plan of concentrating the wastes and rainwater pipes to a centre gully, which in some cases also receives the surface water. Fig. 156 is the same trap, but has the advantage of having an extra raising piece to receive the various inlets; this allows the three pieces—viz., the connection for the drain, the connection from the tank, and the raising piece—for the connections of the various inlets to be turned in any direction, independently of each other. This is perhaps a more convenient form, but requires an extra depth of drain. The tops are supplied with four 2in. holes, or with one, two, or three 4in. holes. The outgoes of the traps are made both 4in. and 6in., the 6in. being recommended, as giving more freedom to the flow of the water.

Housemaids' Slopsinks. — Housemaids' slopsinks, wherever fixed in a house, should be treated exactly as water-closets, for it should be borne in mind that the urine collected from the bedrooms is discharged into them. They should therefore be formed with a flushing rim, so that they may be flushed with clean water from a cistern; the waste must be trapped, having its outgo into a pipe fixed and ventilated in every respect similar to a soil-pipe, and not arranged to discharge over a gully in the open air.

Stable Drainage.—Stable drainage ought to be as carefully considered as house drainage, both in the interest of the horses and in the interest of the pocket. The best arrangement is to have iron channels with movable covers, which allow of their being swept and cleansed, discharging over a deep trapped gully outside, similar to a street gully. A great deal of small pieces of straw and litter find their way into this gully, so to prevent them being carried forward into the drain it must be frequently emptied. In the case of stables already drained they should be disconnected on the outside, and the drain ventilated at the head, and the gullies inside frequently emptied and charged with clean water at least once each day. The outlay and attention expended on stable drainage where connected to the house system is a good investment, as they will not only lessen the chances of the house drain becoming unclean, but will also have an effect upon the length of the veterinary surgeon's bill.

CHAPTER XIV.

The Flushing and Cleansing of Drains.

Flushing. — No scheme of house drainage can be considered entirely satisfactory, however well the disconnection and ventilation may have been designed and executed, unless proper provision has been made for flushing. There are times when there is not sufficient sewage flowing through a drain, even if laid to a gradient that will produce a self-cleansing velocity when running, say, quarter full, to keep the solids from depositing. To prevent the gradual accumulation of deposits, and the consequent generation of gases, flushing must be introduced, preferably at the head of the drain. The turning on of a tap full bore will produce no effect of any value; what is required is a sufficient volume of water to be discharged through the drain as will cleanse the interior surface that has been in contact with the sewage.

Field's Syphon.—No one has done more to further the adoption of flushing than Mr. Rogers Field, whose self-acting flushing cisterns, fitted with a patent annular syphon, have been in general use for very many years, the present pattern being shown in Fig. 157. The annular syphon is fitted into an iron tank. The longer limb of the syphon just dips about ¼in. into the water in the lower tank or trapping box, which is kept at its proper level by a weir. The action is as follows: When the water (fed from inlet or tap) rises in the dome to the top of the lip or adjutage on the longer limb of the syphon, it begins to flow over by a succession of drops at first, which dispel a sufficient quantity of air in the discharge pipe and bell to cause the level of the liquid

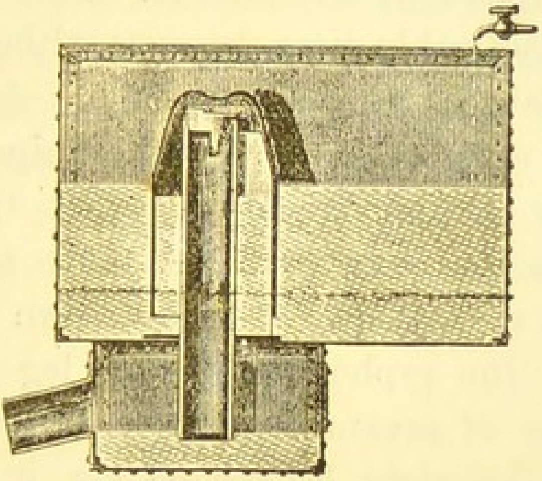


FIG. 157.

within the bell to rise; this rise increases the overflow into the discharge pipe and expels a further quantity of air, gradually forming a vacuum, which again causes a still larger rise and overflow, and thus brings the

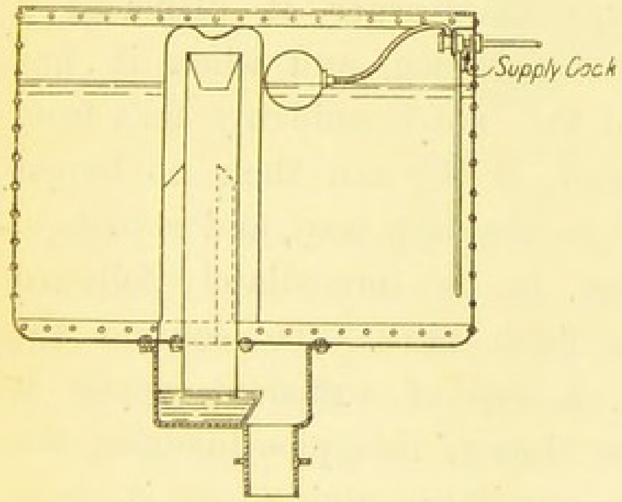


FIG. 158.

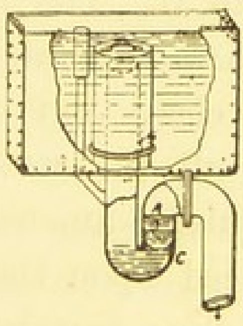


FIG. 159.

syphon into full action, when the tank is emptied with enormous rapidity.

Fig. 158 shows a syphon flushing cistern made by Ham, Baker, and Co., Westminster, and which is fed through a ball tap. Fig. 159 is an illustration of flush tank manufactured by Messrs. Adams and Co., of York, and of Old Queen-street, Westminster. When the flush tank commences to fill, water stands in both legs of the inverted syphon at the level A. This level does not vary for a considerable time, because, although the tank is filling, the air imprisoned under the deep trap over the main pipe can escape by the small pipe at the side, which also has a cap over it. But when the water rises high enough to seal this small pipe, the air is retained. As it becomes compressed, it forces down the water in the left leg of the syphon until this leg is empty. A further increase of pressure causes a large bubble of air to escape up the right leg. This leg, it will be seen, is contracted at C, so that the bubble is delivered up the centre of the pipe in one mass. Were it not for the constriction at C, it would be possible for the bubble to creep up the side of the pipe in detached pieces, when its effect would be less rapid and certain. As it is, as soon as the bubble turns the corner it displaces a quantity of water in the right leg, and when it has passed away the level of the water suddenly falls from A to B. The reduced head, B—C, can then no longer balance the air pressure in the deep trap, and a rush of air clears out the syphon, to be immediately followed by all the water in the flush tank. To confine the requisite amount of air, a cap of sufficient depth is placed upon the vent-pipe shown, this pipe insuring the absolute certainty of the apparatus giving, as it does, free admission of air to the syphon both before and after its discharge, in the latter case completely breaking the partial vacuum which otherwise would exist.

Fig. 160 shows a flushing syphon on an entirely new principle, and is known as Merrill's patent, manufactured by the Water Carriage Engineering Company, of Sheffield, and Berners-street, London. Instead of depending for its action on the gradually increasing pressure of the liquid in the tank, driving out the air compressed in the syphon as in all previous ones, Merrill's syphon depends on the action of a tipping bucket, this being the method of producing automatic action. When the water fed into the cistern or tank reaches the inlet end of the short leg, the air in the syphon is locked up between the water in tank and that in the outlet trap, and

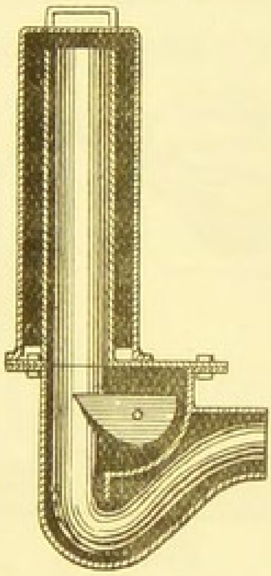


Fig. 160.

consequently rises more slowly in the short leg than in the tank, the difference in level depending on the depth of the seal of the outlet trap. When the feed supplied to the tank has produced a sufficient compression in the syphon, the air is gradually driven out through the trap, in proportion as the water rises in the tank and short leg. When the water reaches the bend or overflow point of the syphon it overflows into the tipping bucket, which, when filled to its tipping point, overturns and throws out its contents into and through the outlet trap, and thus produces a vacuum which permits the head of water to charge the syphon. The syphon is so constructed that the upper part can be lifted and the lower portion exposed for inspection or cleansing. These syphon cisterns when charged with clean water may be placed either inside or outside the house in any convenient position, but if outside and above ground, means must be taken to protect them from frost. To economise in the consumption of water, it is a good arrangement to feed them from the bath waste, as this water is seldom greasy; and as usually about 30 gallons is discharged from a bath, a cistern

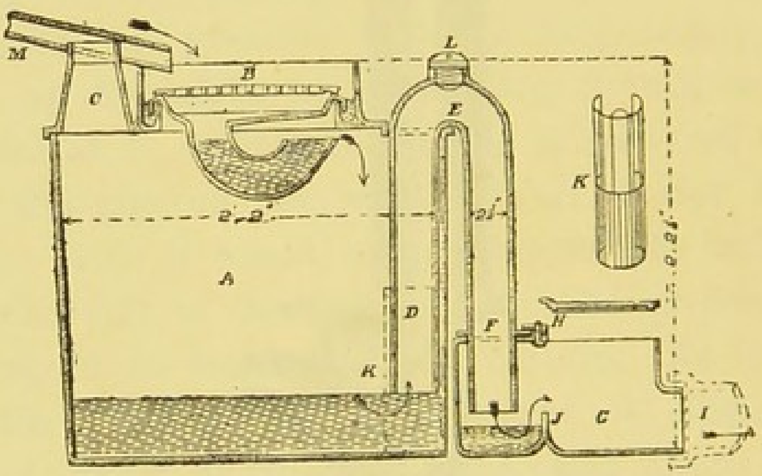


FIG. 161.

to hold this quantity is a suitable size to adopt in such a position.

Mr. Rogers Field has also devised another form of tank, which is shown in Fig. 161, called "Self-acting Flush Tank," and which may be used in connection with sink wastes. The apparatus (shown in section in the figure) consists of a cylindrical water-tight iron tank, A, having a trapped inlet, B, which also forms a movable cover to give access to the inside of the tank, and a socket, C, for a ventilating pipe. The outlet consists of a syphon, D, E, F, so arranged that no discharge takes place till the tank is completely filled with sewage, when the syphon is brought into action and the contents are immediately discharged. The outer end, F, of the syphon dips into a discharging trough, G, attached to the flange of the syphon by a movable button, H, so as to be turned round in the right direction, to connect the tank with the line of outlet pipes, I. This trough has a barrier, J, across it with a notch so contrived as to assist small quantities of liquid in bringing the syphon into action instead of merely dribbling over the syphon without charging it, as they otherwise would do. The cover of this trough can be removed to give access for cleaning. There is also a brass-wire strainer, K, which is clipped on to the

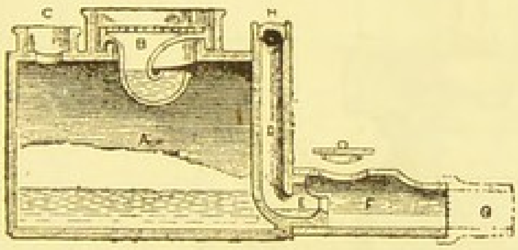


Fig. 162.

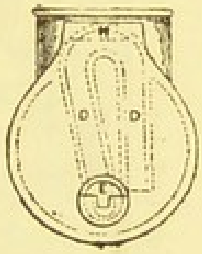


Fig. 163.

inner end, D, of the syphon, so as to be taken off at will; and a screwed brass plug, L, is fitted to the bend, E, of the syphon in case it should at any time be necessary to examine or clear it. The pipe, M, represents a waste-water pipe (usually from a sink) through which the supply of sewage is conveyed to the tank.

Figs. 162 and 163 (shown in section) represent Field's flush tank made in stoneware, which works in the same manner as that made in iron, the only difference being that the syphon is placed in a different position.

When used for flushing drains, all that is required is to fix the tank outside the house or building, and in some convenient position between the supply and the drain to be flushed, and to connect the supply with the inlet and the drain with the outlet of the tank. There is no house in which there is not sufficient waste water for flushing by means of this apparatus. The water from the sink is generally available as a supply, and

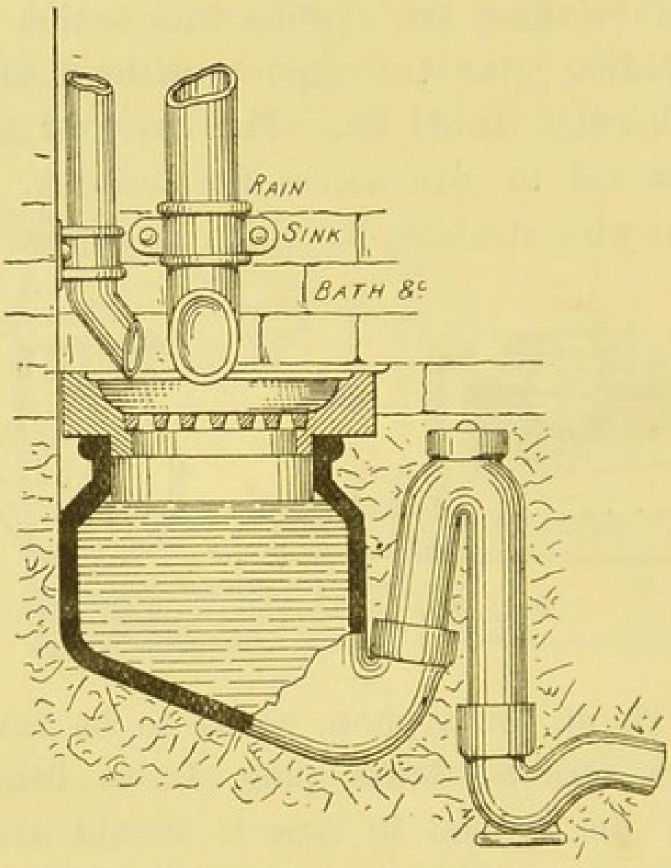


FIG. 164.

the tank is specially adapted for this as it forms the most perfect kind of trap, breaking the connection between the drains and the house, and intercepting the solid matter. Where the drains have only a slight fall, advantage can be taken of the height of the sink by placing the top of the tank above the ground. The drippings from a water-tap, or the rainwater from a roof, may also be used as a supply. A very small accession of water will start the syphon when the tank is once full, but should it occasionally remain full for any time in consequence of insufficient supply, a jug of water thrown on the grating of the inlet will immediately set the syphon in action.

A flushing gully to serve the same purpose, and fed also with dirty water, is made by Messrs. Adams, and shown in Fig. 164. This size is made to discharge about four gallons; or a larger one, in two pieces, can be obtained to discharge eight gallons, as in Fig. 165.

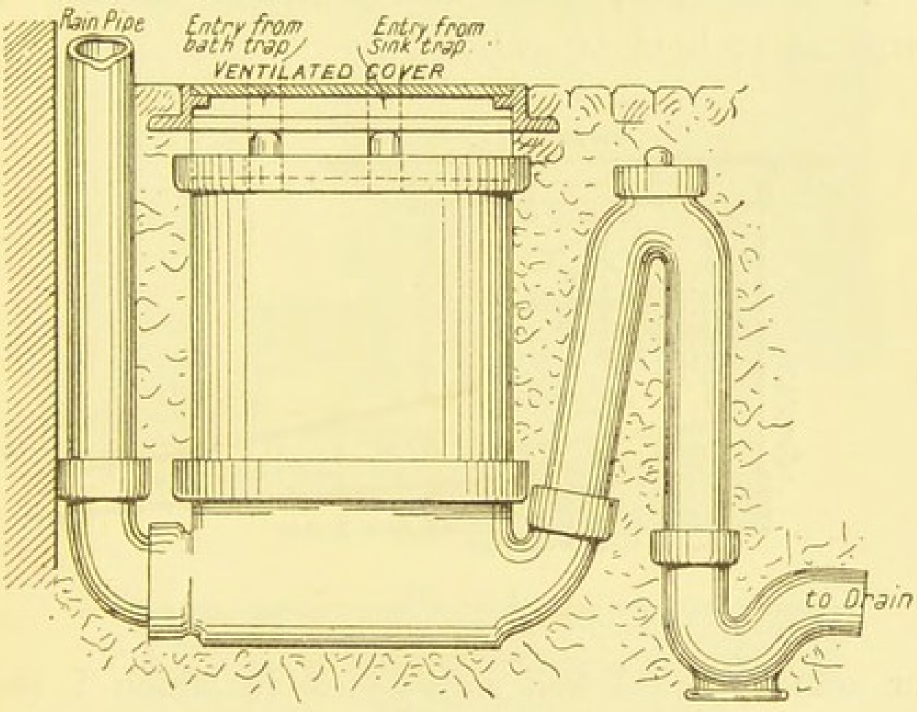


FIG. 165.

A few years ago, in carrying out a scheme of drainage for a large house where a bath waste happened to be at the head of the drain, I got Mr. Duckett, the manufacturer of the well-known slop closet, to make me a glazed fireclay tipper to hold 20 gallons. This was fitted with a wrought-iron crossbar, the trunnions resting on brass steps, and fixed in a brick chamber, the outgo from which was a series of large taper pipes, so that, when the tipper discharged, its contents passed freely into the drain without being broken up, the full force of the flushing water being thus obtained. The true setting of the tipper, so that it returns to a horizontal position when empty, is a delicate operation; and if the chamber is protected with a closed cover so that no solid objects can fall on to the steps, it will work automatically and continuously without any attention. This arrangement is shown in Fig. 166, and was, I believe, the first tipper for flushing on a large scale made by Mr. Duckett; this manufacturer, has, I understand, been successful in making them as large as to hold 60 gallons.

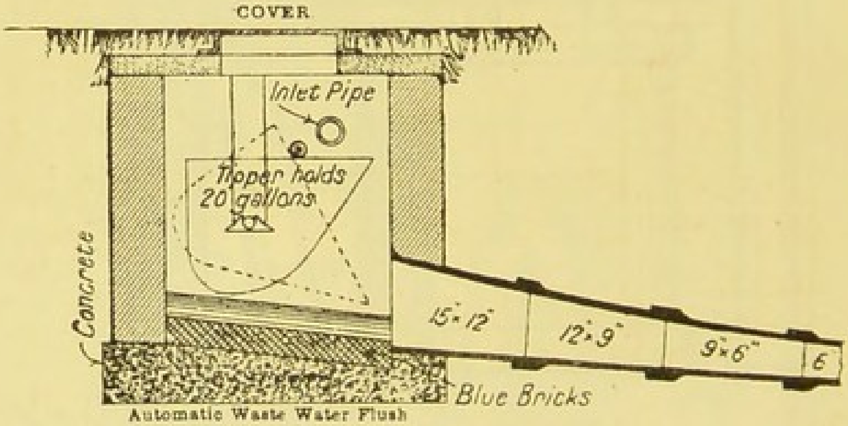


Fig. 166.

For some years I had at a house in which I resided a five-gallon tipper fixed in the gully receiving the bath waste. It worked well and successfully, and as a supplementary flush was very serviceable in keeping the interceptor trap, which was not more than 12 yards away, always sweet and clean.

Flushing Chamber.—For long lengths of drain, and where a more thorough flushing is required, a tank to hold not less than 100 gallons should be constructed, and it will be more economical and stronger to build this in brickwork set in cement faced with impervious bricks and backed with puddle. The feed water may be taken from the service pipe if a daily flush is required. The rainwater and bath wastes may

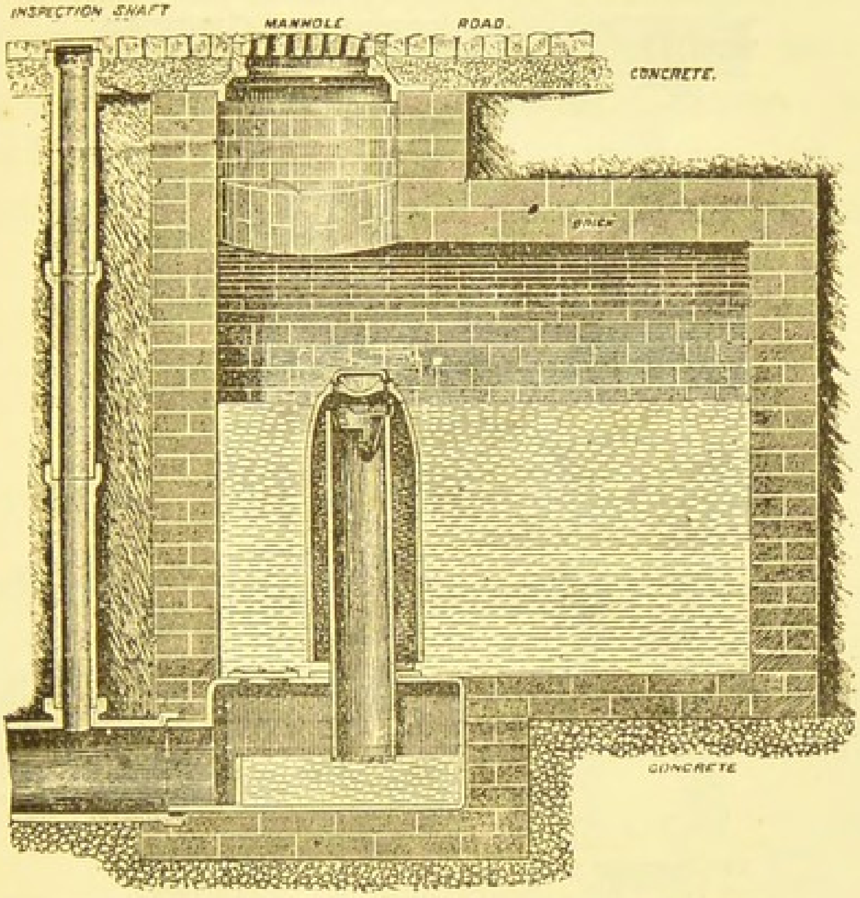


Fig. 167.

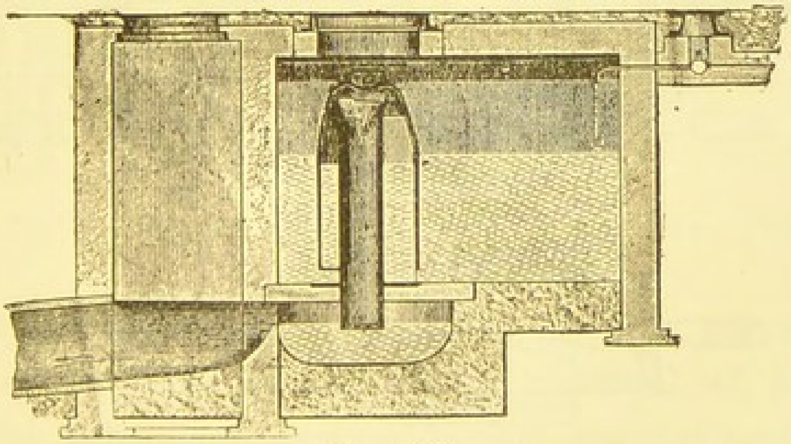


Fig. 168.

be utilised as well as the water expended in washing carriages, or the overflow from any well, spring, or other private supply. The arrangement of the syphon leg and trapping box in the chamber is shown in Figs. 167 and 168, which are Field's pattern.

Fig. 169 shows an arrangement of Palmer's (Becken-

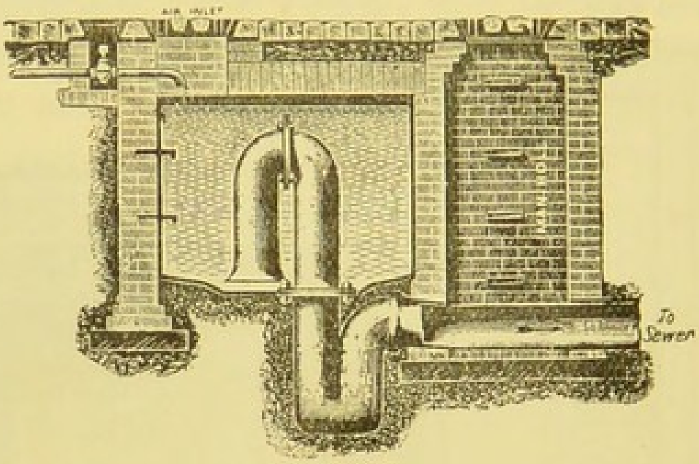


Fig. 169.

ham) automatic flushing apparatus fixed in a chamber. Here it will be noticed that the dome over the leg is dispensed with, and a swan-neck pipe with bell-mouth inlet is carried down close to the bottom of the tank.

Fig. 172. Fig. 171.

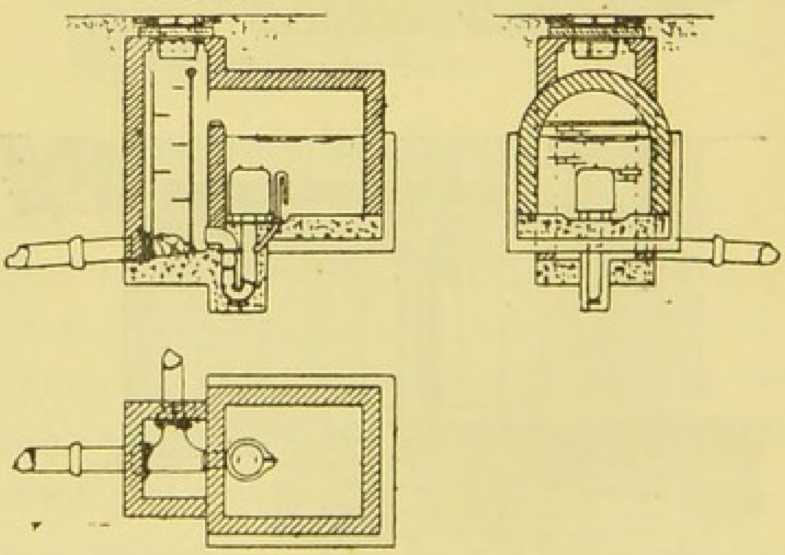


Fig. 170.

Figs. 170, 171, and 172 show an arrangement of Adams's syphon (previously described) set so as to flush two ways if desired.

There has lately been introduced into this country from America a form of syphon called the Miller syphon (illustrated in Figs. 173 to 179), the description of which is taken from *Engineering*, February 1, 1895:

"The flushing syphon is one which has been largely adopted in the United States, having obtained the highest award at Chicago in 1893. Previous syphons have been brought into action by

Fig. 174. Fig. 175.

Fig. 176.

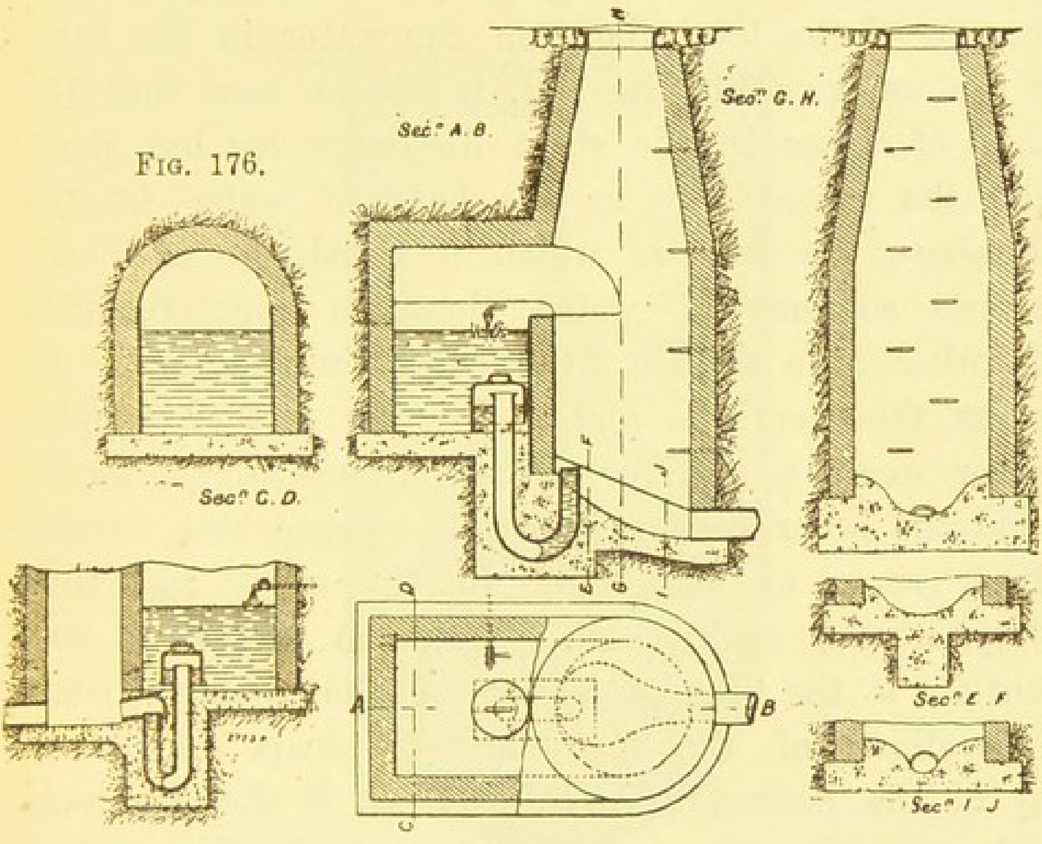


Fig. 178.

Fig. 177. Fig. 173. Fig. 179.

the simple release or rarefaction of the air confined in the syphon, or by the sudden removal of such air by special subsidiary devices, which are entirely absent in the 'Miller' syphon. As shown in Figs. 174 and 177, it consists of two simple castings, a U tube or trap and mouthpiece, cast in one piece, and a cast-iron bell which is placed over the longer leg of the syphon, and is held in place by brackets cast on the trap. The action of the syphon is as follows: As the water entering the tank rises above the lower edge of the bell it encloses the air within, the lower portion of the U or trap being, of course, filled with water. As the water-level in the tank rises, the confined air gradually forces the water out of the long leg of the trap until a point is reached when the air just endeavours to escape round the lower bend. Now as the difference of water-level in the two legs equals the difference of the levels between the water in the tank and the water within the bell, it will be seen that the column of water in the short discharge leg has practically the same depth as the head of water in the tank above the level at which it stands in the bell. The two columns of water therefore counterbalance each other at a certain fixed depth in the tank. As soon as this depth is increased by a further supply, however small, a portion of the confined air is forced around the lower bend, and by its upward rush carries with it some of the water in the short leg, thus destroying the equilibrium. But the secret of this invention is the free projection of the overflow edge, which allows of the instantaneous escape or falling away of the heaved-up water. Thus, if the discharge mouth were formed as an ordinary bend, the syphon would not act (although the confined air rushes around the lower bend), for the simple reason that the heaved up water has no means of instantaneous escape, and therefore the equilibrium is not sufficiently disturbed. It will thus be seen that the action of the syphon depends, not on the escape of air, but on the sudden reduction of a counterbalancing column of water.

"Repeated trials have shown that a 6in. syphon will discharge full bore a 500-gallon tank, fed so slowly as only to be filled in 14 days. There being no internal obstruction, the discharge is extremely rapid. There is, it will be seen, a deep-water well between the flushing tank and the sewer, which is, of course, an advantage. We have had the opportunity of seeing one of these syphons at work in the excellent Sanitary

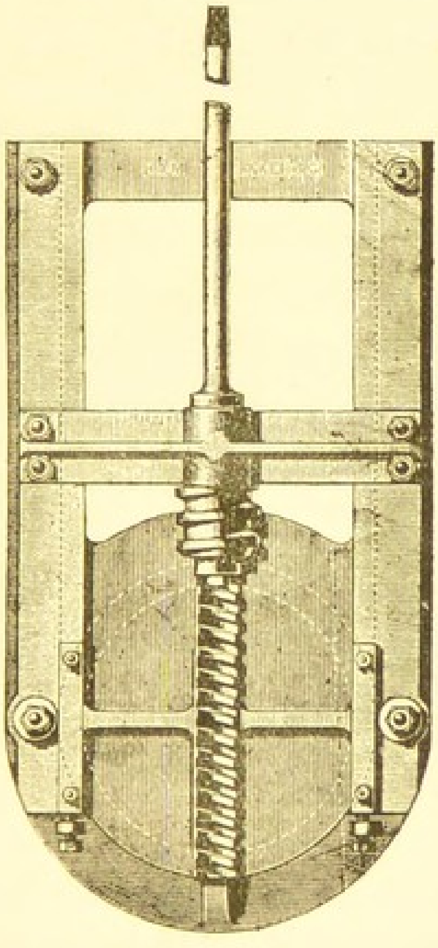


FIG. 180.

Museum at Hornsey, and though severely tried, the syphon worked perfectly. As will be seen by a reference to Figs. 173 and 174, the syphon chamber can be very neatly combined with a manhole. No special mouth-piece is then required; the mouth of the discharge pipe stands quite clear, and delivers the water into a concrete basin, from which it rushes down into the sewer.

Penstocks.—In long lengths of drain, in order to make the fullest use of the flushing water, a penstock should be fixed in an intermediate manhole, so that by closing it the water may be held up, and released so as to flush the lower length of drain. Where water is scarce, the sewage may be dammed up and used for flushing purposes. Penstocks are usually made in two patterns,

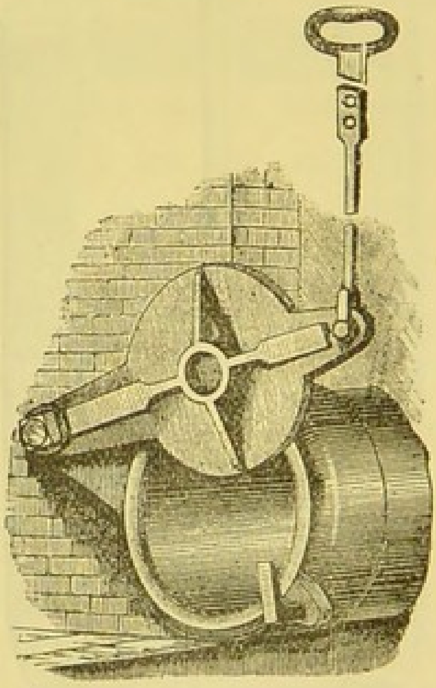


FIG. 181.

the screw-down, as in Fig. 180, being raised and lowered by a key fitted on to the top of the spindle from the surface.

The disc penstock is shown in Fig. 181. This, as will be seen, is self-locking, and works from a side pivot, and is raised or lowered by working the spindle attached. For the purpose of facilitating the periodical hydraulic testing of drains, penstocks are extremely useful, and one should always be fixed on the inlet to the intercepting manhole. But wherever they are fixed, a relief pipe should be carried from the drain behind them communicating with the manhole, so that in case of temporary accident to the penstock, when shut, the sewage can escape without backing up to the surface through the manhole covers or gullies. Gardeners and other servants who are set to do this flushing have a knack of going away in the middle of the operation and forgetting to come back to raise the penstock. The relief pipe affords compensation for these cases of absent-mindedness.

Drain-cleaning Tackle.—Although not one of those who are convinced that all drains will get stopped up sooner or later, experience has taught me that even the best-laid drains occasionally get stopped up, generally from accidental causes. I have found housemaids' scrubbing brushes and floorcloths inside drains; and the water which has been used in washing floors contains a great quantity of lint and grit worn from the cloth and rubbing stone used in the operation, and when the pail is emptied this finds its way into the drain. And especially is trouble likely to arise from this cause at public institutions, where many of the ground-floor rooms are paved with flagging, and where cleanliness is so often practised and so much prized. In these cases I find it a good plan to put a strong galvanised-wire strainer across the most convenient manhole to intercept this lint. For the purpose of removing temporary stoppages in drains, the best tackle to use are the red malacca canes, which are cut in various lengths from 2ft. to 5ft., and fitted with interchangeable brass screws and are brass riveted, and can be procured in bundles ranging from 30ft. long up to 100ft. Brushes, either of bass or whalebone, should be used for finally sweeping out the drain, but in the earlier stages any one of the tools shown in the figures may be required to remove the obstruction.

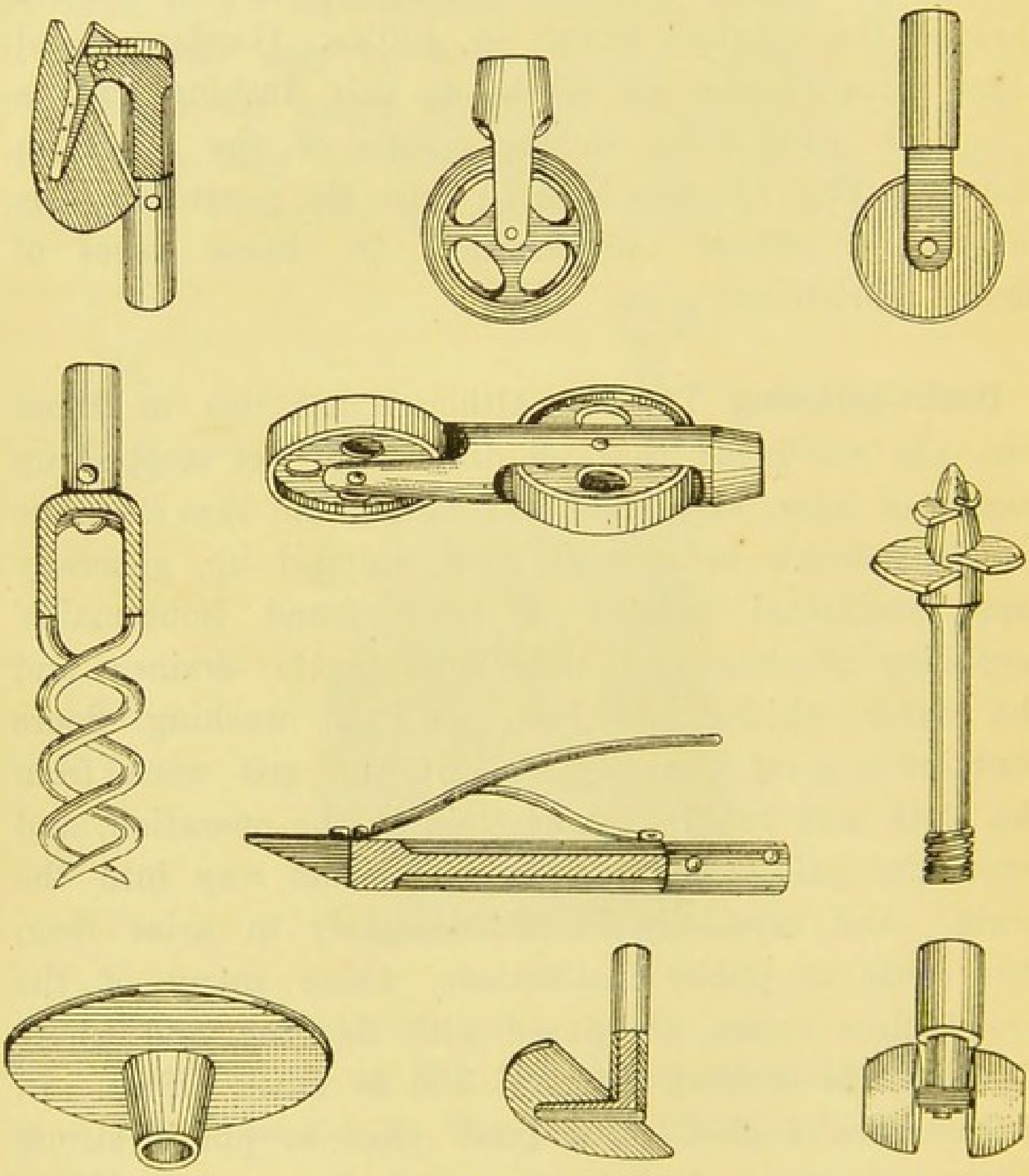


Fig. 182.

The tools and canes are manufactured by Mr. H. Hart, 29, Settles-street, Commercial-road, London, E., and the various types are shown in Fig. 182.

CHAPTER XV.

Disposal of Sewage from Isolated Houses.

Where there is no system of public sewers to which the house drains can be connected, it becomes necessary to adopt means to prevent the pollution of streams and watercourses by the sewage discharged from the house. Section 3 of the Rivers Pollution Prevention Act, 1876, states that "Every person who causes to fall or flow or knowingly permits to fall or flow or to be carried into any stream any solid or liquid sewage matter shall (subject as in this Act mentioned) be deemed to have committed an offence against this Act," and then follow the provisos, procedure, penalties, etc. It is necessary therefore to see that the sewage before being discharged into streams is purified—not clarified only—that is, that not only shall the matter in suspension be removed, but the organic impurities also, so that secondary decomposition shall not set up after the effluent water has commingled with the water in the stream. It must be borne in mind that not only are sewage works subject to inspection by the officials of the local District Council, but also by those of the County Council, who have very stringent powers conferred upon them in regard to the prevention of river pollution; and in those areas where Joint Rivers Boards have been formed, such as in the West Riding of Yorkshire and the watershed areas of the Mersey, the Irwell, and the Thames, a staff of inspectors is kept for the purpose, and the special Acts under which they work are much stricter than the general Act.

The standard of purity which the effluent water from purified sewage shall have has not yet been fixed to be applied universally. The standard of the Rivers Pollution Commissioners, which may serve as a guide, was as follows:

MAXIMUM IMPURITY PERMISSIBLE IN 100,000 PARTS BY WEIGHT OF THE LIQUID.

Dry Mineral Matter in Suspension.	Dry organic Matter in Suspension.	Colour.	In Solution.					
			Organic Carbon.	Organic Nitrogen.	Any Metal except Magnesium, Calcium, Potassium, or Sodium.	Arsenic.	Chlorine.	Sulphur as SH_2 or Sulphate.
3	1	Shown in a stratum of 1in. in a white plate.	2	0·3	2	0·05	1	1

It is usual in conducting analyses of sewage and effluents to arrange the constituents under the following nomenclature:

Free ammonia.
Albuminoid ammonia.
Oxygen taken up in three hours.
Mineral matter in suspension.
Organic matter in suspension.
Mineral matter in solution.
Volatile matter in solution (loss on ignition).

An examination of the changes brought about in the albuminoid ammonia and oxygen taken up will disclose the percentage of purification attained. Albuminoid ammonia represents the nitrogen in organic matter which has not yet begun to decompose by oxidation.

The nitrogenous matters, consisting of urea, uric acid, colouring matters of animal origin, mucus, and various bodies in a state of unstable equilibrium, somewhat resembling albumen in their chemical characteristics.

Processes of Purification.—The processes by which sewage may be disposed of are—

(*a*) By treatment on the surface of land.

(*b*) By precipitation in tanks, with subsequent filtration.

(*c*) By biological treatment; or

(*d*) It may be collected in cesspools, the contents being removed and disposed of on land.

The first system can only be adopted where there is sufficient suitable land available at a convenient distance from the house; the second and third are alternatives where the land available is both unsuitable from its composition, area, and position; and the last is only permissible when the area of land is too restricted to allow of the adoption of purification works.

Cesspools.—As so many houses discharge their sewage into cesspools—so called—it will perhaps be more convenient to deal with that system first. As ordinarily practised it is, of course, a most insanitary one, filthy, and extremely dangerous to health—due to inadequate capacity, bad design, improper construction, the direct connection of drains thereto, want of attention, failure to remove contents and cleanse at proper intervals. Many of them are also provided with overflows, so that the cesspool holds highly putrescent solid filth, and the liquid flowing out is more concentrated than the sewage flowing in. There are also the faults due to position whereby percolation from them causes contamination of the surrounding subsoil, and very frequently the sources of water supply also. It is often considered rank heresy in anyone desirous of promoting efficient sanitation to advocate the adoption of cesspools in any shape or form, but in certain situations the only choice is between a conservancy system of closets and a cesspool. The adoption of the former is only possible where there are no internal water-closets, and where the amount of chamber slops is very limited, otherwise there is no alternative to the cesspool. Attended by proper safeguards it may be made to act satisfactorily, and these may be thus classified :

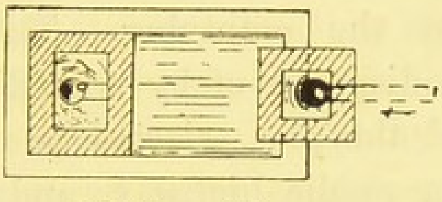
(*a*) *Position.*—This must be sufficiently far from the house as not to cause any nuisance if by an oversight the emptying has been neglected. It should be easily accessible for this purpose, and it should be so placed that in the event of leakage the fouling of watercourses will not take place.

(*b*) *Size.*—The size must be regulated to the amount of sewage discharged and required to be stored, provision being made for not more than one week's supply of sewage. Roof and surface water may be excluded as well as bath water, but drains from soil-pipes, lavatories, sink wastes, stables, cowhouses, laundries, etc., should empty into cesspool.

(*c*) *Disconnection and Ventilation.*—A cesspool should be treated precisely as if it was a public sewer, and all drains emptying into it should be disconnected by means of an intercepting trap with fresh-air inlet, and be properly ventilated.

(*d*) *Construction.*—It should be thoroughly watertight, faced with impervious bricks, and so shaped as to allow of thorough cleansing and the free removal of all deposited solids.

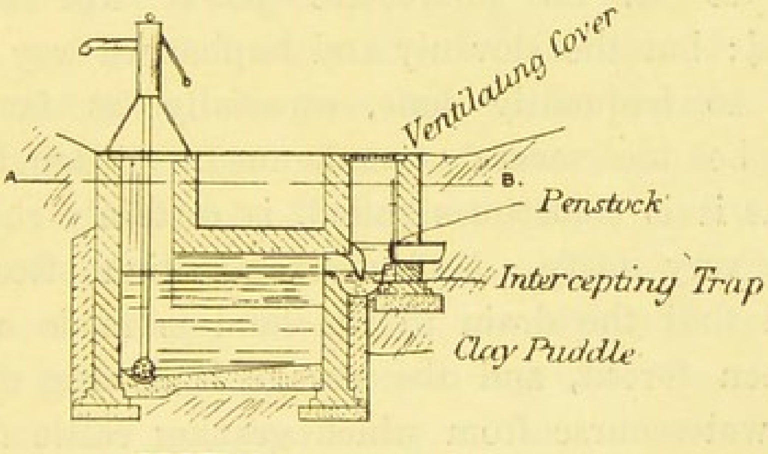
Figs. 183 and 184 are plan and section of cesspool designed to embrace the foregoing requirements. The foundations and floor are formed of concrete, the latter



PLAN AT A.B.

Fig. 183.

rendered to a smooth surface, and inclining from the inlet end and from the sides to a sunk channel in the centre, along which the sludge may be swept into the sump in which the rose at end of pump suction pipe rests. The walls are faced with salt-glazed or blue Stafford-



SECTION

Fig. 184.

shire bricks set in cement and backed all round with a band of 12in. of good clay puddle carried up to level of inlet pipe. There is an access shaft for inspection and cleaning purposes, into which the pump is inserted when required, and this is closed by an airtight iron cover. The inlet pipe is fitted with penstock and disconnecting trap in a shaft covered with an open grating for the admission of fresh air into the drain. When the cesspool has to be cleansed, the penstock fitted on the inlet pipe into this shaft may be lowered so that the sewage will be held back in the drain during the short time that will be taken up by the emptying. The contents of a cesspool may be disposed of by spreading upon land as manure, provided the plot selected is not contiguous to dwellings or to a public highway, and that proper care is exercised in the operation.

Land Purification.—Wherever practicable, the disposal of sewage upon the land is not only the most efficient from a sanitary but also from an economical and utilitarian point of view, because if the land is suitable from its composition, and the sewage is intelligently applied to it, its productive power will be much increased; but the slovenly and haphazard way in which this is so frequently done, especially at farmhouses, cannot be too severely condemned. "Rough irrigation," as it is sometimes called, is certainly rough, and likewise very nasty. A close examination often reveals the fact that the drain to the land is made up, joints have been forced, and the sewage is flowing unchecked into a watercourse from which grazing cattle drink; or may be the pipe delivers only on to one spot in the field, very often quite close to house or garden, and the immediately contiguous ground is supersaturated and impregnated with filth.

Before sewage is applied to land for the purpose of irrigating it, we must be quite sure that the land available for selection is suitable. By irrigation is meant "the distribution of sewage over a large surface of ordinary agricultural land, having in view a maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied." Referring to the treatment of sewage on land, Prof. Henry Robinson says, in his recently published book on "Sewage Disposal," "that the changes that have to take place in sewage to effect purification, or that are necessary to enable the manurial ingredients in it to be best adapted to the requirements of plant life, are due to the nitrifying action of micro-organisms. It is essential that the conditions should be adhered to which favour the cultivation of these bacteria. Where the land under treatment is open and pervious, the most solid part of the sewage, as well as the dissolved and finely-suspended organic matters, admit of being liquefied in the interstices of the soil, and of being converted into the harmless nitrates and nitrites which are so beneficial to plant life. Where the land is impervious this can only be partially effected, and in such cases the liquefaction of the solids by bacteriological influences has to be brought about by chemical treatment, so that the fluid that is applied to the land is both free from that which would clog the pores, and is at the same time highly charged with the nitrates and nitrites which are available for vegetation. If they are not required by the crops, they are in a form that can pass away without causing pollution or nuisance."

The first consideration in sewage treatment is the sanitary necessity for purification and filtration; the agricultural value of the fluid is a subsidiary matter entirely.

The best kind of land for the purpose is that which has a light, open, porous soil, but not sand or gravel, and the most unsuitable are peaty and boggy lands or stiff, tenacious clays. Attempts have been made to adapt these by lightening with ashes, etc., but the process is very expensive, and the experience after a few years' working demonstrates that prior treatment is required before applying the liquid to the land, and it cannot be depended upon in periods of long droughts or continued wet weather.

The most suitable system for treating sewage from isolated houses on land is by intermittent downward filtration. The area being laid out into suitably sized plots, which must be underdrained about 5ft. to 6ft. deep, the distance of the drains from each other will depend upon the porosity of the subsoil. It is advisable in the first instance not to lay them too close together, but to add branches wherever the experience gained in working points out to be desirable. The object in land treatment of sewage is to utilise it and not waste it, and the land should be so prepared that it will absorb the sewage uniformly over its surface without flooding or overflowing. The area should be laid out in slopes according to the contour of the surface and nature of the soil; on impervious soil these must be flat, else the sewage will pass over without being absorbed; and on porous land, the slopes should be greater to prevent the sewage being absorbed unequally.

There are several methods of distributing sewage over land, which are regulated by the nature of the soil and the methods by which it is intended to be worked; but it is not necessary, as Sir R. Rawlinson says, to prepare the surface like a bowling-green. One method is to prepare it in beds about 40ft. wide, inclining from the sides to the apex, according to the nature of the soil, at the rate of from 1 in 50 to 1 in 150; the sewage being brought on at the ridge and flowing down distributing channels formed in the slopes in a uniform layer or film. Another method used where the areas are very porous and the sewage applied in small volumes is the "ridge and furrow," as adopted by Mr. Bailey Denton—the sewage being diverted down each furrow successively to ensure uniformity of application. Fig. 185 shows the usual form of "ridge and furrow" adopted in these cases. The sewage passes laterally into the ridges, and is carried by capillary attraction above the line of saturation, its fertilising constituents thus being available for the nourishment of plant life.

There are also other methods of laying-out land for the purpose of receiving and treating the sewage. Assuming that a saddle-backed ridge of suitable subsoil

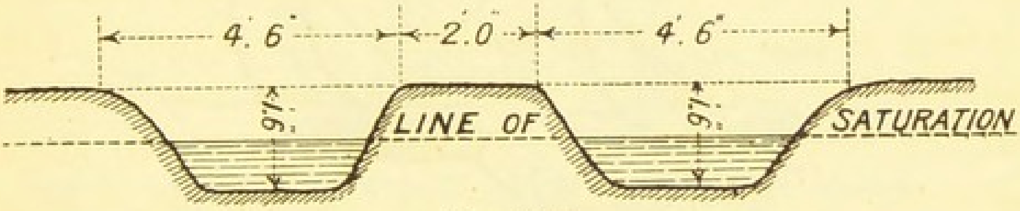


Fig. 185.

is available, the main carrier may be laid along the apex of the ridge having short spurs at intervals for distributing the sewage when required, and from the point where the spur drain cuts the surface of the ground little gutters should be cut in various directions to distribute the sewage uniformly. At the junctions there should be a small chamber in which there should be a hand "clow" or "paddle," which can be transferred from the branch to the main and *vice versâ* when it is desired to turn the sewage.

Before the sewage passes into the main carrier it is very desirable that all floating and heavy matter should be strained off at some suitable point. These strainers may be fixed across the invert of one of the manholes, which should be slightly widened and deepened when so used. The main carriers should be of half round pipes securely jointed and firmly bedded on concrete to ensure regularity in the inverts, and to prevent upheaval during extreme frosts. At suitable intervals cross carriers must be introduced for turning the sewage, or carriers may be formed by cutting grips in the ground. These will be regulated by sluices and stops as shown on the enlarged plan of a junction carrier, Fig. 186.

Where the ground is rough and irregular on the surface, the "catch-water" system may be adopted by

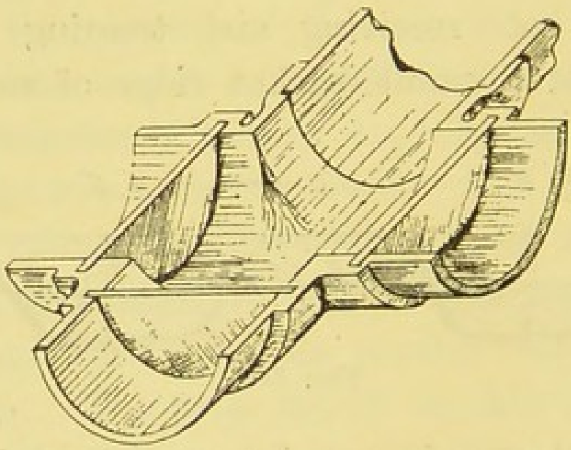


FIG. 186.

running the carriers along contours, which should be carefully levelled and set out. Fig. 187 is a specimen plan showing an area laid out on this system; the central line 1 to 4 is the main carrier from the meter tank. The whole area is first set out into squares of a convenient size, and the surface levels taken at each intersection. At No. 1 the reduced level is seen to be 37·00 above the datum—therefore the branch carried will follow that contour, as shown by the thick black line; at No. 2 it is 34·30; at No. 3, 32·10; and No. 4, 29·80; and the respective contours are also shown as following these levels, up or down, as the case may be.

The dotted lines show the course of the subsoil drains, with manholes for the purpose of obtaining samples of the effluent water in order that the amount of purification accomplished can be tested from time to time, and the efficiency of the separate filtration areas compared. These comparisons, to be of any value, must also show the condition of the raw sewage previous to filtration in each case.

The amount of sewage from one house is so small and irregular in volume that at times it will be a mere

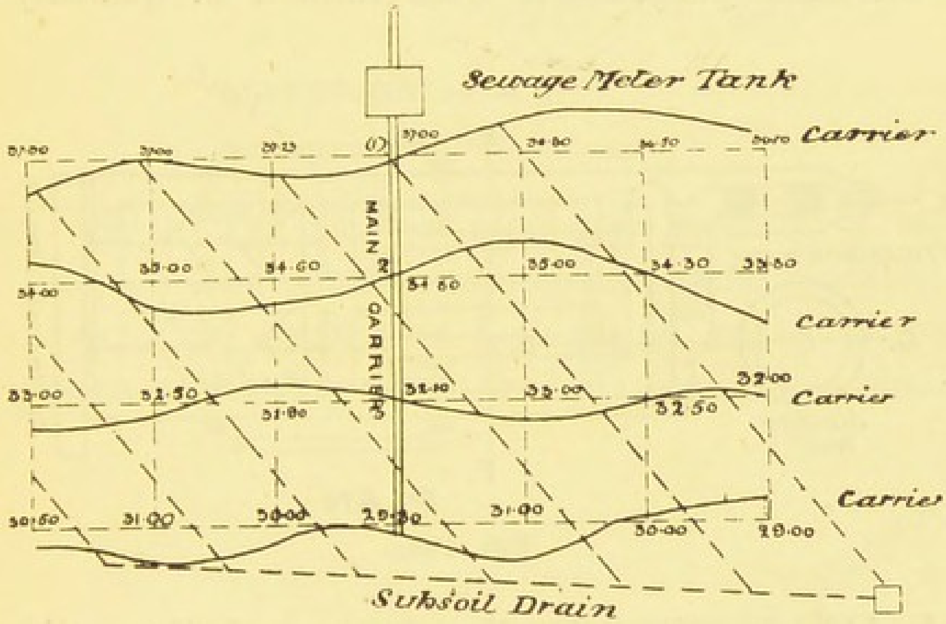


FIG. 187.

trickle, and not have sufficient velocity to carry forward on to the land the heavier matters which are in suspension, which become deposited in the drains and carriers, and thus, assisted by evaporation as well, a considerable proportion of the sewage will never reach the land. The most successful method of dealing with such sewage is to run it direct into what is called a sewage-meter tank, which is nothing more or less than a large tank fitted with a flushing syphon, and constructed in a similar manner to those shown in Figs. 167, 168, and

169. Before entering the tank the sewage should be passed through strainers, and at the outlet of the tank there should be a manhole for giving access to the drain leading to the irrigation area. The working of the tank has already been explained, but it will be at once seen that this system enables a large volume of sewage to be uniformly directed over the filtration plots. If the tank is sufficiently elevated, the sewage may be delivered direct into the main carriers.

Precipitation Processes.—Where the land available for filtration purposes is both limited in quantity and

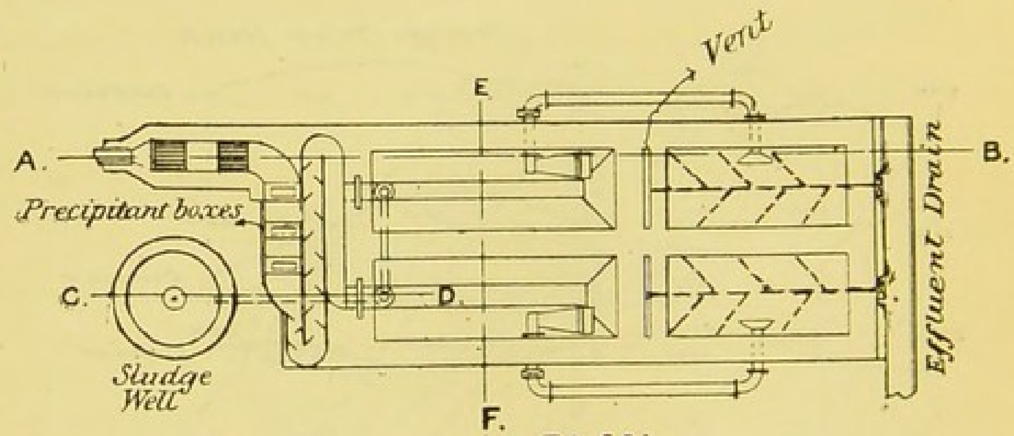
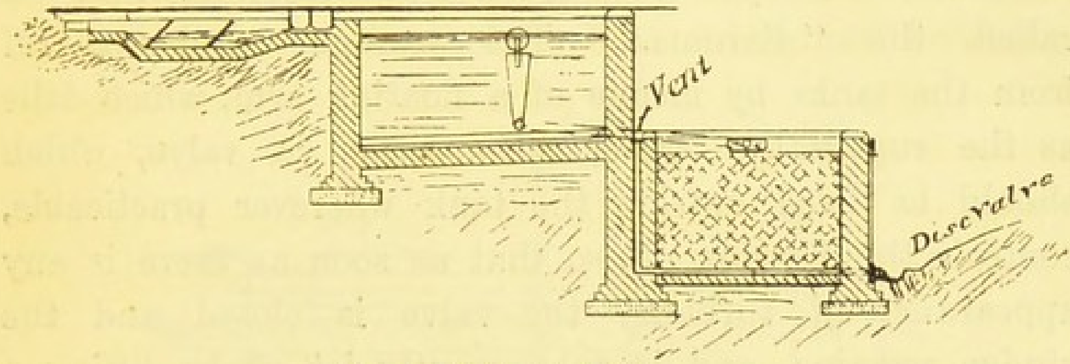


Fig. 188.

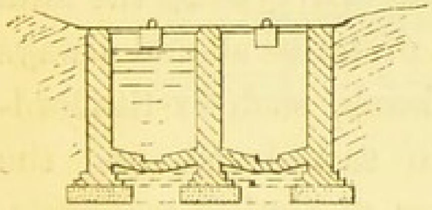
of doubtful quality, the liquefaction of the solids by bacteriological influences can best be brought about by precipitating the sewage into tanks by chemical agency, so as to remove the suspended matters and as much as possible of the organic impurities. The tanks should be in duplicate so that one may be in work while the other is being cleansed, and each should be capable of holding about one day's flow of sewage. It has been customary to construct these tanks rectangular in shape, but of late years there have been variations introduced which will be fully described later on. The length should be about three times the breadth, and the depth at the inlet end about 5ft. below water-line, and at the outlet end 4ft., and the floor should slope to a central channel along which the sludge may be swept when the tank is being cleansed.



SECTION ON A.B.

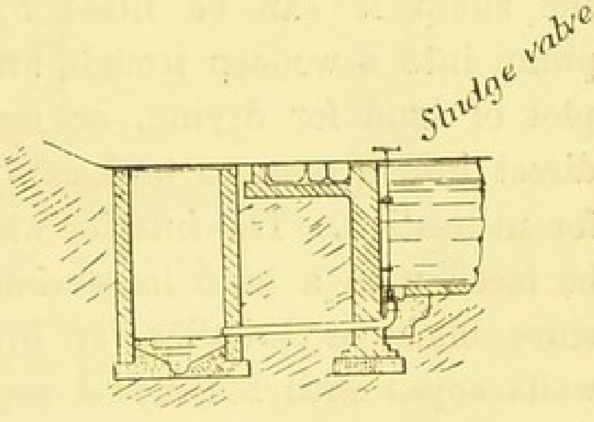
FIG. 189.

Figs. 188 to 191 show a plan and sections of tanks with filters. The general arrangement and working is as follows: The sewage is first of all passed through two screens of varying mesh fixed diagonally in a shallow



SECTION ON E.F

FIG. 190.



SECTION ON C D

FIG. 191.

sump, into which the heavier solid and foreign matters fall. It then flows through a number of cages in which are fixed slabs of soluble precipitant, such as aluminoferric, kremnolite, etc.; and in order that the constituents of this and the sewage may become thoroughly incorporated, it afterwards traverses a mixing race formed by baffling plates across the channel. For some time past I have had these made in glazed fireclay, and found them to answer admirably. They are very durable and easily cleansed; the pattern has been registered, and is called the "Erimus." The sewage is drawn off from the tanks by means of a floating arm, which falls as the supernatant water flows away. A valve, which should be fixed outside the tank wherever practicable, controls the drawing off, so that as soon as there is any appearance of turbidity the valve is closed and the sludge remains, and is subsequently let off by lifting a plug valve fixed on to a drain from the deep end of tank communicating with a sump placed in some convenient position for ultimately disposing of the sludge. The sludge must be removed from the sides and floor of tank with an indiarubber "squeegee," and finally swept along the central channel into the drain; from the sump it can be lifted by an ordinary farmyard pump into a wooden trough, and run on to a convenient plot of land for drying, or may be preferably pumped direct into a manure tank-cart and conveyed to the land for utilisation. The interior walls of tanks should always be faced with a hard impervious brick, such as Staffordshire blues or brindles, or brown salt-glazed, and the walls coped with bull-nosed copings of similar materials. The floors should be of Portland cement concrete, the surface being rendered smooth.

Vertical Tanks.—Some few years ago a new departure in the design of tanks was adopted at Essen and Dortmünd, in Germany, the form of these being circular and vertical, with a conical bottom; this arrangement has been further modified in the tank designed by Mr. Frank Candy, and which is shown in Figs. 192.

The bottom of the tank is built flat, and in the centre is pivoted a horizontal perforated pipe which reaches to the side of the tank, this pipe being pivoted on another pipe which is carried up to within a foot or two of the full water-level of the tank, and at that point the sludge

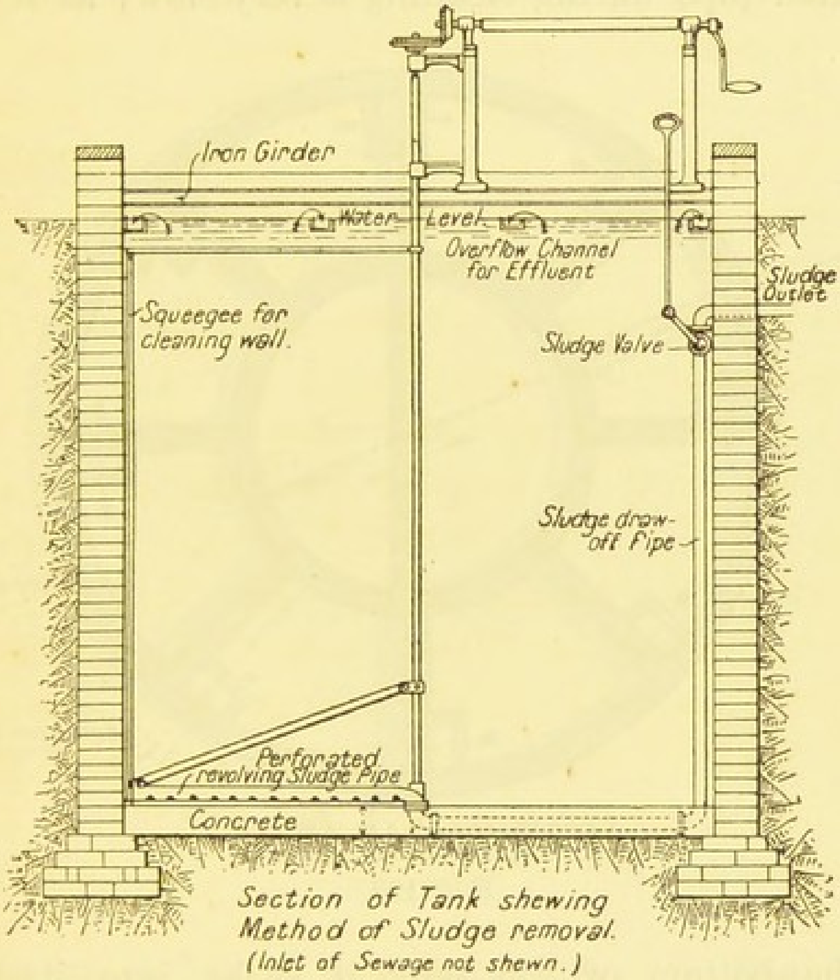
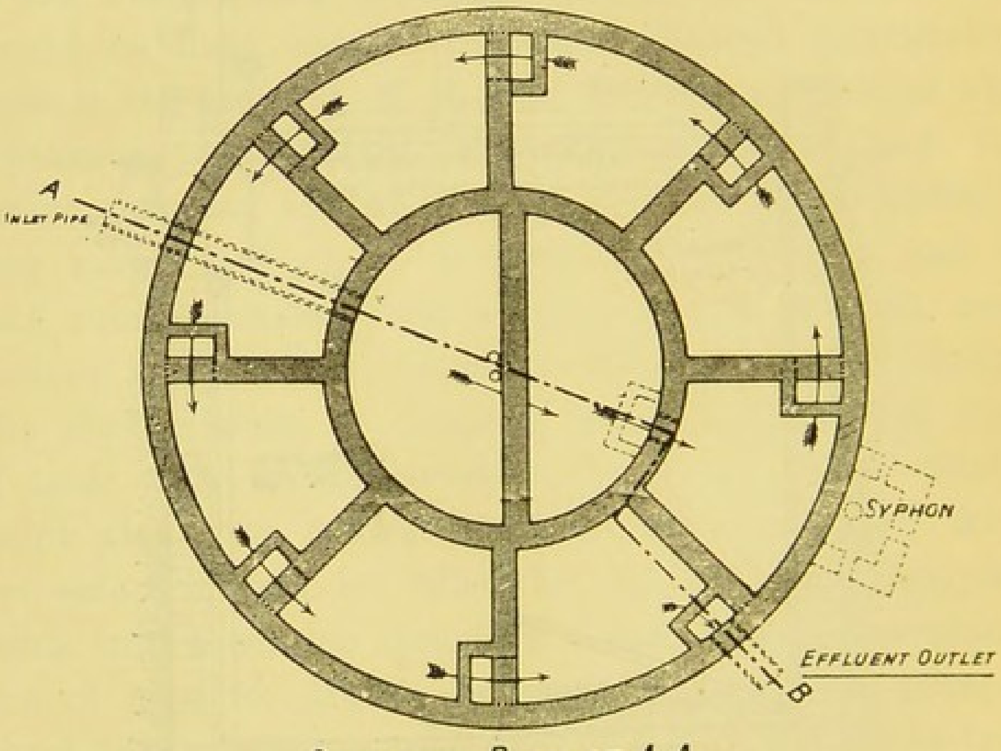


Fig. 192.

is discharged without pumping. The pivoted pipe is revolved from the outside of the tank when the tank is being cleaned. The perforations in the pipe being on the underside thereof and only a few inches apart, and the pipe itself being but a very little above the bottom of the tank—just enough to clear it, in fact—it will be seen at once that the rotation of the pipe covers every inch of the bottom, and the sludge is drawn or sucked away from the whole of the surface. The pressure of water in the tank forces the sludge through the connecting pipe and out at a height, as before mentioned, only some 12in. to 24in. below the water-level, from whence the sludge can be run into a drying pit or well or pumped to any desired spot. The movement of the perforated pipe during cleaning is very slow; as it creeps

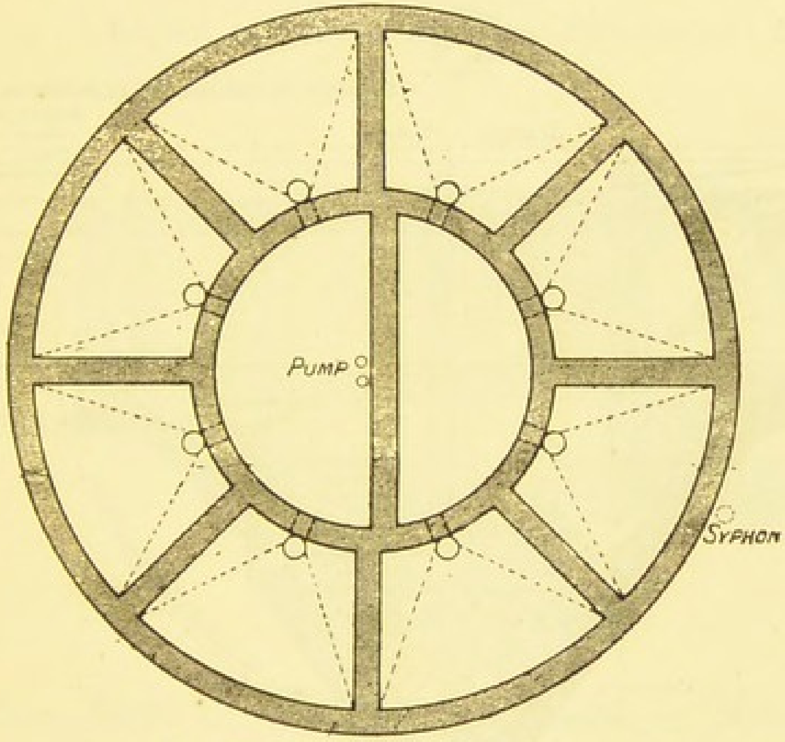


SECTIONAL PLAN AT A.A.

FIG. 193.

over the bottom of the tank it sucks into itself the thick sludge, and so eats its way along without the possibility of any disturbance. The removal of the sludge as described does not interfere with the flow of the sewage into the tank, and when once the tank is started its working need never cease. The rotation of the sludge-pipe can be caused to cleanse the sides of the tank by means of a squeegee attached to the shaft. Practically no power is required to rotate the perforated sludge-pipe—a lad can easily do it. The tank should be cleaned (by rotating the sludge-pipe) once a day.

Another form of the vertical tank is shown in Figs. 193, 194, 195, and 196, and is called the continuous automatic precipitating tank of the "Natural" Purification Company's (Nottingham) process. After the sewage has been strained and received the precipitant, it is conveyed by a pipe discharging into the central portion of the

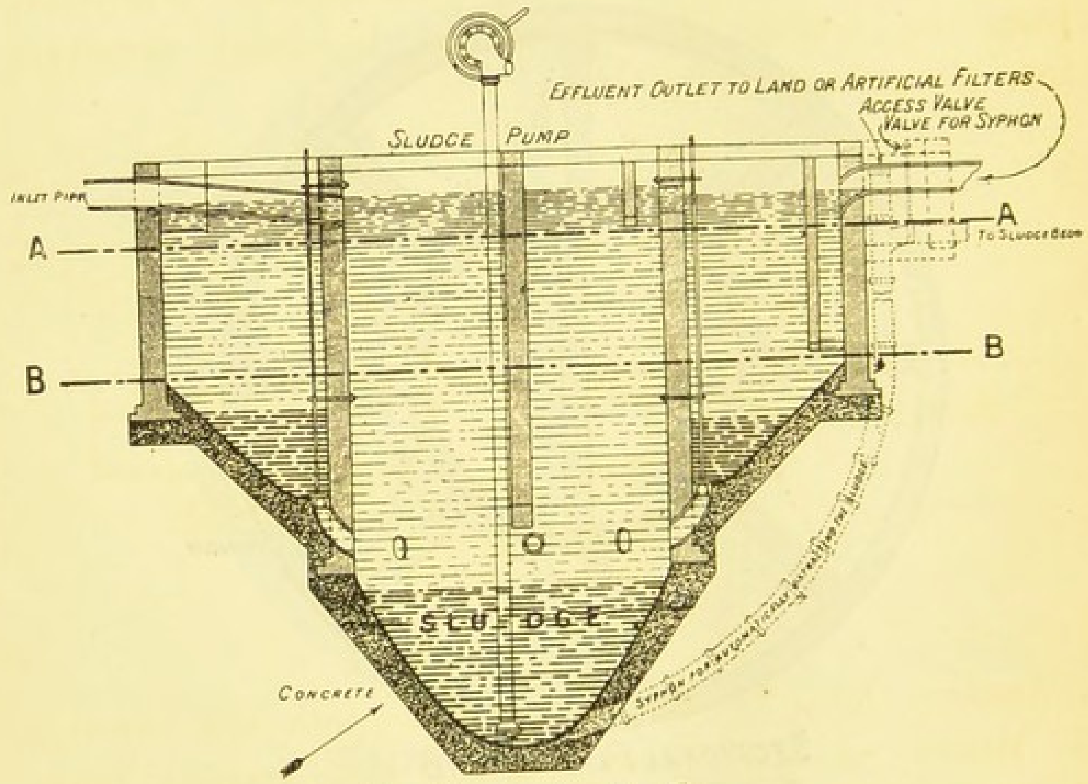


SECTIONAL PLAN AT B.B

FIG. 194.

tank, where it has a downward flow; it then passes under the divisional wall and rises up the portion of the tank on the other side of same. The central tank effluent then passes up the flocculent flue (which traps back the bulk of the flocculent matter and so prevents same from passing into the divisional chambers) and so into the first of the series of divisional chambers. It then passes through each chamber in succession, having a combined flow in each—viz., a downward, followed by an upward—which is obtained by the flocculent flues, and finally is taken away for filtration.

In the first portion of the downward flow in the central portion of the tank the sewage gets thoroughly and evenly impregnated with the precipitatant, the precipitation actually commencing to take place about two-thirds down. As the sewage rises on the other side of the divisional wall the precipitation continues; and the



SECTION A B

FIG. 195.

albuminoids in solution on rising are rapidly coagulated by chemical combination, and so caused to descend, leaving a clarified effluent for further treatment in the specially-constructed trapped flocculent-arresting chambers.

The sludge is removed without interfering with the working of the tank, and with the minimum expenditure of labour. The bulk of the sludge precipitates in the central portion of the tank and accumulates in the sludge-sump formed at the bottom of same. The flocculent matter precipitates in the series of divisional chambers and accumulates at the bottom of each, more precipitation taking place in the first two or three chambers than in the latter ones. The sludge from the central compartment is first extracted, and the sewage lowered in the central compartment, after which, by lifting the valves placed at the bottom of each divisional chamber, the head of effluent presses out the precipitate from the bottom of each of the divisional chambers into the central sludge-sump.

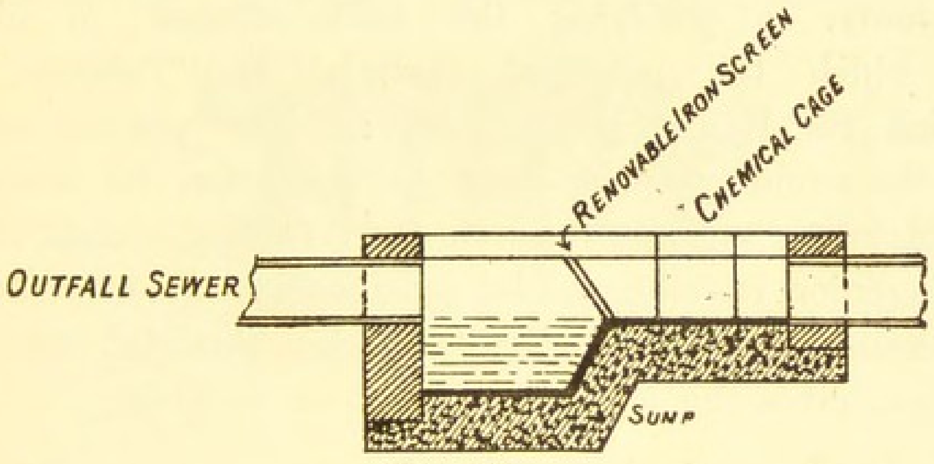


FIG. 196.

Another form of vertical tank used in this country is known as the "Ives" tank; and vertical tanks designed by Mr. Kaye Parry are also in use at Dundrum Asylum.

Precipitants.—It is not necessary here to enlarge upon the various agents offered for the precipitation of sewage, as space is too limited to do justice to them all. Lime for many years was all the vogue, but, while possessing some merit in its cheapness, its nastiness has finally caused it to be discarded. After much research and experiment, both in this country and in America, it has been found that, for ordinary domestic sewage, sulphate of iron and sulphate of alumina give the best results. Soluble slabs containing these constituents are manufactured by Messrs. Spence and Sons, Manchester, under the trade name of "Aluminoferric," and by the Kremnolite Company, of Rochdale. It is easily applied, requiring no elaborate mixing machinery, and the cost is about ½d. per 1,000 gallons.

Purification by Proprietary Processes.—The process of treating sewage by the system of the International Company consists, first of all, of precipitation by a material commercially known as "Ferrozone," and secondly, in purifying the tank effluent in filters, in which the principal material is "Polarite," of which Sir Henry Roscoe says: "The porous nature of the oxide which is used in the filter, its complete insolubility, and its freedom from rusting, constitute in my opinion its claim to be considered a valuable filtering medium. A sample of this filtering material, taken at Acton, gives the following results on analysis:

Magnetic oxide of iron	53·85
Silica	25 50
Lime	2·01
Alumina	5·68
Magnesia	7·55
Carbonaceous matters and moisture	5·41
	100·00"

The filter beds have recently been arranged to work intermittently, with a period of rest for aeration. The composition of the filtering medium is a top layer of fine sand, then the polarite bed resting upon broken stone or gravel, in which 3in. agricultural drains are laid 3ft. apart. The filter beds are arranged on each side of a central channel of sufficient capacity to cover the beds 3in. in depth with water. Each bed is supplied by two automatic flushing syphons, which discharge the water from the inlet channel in the space of about 30 seconds over the entire area of the filter bed. The water sinks through the bed and disappears in about five minutes; the flow of water to the inlet channel is so regulated to take exactly 20 minutes to fill and discharge, consequently the filter bed is entirely empty and exposed to the atmosphere for 15 minutes out of every 20. Three inches of water spread over the surface every 20 minutes is equal to 1,000 gallons to the square yard in 24 hours.

Another proprietary system of sewage purification is the Magnetite Company's process. The precipitating

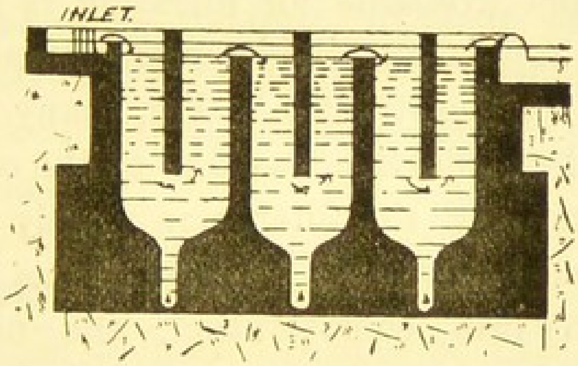


FIG. 197.

tanks differ in form from the others previously described. They are small square tanks, divided up into three compartments by cross-walls, the vertical shape of the compartments being like an inverted wine-bottle, and this again is divided by a wall carried on a girder. A reference to sketch cross-section (Fig. 197) will show how the sewage flows through these tanks, and their method of working. The sludge is deposited in the bottom of the inverted bottle-tank, then passes through a slotted tile, and thence discharged by the pressure of water through a sludge-pipe, and delivered at a height of within 18in. of the ground level. The filters are composed of a top layer of 4in. of coarse sand, for the purpose of arresting light flocculent matter; under this, 6in. of fine magnetite; beneath this, 3in. of medium magnetite, and 3in. of coarse magnetite, resting on square salt-glazed tiles, with 16 perforations to the square foot. An air-chamber is formed by placing these tiles on brick on edge, and when the filters are in operation they are revivified by a constant current of air passing through them by means of extract and inlet cowls. The filters are cleansed by means of an upward wash.

Purification on Biological Principles.—Where the amount of land available for filtration is too restricted, or where the soil is unsuitable, specially prepared filters will have to be constructed. For many years it was supposed that purification was due to the oxidising effect of the air, and that the filter was merely a mechanical strainer. Recent research, however, has brought biological action into consideration, the nitrification of the sewage being brought about by living organisms; and to develop the conditions which favour the action of bacteria by the exposure of the sewage in the presence of air, the filter should be worked intermittently. For some years past very careful and exact experiments in filtration have been conducted at Lawrence. Massachusetts, by the State Board of Health, from which we find that gravels and sands, from the coarsest to the finest, enable purification to take place when the quantity of sewage is adapted to their capability, and when the surface is not allowed to become clogged by organic matter to the exclusion of air.

Mr. Hagen, the chemist to the experiments, states in a report that:

"The purification of sewage by intermittent filtration depends upon oxygen and time; all other conditions are secondary. Temperature has only a minor influence. The organisms necessary for purification are sure to establish themselves in a filter before it has long been in use. Imperfect purification for any considerable period can invariably be traced either to a lack of oxygen in the pores of the filter or to the sewage passing so quickly through that there is not sufficient time for the oxidation processes to take place. Any treatment which keeps all particles of sewage distributed over the surface of sand particles in contact with an excess of air for a sufficient time is sure to give a well oxidised effluent; and the power of any material to purify sewage depends almost entirely upon its ability to hold the sewage in contact with air. *It must hold both air and sewage in sufficient amounts.*"

Scott-Moncrieff's Cultivation Filter. — Mr. Scott-Moncrieff claims to have constructed the first biological filter bed ever used in England, at his own house, and which commenced to work in July, 1892, receiving the entire sewage discharge and waste waters from a household of from 10 to 12 persons (with the exception of the grease, which is held back as far as possible by a grease-trap). The filter bed is about 3ft. deep, 2½ft. wide, and 10ft. in length. The sewage finds its way into one end, the liquid portion rises through a false bottom and then through successive layers of flint, coke, and gravel till it reaches the level of the overflow pipe, which is about 2in. below the level of the invert of the drain. The depth of the filtering medium is only about 14in. The cubic capacity of the filter bed is thus so small that the natural expectation would be that in a few days the filtering medium would become choked, and a nuisance result. As a matter of fact, however, the reverse of this happens, the effluent up to a certain point actually improving in quality as time goes on, and the whole process continuing to work satisfactorily and uninterruptedly for months together without constituting a nuisance. The filter beds and channels are in duplicate to allow of periodical aeration.

Lowcock's Process.—For some years past Mr. Sydney R. Lowcock, A.M.I.C.E., has been experimenting with filters, into which he has introduced air mechanically, to assist in bringing about the conditions necessary for the favourable working of the micro-organisms which exist in the sewage itself, and also in the body of the filter, and as a result of these experiments Mr. Lowcock has patented a filter which is composed of a top layer of sand 9in. thick, 4½in. of pea gravel, 4½in. bean gravel, 12in. pebbles, with air-pipes inserted, 2ft. 6in. pea gravel, 6in. bean gravel, and a bottom layer of 12in. of pebbles, in which the drains are laid. The liquid to be filtered is run evenly over the surface by means of sunk channels, and passes downwards to the drains, whence it flows away in a purified condition. In the upper layer of pebbles are embedded perforated pipes, or pipes laid with open joints, by means of which air is forced into the filter by a blower or other similar arrangement, and finds its way through the whole body of the filter and out with the purified liquid through the drains, which have a free discharge. In its passage through the filter the liquid is only allowed to percolate slowly down by the top layer of sand, after passing which it travels somewhat faster in thin films over the grains of the coarser material below, and thus presents an enormous surface to the purifying organisms and to the air contained in the interstitial spaces. The air pressure required is so slight that the requisite power and the cost is very small indeed.

The surface of the filter is divided up into small areas by divisions below the top layer of sand; the liquid to be filtered can thus be diverted at will from any one of these spaces by shutting down the sluices in the divisions so as to allow of the surface of any section or sections being cleaned without interfering with the working of the lower part of the filter.

Mr. Lowcock states that if the rate of flow through the filter is regulated to 200 gallons per square yard per 24 hours, with two divisions shut off for cleaning, a very high degree of purification is attained. Amongst the advantages claimed for this process is that, where preliminary precipitation is in use, the areas occupied by the filters is only from one-third to one-sixth of the area of the intermittent filters.

Septic Tank Treatment. — The dissolution of the suspended solids in sewage has been brought about without the aid of any chemical agents in the process adopted by Mr. Cameron for a treatment of a portion of the sewage of Exeter, and which he calls the "Septic Tank System." The sewage first passes slowly through a closed underground tank, the heavier suspended particles being deposited in the grit chamber. Beyond this it flows over a submerged partition into the main chamber of the tank, from which at the further end it is drawn off continuously by a "slotted pipe," placed transversely to the flow, 6in. below the surface. The rate of flow being exceedingly small, is very favourable to the settlement of the finer particles in suspension, and a marked clarification of the raw sewage takes place. By the absence of light and the comparative absence of movement, more radical changes are produced by the bacteria present in the sewage, which denote a marked alteration in the chemical characteristics of its constituents as compared with that of the raw sewage. Mr. Dibdin, in a paper read at the annual meeting of the Association of Municipal and County Engineers held in London on July 8, 1897, referring to this process, said: "By the biological action in the septic tank itself, the organic matter in the sewage was so changed that the amount of oxidisable organic matter in solution was reduced by 30·8 per cent., the free ammonia by 26·9, and the albuminoid ammonia by 17·5 per cent., and the suspended solids by 55 per cent. The condition of the organic matter remaining was also changed, rendering it more easily broken up." After passing through the tank, the effluent is finally purified by the use of a series of coke filters.

A very full and complete description of this process, together with plans and analyses of the effluents, etc., will be found in the paper read by Dr. Samuel Rideal before the Sanitary Institute on December 9, 1896 (*vide* Vol. XVIII., Part I., *Journal of Sanitary Institute*, p. 59).

Dibdin's Barking Experiments.—Mr. W. J. Dibdin, the chemist to the London County Council, has carried out a series of experiments at Barking with a view to determining the best methods of filtering the sewage effluent obtained at the Northern Outfall Precipitation Works: In the first series of experiments four small tanks, each equal in area to $\frac{1}{200}$th of an acre, were used, and were filled with pea ballast, coke breeze, burnt clay, and polarite (with gravel and sand) respectively.

The four small filters were all worked at the same rate and during the same hours. The average rate of working, including periods of rest, was 411,000 gallons per acre in 24 hours, equal to 85 gallons per square yard, and from the published report (September, 1895) the following particulars are taken:

Filter No. 1.—Burnt ballast, 4ft. deep, the larger pieces being laid at the bottom and the remaining unsifted portions being placed above. Average purification effected = 43·1 per cent.

Filter No. 2.—Pea ballast, 4ft. thick of Lowestoft shingle. Average purification, 52·3 per cent.

Filter No. 3.—Coke breeze to a depth of 4ft., with 3in. of gravel on top to prevent the coke from floating. Average purification, 62·2 per cent.

Filter No. 4 (Sand) had an area of 16 square yards, or $\frac{1}{300}$th of an acre, and was filled with gravel—walnut size, 5in.; bean size, $2\frac{1}{2}$in.; pea size, $1\frac{1}{2}$in.; and sand 10in., taken in order from below upwards. It formed part of the compound proprietary filter (No. 5). The rate at which effluent was passed through was one-half more per yard than in the case of the other filters. The sand filtration was stated to be preliminary to the treatment by the polarite, and the areas of the two portions together being equal to one of the remaining filters already described. Average purification = 46·6 per cent.

No. 5 (*Proprietary Filter*) contained an area of 8 square yards, and was filled with 3in. of gravel walnut size, 2in. gravel bean size, $1\frac{1}{2}$in. gravel pea size, 1in. sand, and 12in. polarite. The effluent which it received had already passed through filter No. 4 (sand), and had thus been greatly clarified, whilst the dissolved impurity had been removed to the extent of 46·6 per cent. The rate of filtration was three times that of the other filters, so as to bring up the rate of the combined filter to an equality with the rest. Average purification effected = 61·6 per cent.

Summary of Experiments.—The mechanical cleansing or clarification is shown as follows, the figures representing units of depth required to obscure a standard mark:

Burnt ballast	1
Coke breeze	1
Pea ballast	1¾
Sand (first portion of compound filter)	2¼
Polarite (second portion of compound filter after sand)	2½

The following table shows the extent of the purification effected as indicated by the reduction in oxidisable organic matter in solution:

Burnt ballast	43·3 per cent.
Sand (first portion of compound filter)	46·6 ,,
Pea ballast	52·3 ,,
Polarite and sand combined	61·6 ,,
Coke breeze	62·2 ,,

While a considerable amount of purification could be effected by any filtering material, burnt ballast or gravel may be made much more efficient by using a greater depth of more finely granulated material combined with a slower rate. The polarite filter excelled the coke breeze only in appearance, the actual purification not being quite so much.

In the course of the experiments numerous gelatine plate cultivations were made to ascertain the effect of filtration upon the number of micro-organisms present. The number in the tank effluent before filtration and in the filtrate was found to vary very considerably, those in the filtrate generally being present in larger numbers; but it soon became apparent that the presence of comparatively few or more microbes afforded no indication of the degree of purification effected, the main point being that the presence of a large number of organisms was evidence of the activity of the process of splitting up the organic compounds in the sewage matters passing through the filters. A considerable reduction of organisms might have been effected by the use of a finer-grained material and slower filtration, but the object held in view during the experiments was the attainment of the highest degree of speed consistent with such purification as would remove all objectionable characters, such as odour, colour, and liability to putrefaction.

In the second series of experiments a filter was constructed, covering exactly one acre of land, and perforated drains laid, meeting in a common trunk for discharge. The filtering material consisted of 3ft. of coke breeze, covered with 3in. of gravel. Commencing in September, 1893, at the rate of 500,000 gallons to the acre, it was gradually increased, and from May to the end of September, 1895, the rate was 1,000,000 gallons per acre—or, say, 200 gallons per square yard per day, and the average reduction in the oxidisable organic matters in solution was 75 per cent., the maximum being 87·6 per cent.

Mr. Dibdin in his report summarises the accomplishments of both series of experiments, extending over four years, in the following conclusions :

"The action of a filter is twofold : (1) It separates mechanically all gross particles of suspended matter, and renders the effluent clear and bright ; (2) it effects the oxidation of organic matters, both those in suspension and those in solution, through the agency of living organisms. It is the preliminary establishment and subsequent cultivation of these organisms which is to be aimed at in the scientific process of purification by filtration.

"The ordinary putrefactive and other similar organisms commences the work by breaking down the organic compounds and converting them to less complex forms—principally water, carbonic acid, and ammonia. The nitrifying organism then acts upon the ammonia, the nitrogen being converted into nitric acid. For this process to go on, three conditions are essential. First, the organisms must be supplied with plenty of air; secondly, there must be present a base, such as lime, with which the nitric acid can combine; and thirdly, the biological action must take place in the dark—*i.e.*, in the body of the filter, and not in the water exposed to the light above the filtering material. Filtration, on biological lines, of sewage or other foul water containing in solution but little free oxygen and a large quantity of oxidisable matter, therefore means—

"1. That the filter, by cautious increments in the quantity of effluent, which in itself contains the necessary organisms, must be gradually brought to a state of high efficiency. This condition will be shown by the existence in the filtrate of a constantly increasing proportion of nitric acid.

"2. That the contact of the micro-organisms with the effluent to be purified must be effected by leaving such effluent at rest in the filter for a greater or less time, according to the degree of purification required, the process being analogous to that of fermentation. The system employed in many places is to run the water straight through the filter, and thus allow insufficient time for the work, with the result that the filtrate is soon in an unsatisfactory condition.

"3. That after each quantity of effluent has been dealt with, the micro-organisms must be supplied with air, which is readily effected by emptying the filter from below, whereby air is drawn into the interstices. The filter must stand empty for an hour or more previous to another filling, and a longer period of aeration—say 24 hours—must be allowed every seven or eight days.

"The life of a coke-breeze filter worked in this manner is practically without a limit.

"From the general results obtained by these several trials under various actual working conditions, it is apparent that there is no difficulty in obtaining any desired degree of purification by means of a system of filtration, conducted on biological principles. If a higher degree of purity be required than that indicated by the foregoing, it can be obtained by an augmentation of the filtering appliances at a comparatively small cost, as where clay is obtainable (and it often forms the subsoil of the area available for filtration) it may be simply dug out so as to form a pit about 3ft. deep, and be filled up with the same clay after burning, and thus a cheap and efficient filter bed is obtained, the cost, including all charges, being about 4s. per square yard.

"In such a system the results are completely under control, and the filters can be arranged to suit all requirements it is possible to contemplate."

Bacterial Tank at Sutton.—In view of the results recorded in the preceding pages, Mr. Dibdin concluded that under proper conditions there was no reason why the whole of the suspended matters in sewage should not be amenable to similar treatment; accordingly an experiment was tried at Sutton by converting one of the tanks into a bacteria tank. In the *Sanitary Record* of July 23, 1897, page 92, the method of construction is described as follows:

"On the floor of the tank, which has an area of

183⅓ super yards, was laid a 6in. main trunk drain, with 3in. branch drains, 19 in number, laid from the main running down the centre to the side walls. The main effluent pipe is provided with a 6in. valve, which is a necessary adjunct, so as to be shut down when the tank is filled, and the valve is enclosed in a chamber for ease of access. On the pipes being laid, the joints, which of course are open, were covered with the coarsest ballast, and the tank was then filled up with ballast burnt from the clay which covers the whole site of the farm, the average depth of the ballast in the filter being 3ft. 6in. Prior to the filter being charged with crude sewage it was filled with filtrate from the coke-breeze filters, which filtrate was known to contain the essential bacteria.

"In filling the filter with the ballast care was taken to exclude all dust and all material, which passed through a screen of ½in. mesh. The author (Mr. C. C. Smith, C.E.) trusts that the following figures may be interesting and useful: The area of the crude filter or bacteria tank is 183⅓ super yards, the capacity of the crude filter or bacteria tank is 218 cubic yards, the capacity of the filter without ballast is 36,094 gallons, the capacity for sewage of the filter with ballast is 13,500 gallons, the proportions being approximately one-third sewage, two-thirds ballast, the flow of sewage applied per superficial yard per day is 186 gallons, the flow of sewage applied per cubic yard per day is 138 gallons, the flow of sewage applied is at the rate per acre per day of 900,240 gallons. The bacteria tank has been in daily work since the 21st November, 1896, treating on an average 30,000 gallons per day, the resultant filtrate being generally free from odour, the filter being charged twice and sometimes three times per day.

"The mode of applying the sewage is as follows: The whole of the sewage flow without any chemical treatment is turned directly on to the bacteria filter, the sewage having been passed through roughing screens to intercept the larger pieces of paper. The time occupied in filling is about three-quarters of an hour, and care is taken to prevent the sewage heading up or ponding above the surface of the filter, the flow being stopped as soon as the sewage level reaches to within a few inches of the surface of the ballast. The filter is then allowed to remain charged for two hours, after which the valve is opened and the filter is emptied, the time occupied in the latter process being about 1¼ hours, the filtrate being then passed on to the secondary filters or over the land. The bacteria filter is then allowed a rest of two hours, after which it is again charged, the cycle occupying six hours."

Mr. Dibdin estimates the amount of suspended matter per gallon at 60 grains (equal to 3·8 tons of sludge per 100,000 gallons) in addition to the organic matters in solution which have been absorbed in the filter, and without any nuisance from smell, the filtering material being as inoffensive and sweet to-day as when the sewage was first applied, and also without the use of chemicals for precipitation and the cost of sludge treatment.

(I have myself several times visited the filters at Sutton, and so far as relates to the clearness of the effluent, the absence of all smell both from it and the filters, I can personally testify, as well as to the disappearance of the sludge.)

"The results obtained have been of the most satisfactory character. The quantity of oxygen required to oxidise the organic matter in solution on the raw sewage was on an average 5·40 grains per gallon, which was reduced by the bacteria tank to 1·83 grains, or a reduction of 66 per cent. The further treatment of this effluent by the coke breeze and other filter beds reduced this required oxygen to 0·72 grains per gallon, or a total reduction of the oxidisable matter by 86·5 per cent.

"In like manner the solid matters held in suspension in the sewage were reduced by the bacteria tank by 95 per cent., and by the combined system by 99·6 per cent." (Report made by Mr. Dibdin to the

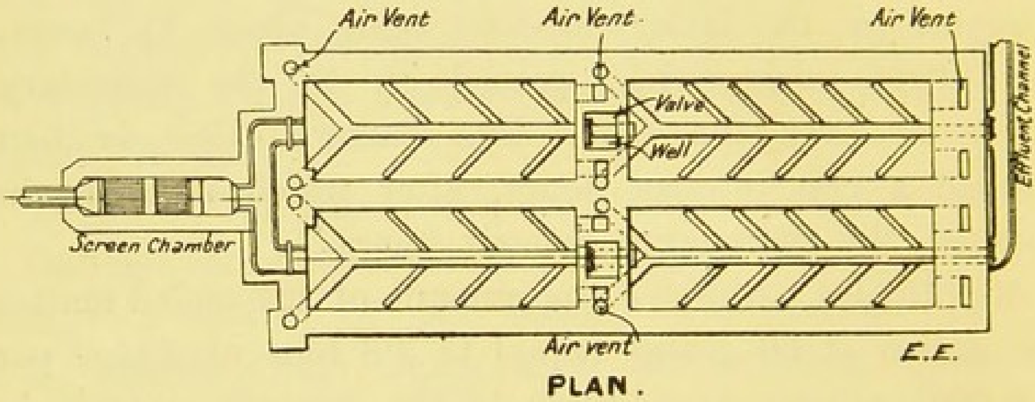


Fig. 198.

Sewage Disposal Committee of the Sutton Urban District Council on February 6, 1897.)

The importance of the saving in working expenses that may be effected by this method of purifying sewage may be gauged when it is calculated that the cost of chemical precipitation is 3s. per 100,000 gallons, and that sludge-pressing costs 2s. 6d. per ton. There will also in this process be a material reduction in the capital outlay on works, those for sludge treatment being entirely dispensed with.

Figs. 198 and 199 show how the bacterial process of purification may be applied for the purification of a small quantity of sewage. The tanks should be large enough when filled with ballast to hold one day's supply of sewage, so that they may be worked alternately; the sewage flowing on one day into the bacterial tank, where it will remain all night, being let off the next morning on to the fine-grained filter, where it will remain until the following morning, the bacteria tank resting empty during the whole of that time. It will be seen that by the suggested arrangement of air-vents complete perflation will be obtained; and while the filters are resting, the outlet penstocks should be kept open.

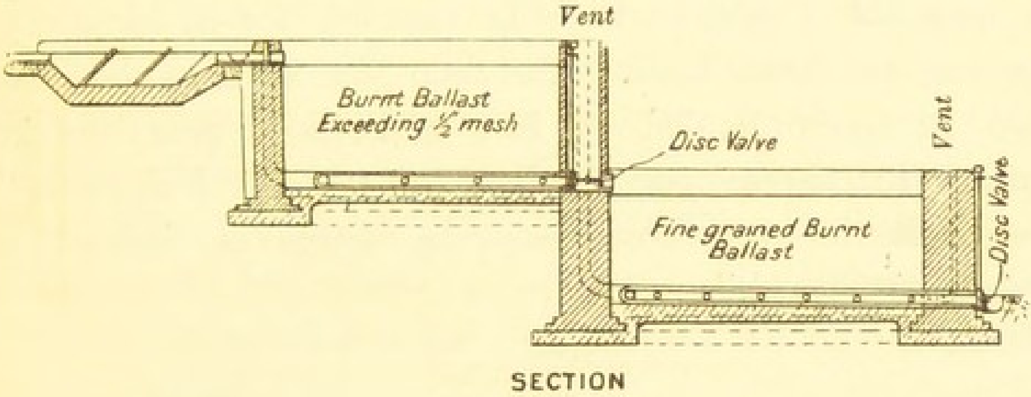


Fig. 199.

Since April last there has been in operation at Hendon a proprietary filter which works on a continuous flow. It is constructed out of ground, and has thus all its sides exposed to the air, these being composed of 3in. agricultural drain tiles with brick piers at each corner. The filter is 8ft. high, and is interlaced with rows of drain tiles and filled with coke breeze. The sewage is applied evenly over the whole surface at the rate of 200 gallons to the square yard per day, and it passes through the breeze and reappears in an open channel formed all round the base of the filter. It is, as I can personally testify, a remarkably clear effluent, entirely free from smell, and keeps well on exposure, nor is there any odour from the filter itself, and the sludge, as at Sutton, has entirely disappeared. It is obvious that some means will have to be taken to counteract the action of frost, and it yet remains to be seen whether any form of protection can be devised that will be successful in keeping the filter working through such a temperature as was experienced in February, 1895.

These experiments of Mr. Dibdin, and at Hendon, and their results express the latest developments of sewage treatment, and as they have attracted a vast amount of attention on the part of all interested in the question I may perhaps be excused for so lengthily referring to them here. Between the systems of disposal as recommended by him and those practised in so many instances upon the lines of "rough irrigation" or deposit in overflow cesspools, there is indeed a "great gulf fixed."

CHAPTER XVI.

Legislation Relating to House Drainage under the Public Health Acts.

With the exception of the area comprised within the jurisdiction of the several Metropolis Management Acts, the whole country is subject to compliance with the various clauses of the Public Health Act, 1875, in respect of drainage. The connections of house drains to the sewers may, under Section 21, be done as a right subject to the conditions and regulations of the district council being complied with, and under Section 22 an owner of a house situated beyond the boundaries of a district may, on terms and conditions to be agreed upon, cause his drains to be connected to the sewer in the neighbouring district, and in the event of the house* being without a drain sufficient for its effectual drainage, then it must be connected compulsorily, in compliance with the terms of a notice to be served upon the owner, under the powers of the twenty-third section.

Before proceeding further, it would be well to point out the distinction between the words "drains" and "sewers," both in a legal and popular sense. Sir Robert Rawlinson, the former chief engineering inspector to the Local Government Board, in his "Suggestions as to the Preparation of Plans for Main Sewerage and Drainage, etc.," defines "sewage" as

* "House" is defined in Section 4 as including schools, also factories and other buildings in which more than 20 persons are employed at one time.

the fluid and feculent refuse of dwellings; "sewer" as the main conduit for sewage, and "drain" as the tributary conduit for sewage from houses to sewers; and there is no doubt but that is how they would be defined by the "man in the street," and the meaning that would be given to the words by everyone concerned in carrying out sanitary work. Unfortunately, the draughtsman of the Public Health Act has constructed entirely different meanings, so that the attempt to fasten a popular interpretation upon common words has failed in the eye of the law, frequently attended with disastrous results. If we turn to Section 4 of the Public Health Act, we find that directly a drain receives the drainage of two or more buildings occupied by different persons it is denominated a sewer. It will be noted also that the liquid material which passes through the drain is here called drainage, but directly it becomes incorporated with material of a like character flowing in the sewer it is transformed into sewage. Surely it must have been sewage from the moment it was discharged from the sanitary appliances of the house into the drain. Again, we have still another definition of the word "drain" which is contradictory.

In the Public Health Amendment Act, 1890,* Section 19 (1) it says: "Where two or more houses belonging to different owners are connected with a public sewer by a single private drain an application may be made under Section 41 of the Public Health Act, 1875 (relating to complaints as to nuisances from drains), and the council may recover any expenses incurred by

* The application of this Act is not universal, it being what is known as an adoptive Act. The several parts can be adopted in any district in the discretion of the council whenever they think fit.

them in executing any works under the powers conferred on them by that section by the owners of the houses in such shares and proportions as shall be settled by the surveyor or (in case of dispute) by a court of summary jurisdiction; (3) for the purposes of this section the expression 'drain' includes a drain used for the drainage of more than one building."

McMorran's note to this sub-section is as follows: "The provisions of Sub-Section (1) and of this subsection make the word 'drain' applicable to a drain which receives the drainage of two or more houses belonging to different owners. Such a drain would formerly have been a sewer, and as such vested in and repairable by the local authority, and there was not such a thing as a single private drain of this kind if the word 'private' means not vested in the local authority." It will be noticed that for the first time we have in this section any statutory recognition of public sewer and private drain. There have been several cases before the Courts relating to points raised upon the interpretation of this sub-section of Section 4 dealing with the word "drain." In the Halifax case of Travis *v.* Uttley,* it was held that a drain passing under three houses and discharging sewage from all three into a public sewer is a sewer.

This decision was given in December, 1893, and since then it has transpired that the Public Health Amendment Act, 1890, had not at that time been adopted in Halifax; and in a more recent case heard in the High Court, Self *v.* Hove Commissioners,† the Court (Justices Wills and Wright) decided that the Hove

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* Court of Appeal, November 27-December 4, 1893 (L.R. 1894, 1 Q.B.D., p. 233).

† Q.B.D., 685, January 25, 1895.

Commissioners were not liable for the cost incurred in reconstructing a drain which it was discovered drained the house adjoining that on which a nuisance notice had been served. The owner did the work, relying on Travis *v.* Uttley to be repaid the cost by the Commissioners. An action in the County Court secured a judgment against the Commissioners, who appealed, and succeeded in getting the judgment reversed, on the grounds that the Commissioners having adopted Part III. of the Public Health Amendment Act, 1890, the drain was not a sewer, and therefore not repairable by them, and consequently their notice did not amount to a "request" to the plaintiff to do the work. This decision was, a few weeks later in the same Court (April 3),* by the Carlisle case of Hill *v.* Hair considerably limited. The respondent was the owner of one of several houses erected before the passing of the old Public Health Act of 1848. The Corporation had adopted Part III. of the Public Health Amendment Act, 1890, and their Improvement Act of 1887 contains a section (134) somewhat similar to Section 19 of the Public Health Amendment Act, with the omission of the words, "belonging to different owners." The combined drain being defective, the Council proceeded against the respondent by summons, which, however, was dismissed by the magistrates, on the ground that the drain was a sewer vested in and repairable by the authority, and the High Court upheld this decision. This judgment seems to imply that the nineteenth section of the Amendment Act does not apply to drains which were already public sewers at the passing of the Act of 1890, and that this combined drain, having already become a sewer vested in

* Q.B.D., 906.

the local authority by virtue of the Public Health Act of 1848, could not possibly be a "single private drain" within the meaning of the later Act.

In 1897, in the case of Seal *v.* Merthyr Tydfil Urban District Council, the Court of Queen's Bench came to an entirely different decision, and an interpretation was given of the words "private drain" which is more in accord with what was generally understood to be the meaning of the words until the Halifax case was decided. It is important to compare this Merthyr case with the others quoted, so I give a complete report of it:

The case of Seal *v.* Merthyr Tydfil Urban District Council, tried in the Queen's Bench Division before Justices Cave and Ridley, was a case stated by the Justices of the Peace for the county of Glamorgan, sitting at Merthyr Tydfil in January of 1897. Upon the complaint of the Merthyr Tydfil Urban District Council, the appellant (Seal) was summoned for that he, being the owner of certain premises, Nos. 23, 30, 31, 32, 33, 34, 35, 36, 38, Cromwell-street, allowed a nuisance to exist thereon. The proceedings were taken under Section 41 of the Public Health Act, 1875, as extended by Section 19 of the Public Health Act, 1890. A large number of houses had been erected by the Tydfil's Well Building Club, of which appellant was the secretary and receiver of rents, upon both sides of a new street called Cromwell-street. The houses on the south side were numbered 21 to 40. A drain was made by the club running at the back of the houses through the gardens, and this drain joined the sewer of the District Council. A connection from each house with the drain at the back was made by a branch drain from the closets and slop gratings. The drain commenced at the back of No. 40, and extended thence at the back of the houses until it reached the Council's sewer, and it could not be used by other premises. This drain was found to be badly made, and it became a nuisance. The Council had adopted the Public Health Act, 1890. Upon the evidence the justices found as facts: that the appellant was the owner within the meaning of the Public Health Acts; that the drain was a drain used by two or more houses belonging to different owners; that it was a drain for the particular houses, Nos. 21 to 40 in Cromwell-street, and for no other premises, and that it was not a general drain into which any houses could be drained; and that the drain was a nuisance and injurious to health. The respondents contended that the drain running at the back of these houses was a private drain under the definition in Sub-Section 3 of Section 19 of the Act of 1890, and that this drain was a nuisance and injurious to health, and that therefore, under Section 41 of the Act of 1875, the appellant must abate the nuisance. The Court, without calling upon the respondents, upheld the decision of the justices, and dismissed the appeal. Justice Cave, in delivering judgment, said, "This is a very clear case. By the Public Health Acts, 1848 and 1875, a sewer was defined to be a drain used for the drainage of one building only, and it was found that within the language of the Act of 1875 a drain draining two or more buildings became a sewer, and consequently as such became vested in the local authority. This was found to create the difficulty that if a person built two or more houses on his own land and drained them by a drain, such drain became a sewer, and the liability to repair the same was thrown on the local authority. This difficulty was got over by holding that it did not apply to a drain draining houses within the same curtilage; but that such drain, until it came out into public property, was a drain only, and not a sewer. Then came another difficulty—namely, where houses belonging to different owners were drained into the same drain by which they communicated into a public sewer. To meet this difficulty, Section 19 of the Act of 1890 was passed, which enacted that 'where two or more houses belonging to different owners are connected with a public sewer by a single private drain,' then Section 41 of the Act of 1875 may be put in force; and Sub-Section 3 says that for the purposes of this section 'drain' includes a 'drain used for the drainage of more than one building.' What is a 'private drain' within the meaning of this section? It appears to me to apply to a drain constructed on private premises to which the public have not access. 'Private' is to be taken in that sense; that is, as being a drain which is private, and constructed on private land—on land which is not open to the public. I think, so far as Hill *v.* Hair is concerned, the law was wrongly applied there, the substantial distinction being that of a private drain kept up by a person for his own profit. If the drain in Hill *v.* Hair was properly a private drain, then the decision in that case misinterpreted the drain there in question. I think the justices were quite right in their decision, as they found as a fact that the drain was a drain for these particular houses, and for no other premises."

The decisions in these cases will be somewhat perplexing to all provincial local authorities and house-owners, and, seeing that the decision in the Merthyr case is entirely different from the Carlisle case delivered in the same Court, it is to be hoped that the difference may be referred to the Court of Appeal to determine which is correct; and it will also be interesting to know whether in those districts where Part III. of the Public Health Amendment Act has not yet been adopted, they will be bound by the decision in Travis *v.* Uttley.

From the occupier's point of view it would be no bad thing to have all these drains declared sewers, as there would then be the certainty of their being maintained in an efficient condition under the powers imposed upon authorities by Section 15 of the Public Health Act, 1875. On the other hand, it will be a great hardship upon councils to have vested in them miles upon miles of sewers which may not only have been constructed without their supervision and approval, but also have been converted into sewers by means of surreptitious connections and additions. It is obvious that, on account of its importance to the ratepayers at large, the question cannot remain where it is at present.

We have seen, by Section 21, that anyone desirous of connecting a drain to a sewer must comply with the conditions and regulations of the council. The first stage is for the person, on behalf of the owner or occupier, undertaking to lay the drain to obtain, as required by Section 149 of the same Act, permission to break open the street, and having obtained this he is then subject to compliance with the terms laid down in Sections 81, 82, and 83 of the Towns Improvement Clauses Act of 1847, and which are incorporated in the Public Health Act. Notice of the intention to make a junction with a sewer is also necessary, as it is possible one may not have been left upon the sewer at the precise spot required; and to prevent this connection being made in a hurried or inefficient manner, it is imperative that it should be done under the direct personal supervision of a responsible officer of the council, as sound work is of more importance than the hurrying to get a trench refilled at the close of a day to save the expense of an extra night's watching. In some districts these connections are only permitted to be made by the workmen in the employ of the council, and in other districts no contractors are allowed to break open streets and lay drains unless the firms are on the "authorised" list, which solely comprises persons who have satisfied the council that they and the workmen they employ are competent to be entrusted with this class of work. In those districts where the Public Health Amendment Act has been adopted, the owner of the property may, if he so desires, under Section 18, agree with the council upon terms to execute this work in his behalf, and so avoid the responsibilities and obligations imposed by the foregoing sections.

Section 24 imposes upon a council the power to enforce the drainage of houses into sewers which they may have provided in lieu of inefficient or objectionable sewers, but the cost of making the connection or altering or renewing the house drains is to be borne by the council.

It has already been pointed out that, under Section 23, a council can compel, under certain conditions, the redrainage of houses, but there does not appear to be any provision in the Act to prevent an owner or occupier redraining his house or making extensions or alterations within the curtilage thereof in his own fashion and without the sanction or supervision of the council, though directly he wishes to make a connection to the sewer he will, of course, have to comply with Section 21, as already pointed out. Generally speaking, this option is not often exercised unless the necessity has arisen for doing the work on improved lines. The officials of a council cannot have their eyes on every spot nor be expected to have the power of penetrating through a brick wall, although some councillors think they do possess such gifts; at the same time, it is not only courteous but expedient to submit any proposals for voluntary redrainage to the proper officials, but not necessarily for approval.

Section 25 makes it unlawful in any urban district to build or occupy any new house, or to rebuild any house, unless and until an efficient drain has been laid; and Section 26 prohibits unauthorised buildings being erected over any sewer belonging to a council. Section 40 imposes upon the council the obligation to see that all drains and cesspools, etc., within their district are constructed and kept so as not to be a nuisance or injurious to health.

By Section 41, after receiving complaint, the council may empower their surveyor or inspector of nuisances after giving 24 hours' notice to the occupier, or in case of emergency without notice, to enter upon the premises and cause the ground to be opened for the purpose of examining the drain or cesspool; and if it then appears to be in a satisfactory condition, he shall reinstate the ground and make all good, but, on the other hand, if it appear to be in a bad condition, or to require alteration or amendment, then notice is to be served upon the owners calling upon them to do the necessary works, and in case of default the council may execute them and recover the expenses in the usual manner. In districts where the Public Health Amendment Act, 1890, has been adopted, this section has been extended by Section 19, so as to empower the council to apportion the expenses upon the various owners in case the drain connecting to the sewer is a joint drain. The apparent contradiction of Sub-Section (3) to the definition in Section 4 of the 1875 Act has already been pointed out.

By Section 16 of the Public Health Amendment Act, 1890, the passing of injurious matters into sewers is prohibited. This is designed for the purpose of keeping out solids. On the face of it this may appear to apply more particularly to drains from manufactories; but even from well-regulated houses such solids as scrubbing-brushes, rubbing-stones, and floorcloths frequently find their way into the drains.

Section 17 prohibits chemical refuse, steam, or condensing water at a higher temperature than 110deg. F. being turned into sewers, which either alone or in combination with the sewage is injurious to health. By Sub-Section (2) the council and their officers are endowed with powers of entry upon premises for the purposes of examination.

By Section 157 urban councils are empowered to issue by-laws regulating the drainage of all new buildings, and since 1877 these throughout the country have been framed on the basis of the model code of the Local Government Board, and which will be found reprinted, and which will be referred to and explained in detail under their several heads in subsequent pages.

Section 23 of the Amendment Act, 1890, extends the foregoing section by giving councils powers to make by-laws relating to the water supply for flushing closets, and such further by-laws shall apply to any buildings erected before the times mentioned in Section 157.

Section 158 of the 1875 Act prescribes that notice from the council of the approval or disapproval of submitted plans shall be sent within one month from the receipt of the plans, and if any work is done within that time which is not in conformity with the by-laws, the council may cause the same to be pulled down or removed, and may recover the expenses incurred in so doing and sue for penalties also.

Section 159 defines a new building in cases where old buildings are being demolished or remodelled.

Section 276 empowers the Local Government Board in their discretion to confer urban powers upon rural district councils for any contributory place therein.

The various notices and forms of agreement required under the several Acts and regulations can be obtained on printed forms of Messrs. Knight and Co., Fleet-street, E.C. With regard to the description of the works referred to in the notices to be served under Sections 23 and 25, it should be pointed out that this should be in the nature of a specification, as the owner has the option of doing the work within a given number of days, and, if he should choose to exercise such option, would no doubt delegate its execution to some responsible contractor. Care must also be taken to see that the specification corresponds with the requirements for new buildings as set forth in the by-laws, and is not in excess thereof. It must be remembered that there is unfortunately a great deal of overlapping in the administrative work of councils, the approval of plans being the duty of one committee and the ordering of notices relating to drainage falling to another. I have frequently seen notices served under Section 23 that have been so carelessly drawn that when the work has been executed in compliance therewith it has still been insanitary. I cannot illustrate the necessity for what I urge better than by putting a hypothetical but by no means impossible case. Supposing an owner of existing houses receives a notice under Section 23 relating to them, and carries out the work accordingly, and that, say, shortly afterwards he submits certain plans for the erection of new houses, then in the latter case the drainage arrangements must be in accordance with the model by-laws, and unless the specification for the work on the old property is similar he will be a very dull fellow if he is not puzzled, and it will be small wonder if he "dunno where 'e are," and to prevent such an absurd and incongruous state of things great care should be taken.

I have also prepared a specimen code of regulations as required by Section 21 relating to the connection of the drain from the house to the public sewer, and in the main have followed the lines suggested by Mr. H. Percy Boulnois, M.I.C.E., city engineer, Liverpool, and published in his well-known book, "The Municipal and Sanitary Engineers' Handbook." Here, again, it is desirable to point out that as the drain to be continued across the public street is an extension of the house drain, it is essential for uniformity sake that the regulations as to the materials and methods of construction shall be similar in all respects to the specification issued with the notice served under Section 23, and also follow the conditions imposed by the by-laws.

With regard to the restoration of the surfaces, custom will of course vary in different districts consequent upon the nature of the materials used and the methods of executing the work—and the prices charged will vary also in a corresponding degree. For macadam roadways a certain amount of additional metal will be required, while for granite and other sett pavements probably the removed setts will suffice ; in the case of wood some blocks are sure to be split in the removal, and will require replacing, while for asphalte it is obvious entirely new work must be executed. For foundations pretty much the same state of things may occur; ballast or rock pitching may be restored without much waste, but concrete will necessitate entire renewal. The refilling of the trench and all other work should be done in accordance with the provisions usually found in sewer specifications.

CHAPTER XVII.

Legislation Relating to House Drainage in the Metropolis.

The Acts of Parliament regulating the sanitary requirements of the metropolitan areas are known as the Metropolis Local Management Act, 1855, and an Amendment Act passed in 1862, and there is also the Public Health (London) Act, 1891. The first-named Act is that which principally affects sewerage and drainage; the second Act provides certain extensions; and the last-named Act, which consolidates and amends the laws relating to public health in London, contains more modern regulations as to nuisances, offensive trades, infectious diseases, water-closets, etc.

By Section 73 of the 1855 Act it is provided that any house may be required to drain to a sewer if there be a sewer within 100ft. of the house (this distance by Section 66 of the 1862 Act is extended to 200ft., and failing that, temporary provision may be made for draining the house subject to certain conditions and regulations) to the satisfaction of the vestry or district board, and subject to their conditions and regulations, and if the owner neglect during 28 days after notice to commence to comply, the vestry or board may execute the works and recover the costs from the owner.

Section 74 of the 1855 Act makes provision for the combined drainage of property—that is, of a group or block of contiguous houses or of adjacent detached or semi-detached houses where it appears to the vestry or board that such group or block of houses may be drained and improved more economically or advantageously in combination than separately. On referring to the definition in Section 250 of the word "drain," it appears to be clear that it was intended that, wherever practicable, each house must be drained separately, and it must also be pointed out that in London it is not the custom, as in the provinces, to provide back passages to property, and that long rows of houses are built without any access from the adjacent streets, so that, while drains under houses are discouraged in the provinces, such a system is a necessity in London; but it is quite clear that a joint drain must not be laid without the express sanction of the vestry or board, although it appears there are thousands of cases where they exist, having been constructed either through lack of supervision or by subsequent surreptitious connection. The subject is too extensive to be dealt with in detail here, and for those requiring further information I must refer them to the papers by Dr. Sykes and Mr. William Nisbet Blair, C.E., published in the *Transactions* of the Sanitary Institute, vol. xvi., Part II., p. 274, *et seq.*

Section 75 makes it unlawful to erect any house unless the drains and their appurtenances are constructed to the satisfaction of the vestry or board, and in such a manner as to be available for the drainage of the lowest floor and the areas, etc., of the house, and in the event of rebuilding, the vestry or board may prescribe the level of the lowest floor or area so as to make it compatible with the drainage system.

Section 76 provides that seven days' notice shall be given to the vestry or board before commencing the excavations for the foundations of any new house and the laying of any drain, in order that directions may be given as to levels of the lowest floor, of the drain, and the usual points in construction, the failure to comply therewith being subject to certain penalties.

In accordance with the provisions contained in the foregoing sections, it is usual for the vestry or board of works to frame a code of regulations prescribing the methods to be observed in the construction and laying of all house drains and their appurtenances. It is, however, disputed whether they have the power to make such regulations, which are practically by-laws, and unless valid are useless in Court, seeing that the Act does not specifically state that a vestry or district board may make by-laws as to drainage — only the Metropolitan Board, now the London County Council, is so authorised; but this contention is met by the argument that the penalty clause of the Act of 1855, Section 83, refers to the "directions or regulations of the vestry or district board," thereby implying that the vestry or board should have such regulations, or, in other words, that they are justified by implication in default of express direction in providing such regulations. At the present time these regulations are not uniform, each vestry or board following its own dictates, a system which must lead to a great deal of confusion amongst builders. By the courtesy of an engineer to one of the vestries I am enabled to reprint one of these codes, and a perusal of it will show that these regulations are somewhat similar to the drainage clauses of the model by-laws. In conjunction with this code must be taken the by-laws made by the London County Council under Section 39 of the Public Health Act (London), 1891, relating to water-closets, their fittings, cisterns, and soil-pipes, a copy of which is also appended.

By Section 78 of the 1855 Act, the vestry or board may in their discretion make as much of and such parts of a branch drain as may be under a public street and its connection to the public sewer and recover the expenses from the owner, and by the succeeding section the vestry or board are empowered to enter into an agreement with an owner to make, alter, or enlarge any drains as required, the cost price of the work to be recouped by the owner. In cases where the sewer has been made at the expense of any person or body other than the Commissioners of Sewers, the vestry or board are empowered by Section 80 of the 1855 Act, if they think fit, to order such sum as they may deem just to be paid towards the cost of the sewer into which the drain is to be branched, and the work must be done in conformity with the directions of the vestry or board with respect to the payment of such contribution, under the provisions contained in the Act.

The vestry or board are empowered by Section 82 of the 1855 Act, after 24 hours' notice, to cause an inspection to be made of any drain and the usual sanitary appliances connected thereto and to have the ground opened where necessary, and they are further empowered by Section 83 in case of infringement of the direction or regulation of the vestry or board to sue for a penalty, and may cut off connection between the drain and sewer, and if they see fit may execute whatever works they consider necessary, and are empowered to recover the expenses in the usual manner.

Section 84 provides that if the examination discloses no default, then the vestry or board must make all good again, the expenses to be borne by them, together with all compensation for any damage or injury done in making the examination. If upon the inspection the drain and other sanitary apparatus appears to be in bad order or to require cleansing or re-modelling, then the vestry or board shall, as authorised by Section 85, serve notices specifying what requires to be done, and in case of default they may execute the works and recover the expenses in the usual manner.

Section 86 of the 1855 Act empowers the vestry or board to deal with such nuisances as may be caused by defective drains, etc., and to do whatever is necessary for their abatement.

Sections 100 of the 1855 Act and 81 of the 1862 Act empower the vestry or board to cause the drainage of *cul-de-sac* courts, and in case of default to execute the works and recover the expenses

Section 202 of the 1855 Act empowers the County Council from time to time to make by-laws, amongst other things, relating to drainage and sanitary appliances, and the various definitions of the words will be found in Section 250 of the 1855 Act, with an extension of the word "drain" in Section 112 of the 1862 Act so as to include any drain used for combined drainage where executed pursuant to the order or direction or with the sanction and approval of the vestry or board.

By Sections 49 and 61 of the 1862 Act it is obligatory upon all persons intending to make a branch drain to be connected into any sewer vested in the London County Council to give seven clear days' notice to the vestry or board, accompanied by a plan showing all particulars required by the regulations of the vestry or board, and no works are to be commenced until the plan has been sanctioned.

CHAPTER XVIII.

Metropolis Management Acts, 1855 and 1862.

Index to Sections Affecting House Drainage.

Metropolis Local Management Act, 1855.

Section 73.—If any house or building, whether built before or after the commencement of this Act, situate within any such parish or district, be found not to be drained by a sufficient drain communicating with some sewer, and emptying itself into the same, to the satisfaction of the vestry or board of such parish or district, and if a sewer of sufficient size be within 100ft. of any part of such house or building, on a lower level than such house or building, it shall be lawful for the vestry or board at their discretion, by notice in writing, to require the owner of such house or building forthwith or within reasonable time appointed by the vestry or board, to construct and make from such house or building into any such sewer a covered drain, and such branches thereto, and of such size, of such materials, at such level, and with such fall as shall be adequate for the drainage of such house or building, and its several floors or storeys, and also of its areas, water-closets, privies, offices (if any), and for conveying the soil, drainage, and wash therefrom into the said sewer, and to provide fit and proper paved or impermeable sloped surfaces for conveying surface water thereto, and fit and proper sinks, and fit and proper syphoned or otherwise trapped inlets and outlets for hindering stench therefrom, and fit and proper water supply and water supplying pipes, cisterns, and apparatus for scouring the same, and for causing the same to convey away the soil, and fit and proper sand traps, expanding inlets, and other apparatus for hindering the entry of improper substances therein and all other such fit and proper works and arrangements as may appear to the vestry or board, or to their officers, requisite to secure the safe and proper working of the said drain, and to prevent the same from obstructing or otherwise injuring or impeding the action of the sewer to which it leads, and it shall be lawful for the said vestry or board to cause the said works to be inspected whilst in progress, and from time to time during their execution to order such reasonable alteration therein, additions thereto, and abandonment of part or parts thereof, as may to the vestry or board or their officers appear on the fuller knowledge afforded by the opening of the ground, requisite to secure the complete and perfect working of such works.

Metropolis Local Amendment Act.

Section 66.—Whereas certain property within the limits of the Metropolis is so situated as to render it impracticable, or practicable only at undue expense, to connect such property with sewers, and it is expedient that some temporary provision should be made for draining such property and abating the nuisances existing thereon or caused thereby: Be it therefore enacted, that in any case in which any house or other building, whether erected before or after the passing of this Act, is without sufficient drainage, and there is no proper sewer within 200ft. of any part of such house or building is situate, by notice in writing to require the owner of such house or building to construct and lay from such house or building a covered drain to lead therefrom into a covered water-tight cesspool or tank or other suitable receptacle, not being under a house or within such distance from a house as the vestry or board shall direct, and to construct such cesspool, tank, or receptacle; and the several provisions in the firstly-recited Act, with respect to the laying of house drains at the expense of the owners of property, and the recovery of such expenses of and the penalties of any omission in respect to the performance of any such works pursuant to the orders of vestries of district boards in accordance with the directions of the said Act, shall be extended to and apply to the making of such cesspools, tanks, receptacles, and drains, and the orders of vestries and district boards in relation thereto and the expenses thereof.

Metropolis Local Management Act, 1855.

Section 74.—If it appear to the vestry or board of any parish or district that a group or block of contiguous houses, or of adjacent detached or semi-detached houses, may be drained and improved more economically or advantageously in combination than separately, and a sewer of sufficient size already exist or about to be constructed within 100ft. of any part of such group or block of houses, whether contiguous, detached, or semi-detached, it shall be lawful for such board or vestry to order that such group or block of houses be drained and improved, as hereinbefore provided, by a combined operation.

Section 75.—It shall not be lawful to erect any house or other buildings in any parish mentioned in Schedule (A) to this Act or in any district mentioned in Schedule (B) to this Act, or to rebuild any house or building within any such parish or district which has been pulled down to or below the floor commonly called the ground floor, or to occupy any house or building so newly built or rebuilt, unless a drain and such branches thereto and other connected works and apparatus and water supply as hereinbefore mentioned be constructed and provided to the satisfaction of the surveyor of the vestry of such parish or board of works for such district, of such materials, of such size, at such level, and with such fall as they may direct, so that the same shall be available for the drainage of the lowest floor of such house or building, and of its several floors or storeys, and also of its areas, water-closet, privies, and offices (if any), which drain shall lead from such house or building to such sewer already made or intended to be constructed near thereto, as the vestry or board shall direct and appoint, or if there be no sewer existing or intended to be constructed within 100ft. of any part of the intended site of such house or building, then to such covered cesspool or other place, not being under any dwelling-house, as the vestry or board shall direct, and whenever any house or building is rebuilt as aforesaid, the level of the lowest floor of such house or building shall be raised sufficiently to allow of the construction of such a drain, and such branches thereto and other works and apparatus as are hereinbefore required, and for that purpose the levels shall be taken and determined under the direction of the vestry or district board.

Section 76.—Before beginning to lay or dig out the foundation of any new house or building within any such parish or district, or to rebuild any house or building therein, and also before making any drain for the purpose of draining directly or indirectly into any sewer under the jurisdiction of the vestry or board, of or for any such parish or district, seven days' notice in writing shall be given to the vestry or board by the person intending to build or rebuild such house or building or to make such drain; and every such foundation shall be laid at such level as will permit the drainage of such house or building in compliance with this Act, and as the vestry or board shall order, and every such drain shall be made in such direction, manner, and form, and of such materials and workmanship, and with such branches thereto and other connected works and apparatus and water supply as hereinbefore mentioned, and as the vestry or board shall order, and the making of every such drain shall be under the survey and control of the vestry or board; and the vestry or district board shall make their order in relation to the matters aforesaid, and cause the same to be notified to the person from whom such notice was received within seven days from the receipt of such notice, and in default of such notice, or if such house, building, or drain, or branches thereto or other connected works and apparatus and water supply, be begun, erected, made, or provided in any respect contrary to the order of the vestry or board made and notified as aforesaid, or the provisions of this Act, it shall be lawful for the vestry or board to cause such house or building to be demolished or altered, and to cause such drain or branches thereto and other connected works and apparatus and water supply to be relaid, amended, or remade, or in the event of omission added as the case may require, and to recover the expenses thereof from the owner thereof in the manner hereinafter provided.

[*Section* 77.—It shall be lawful for any person at his own expense to make or branch any drain into any of the sewers vested in the Metropolitan Board of Works or any vestry or district board under this Act, such drain being of such size and of such conditions and branched to such sewer in such a manner and form of communication in all respects as the vestry or board shall direct or appoint.—*Repealed.*]

Section 78.—Whenever it is necessary to open any part of the pavement or any street or public place for the purpose of making or branching any private drain into any of the sewers or drains vested in the Metropolitan Board of Works, or any vestry or district board under this Act, it shall be lawful for the vestry or board, in case they think fit so to do, to make so much and such part of such private drain, and also to construct so much and such part of the work necessary for branching the same in the public sewers as shall be under or in any street, and to recover the expenses incurred thereby from the owner of the house, building, or ground to which such private drain belongs in the manner hereinafter provided.

Section 79.—It shall be lawful for any such vestry or board to contract and agree with owners or occupiers of any houses, buildings, or ground, that any drains required to be made, altered, or enlarged by such owners, shall be made, altered, and enlarged by the vestry or board: and the cost price of making, altering, or enlarging such drains, as certified by the surveyor of the vestry or board, shall be repaid by the owner or occupier so agreeing to the vestry or board, and in default of payment the same may be recovered in the manner hereinafter provided.

Section 80.—Where any sewer in any of the parishes mentioned in either of the Schedules (A) and (B) of this Act, into which any drain shall be made or branched, has been built since the third day of September, one thousand eight hundred and thirteen, and before the commencement of this Act, at the expense of any person or body other than any commissioners of sewers, the vestry or district board in whom such sewer is vested may order such sum as they may deem just to be paid and contributed by the owner of the house to which such drain belongs towards the expense of the construction of such sewer, which sum shall, on the receipt thereof by such vestry or board, be paid over to the person or body aforesaid, and such vestry or board may, if they see fit, order and accept payment of such sum with interest after a rate not exceeding five pounds for the hundred by the year by instalments within any period not exceeding twenty years.

Section 82.—It shall be lawful for any such vestry or board, or for their surveyor, inspector, or such other person as they appoint, to inspect any drain, water-closet, privy or cesspool, or water-supply apparatus, or sinks, traps, syphons, pipes, or other works or apparatus connected thereto, within the parish or district of such vestry or board, and for that purpose at all reasonable times in the daytime, after twenty-fours' notice in writing has been given to the occupier of the premises to which such drain, water-closet, privy, cesspool, or water-supply apparatus or other connected works or apparatus as aforesaid, is attached, or left upon the premises, or in case of emergency without notice, to enter, by themselves, or their surveyor, inspector, or workmen, upon any premises, and cause the ground to be opened in any place as they think fit, doing as little damage as they may.

Section 83.—In case any drain, water-closet, privy, cesspool, or water-supply, or water-supply apparatus, or other connected works or apparatus hereinbefore mentioned, be found on inspection not to have been made or provided according to the directions or regulations of the vestry or district board, or contrary to the provisions of this Act, or in case any person, without the consent of the vestry or district board, construct, rebuild, or unstop any sewer, drain, water-closet, privy, or cesspool, which may have been ordered by them not to be made, or to be demolished or stopped up, or in case any person discontinue any water supply or destroy any connected works or apparatus as aforesaid, or in case any person without the consent of the vestry or district board break into any sewer vested in such vestry or board, every person so offending shall forfeit and pay any sum not exceeding ten pounds: and in case the person so making any sewer, drain, water-closet, privy, or cesspool, or other works or apparatus as aforesaid, contrary to the directions or regulations of the vestry or board, or contrary to the provisions of this Act, or without such consent as aforesaid constructing, rebuilding, or unstopping any sewer, drain, water-closet, privy, or cesspool which may have been ordered to be demolished or stopped up, or discontinuing any water supply, or destroying any connected works or apparatus as aforesaid, or breaking into any such sewer as aforesaid, do not within fourteen days after notice in writing by the vestry or board, cause such drain, water-closet, privy, or cesspool to be altered or reinstated in conformity with the directions of the vestry or board, or as the case may be, to be demolished or stopped up, or such water supply to be renewed, or such connected works or apparatus to be restored, then and in every such case the vestry or board may cause the work to be done and the expenses thereof shall be paid by the person who has so offended.

Section 84.—If such drain, water-closet, privy, cesspool, or water supply, or water-supply apparatus, or other connected works and apparatus be found on inspection as aforesaid to be made to the satisfaction of the vestry or board, and in proper order and condition, they shall cause the same to be reinstated and made good as soon as may be, and the expenses of examination, reinstating, making good such drain, water-closet, privy, cesspool, or other works or apparatus as aforesaid, shall be defrayed by the vestry or board, and full compensation shall be made by them for all damages or injuries done or occasioned by the examination of any such drain, water-closet, privy, cesspool, or other works or apparatus as aforesaid.

Section 85.—If upon such inspection as aforesaid, any drain, water-closet, privy, or cesspool appear to be in bad order and condition, or to require cleansing, alteration, or amendment, or to be filled up, the vestry or board shall cause notice in writing to be given to the owner or occupier of the premises upon or in respect to which the inspection was made requiring him forthwith or within a reasonable time as shall be specified in such notice to do the necessary works, and if such notice be not complied with by the person to whom it is given the vestry or board may, if they think fit, execute such works, and the expenses incurred by them in so doing shall be paid by them to the owner or occupier of the premises.

Section 86.—Every vestry and district board shall drain, cleanse, cover, or fill up, or cause to be drained, cleansed, covered, or filled up, all ponds, pools, open ditches, sewers, drains, and places containing or used for the collection of any drainage, filth, water, matter, or thing of an offensive nature, or likely to be prejudicial to health, which may be situate in their parish or district; and they shall cause written notice to be given to the person causing any such nuisance, or to the owner or occupier of any premises whereon the same exists, requiring him, within a time to be specified in such notice, to drain, cleanse, cover, or fill up such pond, pool, ditch, sewer, drain, or place, or to construct a proper sewer or drain for the discharge of such filth, water, matter, or thing, or to do such other works as the case may require, and if the person to whom such notice is given fail to comply therewith, the vestry or board shall execute such works as may be necessary for the abatement of such nuisance, and may recover the expenses thereby incurred from the owner of the premises in manner hereinafter mentioned, provided always that it shall be lawful for such vestry or board, where they think it reasonable, to defray all or any portion of such expenses, as expenses of sewerage are to be defrayed under this Act.

Section 100.—The owner of such court, passage, or public place, not being a thoroughfare, shall if required by the vestry or district board of the parish or district in which the same is situate, to the satisfaction of such vestry or district board, sufficiently pave, cover the surface of, or repair the same, and lay at a proper level through, over, under, or along such part thereof as such vestry or board may require, a drain, channel, or gutter, and keep such pavement or covering, and drain, channel, or gutter in good repair to the satisfaction of such vestry or board.

Metropolis Local Amendment Act, 1862.

Section 81.—In any case of default by the owner of any court, passage, or public place, not being a thoroughfare, to comply with the requisition of any vestry or district board to perform works of paving or draining of the nature described in the one hundredth section of the firstly-recited Act, it shall be lawful for the vestry or board, should they see fit, in lieu of enforcing the penalty therein mentioned, to execute and perform such works, and recover the expenses thereof from the owner either by action at law or in a summary manner before a justice, at the option of the vestry or board.

Metropolis Local Act, 1855.

Section 202.—The Metropolitan Board of Works and every district board and vestry respectively may from time to time make, alter, and repeal by-laws for all or any of the purposes following—that is to say, for regulating the plans, level, width, surface, inclination, and the material of the pavement and roadway of new streets and roads, and the plans and level of sites for building and for regulating the dimensions, form, and mode of construction, and the keeping, cleansing, and repairing of the pipes, drains, and other means of communicating with sewers, and the traps and apparatus connected therewith, for the emptying, cleansing, closing, and filling up of cesspools and privies, and for other works of cleaning, and of removing and disposing of refuse, and for regulating the form of appeal and mode of proceeding thereon, and generally for carrying into effect the purposes of this Act.

Interpretation of Terms.

1855: 250.—In the construction of this Act "the Metropolis" shall be deemed to include the City of London and the parishes mentioned in the Schedules (A), (B), and (C) to this Act; "The City of London" shall be deemed to include all parts now within the jurisdiction of the Commissioners of Sewers for the

City of London; and the word "parish" shall include any place mentioned in Schedule (A) to this Act, and any place or combination of places mentioned in Schedule (B) to this Act, for which one or more members is or are to be elected to any district board.

"Owner."—Same as Public Health Acts.

"Drain."—The word "drain" shall mean and include any drain of and used for the drainage of one building only, or premises within the same curtilage, and made merely for the purpose of communication with a cesspool or other like receptacle for drainage or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed, and shall all include any drain for draining any group or block of houses by a combined operation under the order of any vestry or district board.

1862: 112.—The word "drain" shall be deemed to apply to and include the subject-matters specified in Section 250 as above, and also any drain for draining a group or block of houses by a combined operation laid or constructed before the first day of January, 1856, pursuant to the order or direction or with the sanction or approval of the Metropolitan Commissioners of Sewers.

Sewer."—The word "sewer" shall mean and include sewers and drains of every description, except drains to which the word "drain" interpreted as aforesaid applies.

Metropolis Local Management Act, 1862.

Section 49.—All persons intending to make or branch any drain or sewer vested in the Metropolitan Board of Works shall, seven clear days before commencing any works for that purpose, make written application to the vestry or board of the parish, district, or part in which such sewer shall be situate, accompanied by a plan showing such particulars as may be required by any by-law or resolution of the said Metropolitan Board; and no such work shall be commenced until the sanction in writing of the said vestry or district board shall be given.

Section 61. — The seventy-seventh section of the firstly-recited Act is hereby repealed, and in lieu thereof be it enacted, that no person shall make or branch any sewer or drain, or make any opening into any sewer vested in the Metropolitan Board of Works, or in any vestry or district board without the previous consent in writing of such board or vestry: Provided that it be lawful for any person, with such consent, at his own expense, to make or branch any drain into any sewer vested in such board or vestry, or authorised to be made by them or either of them under the firstly-recited Act or this Act, such drain being of such size, materials and other conditions, and branched into such sewer in such manner and form of communication in all respects as the board or vestry shall direct or appoint: Provided also that where any contribution to the cost of the sewer is payable in respect of drainage into the same it shall not be lawful for any person to make or branch any drain into such sewer, except in conformity with the directions of the board or vestry in whom the same shall be vested with respect to payment of contribution under the provisions contained in the firstly-recited Act and this Act in that behalf; and in case any person without the consent of the said Metropolitan

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Board, district board, or vestry as aforesaid, make or branch, or cause to be made or branched, any sewer or drain, or make any opening into any of the sewers vested in any such board or vestry, or authorised to be made by them as aforesaid, or if any person make or branch or cause to be made or branched any drain of a different construction, size, material, or other conditions, or in manner or form of communications than shall be directed or appointed by such board or vestry, every person so offending shall for every such offence forfeit a sum not exceeding fifty pounds, and the board or vestry may cut off the connection between such drain and their sewer, or, if they shall see fit, execute the works necessary for making the said drain conformable to their regulations or directions at the expense of the person making such drain or causing the same to be made, such expenses to be recovered either by action at law or in a summary manner before the justice of the peace at the option of the board or vestry.

SPECIMEN FORM OF NOTICE.

....County of London.

HEALTH DEPARTMENT.

The Metropolitan Management Act, 1855. (18 and 19 Vict., c. 120.)
The Public Health (London) Act, 1891. (54 and 55 Vict., c. 76.)

DRAINAGE OF PREMISES.

Application No. ....

To the Vestry of the Parish of..

Gentlemen,

[1]........................., the undersigned, hereby give you seven days' notice of [2]..................... intention to drain the premises known as [3]...

....

in the parish of ...., as shown on the plan on the other side hereof, and undertake to carry out the whole of the work in accordance with the annexed regulations of the vestry and the provisions of the above-mentioned Acts of Parliament and by-laws made thereunder.

Dated this .... day of .... 189 .
Signature of person intending to drain the premises.....................
Address ....
Name of the owner of the house ....
Address ....

[1] Insert "I" or "we," as the case may be. [2] Insert "my" or "our," as the case may be. [3] Insert the number or name of the house and the name of the street or road.

Note.—Before beginning to lay or dig out the foundation of any new house or building, or to rebuild any house or building, and also before making or reconstructing any drain for the purpose of draining, directly or indirectly, into any sewer, seven days' notice is to be given to the vestry, on forms to be obtained; such notice to be accompanied by a plan showing the position and size of the proposed drain, and all connections therewith.

Every person who shall intend to construct any water-closet, earth-closet, or to fit or fix in or in connection with any water-closet, earth-closet, or privy, any apparatus or any trap or soil-pipe shall, before executing any such works, give notice in writing to the Health Department, at the Vestry Hall, ...

Directions for Making Plan.—Plan, 8ft. to an inch. The plan to be in ink, and the drains are to be shown in red. Existing drains in blue.

N.B.—The plan must show all the following particulars—viz., A, water-closets; B, rain-water pipes; C, sinks to yards and areas; D, sinks to kitchens, sculleries, and wash-houses; E, ventilating pipes; F, interceptor syphon trap.

Depth of sewer below surface of street ....
Depth of basement floor ....
Sizes of drains...

Examined ....
Sanitary Inspector.

Approved { ....
Medical Officer of Health.
....
Engineer and Surveyor. }

Completed ....
Sanitary Inspector.

Regulations of Vestry Respecting House Drains.

1. That all new drains be constructed according to deposited plans to be approved previously by the medical officer of health and by the engineer to the vestry.

2. All drains shall be made of glazed stoneware or cast-iron pipes. When stoneware pipes are used they shall be socket pipes of the best quality, and shall be jointed with cement made of two parts of clean sharp sand and one part of best Portland

cement by measure, and so as to be watertight, and where fixed inside the house shall be embedded in concrete at least 6in. in thickness all round, made with one part of clean sharp sand, five parts of clean ballast, and one part of the best Portland cement; main drains shall be at least 6in. in internal diameter, and branch drains at least 4in. in internal diameter. When cast-iron pipes are used they shall be socket pipes of best quality and heavy metal, and coated internally with Dr. Angus Smith's or some other approved anti-corrosive composition; the joints shall be caulked with lead and the pipes not less than 4in. in internal diameter.

3. The interior of such pipes, after being laid, shall be cleared from any projecting portions of cement or other material.

4. The drain is not to be filled or covered in until it has been inspected and tested by an officer authorised by the vestry.

5. No drain shall be laid on the premises unless the drain from the sewer to the premises is in good condition, and allows a sufficient fall to the house drain or the greatest fall permitted by the depth of the sewer.

6. The drains on the premises shall be laid in straight lines wherever possible, and with an even and regular inclination from the lowest level upwards, to the approval of the officers authorised by the vestry.

7. Each drain shall have a separate drain in direct communication with a sewer, unless express consent from the vestry has been obtained for combined drainage.

8. So much of the work as may be necessary for the connection to the sewer to the extent of a flap trap (if required) and 6ft. of pipe will be constructed by the vestry's contractor at the expense of the owner, and such an amount as shall be required by the vestry's engineer and surveyor must be paid as deposit previous to the commencement of the work.

9. An interceptor syphon trap of approved pattern, with fresh-air inlet or ventilating-pipe (with an internal diameter of not less than 3½in.) on the house side, shall be placed in the drain on the premises as near as practicable to the sewer, and beyond al branch connections. The mouth of the air inlet shall be constructed in such a manner as to prevent the admission of solid matters, and be fixed in the most practicable position available.

10. An inspection-chamber or manhole may be provided where practicable on the house side of the disconnecting trap, to facilitate access to the drain for the purpose of cleansing and repairs.

11. If the drain be not ventilated by a soil-pipe, a pipe at least 3½in. in internal diameter shall be fixed for the purpose of venti-

lating the drain at its highest part, and be constructed in such a manner as if it were for the purpose of ventilating a soil-pipe.

12. The junction pipes used in the drains shall be those known as Y junctions.

13. The inlets to the drains shall be properly trapped with fixed traps, except inlets used for the purpose of ventilation. Traps known as "bell," "lip," or "dip" traps shall not be inserted in the drains. The inlets to the drains shall be outside the house, except the necessary inlets connected with water-closet basins, and water-closets shall be properly ventilated into the external air.

14. The yard gully shall be at least 6in. in diameter, and shall have an outlet connected with the drain at least 4in. in diameter, and shall be covered with an iron or other approved grating.

15. All waste-pipes from scullery sinks, baths, and lavatories, and all pipes conveying foul matters to the drains from inside the house, except soil-pipes from water-closets, and every rain-water pipe, excepting such as may be used for the purpose of ventilation, shall be made to discharge over or into a gully connected with the drain outside the house.

16. Drains shall not be laid under any part of a house if it be practicable to lay them outside of the house.

17. In case of neglect or default by any person to comply with the order of the vestry to execute any works, matters, or things, the person so offending is liable to a penalty not exceeding £5, and also to a further sum not exceeding 40s. for every day during which such offence shall continue, to be recovered by action at law, or before a justice of the peace in a summary manner.

Extracts from the By-Laws made by the London County Council under the Public Health (London) Act, 1891, *Section* 39.

1. Every person who shall hereafter construct a water-closet or earth-closet in connection with a building, shall construct such water-closet or earth-closet in such a position that, in the case of a water-closet, one of its sides at the least shall be an external wall, and in the case of an earth-closet two of its sides at the least shall be external walls, which external wall or walls shall abut immediately upon the street, or upon a yard or garden or open space of not less than 100 square feet of superficial area, measured horizontally at a point below the level of the floor of such closet. He shall not construct any such water-closet so that it is approached directly from any room used for the purpose of human habitation, or used for the manufacture, preparation, or storage of food for man, or used as a factory, workshop, or work-place, nor shall he construct any earth-closet so that it can be

entered otherwise than from the external air. He shall construct such water-closet so that on any side on which it would abut on a room intended for human habitation, or used for the manufacture, preparation, or storage of food for man, or used as a factory, workshop, or workplace, it shall be enclosed by a solid wall or partition of brick or other materials extending the entire height from the floor to the ceiling. He shall provide any such water-closet that is approached from the external air with a floor of hard, smooth, impervious material having a fall to the door of such water-closet of $\frac{1}{2}$in. to the foot. He shall provide such water-closet with proper doors and fastenings: Provided always that this by-law shall not apply to any water-closet constructed below the surface of the ground and approached directly from an area or other open space available for purposes of ventilation, measuring at least 40 superficial feet in extent, and having a distance across of not less than 5ft., and not covered in otherwise than by a grating or railing.

2. Every person who shall construct a water-closet in connection with a building, whether the situation of such water-closet be or be not within or partly within such building, and every person who shall construct an earth-closet in connection with a building, shall construct in one of the walls of such water-closet or earth-closet which shall abut upon the public way, yard, garden, or open space, as provided by the preceding by-law, a window of such dimensions that an area of not less than two square feet, which may be the whole or part of such window, shall open directly into the external air. He shall, in addition to such window, cause such water-closet or earth-closet to be provided with adequate means of constant ventilation by at least one air-brick built in an external wall of such water-closet or earth-closet, or by an air-shaft, or by some other effectual method or appliance.

3. Every person who shall construct a water-closet in connection with a building shall furnish such water-closet with a cistern of adequate capacity for the purpose of flushing, which shall be separate and distinct from any cistern used for drinking purposes, and shall be so constructed, fitted, and placed as to admit of the supply of water for use in such water-closet so that there shall not be any direct connection between any service pipe upon the premises and any part of the apparatus of such water-closet other than such flushing cistern: Provided always that the foregoing requirement shall be deemed to be complied with in any case where the apparatus of a water-closet is connected for the purpose of flushing with a cistern of adequate capacity, which is used solely for flushing water-closets or urinals, he shall construct or fix the pipe and union connecting such flushing cistern with the

pan, basin, or other receptacle with which such water-closet may be provided, so that such pipe and union shall not in any part have an internal diameter of less than $1\frac{1}{4}$in. He shall furnish such water-closet with a suitable apparatus for the effectual application of water to any pan, basin, or other receptacle with which such apparatus may be connected and used, and for the effectual flushing and cleansing of such pan, basin, or other receptacle, and for the prompt and effectual removal therefrom and from the trap connected therewith of any solid or liquid filth which may from time to time be deposited therein. He shall furnish such water closet with a pan, basin, or other suitable receptacle of non-absorbent material, and of such shape, of such capacity, and of such mode of construction as to receive and contain a sufficient quantity of water, and to allow all filth which may from time to time be deposited in such pan, basin, or receptacle, to fall free of the sides thereof and directly into the water received and contained in such pan, basin, or receptacle. He shall not construct or fix under such pan, basin, or receptacle any "container" or other similar fitting. He shall construct or fix immediately beneath or in connection with such pan, basin, or other suitable receptacle an efficient syphon trap, so constructed that it shall at all times maintain a sufficient water seal between such pan, basin, or other suitable receptacle and any drain or soil-pipe in connection therewith. He shall not construct or fix in or in connection with the water-closet apparatus any D trap or other similar trap. If he shall construct any water-closet, or shall fix or fit any trap to any existing water-closet or in connection with a soil-pipe, which is itself in connection with any other water-closet, he shall cause the trap of every such water-closet to be ventilated into the open air at a point as high as the top of the soil-pipe, or into the soil-pipe at a point above the highest water-closet connected with such soil-pipe, and so that such ventilating pipe shall have in all parts an internal diameter of not less than 2in., and shall be connected with the arm of the soil-pipe at a point not less than 3in. and not more than 12in. from the highest part of the trap, and on that side of the water seal which is nearest to the soil-pipe.

4. Any person who shall provide a soil-pipe in connection with a building to be hereafter erected shall cause such soil-pipe to be situated outside such building, and any person who shall provide or construct or refit a soil-pipe in connection with an existing building shall, whenever practicable, cause such soil-pipe to be situated outside such building, and in all cases where such soil-pipe shall be situated within any building shall construct such soil-pipe in drawn lead or of heavy cast iron jointed with molten

lead and properly caulked. He shall construct such soil-pipe so that its weight in proportion to its length and internal diameter shall be as follows :

Diameter.	Lead. Weight per 10ft. length. Not less than	Iron. Weight per 6ft. length. Not less than
3½in.	65lb.	48lb.
4in.	74lb.	54lb.
5in.	92lb.	69lb.
6in.	110lb.	84lb.

Every person who shall provide a soil-pipe outside or inside a building shall cause such soil-pipe to have an internal diameter of not less than 3½in., and to be continued upwards without diminution of its diameter, and, except where unavoidable, without any bend or angle being formed in such soil-pipe, to such a height and in such a position as to afford by means of the open end of such soil-pipe a safe outlet for foul air, and so that such open end shall in all cases be above the highest part of the roof of the building to which the soil-pipe is attached, and, where practicable, be not less than 3ft. above any window within 20ft. measured in a straight line from the open end of such soil-pipe. He shall furnish the open end of such soil-pipe with a wire guard covering, the openings in the meshes of which shall be equal to not less than the area of the open end of the soil-pipe. In all such cases where he shall connect a lead trap or pipe with an iron soil-pipe or drain, he shall insert between such trap or pipe and such soil-pipe or drain a brass thimble, and he shall connect such lead trap or pipe with such thimble by means of a wiped or over-cast joint, and he shall connect such thimble with the iron soil-pipe or drain by means of a joint made with molten lead, properly caulked. In all cases where he shall connect a stoneware trap or pipe with a lead soil-pipe he shall insert between such stoneware trap or pipe and such soil-pipe a brass socket, or other similar appliance, and he shall connect such stoneware trap or pipe by inserting it into such socket, making the joint with Portland cement, and he shall connect such socket with the lead soil-pipe by means of a wiped or overcast joint. In all cases where he shall connect a stoneware trap or pipe with an iron soil-pipe or drain, he shall insert such stoneware trap or pipe into a socket on such iron soil-pipe or drain, making the joint with Portland cement. He shall so construct such soil-pipe that it shall not be directly connected with the waste of any bath, rain-water pipe, or of any sink other than that which is provided for the reception of urine or other excremental filth, and he shall construct such soil-pipe so that there shall not be any trap in such soil-pipe or between the soil-pipe and any drain with which it is connected.

5. A person who shall newly fit or fix any apparatus in connection with any existing water-closet shall, as regards such apparatus and its connection with any soil-pipe or drain, comply with such of the requirements of the foregoing by-laws as would be applicable to the apparatus so fitted or fixed if the water-closet were being newly constructed.

* * * *

14. Every person who shall intend to construct any water-closet, earth-closet, or privy, or to fit or fix in or in connection with any water-closet, earth-closet, or privy any apparatus or any trap or soil-pipe, shall, before executing any such works, give notice in writing to the clerk of the sanitary authority.

* * * *

28. Every person who shall offend against any of the foregoing by-laws shall be liable for every such offence to a penalty of £5, and in the case of a continuing offence, to a further penalty of 40s. for each day after written notice of the offence from the sanitary authority : Provided, nevertheless, that the court before whom any complaint may be made or any proceedings may be taken in respect of any such offence may, if the court think fit, adjudge the payment as a penalty of any sum less than the full amount of the penalty imposed by this by-law.

By order,

........................, Vestry Clerk.

Note. — The vestry are empowered to open ground, to inspect any drain, or works connected therewith, that may be covered over. In order to avoid the annoyance and inconvenience occasioned by opening ground and uncovering work, persons executing such work, when it is ready for covering, should forthwith give notice to that effect to the medical officer of health, when it will be inspected in due course. If on inspection of any work ordered by the vestry it is found that the order of the vestry has been departed from in any particular, the person so offending is liable to a penalty not exceeding £10 ; and if such person, after notice from the vestry, neglect to amend such work, the vestry may amend it at the expense of the person so offending.

CHAPTER XIX.

PUBLIC HEALTH ACT, 1875 (AND INCORPORATED SECTIONS OF TOWN'S IMPROVEMENT CLAUSES ACT, 1847), AND PUBLIC HEALTH AMENDMENT ACT, 1890.

Index to Sections Relating to House Drainage.

Public Health Act, 1875.

Section 4. *Definitions.*—" Lands " and " premises " include messuages, buildings, lands, easements, and hereditaments of any tenure:

"Owner" means the person for the time being receiving the rack rent of the lands or premises in connection with which the word is used, whether on his own account, or as agent or trustee for any other person, or who would so receive the same if such lands or premises were let at a rack rent.

"House" includes schools, also factories and other buildings in which more than twenty persons are employed at one time.

"Drain" means any drain of and used for the drainage of one building only, or premises within the same curtilage, and made merely for the purpose of communicating therefrom with a cess-pool or other like receptacle for drainage, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed.

"Sewer" includes sewers and drains of every description, except drains to which the "drain" interpreted as aforesaid applies, and except drains vested in or under the control of any authority having the management of roads, and not being a local authority under this Act.

Section 21.—The owner or occupier of any premises within the district of a council shall be entitled to cause his drains to empty into the sewers of that authority on condition of his giving such notice as may be required by that authority of his intention so to do, and of complying with the regulations of that authority in respect of the mode in which the communications between such drains and sewers are to be made, and subject to the control of any person who may be appointed by that authority to superintend the making of such communications. Any person causing a drain to empty into a sewer of a council without complying with this section shall be liable to a penalty not exceeding twenty pounds, and the council may close any communication between a drain and a sewer made in contravention of this section, and may recover in a summary manner from the person so offending any expenses incurred by them under this section.

Town's Improvement Clauses Act, 1847.

Section 79.—The council shall during the construction or repair of any sewers or drains take proper precaution against accident by shoring up and protecting the adjoining houses, and shall cause such bars or chains to be fixed across or in any of the streets to prevent the passage of carriages and horses while such works are carried on as to them shall seem proper; and the council shall cause any sewer or drain or other works during the construction or repair thereof by them to be lighted and guarded during the night so as to prevent accidents; and every person who takes down, alters, or removes any of the said bars or chains, or extinguishes any light, without the authority or consent of the council shall for every such offence be liable to a penalty not exceeding five pounds.

Section 81.—When any building materials, rubbish, or other things are laid, or any hole made in any of the streets, whether the same be done by order of the council or not, the person causing such materials or other things to be so laid, or such hole to be made, shall, at his own expense, cause a sufficient and proper light to be fixed in a proper place upon or near the same, and continue such light every night from sun setting to sun rising while such materials or hole remain; and such person shall, at his own expense, cause such materials or other things and such hole to be sufficiently fenced and enclosed until such materials or other things are removed or the hole filled up or otherwise made secure; and every such person who fails so to light, fence, or enclose such materials or other things or such hole shall for every such offence be liable to a penalty not exceeding five pounds, and a further penalty not exceeding forty shillings for every day while such default is continued.

Section 82.—In no case shall any such building materials or other things or such hole be allowed to remain for an unnecessary time under a penalty not exceeding five pounds to be paid for every such offence by the person who causes such materials or other things to be laid or such hole to be made, and a further penalty not exceeding forty shillings for every day during which such offence is continued after the conviction for such offence; and in any such case the proof that the time has not exceeded the necessary time shall be upon the person so causing such materials or other things to be laid or causing such hole to be made.

Section 83.—If any building or hole or any other place near any street be, for want of sufficient repair, protection, or enclosure, dangerous to the passengers along such street, the council shall cause the same to be repaired, protected, or enclosed, so as to prevent danger therefrom; and the expense of such repair, protection, or enclosure shall be repaid to the council by the owner of the premises so repaired, protected, and enclosed, and shall be recoverable from him as damages.

Public Health Amendment Act, 1890.

Section 18.—(1) Where the owner or occupier of any premises is entitled to cause any sewer or drain from those premises to communicate with any sewer of the council, the council shall, if requested to do so by the owner or occupier, and upon the cost thereof being paid in advance to the council, themselves make the communication and execute all works necessary for that purpose. (2) The cost of making such communication (including all costs incidental thereto) shall be estimated by the surveyor of the council, but in case the owner or occupier of the premises, as the case may be, is dissatisfied with such estimate he may, if the estimate is under fifty pounds, apply to a court of summary jurisdiction to fix the amount to be paid for such cost, and if the estimate is over fifty pounds have the same determined by arbitration in manner provided by the Public Health Act. (3) A council may agree with the owner of any premises that any sewer or drain which such owner desires to or is required to make, alter, or enlarge, or any part of such sewer or drain, shall be made, altered, or enlarged by the council.

Public Health Act, 1875.

Section 22.—The owner or occupier of any premises without the district of a council may cause any sewer or drain from such premises to communicate with any sewer of the council on such terms and conditions as may be agreed on between such owner or occupier and such council, or as in case of dispute may be settled, at the option of the owner or occupier, by a court of summary jurisdiction or by an arbitration in manner provided by this Act.

Section 23.—Where any house within the district of a council is without a drain sufficient for effectual drainage, the council shall by written notice require the owner or occupier of the house, within a reasonable time therein specified, to make a covered drain or drains emptying into any sewer which the council are entitled to use, and which is not more than one hundred feet from the site of such house; but if no means of drainage are within that distance, then emptying into such covered cesspool or other place not being under any house as the council direct; and the council may require any such drain or drains to be of such materials and size, and to be laid at such level, and with such fall as on the report of their surveyor may appear to them to be necessary. If such notice is not complied with the council may, after the expiration of the time specified in the notice, do the work required, and may recover in a summary manner the expenses incurred by them in so doing from the owner, or may by order declare the same to be private improvement expenses: Provided that where, in the opinion of the council, greater expense would be incurred in causing the drains of two or more houses to empty into an existing sewer pursuant to this section than in constructing a new sewer and causing such drains to empty therein, the council may construct such new sewer and require the owners or occupiers of such houses to cause their drains to empty therein, and may apportion as they deem just the expenses of the construction of such sewer among the owners of the several houses, and recover in a summary manner the sums apportioned from such owners, or may by order declare the same to be private improvement expenses.

Section 24.—Where any house within the district of a council has a drain communicating with any sewer, which drain, though sufficient for the effectual drainage of the house, is not adapted to the general sewerage system of the district, or is in the opinion of the council otherwise objectionable, the council may, on condition of providing a drain or drains as effectual for the drainage of the house, and communicating with such other sewer as they think fit, close such first-mentioned drain, and may do any work necessary for that purpose, and the expenses of those works, and of the construction of any drain or drains provided by them under this section, shall be deemed to be expenses properly incurred by them in the execution of this Act.

Section 25.—It shall not be lawful in any urban district newly to erect any house or to rebuild any house which has been pulled down to or below the ground floor, or to occupy any house so newly erected or rebuilt, unless and until a covered drain or drains be constructed of such size and materials and at such level and with such fall as on the report of the surveyor may appear to the council to be necessary for the effectual drainage of such house; and the drain or drains so to be constructed shall empty in any sewer which the council are entitled to use and which is within one hundred feet of some part of the house to be built or to be rebuilt; but if no such means of drainage are within that distance, then shall empty into such covered cesspool or other place not being under any house as the council direct. Any person who causes any house to be erected or rebuilt or any drain to be constructed in contravention of this section shall be liable to a penalty not exceeding fifty pounds.

Section 26.—Any person who in any urban district, without the written consent of the council (1) causes any building to be newly erected over any sewer of the council, or (2) causes any vault, arch, or cellar to be newly built or constructed under the carriageway of any street, shall forfeit to the council the sum of five pounds, and a further sum of forty shillings for every day during which the offence is continued after written notice in this behalf from the council, and the council may cause any building, vault, arch, or cellar erected or constructed in contravention of this section to be altered, pulled down, or otherwise dealt with as they may think fit, and may recover in a summary manner any expenses incurred by them in so doing from the offender.

Section 40.—Every council shall provide that all drains, water-closets, earth-closets, privies, ashpits, and cesspools within their district be constructed and kept so as not to be a nuisance or injurious to health.

Section 41.—On a written application of any person to a council, stating that any drain, water-closet, earth-closet, privy, ashpit, or cesspool on or belonging to any premises within their district is a nuisance or injurious to their health (but not otherwise), the council may, by writing, empower the surveyor or inspector of nuisances, after twenty-four hours' written notice to the occupier of such premises, or in case of emergency without notice, to enter such premises with or without assistants, and cause the ground to be opened, and examine such drain, water-closet, earth-closet, privy, ashpit, or cesspool. If the drain, water-closet, earth-closet, privy, ashpit, or cesspool on examination appear to be in proper condition, he shall cause the ground to be closed, and any damage done to be made good as soon as can be, and the expenses of the works shall be defrayed by the council. If the drain, water-closet, earth-closet, privy, ashpit, or cess-pool on examination appear to be in a bad condition, or to require alteration or amendment, the council shall forthwith cause notice in writing to be given to the owner or occupier of the premises requiring him forthwith, or within a reasonable time therein specified, to do the necessary works; and if such notice is not complied with the person to whom it is given shall be liable to a penalty not exceeding ten shillings for every day during which he continues to make default, and the council may, if they think fit, execute such works, and may recover in a summary manner from the owner the expenses incurred by them in so doing, or may by order declare the same to be private improvement expenses.

Public Health Act, 1890.

Section 19.—(1) Where two or more houses belonging to different owners are connected with a public sewer by a single private drain, an application may be made under Section 41 of the Public Health Act, 1875 (relating to complaints as to nuisances from drains), and the council may recover any expense incurred by them in executing any works under the powers conferred on them by that section from the owners of the houses in such shares and proportions as shall be settled by their surveyor or (in case of dispute) by a court of summary jurisdiction. (2) Such expenses may be recovered summarily or may be declared by the urban authority to be private improvement expenses under the Public Health Acts, and may be recovered accordingly. (3) For the purposes of this section the expression "drain" includes a drain used for the drainage of more than one building.

Section 16.—(1) It shall not be lawful for any person to throw, or suffer to be thrown, or to pass into any sewer of a council or any drain communicating therewith, any matter or substance by which the free flow of the sewage or surface or storm water may be interfered with, or by which any such sewer or drain may be injured. (2) Every person offending against this enactment shall be liable to a penalty not exceeding ten pounds, and to a daily penalty not exceeding twenty shillings.

Section 17.—(1) Every person who turns or permits to enter any sewer of a council or any drain communicating therewith (*a*) any chemical refuse, or (*b*) any waste steam, condensing water, heated water, or other liquid (such water or other liquid being of a higher temperature than one hundred and ten degrees Fahrenheit) which, either alone or in combination with the sewage, is injurious to health, shall be liable to a penalty not exceeding ten pounds and to a daily penalty not exceeding five pounds. (2) The council, by any of their officers either generally or specially authorised in that behalf in writing, may enter any premises for the purpose of examining whether the provisions of this section are being contravened, and if such entry be refused, any justice, on complaint on oath by such officer, made after reasonable notice in writing of such intended complaint has been given to the person having custody of the premises, may by order under his hand require such person to admit the officer into such premises, and if it be found that any offence under this section has been or is being committed in respect of the premises, the order shall continue in force until the offence shall have ceased or the work necessary to prevent the recurrence thereof shall have been executed.

Public Health Act, 1875.

Section 157.—Every urban council may make by-laws with respect to the following matters—that is to say, (4) with respect to the drainage of buildings, to water-closets, earth-closets, ashpits, and cesspools in connection with buildings; and they may further provide for the observance of such by-laws by enacting therein such provisions as they think necessary as to the giving of notice, or to the deposit of plans and sections by persons intending to lay out streets or to construct buildings, as to inspection by the urban authority, and as to the power of such authority (subject to the provisions of this Act) to remove, alter, or pull down any work begun or done in contravention of such by-laws: Provided that no by-law made under this section shall affect any building erected in any place (which at the time of the passing of this Act is included in an urban sanitary district) before the Local Government Acts came into force in such place, or any building erected in any place (which at the time of the passing of this Act is not included in an urban sanitary district) before such place becomes constituted or included in an urban district, or by virtue of an order of the Local Government Board subject to this enactment. The provisions of this section and of the last preceding sections shall not apply to buildings belonging to any railway company and used for the purposes of such railway under any Act of Parliament.

Public Health Act, 1890.

Section 23.—(1) Section 157 of the Public Health

Act, 1875, shall be extended so as to empower every urban authority to make by-laws with respect to the following matters—that is to say, the keeping water-closets supplied with sufficient water for flushing. (2) Any by-laws under that section as above extended with regard to the drainage of buildings, and to water-closets, earth-closets, privies, ashpits, and cesspools in connection with buildings, and the keeping water-closets supplied with sufficient water for flushing, may be made so as to affect buildings erected before the times mentioned in the said section.

Public Health Act, 1875.

Section 158.—Where a notice, plan, or description of any work is required by any by-law made by a council to be laid before that authority, the urban authority shall, within one month after the same has been delivered or sent to their surveyor or clerk, signify in writing their approval or disapproval of the intended work to the person proposing to execute the same, and if the work is commenced after such notice of disapproval, or before the expiration of such month without such approval, and is in any respect not in conformity with any by-law of the urban authority, the council may cause so much of the work as has been executed to be pulled down or removed. Where a council incur expenses in or about the removal of any work executed contrary to any by-law, such authority may recover in a summary manner the amount of such expenses either from the person executing the works removed or from the person causing the works to be executed at their discretion. Where a council may under this section pull down or remove any work begun or executed in contravention of any by-law, or where the beginning or the execution of the work is an offence in respect whereof the offender is liable in respect of any by-law to a penalty, the existence of the work during its continuance in such a form and state as to be in contravention of the by-law shall be deemed to be a continuing offence, but a penalty shall be incurred in respect thereof after the expiration of one year from the day when the offence was committed or the by-law was broken.

Section 159.—For the purposes of this Act the re-erecting of any building pulled down to or below the ground floor, or of any frame building of which only the framework is left down to the ground floor, or the conversion into a dwelling-house of any building not originally constructed for human habitation, or the conversion into more than one dwelling-house of a building originally constructed as one dwelling-house only, shall be considered the erection of a new building.

Section 276.—The Local Government Board may, on the application of the council of any rural district, or of persons rated to the relief of the poor, the assessment of whose hereditaments amounts at least to one-tenth of the net ratable value of such district, or of any contributory place therein, by order, to be published in the *London Gazette*, or in such other manner as the Local Government Board may direct, declare any provisions of this Act in force in urban districts to be in force in such rural districts or contributory place, and may invest such authority with all or any of the powers, rights, duties, capacities, and obligations of an urban council under this Act, and such investment may be made either unconditionally or subject to any conditions to be specified by the Board as to the time, portion of the district, or manner during at or in which such powers, rights, duties, liabilities, capacities, and obligations are to be exercised and attach: Provided that an order of the Local Government Board, made on the application of one-tenth of the persons rated to the relief of the poor in any contributory place, shall not invest the rural council with any new powers beyond the limits of such contributory place.

CHAPTER XX.

EXTRACTS FROM THE MODEL BY-LAWS ISSUED BY THE LOCAL GOVERNMENT BOARD.

With respect to the Drainage of Buildings.

60. *Drainage of Subsoil.*—Every person who shall erect a new building shall cause the subsoil of the site of such building to be effectually drained by means of suitable earthenware field pipes, properly laid to a suitable outfall, whenever the dampness of the site renders such a precaution necessary.

He shall not lay any such pipe in such a manner or in such a position as to communicate directly with any sewer or cesspool, or with any drain constructed or adapted to be used for conveying sewage, but shall provide a suitable trap, with a ventilating opening, at a point in the line of the subsoil drain as near as may be practicable to such trap.

61. *Lowest Storey to be at Level above Sewer.*—Every person who shall erect a new building shall construct the lowest storey of such building at such level as will allow of the construction of a drain sufficient for the effectual drainage of such building, and of the provision of the requisite communication with any sewer into which such drain may lawfully empty, at a point in the upper half diameter of such sewer, or with any other means of drainage with which such drain may lawfully communicate.

62. *Materials for Drains.*—Every person who shall erect a new building shall, in the construction of

every drain of such building, other than a drain constructed in pursuance of the by-law in that behalf for the drainage of the subsoil for the site of such building, use good sound pipes, formed of glazed stoneware, or of other equally suitable material.

He shall cause every such drain to be of adequate size, and, if constructed or adapted to be used for conveying sewage, to have an internal diameter not less than 4in., and to be laid in a bed of good concrete or other suitable material, with a proper fall, and with watertight, socketed, or other suitable joints.

He shall not construct any such drain so as to pass under any building, except in any case where any other mode of construction may be impracticable, and in that case he shall cause such drain to be so laid in the ground that there shall be a distance equal at the least to the full diameter thereof between the top of such drain at its highest point and the surface of the ground under such building.

He shall also cause such drain to be laid in a direct line for the whole distance beneath such building, and to be completely embedded in and covered with good and solid concrete, at least 6in. thick all round.

He shall likewise cause adequate means of ventilation to be provided in connection with such drain at each end of such portion thereof as is beneath such building.

He shall cause every inlet to any drain, not being an inlet provided in pursuance of the by-law in that behalf as an opening for the ventilation of such drain, to be properly trapped.

63. *Trapping of Drains.*—Every person who shall erect a new building shall provide, within the curtilage thereof, in every main drain or other drain of such building, which may directly communicate with any

sewer or other means of drainage into which such drain may lawfully empty, a suitable trap at a point as distant as may be practicable from such building and as near as may be practicable to the point at which such drain may be connected with such sewer or other means of drainage.

64. *No Right-Angled Junction permitted in Formation of Drains.*—A person who shall erect a new building shall not construct the several drains of such building in such a manner as to form in such drains any right-angled junction, either vertical or horizontal. He shall cause every branch drain or tributary drain to join another drain obliquely in the direction of the flow of such drain.

65. *For securing Ventilation of Drains.* — Every person who shall erect a new building shall, for the purpose of securing efficient ventilation of the drains of such building, comply with the following requirements :

(i.) He shall provide at least two untrapped openings to the drains, and, in the provisions of such openings, he shall adopt such of the two arrangements hereinafter specified, as the circumstances of the case may render more suitable and effectual.

(*a*) One opening being at or near the level of the surface of the ground adjoining such opening, shall communicate with the drains by means of a suitable pipe, shaft, or disconnecting chamber, and shall be situated as near as may be practicable to the trap, which, in pursuance of the by-law in that behalf, shall be provided between the main drain or other drain of the building and the sewer or other means of drainage with which such drain may lawfully communicate. Such opening shall also in every case be situated on that side of the trap which is the nearer to the building.

The second opening shall be obtained by carrying up from a point in the drains, as far distant as may be practicable from the point at which the first-mentioned opening shall be situated, a pipe or shaft, vertically to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to a less height than 10ft.

(*b*) In every case where the foregoing arrangement of the openings to the drains may be impracticable, there shall be substituted the arrangement hereinafter prescribed.

One opening shall be obtained by carrying up from a point, as near as may be practicable to the trap, which, in pursuance of the by-law in that behalf, shall be provided between the main drain or other drain of the building and the sewer or other means of drainage with which such drain may lawfully communicate, a pipe or shaft, vertically, to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to a less height than 10ft. Such opening shall also in every case be situated on that side of the trap which is the nearer to the building.

The second opening, being at a point in the drains as far distant as may be practicable from the point at which such last-mentioned pipe or shaft shall be carried up, shall be at or near the level of the surface of the ground adjoining such opening, and shall communicate with the drains by means of a suitable pipe or shaft.

(ii.) He shall cause every opening provided in accordance with either of the arrangements hereinbefore specified to be furnished with a suitable grating or other suitable cover for the purpose of preventing any obstruction in or injury to any pipe or drain by the introduction of any substance through any such opening. He shall, in every case, cause such grating or cover to be so constructed and fitted as to secure the free passage of air through such grating or cover by means of a sufficient number of apertures, of which the aggregate extent shall be not less than the sectional area of the pipe or drain to which such grating or cover may be fitted.

(iii.) Every pipe or shaft which may be used in connection with either of the arrangements hereinbefore specified shall be of a sectional area not less than that of the drain with which such pipe or shaft may communicate, and not less in any case than the sectional area of a pipe or shaft of the diameter of 4in.

(iv.) No bend or angle shall (except where unavoidable) be formed in any pipe or shaft used in connection with either of the arrangements hereinbefore specified.

(v.) Provided always that for the purpose of either of the arrangements hereinbefore specified the soil-pipe of any water-closet, in every case where the situation, sectional area, height, and mode of construction of such soil-pipe shall be in accordance with the requirements applicable to the pipe or shaft to be carried up from the drains, may be deemed to provide the necessary opening for ventilation which would otherwise be obtained by means of such last-mentioned pipe or shaft.

66. *No Inlets to Drains within Buildings.*—A person who shall erect a new building shall not construct any

drain of such building in such a manner as to allow any inlet to such drain (except such inlet as may be necessary from the apparatus of any water-closet) to be made within such building.

Size, Situation, and Ventilation of Soil-Pipe.—He shall cause the soil-pipe from every water-closet in such building to be at least 4in. in diameter, and to be fixed outside such building, and to be continued upwards without diminution of its diameter, and (except where unavoidable) without any bend or angle being formed in such soil-pipe to such a height and in such a position as to afford, by means of the open end of such soil-pipe, a safe outlet for sewer air.

Soil-Pipe not to be Trapped at Foot.—He shall so construct such soil-pipe that there shall not be any trap between such soil-pipe and the drains, or any trap (other than such as may necessarily form part of the apparatus of any water-closet) in any part of such soil-pipe.

Waste-Pipes to Discharge in the Open Air.—He shall also cause the waste-pipe from every bath, sink (not being a slopsink constructed or adapted to be used for receiving any solid or liquid filth), or lavatory, the overflow pipe from any cistern and from every safe under any bath or water-closet, and every pipe in such building for carrying off waste water to be taken through an external wall of such building, and to discharge in the open air over a channel leading to a trapped gully grating at least 18in. distant.

Slopsinks to be as Water-Closets.—He shall, as regards the mode of construction of the waste-pipe from any slopsink constructed or adapted to be used for receiving within such building any solid or liquid filth, comply in all respects with such of the provisions of this by-law as are applicable to the soil-pipe from a water-closet.

With respect to Water-Closets, Earth-Closets, Privies, Ashpits, and Cesspools in connection with Buildings.

67. *Water-Closets or Earth-Closets in Buildings.*—Every person who shall construct a water-closet or earth-closet in a building shall construct such water-closet or earth-closet in such a position that one of its sides at the least shall be an external wall.

68. *Water-Closets to have a Window opening directly into Open Air.*—Every person who shall construct a water-closet or earth-closet in connection with a building, whether the situation of such water-closet or earth-closet be or be not within such building, shall construct in one of the walls of such water-closet or earth-closet a window of not less dimensions than 2ft. by 1ft., exclusive of the frame, and opening directly into the external air.

Air-Brick or Air-Shaft in Water-Closets, etc.—He shall, in addition to such window, cause such water-closet or earth-closet to be provided with adequate means of constant ventilation by at least one air-brick built in an external wall of such water-closet or earth-closet, or by an air-shaft, or by some other effectual method or appliance.

69. *Water-Closets.*—Every person who shall construct a water-closet in connection with a building shall furnish such water-closet with a separate cistern, or flushing box of adequate capacity, which shall be so constructed, fitted, and placed as to admit of the supply of water for use in such water-closet without any direct connection between any service pipe upon the premises

and any part of the apparatus of such water-closet, other than such cistern or flushing box.

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

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

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

He shall not construct or fix in or in connection with the water-closet apparatus any trap of the kind known as a "D trap."

70. *Earth-Closets.*—Every person who shall construct an earth-closet in connection with a building shall furnish such earth-closet with a reservoir or receptacle, of suitable construction and of adequate capacity, for dry earth or other deodorising substance, and he shall construct and fix such reservoir or receptacle in such a manner and in such a position as to admit of ready access to such reservoir or receptacle for the purpose of depositing therein the necessary supply of dry earth or other deodorising substance.

He shall construct or fix in connection with such reservoir or receptacle suitable means or apparatus for the frequent and effectual application of a sufficient quantity of dry earth or other deodorising substance to any filth which may from time to time be deposited in any pan, pit, or other receptacle for filth constructed, fitted, or used in or in connection with such earth-closet.

71. Every person who shall construct an earth-closet in connection with a building, and shall provide in or in connection with such earth-closet a fixed receptacle for filth, shall construct or fix such receptacle in such a manner and in such a position as to admit of the frequent and effectual application of a sufficient quantity of dry earth or other deodorising substance to any filth which may from time to time be deposited in such receptacle, and in such a manner and in such a position as to admit of ready access to such receptacle for the purpose of removing the contents thereof.

He shall not construct such receptacle of a capacity greater than may be sufficient to contain such filth and dry earth or other deodorising substance as may be deposited therein during a period not exceeding three months, or in any case of a capacity exceeding 40 cubic feet.

He shall construct such receptacle of such material or materials, and in such a manner, as to prevent any absorption by any part of such receptacle of any filth deposited therein, or any escape, by leakage or otherwise, of any part of the contents of such receptacle.

He shall construct or fix such receptacle so that the bottom or floor thereof shall be at least 3in. above the level of the surface of the ground immediately adjoining the earth-closet, and so that the contents of such receptacle may not at any time be exposed to any rainfall or to the drainage of any waste water or liquid refuse from any adjoining premises.

72. Every person who shall construct an earth-closet in connection with a building, and shall provide in or in connection with such earth-closet a movable receptacle for filth, shall construct such earth-closet so that the position and mode of fitting of such receptacle may admit of the frequent and effectual application of a sufficient quantity of dry earth or other deodorising substance to any filth which may from time to time be deposited in such receptacle, and may also admit of ready access to that part of the earth-closet in which such receptacle may be placed or fitted, and of the convenient removal of such receptacle or of the contents thereof.

He shall also construct such earth-closet so that the contents of such receptacle may not at any time be exposed to any rainfall or to the drainage of any waste water, or liquid refuse from any adjoining premises.

73. *Privies.*—Every person who shall construct a privy in connection with a building shall construct such privy at the distance of 6ft. at the least from the dwelling-house or public building, or any building in which any person may be or may be intended to be employed in any manufacture, trade, or business.

74. A person who shall construct a privy in connection with a building shall not construct such privy within the distance of 40ft. from any well, spring, or stream of water used or likely to be used by man for drinking or domestic purposes, or for manufacturing drinks for the use of man, or otherwise in such a position as to render any such water liable to pollution.

75. Every person who shall construct a privy in connection with a building shall construct such privy in such a manner and in such a position as to afford ready

means of access to such privy, for the purpose of cleansing such privy and of removing filth therefrom, and in such a manner and in such a position as to admit of all filth being removed from such privy, and from the premises to which such privy may belong, without being carried through any dwelling-house or public building, or any building in which any person may be or may be intended to be employed in any manufacture, trade, or business.

76. Every person who shall construct a privy in connection with a building shall provide such privy with a sufficient opening for ventilation, as near to the top as practicable, and communicating directly with the external air.

He shall cause the floor of such privy to be flagged or paved with hard tiles or other non-absorbent material, and he shall construct such floor so that it shall be in every part thereof at a height of not less than 6in. above the level of the surface of the ground adjoining such privy, and so that such floor shall have a fall or inclination towards the door of such privy of in. to the foot.

77. Every person who shall construct a privy in connection with a building, and shall construct such privy for use in combination with a movable receptacle for filth, shall construct over the whole area of the space immediately beneath the seat of such privy a flagged or asphalted floor, at a height of not less than 3in. above the level of the surface of the ground adjoining such privy; and he shall cause the whole extent of each side of such space between the floor and the seat to be constructed of flagging, slate, or good brickwork, at least 9in. thick, and rendered in good cement or asphalted.

He shall construct the seat of such privy, the aperture in such seat, and the space beneath such seat, of such dimensions as to admit of a movable receptacle for filth of a capacity not exceeding two cubic feet being placed and fitted beneath such seat in such a manner and in such a position as may effectually prevent the deposit upon the floor or sides of the space beneath such seat or elsewhere than in such receptacle of any filth which may from time to time fall or be cast through the aperture in such seat.

He shall construct the seat of such privy so that the whole of such seat or a sufficient part thereof, may be readily removed or adjusted in such a manner as to afford adequate access to the space beneath such seat for the purpose of cleansing such space or of removing therefrom or placing and fitting therein the appropriate receptacle for filth.

78. Every person who shall construct a privy in connection with a building, and shall construct such privy for use in combination with a fixed receptacle for filth, shall construct or fix in or in connection with such privy suitable means or apparatus for the frequent and effectual application of ashes, dust, or dry refuse to any filth which may from time to time be deposited in such receptacle.

He shall construct such receptacle so that the contents thereof may not at any time be exposed to any rainfall or the drainage of any waste water or liquid refuse from any adjoining premises.

He shall construct such receptacle of such material or materials, and in such a manner as to prevent any absorption by any part of such receptacle of any filth deposited therein or any escape, by leakage or otherwise, of any part of the contents of such receptacle.

He shall construct such receptacle so that the bottom or floor thereof shall be in every part at least 3in. above the level of the surface of the ground adjoining such receptacle.

He shall not in any case construct such receptacle of a capacity exceeding eight cubic feet.

He shall construct the seat of such privy so that the whole of such seat, or a sufficient part thereof, may be readily removed or adjusted in such a manner as to afford adequate access to such receptacle for the purpose of removing the contents thereof, and of cleansing such receptacle, or shall otherwise provide in or in connection with such privy adequate means of access to such receptacle for the purpose aforesaid.

79. *Space under Privy Seats not to Communicate with any Drain.*—A person who shall construct a privy in connection with a building shall not cause or suffer any part of the space under the seat of such privy, or any part of any receptacle for filth in or in connection with such privy, to communicate with any drain.

80. *Ashpits.*—Every person who shall construct an ashpit in connection with a building, shall construct such ashpit at a distance of 6ft. at the least from a dwelling-house or public building, or any building in which any person may be or may be intended to be employed in any manufacture, trade, or business.

81. A person who shall construct an ashpit in connection with a building shall not construct such ashpit within the distance of 30ft. from any well, spring, or stream of water used or likely to be used by man for drinking or domestic purposes, or for manufacturing drinks for the use of man, or otherwise in such a position as to render any such water liable to pollution.

82. Every person who shall construct an ashpit in connection with a building shall construct such ashpit in such a manner and in such a position as to afford a ready means of access to such ashpit for the purpose of cleansing such ashpit, and of removing the contents thereof, and, so far as may be practicable, in such a manner and in such a position as to admit of the contents of such ashpit being removed therefrom, and from the premises to which such ashpit may belong, without being carried through any dwelling-house or public building, or any building in which any person may be or may be intended to be employed in any manufacture, trade, or business.

83. Every person who shall construct an ashpit in connection with a building shall construct such ashpit of a capacity not exceeding in any case six cubic feet, or of such less capacity as may be sufficient to contain all dust, ashes, rubbish, and dry refuse which may accumulate during a period not exceeding one week upon the premises to which such ashpit may belong.

84. Every person who shall construct an ashpit in connection with a building shall construct such ashpit of flagging, or of slate, or of good brickwork, at least 9in. thick, and rendered inside with good cement or properly asphalted.

He shall construct such ashpit so that the floor thereof shall be at a height of not less than 3in. above the surface of the ground adjoining such ashpit, and he shall cause such floor to be properly flagged or asphalted.

He shall cause such ashpit to be properly roofed over and ventilated, and to be furnished with a suitable door in such a position and so constructed and fitted as to admit of the convenient removal of the contents of such ashpit, and to admit of being securely closed and fastened for the effectual prevention of the escape of any of the contents of such ashpit.

85. A person who shall construct an ashpit in connection with a building shall not cause or suffer any part of such ashpit to communicate with any drain.

Cesspools.

86. *Proximity of Cesspools to Buildings.* — Every person who shall construct a cesspool in connection with a building shall construct such cesspool at a distance of 50ft. at the least from a dwelling-house or public building, or any building in which any person may be or may be intended to be employed in any manufacture, trade, or business.

87. *Proximity of Cesspools to Water Supply.* — A person who shall construct a cesspool in connection with a building shall not construct such cesspool within the distance of 60ft. from any well, spring, or stream of water used or likely to be used by man for drinking or domestic purposes, or for manufacturing drinks for the use of man, or otherwise in such a position as to render any such water liable to pollution.

88. *Position of Cesspools to allow Removals of Contents therefrom.*—Every person who shall construct a cesspool in connection with a building shall construct such cesspool in such a manner and in such a position as to afford ready means of access to such cesspool for the purpose of cleansing such cesspool, and of removing the contents thereof, and in such a manner and in such a position as to admit of the contents of such cesspool being removed therefrom, and from the premises to which such cesspool may belong, without being carried through any dwelling-house or public

building, or any building in which any person may be or may be intended to be employed in any manufacture, trade, or business.

Cesspools not to Communicate with Sewers. — He shall not in any case construct such cesspool so that it shall have, by drain or otherwise, any outlet into or means of communication with any sewer.

89. *Construction of Cesspools.* — Every person who shall construct a cesspool in connection with a building shall construct such cesspool of good brickwork in cement properly rendered inside with cement, and with a backing of at least 9in. of well-puddled clay around and beneath such brickwork.

He shall also cause such cesspool to be arched or otherwise properly covered over, and be provided with adequate means of ventilation.

As to the giving of notices, deposit of plans and sections by persons intending to construct buildings; as to inspection by the Sanitary Authority; and as to the power of such Authority to remove, alter, or pull down any work begun or done in contravention of the by-laws.

Notice and Plan required before Erecting a Building. Every person who shall intend to erect a building shall give to the Local Board notice in writing of such intention, which shall be delivered or sent to their clerk at his or their office, or to their surveyor at his or their office, and shall at the same time deliver or send, or cause to be delivered or sent, to their clerk at his or their office, or to their surveyor at his or their office, complete plans and sections of every floor of such intended building, which shall be drawn to a scale of not less than 1in. to every 8ft., and shall show the position, form, and dimensions of the several parts of such building, and of every water-closet, earth-closet, privy, ashpit, cesspool, well, and all other appurtenances.

Such person shall at the same time deliver or send, or cause to be delivered or sent, to the clerk to the Local Board at his or their office, or to their surveyor at his or their office, a description in writing of the materials of which it is intended that such building shall be constructed, and of the intended mode of drainage and means of water supply.

Such person shall at the same time deliver or send, or cause to be delivered or sent, to the clerk to the Local Board at his or their office, or to their surveyor at his or their office, a block plan of such building, which shall be drawn to a scale of not less than 1in. to every 44ft., and shall show the position of the buildings and appurtenances of the properties immediately adjoining, the width and level of the street in front, and of the street, if any, at the rear of such building, the level of the lowest floor of such building, and of any yard or ground belonging thereto.

Such person shall likewise show on such plan the intended lines of drainage of such building, and the intended size, depth, and inclination of each drain, and the details of the arrangement proposed to be adopted for the ventilation of the drains.

Notice before Commencement of New Street or Building, and before Covering up Drains and Foundations.—Every person who shall intend to lay out or construct a street, or to erect a building, or otherwise to execute any work to which any of the by-laws relating to new streets and buildings may apply, shall *before beginning to lay out or construct such street*, or *to erect such building*, or to execute such work, deliver or send, or cause to be delivered or sent to the surveyor of the Local Board at his or their office notice in writing, in which shall be specified the date on which such person will begin to lay out or construct such street, or to erect such building, or to execute such work.

Such person shall, also *before proceeding to cover up any sewer or drain, or any foundation of a building,* deliver or send, or cause to be delivered or sent to the surveyor of the Local Board at his or their office notice in writing in which shall be specified the date on which such person will proceed to cover up such sewer, drain, or foundation.

If such person neglect or refuse to deliver or send any such notice, or to cause any such notice to be delivered or sent to such surveyor, and if such surveyor, on inspecting any work in connection with such street or building, or such other work as aforesaid, finds that such work is so far advanced that he cannot ascertain whether anything required by any by-law relating to new streets or buildings has been done contrary to such by-law, or whether anything required by such by-law to be done has been omitted to be done, and if, within a reasonable time after such survey or inspection, such person shall, by notice in writing under the hand of such surveyor, be required within a reasonable time which shall be specified in such notice, to cause so much of such work as prevents such surveyor from ascertaining whether anything has been done or omitted to be done as aforesaid, to be cut into, laid open, or pulled down to a sufficient extent to enable such surveyor to ascertain whether anything has been done or omitted to be done as aforesaid, such person shall within the time specified in such notice cause such work to be so cut into, laid open, or pulled down.

As to Works Executed in Contravention of By-laws.—In every case: where a person who shall lay out or construct a street, or shall erect a building, or shall execute any other work to which the by-laws relating to new streets and buildings may apply, shall, at any reasonable time during the progress or after the completion of the laying out or construction of such street, or the erection of such building, or the execution of such work, receive from the surveyor of the Local Board notice in writing specifying any matters in respect of which the laying-out or construction of such street, the erection of such building, or the execution of such work may be in contravention of any by-law relating to new streets or buildings, and requiring such person within a reasonable time, which shall be specified in such notice, to cause anything done contrary to any such by-law to be amended, or to do anything which by any such by-law may be required to be done but which has been omitted to be done:

Such person shall, within the time specified in such notice, comply with the several requirements thereof so far as such requirements relate to matters in respect of which the laying-out or construction of such street, the erection of such building, or the execution of such work may be in contravention of any such by-law.

Such person within a reasonable time after the completion of any work which may have been executed in accordance with any such requirement, shall deliver or send, or cause to be delivered or sent to the surveyor of the Local Board at his or their office notice in writing of the completion of such work, and shall, at all reasonable times within a period of seven days after such notice shall have been so delivered or sent, afford such surveyor free access to such work for the purpose of inspection.

Surveyor or Sanitary Authority to be Permitted to Inspect Streets, Buildings, and Works.—Every person who shall lay out or construct a street, or shall erect a building, or shall execute any other work to which any of the by-laws relating to new streets and buildings shall apply, shall, at all reasonable times, during the laying-out or construction of such street, or the erection of such building, or the execution of such work, afford the surveyor of the local board free access to such street, building, or work for the purpose of inspection.

Notice to Surveyor on Completion of Building.—Every person who shall erect a building shall, within a reasonable time after the completion of the erection of such building, deliver or send, or cause to be delivered or sent, to the surveyor of the Local Board, at his or their office, notice in writing of the completion of the erection of such building, and shall, at all reasonable times within a period of seven days after such notice shall have been so delivered or sent, and before such building shall be occupied, afford such surveyor free access to every part of such building for the purpose of inspection.

Penalty for Breach of By-laws.—Every person who shall offend against any of the foregoing by-laws shall be liable for every such offence to a penalty of £5, and in the case of a continuing offence to a further penalty of £1 for each day after written notice of the offence from the Local Board.

Provided nevertheless that the Justices or Court before whom any complaint may be made, or any proceedings may be taken in respect of any such offence, may, if they think fit, adjudge the payment as a penalty of any sum less than the full amount of the penalty imposed by this by-law.

Removal, etc., of Work Done in Contravention of By-laws.—If any work to which any of the by-laws relating to new streets and buildings may apply be begun or done in contravention of any such by-law, the person by whom such work shall be so begun or done, by a notice in writing, which shall be signed by the clerk to the Local Board, and shall be duly served upon or delivered to such person, shall be required on or before such day as shall be specified in such notice by a statement in writing under his hand or under the hand of an agent duly authorised in that behalf, and addressed to and duly served upon the Local Board, to show sufficient cause why such work shall not be removed, altered, or pulled down; or shall be required on such day and at such time and place as shall be specified in such notice to attend personally or by an agent duly authorised in that behalf before the Local Board and show sufficient cause why such work shall not be removed, altered, or pulled down.

If such person shall fail to show sufficient cause why such work shall not be removed, altered, or pulled down, the Local Board shall be empowered, subject to any statutory provision in that behalf, to remove, alter, or pull down such work.

APPENDIX.

SPECIMEN CODE OF REGULATIONS REFERRED TO ON PAGE 239.

Local Government Act, 1894, 56 *and* 57 *Vict.*, *c.* 73.
Public Health Act, 1875, 38 *and* 39 *Vict.*, *c.* 55, *Sec.* 21.

The .... District Council for the............... District of .... in the County of.....................

Regulations made and ordained by the said............ District Council as to the giving of notice before any drains are made to communicate with the sewers of the said .... District Council: regulating the mode in which such communications are to be made, and appointing the person under whose superintendence such communication is to be made.

1. No communication shall be made with any sewer belonging to the said .... District Council, nor any drain made to empty therein unless notice of an intention so to do, signed by the owner or occupier of the .... premises to which such drains belong, be left at the office of the Council's surveyor at least two days previously, and such notice must be upon the printed form only, and which is provided by the Council, and must specify the point at which it is desired that communication may be made, the time at which it is proposed the work shall be commenced, and the name and address of the contractor who is to execute the work; and any person not complying with these regulations will be liable to a penalty not exceeding twenty pounds, and the said Council may close any communication between a drain and sewer made in contravention of this section, and may recover in a summary manner from the person so offending any expenses incurred by them in so doing.

2. Work required to be done in connecting any house drain or drains with the sewer shall be executed in the following manner, and the materials shall be of the quality and dimensions hereinafter described.

The flags, setts, metal, macadam, or other surface materials, together with the materials forming the foundation therefor, shall be carefully removed with as little damage and loss as possible, and shall be carefully preserved for re-instatement in their proper positions.

The ground to be excavated to the required depth with all possible expedition. The work to proceed by night and day, if in the opinion of the surveyor the circumstances should so warrant, and there shall be maintained during the progress of the work all such fencings, hoardings, struttings, and shorings as may be necessary for or in consequence of any of the works for the due protection of the public and traffic, and of all buildings and property whatever near to or liable to be affected by the work, which shall also be well watched and lighted.

The shoring and strutting of the excavation is to be done in such manner with poling boards, waling pieces, struts, and stretchers, as the surveyor shall consider necessary, and all pipes of whatever character crossing the excavation shall be properly slung and supported and maintained at the risk of the person making the excavation.

The excavation shall only be got out at a width sufficient for the purposes of the work, and all surplus earth is to be carted away as speedily as possible. In all cases where practicable, the excavation shall be in open cutting, no tunnelling to be undertaken without the written permission of the surveyor.

All materials of whatever kind found in the excavation belong to and shall remain the sole property of the Council, and may be disposed of as the surveyor shall determine.

The junction with the main sewer to be done in the following manner:

The drain shall in no case be less than 4in. internal diameter, and shall be constructed of .... (here specify the quality of pipe to be used, whether ordinary or a proprietary article, and the method of making the joints), with a uniform fall of 1 in ...., well bedded on well-rammed and solid ground, the sockets being sunk into it so as to give an even bearing. Wherever in the opinion of the surveyor it is necessary, the pipes must be laid on a foundation of properly prepared and mixed Portland cement concrete. No vertical shafts or sudden falls will be allowed.

Where the junction is with a sewer of pipes, one length thereof (or more if necessary) shall be removed, and an oblique, proper glazed, socket junction pipe, jointed as required, inserted in its place. If in the opinion of the surveyor the circumstances make it desirable, the connection may be made by carefully cutting a hole in the sewer pipe, and the insertion of a suitably curved flanged connecting saddle and socketed collar, which must be set and pointed with Portland cement.

When the junction is with a brick sewer, the connection shall be made at such height above the invert as the surveyor shall determine, and be made with a glazed socket pipe set obliquely in line of flow of main sewer and properly bedded in cement mortar, cut off to the curvature of the sewer walls and flush with the face so as to offer no obstruction to the proper flow of sewage therein, or with a properly constructed purpose-made glazed fireclay or stoneware junction block set in the same manner.

On completion of the junction, which shall be made before any of the pipe drain is laid, it shall be inspected by the surveyor, and the work must not be further proceeded with until such inspection has been made, and the junction pronounced satisfactory.

A properly constructed intercepting trap of approved pattern shall be placed upon the line of drain between the house and the public sewer, with a suitable ventilating pipe or opening to the drain on the house side of such trap. The capacity of this ventilating pipe or shaft to be equal to the sectional area of the drain, and to be fixed in such position and completed in such manner as the surveyor may direct.

The excavation is to be filled in within .... inches of the surface of the ground with layers of earth not more than 6in. in thickness, carefully rammed or punned with iron rammers or punners of not less weight than 10lb. The finest material to be closely packed round the sides of the pipes, and no clay to be brought within .... inches of the surface. The remainder of the trench to be refilled with sound furnace ashes, and maintained in good order until such time as in the opinion of the surveyor the refilling shall have become sufficiently consolidated.

The restoration of the surfaces and foundations will in all cases be undertaken by the Council, and a deposit must be made with them to cover the costs thereof at the following rates per square yard:

	Per sq. yd. s.	d.
For macadam roadways	1	0
,, pavements with gravel racked joints	1	0
,, pavements with joints grouted with asphalte or cement	2	0
,, wood or asphalte pavements	12	6
,, stone or pitched foundations, extra per square yard	1	0
,, concrete foundations 6in. thick, extra	3	0
,, ,, ,, 9in. thick, extra	5	0

The Council shall not be held responsible for any accident that may occur, and no charge whatever will be incurred by them in respect of accidents occurring in consequence of neglect of these regulations or otherwise.

3. A, B, C, the present surveyor to the Council and his successors in office, or the person for the time being acting as or discharging the duties of surveyor to the Council, are hereby appointed as the person or persons to superintend the making of such communications with the public sewers as aforesaid.

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