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OF

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THE DRAINAGE

OF

HABITABLE BUILDINGS.

BY

W. LEE BEARDMORE,

ASSOCIATE MEMBER OF THE INSTITUTION OF C.E. ; MEMBER OF COUNCIL AND HON. SEC. CIVIL AND MECHANICAL ENGINEERS' SOCIETY, ETC.

BEING A REPRINT AND REVISION OF A SERIES OF ARTICLES WHICH APPEARED IN THE PAGES OF 'THE PLUMBER AND DECORATOR, AND JOURNAL OF GAS AND SANITARY ENGINEERING.'

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PREFACE.

In the early part of the year 1881, I was employed to write for the *Plumber and Decorator, and Journal of Gas and Sanitary Engineering,* a series of articles which now comprise this work; and in writing upon such a subject as Habitable Buildings, I elected to touch, but briefly, upon what has been done in such an insanitary manner in the past, and to point out mainly what should be done to render a dwelling thoroughly sanitary as regards its drainage arrangements. The title therefore of *The Drainage of Habitable Buildings* suggested itself to me as an appropriate one.

It is a great question if there is any necessity at all for a preface to such a book, but I beg to take the liberty with my readers of opening this edition with a few words of a prefatory nature.

For many years past I have made a special and particular study of the Science of House Drainage, and that fact being known was the reason of my being employed to write this work for the above Journal, in the pages of which it appeared.

It is probable that I should never have taken up this subject as a specialist had it not been that I was employed as an assistant to Mr. E. F. Griffith, Associate Member Institution C.E. (so well known in connection with his work at Oxford), who at one time was manager to that eminent sanitarian Mr. Rogers Field, M.A., Member Institution C.E.

My obligations are great to certain gentlemen at the Natural History Museum (British Museum), South Kensington, S.W., for their kind assistance, but this has been acknowledged in one of the chapters of the book.

Some critical readers may maintain that I have neither gone sufficiently deep into the theory, nor into the practice, but I trust that, at the same time, it will be said that I have made a hearty endeavour to place before the public what should be done in order to have a truly habitable building.

I beg to acknowledge the kindness and courtesy of Messrs. Dale, Reynolds & Co., the proprietors of the above Journal, and of the present publishers, Messrs. Whittaker & Co. of Paternoster Square, and to claim the indulgence of the many critics that I trust will read this book.

W. LEE BEARDMORE,
ASSOC. M. INST. C.E.

7, LITTLE QUEEN ST.,
GREAT GEORGE ST., WESTMINSTER, S.W.
December 1891.

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THE DRAINAGE

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CHAPTER I.

INTRODUCTORY.

The Air we breathe—How and why we do breathe such Air—How the Blood is cleansed by good Atmosphere—Those Gases generated in sewers, &c. which we should not breathe—The Danger arising from breathing such Gases—The necessity of preventing such Gases and Germs or Bacilli entering our Dwellings.

THIS question is one of the greatest import. Although some few years ago it commanded but little consideration, its vital consequence is now fully recognized. As the inward man cannot be judged by the outward coat he wears, the visible exterior or interior of a dwelling cannot be a criterion of its healthy condition. The disclosures so constantly made in both palace and cottage on the investigation of their drainage arrangements tend to prove this. Not many years ago a nation was anxiously watching round the bed of a prince afflicted with a dangerous illness, caused by the poisonous effects of sewer gas;—a few years later a princess was struck down with serious blood-poisoning, supposed to be the result of defective drainage, and since then how many princes and people, peers and peasants, have suffered in a greater or less degree from similar causes? Can we wonder that this subject of house drainage receives the prominence it does in the minds of both professional men and the intelligent public generally? How many diseases such as diphtheria, typhoid, scarlet, and other fevers, cholera pestifera, &c., if not actually created are provoked and aggravated by inefficient house drainage? Many people appear to be expecting a visit from the last-mentioned terrible scourge, and perhaps the words on house drainage, &c., referring to this malady, of the late eminent author of *Two Years Ago* (whose novels were always written with some good object in view), may be here appropriately quoted—"It is hard," he writes, "to human nature to make all the humiliating confessions which must precede sanitary repentance; to say—I have been a very nasty, dirty fellow. I have lived contented in evil smells, till I care for them no more than my pig does. I have refused to understand Nature's broadest hints, that anything which is so disagreeable is not meant to be left about. I have probably been more or less the cause of half my own illnesses, and of three-fourths of the illness of my children; for aught I know it is very much my fault that my own baby has died of scarlatina, and two or three of my tenants of typhus. No, hang it! that's too much to make a man confess to! I'll prove my innocence by not reforming! So sanitary reform is thrust out of sight, simply because its necessity is too humiliating to the pride of all, too frightful to the consciences of many."

Before proceeding to the technical portion of our subject it may be advantageous to consider cursorily the reason why it is unhealthy to breathe the gases arising from sewers and drains, but it is not proposed to do so from a medical point of view, but merely in a popular manner.

In order to do this, let us observe what composes the atmosphere we should breathe.

The globe is enveloped in an atmospheric sea, indispensable to life, which is known to be at least forty-five miles in depth. This atmosphere is a mixture of different matters, each fulfilling to the life of both animals and vegetables a marvellous, awe-inspiring, and beautiful office. Oxygen, nitrogen, carbonic acid, and watery vapour are known at least to be its components, the two former almost constituting its whole bulk, whilst the carbonic acid and watery vapour exist but in small quantities.

Oxygen is a gas with neither colour, taste, nor smell, and gives to animals breathing it increase of enjoyment, their circulation being quickened, producing finally a state of fever. When combustion takes place in this gas, the process is greatly accelerated.

Nitrogen is also a gas without colour, taste, or smell, but is almost opposite in its action to oxygen, animals no longer breathing, and burning objects being immediately extinguished, when placed in it.

Carbonic acid is a gas which is slightly odorous, and has a sharp, sour, and acid taste, but no colour; as in the case of nitrogen, animals cease to breathe, and burning bodies are extinguished, when introduced into it.

The watery vapour is a result of evaporation which takes place.

These four substances are always to be found in the atmosphere, and are necessary to life, although it is customary in speaking of dry air, to say that it only consists of nitrogen and oxygen, and when the watery vapour and carbonic acid, &c., are absent, the proportions of the two former gases in one hundred parts is seventy-nine of nitrogen to twenty-one of oxygen.

Having deliberated somewhat on the atmosphere we should breathe, let us glance at how and why we do breathe it.

The heart is situated in our bodies between our two lungs, and is a muscular organ consisting of four chambers, the two in the upper portion being termed auricles and the two in the lower ventricles.

Roughly viewed, there are two classes of circulation of the blood, the one being the "pulmonic," by which, as implied by the name, the blood is circulated to the lungs and back to the heart; the other being the "systemic," by which the blood is conveyed all over our systems.

By the muscular contraction of the left auricle the blood is driven to the left ventricle, and by a similar action of the left ventricle, to the extremities of our bodies by the arteries; then, the blood, having become impure and charged with carbonic acid, is returned by the capillaries and veins to the right auricle, and thence by muscular contraction to the right ventricle; this, in its turn, forces our life fluid to the lungs, where, after purification by the oxygen we inhale, it is returned to the left auricle, to be once more circulated over the system, to perform its offices in a properly cleansed condition.

But although the greater portion of respiration takes place in the lungs, yet it also does so in a less degree through the outer skin or cuticle by the pores in it.

Thus the oxygen we breathe is carried along by our blood, and, combining with the carbon and hydrogen of our fat, ultimately is exhaled in the forms of watery vapour and carbonic acid, and the waste tissues and matter of our system being oxidized, pass off with the fluid excretions of our skin and organs in the form of urea and uric acid, &c.

Therefore, of all the constituents of the atmosphere, oxygen is directly of the greatest importance to animal life, but the nitrogen is necessary to counteract the effects of the oxygen, which alone would give us but rapid life; without the watery vapour our skin would be dry and arid, and without the carbonic acid vegetable life could not exist.

Having slightly considered the atmosphere we should breathe, let us turn our attention to some of those gases we should not breathe, but which, nevertheless, Nature has ordained we shall have to contend with.

By the decomposition of animal and vegetable matter gases are generated, and the following are some which may be advantageously considered in connection with this subject.

Sulphuretted hydrogen is a highly poisonous gas; it has no colour, whilst its smell is of a most disagreeable, fœtid sulphury nature, and is of a sour and sulphureous taste.

Bi-carburetted hydrogen (olefiant gas) is a poisonous gas, being colourless, but of an unpleasant odour.

Carbonic acid gas has been already referred to. Light carburetted hydrogen (marsh gas) is a non-poisonous gas, and is without smell, taste, or colour.

Ammoniacal gas is also colourless, but, as is generally known, has a strong alkaline taste, and stinging smell.

Excreta and sewage matter generally give off all these gases when decomposing, which process takes place at different times in various climates, but in this country commences in about three or four days; excreta from a healthy person, although so offensive, being practically harmless when fresh. But when we consider that one gallon of sulphuretted hydrogen, mixed with one hundred gallons of air, will make a mixture poisonous enough to kill a dog, when we reflect that near the earth's surface in every five thousand gallons of air there are but two gallons of carbonic acid gas, and that if this proportion were much increased it would be injurious to the health of animals, can we wonder that the endeavours to avoid such gases entering our houses have resulted in the important and necessary science of house drainage? When, owing to untrapped drains, leaky joints, broken and unconnected pipes, ill-ventilated soil pipes, &c., such gases escape into our dwellings, can our blood be properly cleansed, can we enjoy good health, when, instead of the normal atmosphere we should breathe, we inhale a mixture of pure air with such deadly gases as sulphuretted hydrogen and carbonic acid?

Does it not, therefore, behove us to retain, if possible, in an unvitiated condition, the natural atmosphere as given to us by our wise and all-provident God?

But, in referring to these gases, we must remember that besides differing in nature they vary also in weight; for instance, carbonic acid is heavier than oxygen, which is heavier than nitrogen, the two former being heavier than common air, whilst the latter is lighter. Thus a question I was once asked in connection with this subject of house drainage suggests itself, viz. How is it the heavier gases do not lie in distinct strata nearest the earth's surface?

It is a fact not generally known that a vast amount of the ventilation of our dwellings takes place actually through the brick walls of them; but it is only in some degree due to the natural winds and aerial currents that this takes place, for independent of these there is a grand law of Nature which governs the blending and intermixture of all gases. This law is known as the "Diffusion of Gases," and in conformity with it the heavier gases intermingle with the lighter, even through porous partitions. Thus the poisonous gases of decomposing sewage matter, if properly discharged into the atmosphere, are diffused with it to a harmless condition.

Graham, by various experiments, demonstrated the law that "the rates of diffusion of two gases into each other are in the inverse ratio of the square roots of their densities."

But, besides the danger of the poisonous gases generated by decaying refuse, there is also another to be faced wherever the house drains discharge into a main sewer.

Whether the cause or effect, it is, I believe, still a disputed question, but I think the medical faculty agree that minute germs or bacilli, capable of transmitting disease, emanate from the fæces of patients suffering from zymotic disorders.

Therefore, if the evacuations of such patients pass into the main sewer, is there not a danger of such germs passing into any house drains that may be in direct open communication with the main sewer, thereby tending to spread disease?

In order, then, to prevent such germs and the gases generated in the main sewer, sewage meter tank, irrigation tanks, or cesspools, &c., from entering the house drains, a trap of syphon shape, consisting of a water seal, has been devised in order to disconnect entirely the house drains from the main sewer, &c. With this disconnection I shall open my next article.

CHAPTER II.

THE DISCONNECTING MANHOLE.

The Stoneware Syphon Trap—American Practice—Argument in favour of a "Disconnecting" Trap, and with regard to the Danger of Gases from the Main Sewer entering the House—Introduction of Fresh Air through the House Drain for the purpose of Oxidizing any Foul Gases that may be generated—The Stoneware Syphon Trap—Demonstration of the Principle of same—Liability of the Syphon Trap to choke, and arrangement for its Examination—Chamber known as the Disconnecting Manhole—Method of discharging Branch Drains into Main House Drain—White Glazed Faced Bricks should form the Brickwork inside the Manhole—Syphon Traps sometimes of too large Diameter—The same consequently never Scoured thoroughly.

In England, all those Civil Engineers who have made House Drainage their especial study, and all those who have given serious attention to sanitary work, agree, I think, that whether discharging into a main sewer, sewage meter tank, irrigation tanks, or cesspool, &c., the house drain should be disconnected from them in such a way that the gases generated in them shall not be diffused with those of the latter, and they further, I believe, concur in the opinion that the proper and most suitable form of trap for this purpose is that known as the "Stoneware Syphon Trap."

In America, however, this view does not appear to have gained such universal approval; for in some recent articles on house drainage by Mr. George E. Waring, junr. (who by his writing shows the great attention he has given to this subject, and his vast knowledge of it), this "disconnection is not advocated."

He contends that "the trap itself, unless the course of the drain is very steep, and its flushing very copious," may "form a seat of decomposing filth," and will also "set back the flow," thereby causing a "deposit of foul material for some distance along the house-side of the drain;"—but if the suitable form of trap is employed, viz. the "Glazed Stoneware Syphon Trap," and is properly arranged, and if the drains are laid with a proper fall, I think there can be little chance of danger arising from the employment of such a trap, and my opinion is most positive that its use is highly necessary and advantageous.

Again, he states that "if the sewer is not extremely offensive, there will be less stench coming from a current of air flowing from the sewer without a trap, than will be developed in the house drain itself with a trap. The absence of the trap will secure a pretty constant and effective current of air from the sewer through to the top of the soil pipe. Without the trap a sufficient current can be established by the use of a well-placed fresh air inlet."

But is not the presence of a trap required especially to prevent any current of air from the sewer passing through the house drain and up the soil pipe to the outlet at the top? Again, it is true that a sufficient current can be established without a trap by the use of a well-placed fresh air inlet, but let us look at what the nature of such a current will be.

When a current of gases is established in a channel, there is a tendency to create a vacuum at the point at which the current arises, and all gases about that point rush to it in consequence. Therefore, if there is no disconnecting trap, the gases of the main sewer, or whatever be used, will be in direct communication with those of the house drain, and when a current is caused in this drain by a fresh air inlet, in the absence of a disconnecting trap, not only will fresh air pass up the house drain, but the gases generated in the main sewer or what not, will do so also; thus the house drain will act as a ventilating shaft for the main sewer, or whatever receptacle it may discharge into. I fail entirely to see how "there can be less stench coming from a current of air flowing from the sewer without a trap," for no sewer is entirely inoffensive, and if the gases arising in it pass into the house drain owing to there being no disconnecting trap, it is obvious that there must be more stench caused by a current of such gases mingled with fresh air than there would be from fresh air alone passing from the external atmosphere into the house drain, &c., by the fresh air inlet; therefore, I consider it most necessary to disconnect the receptacle, into which the house drain discharges, from that drain, with such a trap as will entirely prevent the gases of the one diffusing into the gases of the other. A fresh air inlet should be placed near this trap on the house-side of it in connection with the house drain, in order that a current of air may be created throughout the house drain, soil pipe, and ventilating pipe to the outlet at the top, and that any offensive gases generated in the house drains, &c., may be intermingled with the fresh air current, or ventilated to the outlet to be diffused into the atmosphere, for the purpose of oxidization.

All those who read the introductory chapter to this series, will, I think, agree as to the necessity for, and importance of, such a trap as will completely sever the gases of the main sewer, &c., from the house drain.

Fig. 1 shows a "Stoneware Syphon Trap," which is tubular, and has a socket sometimes at one end, being similar to an ordinary stoneware drain pipe, bent to a syphon shape; this trap is also sometimes made with half

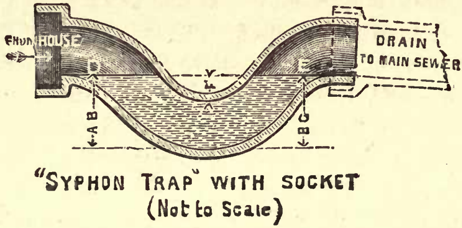

FIG. 1.

the socket of the above, and with a branch from the spigot end as shown by Fig. 2. Inasmuch that if a liquid is contained in a vessel its surface must be level, if water be poured in at the end D (Fig. 1), till the syphon is filled to the surface DE, that surface will be horizontal, and the

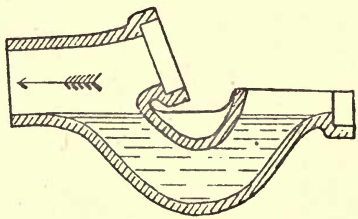

FIG. 2.

columns AB and BC will be in equilibrium; but if more water be poured in at D, the column AB will tend to increase in height, and become heavier, thereby equilibrium will no longer take place, and the column AB will tend to force BC upwards; then, by the force of gravity, the water at E will flow down the drain until the surface of water in the syphon columns again assumes the level DE, when equilibrium will again take place and the water will be at rest; thus, when water passes through the syphon a quantity always remains to fill it to the level DE. But if the syphon is always full to the level DE, then for all practical purposes the passage of the gases up the drain to E will be barred by the surface E, or in other words the trap is "sealed" by the water being to the level DE, and the amount of "seal" is measured by the distance F. But owing to the peculiar shape which the syphon trap is made to assume, there is necessarily considerable liability to its becoming choked, from time to time, and consequently it should be accessible so that a man can at any time clear and clean it thoroughly. For this purpose, it is usual to construct at the house end of the syphon trap a chamber not exceeding about three feet square, in nine inches thick brickwork, which is termed the disconnecting manhole; concrete should be laid in the bottom of this manhole, and a straight, open, glazed stoneware channel should be laid on and in this concrete, forming a butt joint with the house drain, and being bedded in cement on the socket of the syphon trap. It is better, if possible, to give this channel about an inch more fall than the house drain has, as thereby the sewage receives a greater impetus before entering the syphon trap, which is consequently better flushed.

The concrete should be brought some few inches above the channel on each side, and then "battered" off to the side of the manhole, the whole of the concrete should then be neatly rendered over with a smooth surface of cement with a float, "the cement being flush" with the internal face of the channel on each side.

The concrete should be made with good Portland cement, and it may be well to state here that it is advisable in all house drainage work to use this cement for the joints of brickwork and all stoneware pipes, &c. The manhole should be covered with an iron, air-tight cover (such as invented by Mr. A. T. Angell), and a stone carefully sealed down with cement.

Immediately adjoining the syphon trap, at that end farthest from the house, there should be a **Y** junction pipe, with its branch pointing to the manhole, and an inspection pipe should be fixed, accessible from the manhole and jointed with this branch. A stoneware inspection cap should be placed in the socket of the inspection pipe, and be carefully sealed down with Portland cement.

Thus at any time by the removal of this inspection cap the connecting drain between the syphon trap and main sewer, (or whatever be used,) can be cleared in the event of its becoming choked. For the purpose of clearing drains of any stoppage that may occur, a bundle of "Rods" is employed, each rod being of a convenient length to enter a drain from a manhole, and being fitted at each end with a screw joint, so that as each length is passed into the drain a fresh one can be attached to its end by the screw joint; various tools can be fixed to the first "rod," for the purpose of either pushing forward or raking back, &c., any matter that may be blocking the course of the drain. It will therefore be understood that the disconnecting manhole admits of the "house drain" being cleared from it in one direction, and the "connecting drain" and syphon trap in another, at least as far as the extent of the total number of "rods" when all joined together will admit, which reaches about one hundred feet. From a side wall of the manhole, a little above the concrete batter, and communicating with the inside of the manhole, a pipe of the same size as the house drain at

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least, should be carried up to a few feet above the surface, this terminating in a wall or chamber on which a vase or statue may be placed, in order that fresh air may pass into the manhole and thence up the "house drain," soil and ventilating pipes to the outlet at the top, thus ventilating the house drain.

The current of air up the house drain, &c. (when properly arranged) is nearly always found to be very considerable, but in the event of there being a down draught into the disconnecting manhole, then the pipe leading from the side wall of the manhole will be serviceable as an outlet to ventilate the manhole; it is therefore wise to conduct it to a point on the surface sufficiently apart from any approach to the building. Branch drains may be conveniently led into the disconnecting manhole, discharging through curved open glazed stoneware channels, into the straight, open channel, on either side of it, so that such drains may be cleared with as much ease as the house drain, should they become choked.

It is advisable to face the inside of the manhole, where the brickwork is exposed, with white glazed faced bricks (especially when the manhole is of considerable depth), for such bricks reflecting the light more efficiently than ordinary ones, enable the man when clearing the drains, &c., to see his work better.

Before leaving this subject of the disconnecting manhole, it may not be out of place to refer to a mistake that is sometimes made in the employment of a syphon trap of too large a diameter. I have known one of these traps used of a diameter of nine inches, the diameter of the "house drain" discharging into it being also nine inches; in this case the diameter of both drain and trap alike was too large, the consequence being that when a closet or sink was used, instead of the discharge coming down the drain as a good flush, to thoroughly scour out the syphon trap, it only trickled through the large drain (although there was a good fall), to little more than ooze into the syphon trap.

In this instance, even the flushing of a closet did not appear to be sufficient to change the contents of the trap, heavier matter being deposited in the lowest bend of the

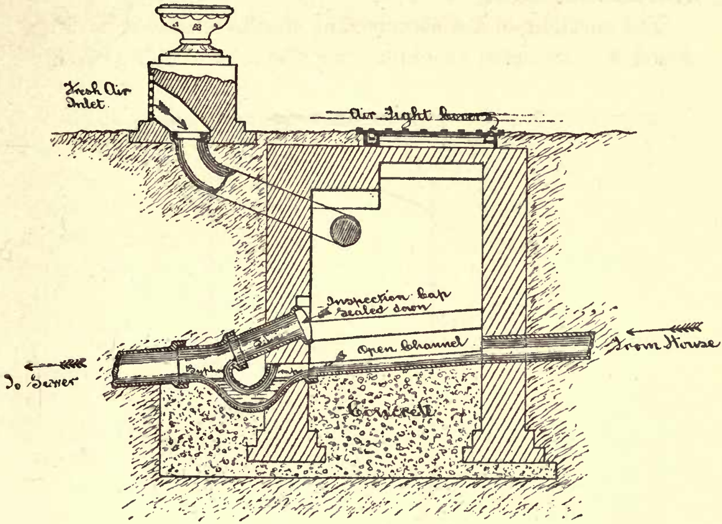

Fig. 3.

syphon, and a slight film collecting about the surface of the contents of the socket end of the syphon trap.

In my opinion it is rarely, if ever, (in house drainage work,) necessary to use a syphon trap of larger diameter than four inches; even if it be essential to employ a house drain of six inches diameter. I think a trap four inches in diameter will be found more advantageous when connected to the house drain by a reducing, (from six inches to four inches,) open glazed stoneware channel in the bottom of the manhole.

If there be a proper flush from the closets, through a properly laid drain, there will be little fear of the contents of a syphon trap of four inches diameter not being flushed out, and little chance of the trap forming a "seat of decomposing filth."

The sections of a disconnecting manhole, shown by Figs. 3 and 4, may assist in explaining the text of this article.

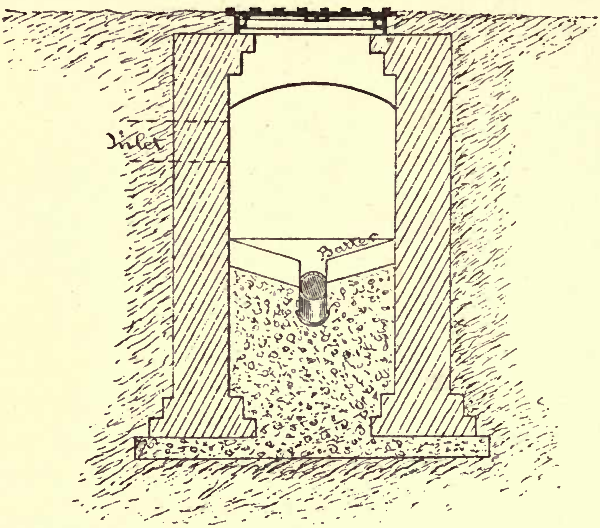

Fig. 4.

CHAPTER III.

THE MAIN HOUSE DRAIN, ETC.

The Distinction between the "Main House Drain" and the "Connecting Drain"—Position of the Disconnecting Manhole—Compulsory Position of the Disconnecting Manhole in the cases of Houses in Towns—The Objection to Excessive Fall—The Practice pursued in laying the House Drain and the Connecting Drain—The Laying of Drains generally to insure their being Self-Cleansing—Glazed Stoneware Drain Pipes—The Reduction of Friction in, and of Porosity of, Pipes by being Glazed—The "Stanford Joint," and the Joints of Glazed Stoneware Pipes—The Selection of such Pipes—The Danger of Cement being left in the Pipes—Drains should not be laid under the House—Coated Cast-Iron Pipes—The Employment of such Pipes gives a minimum of Joints—General Argument for use of Cast-Iron Pipes under House—The Geological Nature of Ground through which they may have to be laid—Concrete Bed, &c., for Drains—Glazed Stoneware Bend Pipe for reception of Soil Pipe—Such Bend Pipe should be accessible from a Manhole—Construction of such Manhole—Branch Drains—A Manhole to admit of Inspection of same—Change of Direction of the Line of Drains—The Turning Chamber—Test as to the proper laying of a Drain—The Enlargement of Syphon Trap at Spigot end—The Flap Trap—The Size of House Drains—Formula for calculating the Discharge through Drains—Drains should be Self-Cleansing.

ATTENTION must now be turned to the house drain, and although, of course, literally it is all "house drain," yet it will be easier to make a distinction between that part of the drain from the soil pipe foot to the disconnecting manhole, and the drain from the syphon trap to the main sewer, or whatever it may discharge into; therefore, hereafter the former part will be referred to as the "house drain," and the latter part as the "connecting drain."

The "disconnecting manhole" should be built, if possible, at a distance of—say, some seventy feet from the house; and I have known a good draught up the "house drain" and ventilating pipe when it has been situated about, or over, two hundred feet from the house; but, of course, this is too great a distance to admit of the "house drain" being efficiently cleaned by the "rods"; however, in the case of houses in towns drained on a main sewerage system, it is rarely possible to place the "disconnecting manhole" at a greater distance than a few feet from the house.

Now, as the main sewer is often as much as seventeen or twenty feet below the crown of the road, and often only some twenty or thirty feet from the house, the fall from the head of the drain to the main sewer is necessarily great, and objection to excessive fall is raised on the score that, the sewage flowing at a high velocity, there is a tendency for the solids to deposit and the fluids only to pass to the main sewer, &c.; again, the expense of deep excavations must be considered, where no advantage is gained by it, as all that is necessary is a proper and sufficient fall. It is therefore the practice to lay the "house drain" to a proper fall, (to which I shall refer hereafter,) and to lay the "connecting drain" at whatever fall may be left between the manhole and main sewer, provided such fall be not less than the minimum fall to which the drain in question should be laid. Of course there may be occasions when both "house drain" and "connecting drain" can be laid to the same fall, or when a sufficient fall cannot be obtained, and to this latter case I shall refer later on.

All drains should be laid perfectly straight from point to point, and when possible to a good and true and even fall, such that will ensure their being self-cleansing. When a drain is laid of four-inch pipes, it should have a fall of at least one in thirty, one of six-inch pipes should have a fall of at least one in forty, and one of nine-inch pipes should not have a less fall than one in sixty. But, of course, it is not always feasible to lay drains to these falls, and when such falls cannot be procured, recourse must be had to automatic flushing.

It is generally admitted now, I think, that in most cases the glazed stoneware drain pipes form the best and most efficient drains for house drainage, owing to the truth with which they can now be made, and the smooth surface the glazing presents to the sewage; the process of glazing reduces frictional resistance very materially, and, no doubt, greatly diminishes the otherwise porosity of the stoneware. These pipes are made with the ordinary socket and spigot, the joint being made with cement luting; there are also, I believe, various other patent joints employed with these pipes, notably amongst them being the "Stanford joint." This joint is formed by rings of durable material being moulded and cast on the socket and spigot of each pipe, which, when brought together, form a joint, and in addition to this the joint may be luted with cement. It is, however, my practice to use the ordinary socket and spigot pipes, with a Portland cement joint, which, if properly laid, gives satisfaction, and I believe, taken all round, to be the best class of pipes.

It must be the duty of the engineer, in selecting these pipes for use, to inspect and ascertain that they are straight, and of uniform and sufficient thickness, not over or under-fired in the kiln, so that they are not too brittle or too soft; that they are free from cracks, flaws, and blurs; that the spigot fits well and evenly in the socket;

that a good joint can be made, and that they are thoroughly glazed inside as well as outside. A good pipe should ring well when knocked. In laying these pipes, the greatest care must be taken that none of the cement is left inside the barrel of the drain, as thereby the danger is incurred of an accumulation of the solids of the sewage. If a piece of cement is left in the sewage channel, a small portion of solid matter may catch on it in passing down the drain, then more solid matter may catch on the first portion, and more again on the two deposits, and so on, till at length a very considerable obstacle may be presented to the flow of the sewage down the drain, perhaps, eventually, causing a complete block.

For the purpose of cleaning out any cement that may be left in the barrel of the drain, a tool should be made of a piece of wood cut to a chord of a circle rather smaller than the circle of the barrel of the drain, its versed sine being about one-third of the diameter of the barrel; this, having been secured to a handle about eighteen inches long, at right angles to the versed sine and chord, should have flannel or some similar material wrapped round it and secured; then, when each pipe is laid, the workman should pass the tool up the drain and wipe back any cement that may have been squeezed into the drain from the joint, when the socket was placed home over the spigot.

This removal of superfluous cement is very important, and is one of those things which, when proper superintendence of house drainage work is not employed (too often the case), can easily be neglected without detection, and which is, no doubt, very often left undone.

If possible to avoid it, no drains should be laid under the house, for should the pipes be faulty or have leaky joints, owing to " scamped " work, &c., the ground is apt to become saturated with the leaking sewage, converting the subsoil of the basement into little better than a cesspool with its consequent dangers. However, in town houses the laying of drains underneath the house is often unavoidable, and in such cases the use of cast-iron pipes coated inside and out with Dr. Angus Smith's paint, or some suitable preparation, for the prevention of rust and the eating away of the iron by acids, &c., is to be strongly recommended. It is indisputable that the more joints there are employed the greater must be the chance of leakage, &c., and as, by the employment of iron pipes, about seven joints less are used in every two nine-feet lengths of iron piping than would be the case if stoneware pipes were used, this alone, I think, should advocate the use of iron pipes, with well-caulked lead and spun yarn joints underneath the house. But, again, iron is stronger than the more fragile stoneware, and consequently, in the event of the house giving away at its foundations, pipes made of the former are better able to cope with the compressive force brought to bear on them, on the house "dropping." For similar reasons, the use of iron pipes is to be advised when the drain is laid under a road, over which there is liable to be heavy traffic passing, unless it is laid at some considerable depth below the crown of the road. In laying a drain, careful observation of the geological nature of the excavated bed, on which the pipe will rest, must be made by the engineer, and if of soft ground or running sand, an artificial bed of harder substance must be provided, so as to retain the continuity of straightness of the drain; for this purpose, in such instances a bed of six inches to one foot in depth of concrete should be laid under the pipes. It is the practice, I believe, of most of our leading authorities on House Drainage, to specify that such concrete shall be made of Portland cement; but, in my opinion, it may sometimes be made of blue lias lime, which will be found, when such a bed is of considerable length, not only nearly equally effective, but of less cost.

By some people, the use of glazed stoneware cradles, as introduced by the late Mr. George Jennings, of Lambeth, is advocated ; upon these, both pipe and socket can be supported, and no doubt there is an advantage gained by keeping the joint from off the ground, as the workman is thus enabled to better get at it ; but, all considered, I think, if a bed is required at all, the concrete one is the best. The soil pipe foot should be connected to the "house drain" by a glazed stoneware bend, of the same diameter as the "house drain"; and, in case there should be any stoppage at this bend, it should be accessible from a manhole covered by an iron air-tight cover; this manhole should have an open glazed stoneware channel running through the bottom of it, similar to the disconnecting manhole, and, in fact, this manhole should be so similar to the disconnecting manhole—minus its inspection pipe, syphon trap, and fresh air inlet (see Figs 3 and 4, Chap. II.)—that I consider an illustration of it unnecessary. It is my experience, however, that in the majority of cases, people rarely have sufficient money to lay out, in order to have their drainage arrangements efficiently carried out, and the engineer is much exercised as to what can be best done for the limited means at command. In such a case, in my opinion, this manhole may be omitted from the specification, although it is, undoubtedly, better to have one. When there is not one, the "house drain" can be cleared from the disconnecting manhole, and should there be any stoppage at the bend, then the water, &c., would rise up the soil pipe, and consequently considerable hydraulic pressure would be brought to bear on the stoppage, with the result that the blockage would probably soon be removed.

When the "house drain" has to pass under the house, no branch drain should, if possible, be connected to it under the house, and in cases where a branch drain discharges into the "house drain," a manhole should be constructed similar to the one just referred to, in the line of "house drain," and the branch drain should be discharged into the straight open channel in the line of "house drain," through an opercular or straight open glazed stoneware channel, unless the branch drain only be a very few feet in length, when perhaps the manhole may be dispensed with; such a manhole admits of the branch drain being cleared by the rods at any time, in the event of choking. Whenever a change of direction of the line of drain is necessary, a manhole should be constructed at such a point, somewhat like the one at the soil pipe foot, only the open glazed stoneware channel must be curved, and of such a sweep that the centre line of the drain in each direction from the manhole shall form a tangent to the centre line of the curved channel; by this means the drain, in either direction, can be inspected and cleared. Such a manhole is more properly termed a "turning chamber."

An easy and rapid test, as to whether a drain has been laid straight and to a true and even fall, can be effected almost at a glance, by looking through a length of drain from one manhole or turning chamber to another. If the length of drain has been laid efficiently in these respects, the disc of light visible at the far end will be circular (the size of the disc is immaterial, as this is only dependent on the length of the drain looked through), but if elliptical, or otherwise than circular, or invisible, the drain will have been irregularly laid. There is perhaps no simpler test as to whether a drain is air and water-tight, than by blocking one end and filling it with water; if, after being left for an hour or two, no leakage is observable at the joints or elsewhere, the drain may be considered as satisfactory.

Manufacturers make the spigot end of a four-inch syphon trap of six-inch diameter, which admits of a **Y** branch of four-inch diameter, forming part of the trap, for the reception of the inspection pipe, as shown in Fig. 3, and consequently the connecting drain is laid from such a syphon trap of a diameter of six inches, although, perhaps, a smaller diameter would quite suffice; but it must be remembered that the drain enlarging after the syphon trap will effectually prevent syphonage of that trap.

The connecting drain is often terminated at the main sewer end by what is termed a "flap-trap"; this trap has a galvanized iron flap which, by the force of gravity, falls on a seat or bed, and the sewage passing down the drain to the main sewer, lifts it; but I am doubtful if it is of much service, unless it be a prevention against rats entering the drain.

Towards the conclusion of Chap. II., I refer to a case in which the diameter of the drain was too large for the work required of it, and whilst upon the subject of the drains, reference to their size will not be out of place, as it is of great importance that it shall be neither too small nor too large.

The minimum size of a house drain is almost universally fixed, no doubt empirically, at a diameter of four inches, the reason being that, after use of a closet, the solid mass of paper, &c., would probably become wedged in a drain if of smaller diameter, although a pipe of four inches diameter would pass considerably more liquid sewage, at a good fall, than many houses would produce. But whilst the minimum size of a drain is fixed, the maximum may vary in accordance with the size and nature of the building to be drained.

The following rule, of which Mr. Henry Robinson is the author, I believe, may be of assistance in calculating the discharge through a drain:—

x = Area of sewer ÷ the wetted perimeter in feet.
f = Fall in feet per mile.
v = Velocity in feet per minute.
a = Area in square feet.
c = Cubic feet of liquid delivered per minute.

$$v = 55 \sqrt{x + 2 f.}-$$

$$c = V + a.$$

Another very good method of ascertaining the discharge, &c., from a drain, will be found at Table VIII. page 49, in Beardmore's *Manual of Hydrology,* which can be seen in most professional libraries.

All house drains ought to be laid in such a way that, not only when half full, but also if only about an inch of sewage were passing down them, they would be self-cleansing, and any water discharged from a bath, sink, or closet into them should pass down the drains *en masse,* so to speak, in order to flush them. In case of stoppage, all drains and pipes should be accessible, if possible, without having to remove ground, paving, or brick-work, &c.

Glazed stoneware goods are easily obtainable in this country, and notably amongst the various manufacturers may be mentioned Messrs. Doulton and Co., of the Lambeth Sanitary Engineering Works, and Messrs. Bailey and Co., of the Fulham Potteries, London, S.W.

The length of this chapter prevents my referring to automatic flushing, but this subject will form the commencement of Chapter IV.

CHAPTER IV.

AUTOMATIC FLUSHING—SOIL AND VENTILATING PIPE.

The Annular Syphon—The Soil Pipe—The Connecting Soil Pipe—Lead and Iron for such Pipes—The Ventilating Pipe—The Size of same—Cowls.

THE automatic flushing of drains was, I believe, first introduced by Mr. Rogers Field, B.A., M. Inst. C.E., by his invention of the annular syphon.

The action of this syphon is caused by pneumatic pressure; the syphon is constructed by a pipe A (see fig. 5), which forms the longer limb, and by a pipe B closed at one end, which encases the upper portion of pipe A, and with it forms the shorter limb; the syphon is fixed in a tank, supplied with water by a tap or other means, as shown in the figure, the longer limb passing through the bottom of the tank into the trapping box, C, about an eighth to a quarter of an inch below the level of the weir D, which keeps the water in the trapping box at the level E, by which means the bottom end of the longer limb of the syphon is sealed. As the tank fills, the water rises up the shorter leg of the syphon, and on reaching the level of the top of the longer one, commences to flow down it over the lip F, which causes the water to pass down clear of the sides; thus a quantity of air is displaced, and a partial vacuum formed thereby in the longer limb of the syphon, which is sufficient to create syphonage, flushing the contents of the tank, to the level of the bottom of the shorter leg of the syphon at G, with considerable force and velocity into the drains. The sole licensees and manufacturers of this efficient patent are Messrs. Bowes, Scott, and Reed, of Westminster, who will, I believe, readily give any information as to the working of this syphon, which prevents my going further into details respecting it, except to add that care must be taken, when erecting one of these flushing cisterns, that

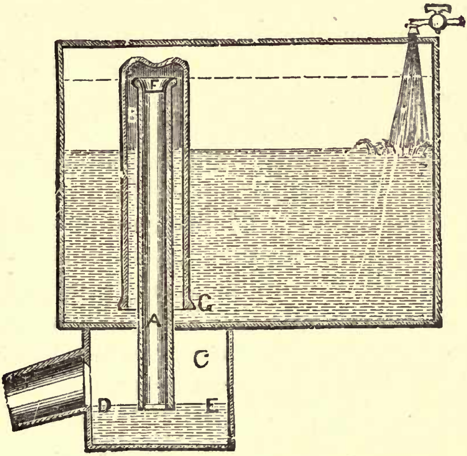

FIG. 5.

it is fixed "plumb," for if not the "seal" in the trapping box may be done away with, and the syphonage no longer able to take place. Of course the frequency of flushing is regulated by the supply of water to the tank; the greater the feed, the more often the tank discharges. Amongst the numerous other flushing tanks, the one made by Messrs. Doulton and Co., of Lambeth, may be noticed;

this one, although different in action to the one mentioned above, is very similar in results. This firm will also, I believe, willingly give any information, and a tank may be seen at their show-rooms, so fitted with glass that the action may be more easily understood, and which, perhaps, hardly necessitates my explaining its working here. When automatic flushing has to be employed, the flushing tank should be placed at the head of the drain, but if a proper fall can be obtained for the drains, a flushing tank is unnecessary, and then, if possible, the soil pipe should form the head of the drain.

The importance which attaches to the careful attention to all details of house drainage, does so particularly to the "soil pipe"; its close proximity to the house renders it especially a source of danger, if not fixed, jointed, &c., with the greatest caution. The carelessness with which soil pipes are made, both as regards the material used and the class of workmanship bestowed on them, makes it a matter of considerable surprise that more illness does not emanate from bad drainage than is the case. Wood, zinc, earthenware, and wrought-iron have been used, no doubt as soil pipes, but in these more enlightened days any architect or engineer would condemn such use, it being now admitted that the two materials most suitable for use in a soil pipe are lead and cast-iron. Lead has its superiority over cast-iron, owing to the smoother surface it presents to the passing sewage, it being more compact in its molecules; but otherwise, I am doubtful if it has any advantage over cast-iron when employed in a proper manner for use in soil pipes, and it certainly has the disadvantage of being more expensive. Of course, owing to the ductile nature of lead, which allows of its being bent with great ease, in such cases where the soil pipe has to turn corners and angles, its use is to be advocated, but I consider such cases ought to be most rare, for if it is necessary to pass a soil pipe round obstructions, then the W.C. ought to be removed elsewhere to such a point where the structural arrangements of the house will admit of the soil pipe being taken ".plumb down" to the head of the drains; however, the money to be laid out on the drainage of a house will not often admit of such extensive alterations as this, and in such an event I should recommend the use of lead for the soil pipe. All soil pipes should be erected in a truly vertical position outside the house, and fixed so as to ensure their being thoroughly rigid and stable. It has too often been, and is too often now, the pernicious custom to fix soil pipes inside the house. When such is the case, not only are the joints less accessible for inspection probably, but, in event of there being any leakage at any of them, the gases escape into the house, with much less chance of oxidization before reaching the inmates. It has not only been the practice to erect soil pipes inside the house, but actually to build them inside the walls.

I would impress on my readers the great necessity for careful attention to all these seemingly almost needless precautions, but I can assure them that it is often such attention which distinguishes between a well and a badly drained building. In using the term soil pipe, I do not refer to the connecting pipe, (although, of course, it is practically a soil pipe,) which connects the vertical soil pipe and P trap of the W.C. I shall refer hereafter to this pipe as the "connecting soil pipe." No soil pipe should, in my opinion, be less than four inches in diameter, and it very rarely occurs that it need be more than four inches, if ever.

A disadvantage attaching to the use of leaden soil pipes is that rats will sometimes gnaw holes in them, thus causing leakage. If lead be selected as the material to be used, the drawn lead soil pipe should be adopted, and not the piping made from sheet lead with a soldered seam all the way down it, it being an admitted fact that, the solder being of a soft nature, such piping is more perishable. Drawn lead soil pipe may be obtained, I believe, in lengths of twelve feet, the weight generally used being seven pounds to the superficial foot, which lengths should be joined together by carefully-made "wiped joints," this class of joint being the one which should be used throughout in such work. About the point where the vertical soil pipe passes into the house, a **Y** junction should be fixed, with one limb pointing vertically upwards, to be continued as the ventilating pipe, and the other pointing into the house to be jointed to the "connecting soil pipe," as shown in cast-iron in Fig. 6; these **Y** junctions are now made in cast-lead, and are extensively used, I believe.

Exception is taken to cast-iron for soil pipes on the score of corrosion, but this may be avoided, at any rate for some time, if the pipes are properly coated inside and outside with Dr. Angus Smith's or some similar preparation, or if galvanized; there is also the treatment known as the Bower-Barff process for preventing rust; but I have lately been informed that after a time iron so treated, scales, flakes of the parts acted on by the process coming away. Whether this is so or not I cannot testify to, from practical experience.

Iron soil pipes should not be fixed unless treated in some way for the prevention of corrosion both inside and outside. There is no doubt that the best class of joint for iron socket and Spigot pipes for sanitary work is that made by caulking tow down into the bottom of the socket, and then running the socket of the pipe full of lead and then caulking that well home. I believe the iron filings and sal ammoniac joint is also resorted to sometimes, but I give preference to the former. Such joints should not be made with Portland cement or red-lead.

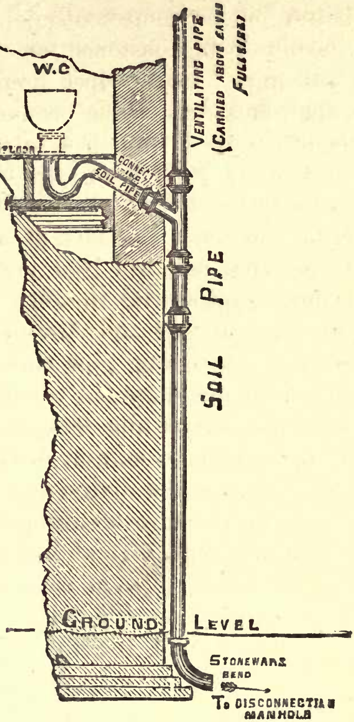

FIG. 6.

A cast-iron **Y** junction pipe should be jointed to the vertical iron soil pipe, as shown in Fig. 6, to connect it with the "connecting soil pipe," which should be made of lead.

I believe the most common method of making the joint of the "connecting soil pipe" with the cast-iron **Y** junction, is by caulking home tow or some fibrous substance in the bottom of the socket and then filling it in with red-lead.

A much better, but far more costly joint may be made by a brass ferrule being fastened on the end of the "connecting soil pipe," by a wiped joint, and caulked with lead in the iron socket. The "connecting soil pipe" should be attached to the P trap by a wiped joint. From the vertical limb of the **Y** junction pipe, a pipe should be carried up vertically to at least six feet above the eaves of the house, of the same diameter as the vertical soil pipe, and of the same material (the joints being made as described above respectively), in order to form a ventilating pipe to the soil pipe and drains. It should be arranged that the ventilating pipe should be removed as far as possible from any chimneys, windows, or openings in the roof, or carried at least nine feet above such.

Thus it will be seen that a current of fresh air can be established right through the drains and soil pipe, from the fresh air inlet at the disconnecting manhole to the top of the ventilating pipe. Great importance attaches to having this ventilating pipe of sufficient size. It is often the custom to continue the soil pipe upwards as a ventilating pipe only half the diameter of the soil pipe, (or even less). But recently, I had great trouble in convincing a gentleman (even if I have now done so, although he adopted my suggestions) that a pipe, if I remember rightly, about three-quarters of an inch diameter of wrought-iron gas barrel, carried up from the stoneware drain quite away from the soil pipe was insufficient and incorrect; such a pipe was fixed in a wrong place, was too small, and probably blocked with dirt and rust. It is well to test any piping that comes on the site, for use as soil piping, by blocking one end of a length, and standing the pipe upright on the blocked end, filling it with water, and watching for any leakage there may be, and having done this, unblocking the end and doing the same with the other end. Some people advocate a cowl being fixed on the top of the ventilating pipe, but most of our leading sanitary experts have now, I believe, discarded its use. A short time ago, discussing this question with one of a large and well-known firm of manufacturers of sanitary appliances, I asked him if he would guarantee their cowl to pump air? He replied, "No; but I'll guarantee it will not admit a down draught."

There should be no persistent down draught in properly-arranged drains; if there is, I should say use a cowl, but think more than a cowl would be required in such a case, for if there is a tendency to down draughts it is most probably due to badly-arranged drainage and ventilation, which should be re-arranged, cowl or no cowl.

For a proper system of drainage, no cowl, in my opinion, should be necessary. In order, however, to prevent birds building their nests in and blocking the ventilating pipe, it is well to finish it with a wire "balloon," which should be of an open area, rather larger than that of the pipe.

CHAPTER V.

"W.C.'S."

Disconnection of W.C. Apparatus, &c., from the House Drain and Soil Pipe, &c.—"P" and "S" Traps—The Pan Closet—The Container—The "D" Trap—The Long Hopper Closet—The Improved Hopper Closet—The Valve Closet—Its Overflow Pipe—The Safe—The "Warning Pipe"—The Hinged Seat—The Loose Riser—Situation of the W.C.—The Flush—The Waste Preventer Cistern—The Screw-down Stop-Cock—Cistern Overflow Pipes.

IN the same way that it is necessary to separate the house drain from the main sewer by the syphon trap, so it is essential to disconnect the W.C. apparatus, rain-water pipes, sinks, bath, lavatory, &c., from the house drain, its branches and soil pipe, by suitable traps.

Experience has shown that the form such traps should assume should be of a syphon nature, of which such class of traps known as the P and S for use in disconnecting the soil pipe and drain from the W.C. apparatus are the result.

The P trap is the more preferable one for this purpose when it can be used; it has been shown, I think, in Chap. II. how effectual the syphon form of trap is, and it will not be out of place here to remark that nearly all traps employed in house drainage work should, when possible, assume this shape.

A P trap may be described as a pipe bent to the shape, as shown in Fig. 6 (p. 31), under the floor, fixed between the W.C. apparatus and connecting soil pipe. It will be seen that the form of it presents a passage through it, having practically a circular section throughout, free from angles, obstructions, or even very sharp bends, so that sewage matter is unlikely to be arrested or lodged in it, and admitting the flush to pass through in a body.

For servants' W.C.'s on the ground, such traps are usually made of stoneware, but for valve or other W.C.'s (unless the basin and trap are in one piece), they are more generally made in lead.

The various kinds of W.C. apparatus are so numerous, many of them most undesirable from a sanitary aspect, that to discuss all their merits and demerits might alone easily fill more than one chapter, if not a volume. The majority of them are unworthy of notice, and their use is to be deprecated, chief amongst them being the still much used, but excessively filthy, pan-closet. As nearly every one who has taken up a pen of late years on the subject of house drainage has described this baneful class of apparatus, pointed out its defects, and condemned its use, it appears to me almost superfluous to give a description of it here, although its much-continued use sorely tempts one to give an illustration of it, and point out its defects yet again. I will, however, content myself with one or two remarks on it. Amongst the objections to this disgusting W.C. apparatus, the chief is due to that part of it known as the container; this is a receptacle into which the contents of the pan, on its being lowered, are shot, the consequence being that in time a large portion of the internal surface of the container becomes coated with soil. This collection gives off obnoxious gases, which, whenever the pan is lowered, rise into the house and face of the user, and in the course of a year or two this becomes such an intolerable nuisance that, in the better class of houses, the apparatus has to be taken to pieces and the container cleaned and repainted—its contents being first burnt out. This can only be done at a cost, I should say, of about £1. Yet people prefer to go on paying this sum once in every year, or two years, rather than expend from £6 to £8, once for all, in having a wholesome valve closet and P trap fixed, and avoid an inconvenience, risk of danger, and expenditure of the equivalent of from ten to twenty per centum per annum on the capital they would thus invest. I think it unnecessary to say more, except that long ago this class of W.C. apparatus has been condemned by sanitary experts as dangerous and filthy, and I can corroborate this condemnation. It is in connection with these pan-closets that D traps have been so much used. A pan-closet, when fitted with a P trap, is insanitary enough, but when a D trap is employed it is a filthy and insanitary arrangement in the extreme. This trap may be characterized as being in effect a small cesspool.

It is a very deleterious form of trap, as it admits of a gradual accumulation of sewage matter, which the flush of water coming from the W.C. apparatus cannot displace; under no circumstances should one be used.

In most houses where the pan-closet is found in use up-stairs, a class of closet known as the Long Hopper closet is found on the ground floor or basement for the use of servants. This apparatus is almost as disgusting and filthy as the pan-closet, although perhaps not quite so dangerous; with the cistern fixed only a few feet above this apparatus, supplying the water probably through a pipe of too small a diameter, the flush is inadequate, which being admitted at one side of the basin, flows round and round it in such a manner that instead of dislodging the contents of the trap they are only whirled round it. This W.C. apparatus should never be used. The best kind of W.C. apparatus for servants' use is the Hopper, of improved shape, with a flushing rim, which admits the water all round the basin almost at once, in such a way as to thoroughly scour the internal face of the basin, and keep it clean, and completely remove its contents.

This W.C. basin should be trapped by a stoneware "P" or "S" trap, jointed carefully to the basin by cement. All W.C.'s for other use in an ordinary house should, in my opinion, be fitted with that type of apparatus called the Valve W.C. In this there is a valve, from which it takes its name, just below the foot of the basin, which is lowered and raised by a lever, and which always retains a certain amount of water in the basin when shut; this valve is technically termed a "batt." Thus in addition to the flush (when the supply valve is opened), and the water, which is always standing in the P trap below, there is, on the "batt" being opened, the water left in the basin from the previous flush to wash through the P trap. This W.C. apparatus has also a flushing rim. The P trap that should be employed in connection with this class of W.C. apparatus, is the leaden one, and the usual method of jointing it to the W.C. apparatus is by turning the lead of the trap over on to the lead safe, so as to form a flange; this flange should be covered with red-lead putty, and the outlet of the W.C. apparatus bedded thereon, which, when screwed down, should squeeze out the surplus putty, leaving a good joint.

It should, however, be the duty of those overlooking the work to ascertain that careless workmen, in placing the W.C. apparatus over the P trap, have not displaced the putty, thereby causing a defective joint.

Amongst the leading manufacturers of this valve closet class of W.C. apparatus, Messrs. J. Tylor and Sons may be mentioned. Both the design and the workmanship bestowed on their apparatus is excellent, and of the many types supplied by them, I recommend chiefly their patent clear-way regulator valve closet (Mr. Rogers Field's pattern). This varies from the majority of valve closets in not having an overflow pipe leading from the basin, and, generally, discharging into the soil pipe by a connection with the valve box below the "batt" at the bottom of the basin. It is usual to bend this overflow pipe near the bottom in such a manner as to form a syphon trap, so that the after flush (which should always be arranged with this type of W.C.) will fill the basin sufficiently to flow slightly over the inlet of the overflow pipe. Thus, when the apparatus is in use, the syphon trap seal is replenished. However, it often happens that the supply regulator is not so set as to fill the basin sufficiently for this to take place, and of course without the seal the trap is useless; or it may happen when a W.C. is not much used, that the seal may dry up, thus the use of an overflow pipe is not to be advocated, for under such circumstances just referred to, noxious gases may rise into the house through this pipe, owing to soil having been splashed into the end of it, or near it in the valve box, at its connection with the valve box. Another objection to the use of such an overflow pipe is that defects in the water supply fittings are not so readily or easily detected.

Under every W.C. apparatus, (except, perhaps, when it is fixed on the ground,) a safe should be fixed. A safe is, as implied by the name, a safeguard against the flooding and consequent damaging of a house in the event of overflowing or leakage at the water supply fittings. It may be described as a tray, with the edges turned up all round, forming flanges, and when properly made is constructed in lead. A waste pipe should be connected with the safe, and should on no account have any connection with the soil pipe, or P trap, but should be made to discharge in the open air through an external wall of the house, so that in the case of an overflow or leakage, warning is at once given, by the splashing of water on the ground, that something is wrong with the water supply fittings.

From the office they so fulfil, such pipes are often very properly termed " warning pipes."

A very common mistake is often made in supplying these pipes, in fixing them of a diameter very materially smaller than the water supply pipe or valve. They should be of a rather larger diameter, for it must be remembered that the water is supplied under a head, whereas when discharging from a safe, in the case of overflows, &c., there is comparatively no pressure at all. When a W.C. apparatus without a basin overflow pipe does overflow, the water runs into the safe, and thence through the warning pipe, manifesting to the inmates of the house that the water is being wasted. If an overflow pipe is used in connection with a W.C. basin, it should be carried straight through an external wall of the building, or be made to discharge over the lead safe near the warning pipe. But its use seems altogether superfluous, for, in any event, a safe should be employed. It is a common practice to terminate the warning pipes outside the house with a copper flap.

The wooden enclosure of the W.C. apparatus now demands attention.

It is too often the case that the apparatus is so enclosed, that an inspection of the lead safe, water fittings under the basin, &c., necessitates a workman being sent for to enable such inspection to be made.

This should not be; in addition to the hinged seat-cover, the seat itself should be hinged, and the casing in the front of the basin termed the "Riser" should be so arranged that it can be easily taken out, so that the safe, &c., may be readily examined or cleaned. Another advantage in the hinged seat is, that, if a W.C. be used for pouring away slops, the seat may be lifted and the slops emptied direct into the basin without the chance of the seat being splashed.

Deeming some of them unworthy of notice, I have not above referred to every class of W.C. apparatus, but, before passing from this part of our subject, there is one which calls for attention as being suitable, perhaps, for use in boys' schools or by servants. It is one in which the basin and trap are all in one piece, made of glazed stoneware or china, and of such a shape that it will stand unique, and the usual wooden enclosure may be dispensed with. This class of apparatus is, I believe, made by several makers, amongst them Messrs. Doulton and Co., and Messrs. J. Tylor and Sons, the latter giving theirs the name of "The Torrent." They advocate the use of as large a down supply pipe as two inches in diameter, claiming that the flush clears the closet instantaneously.

They fix to this basin a spring seat, which flies up when not in use, and leaves the basin for use, either as a W.C., slop-sink, or urinal. Owing, however, to the basin and trap being in one piece, there is some objection to this form of W.C., for should the basin ever become loosened, then of course there is no longer any trap to the soil pipe, and this danger is greater when the basin is situated on any floor above the basement, for in the case of settlement of a building, the joint between the basin (with trap,) and soil pipe is likely to be broken.

With regard to the room forming the W.C. it should, when possible, always be situated against two outer walls, being roomy, well-ventilated, and lighted, and an anteroom, which may be used advantageously as a lavatory, should intervene between it and the main portion of the house.

Before concluding this chapter, the very important question of W.C. water supply must be referred to. No cistern supplying water for drinking or washing purposes should furnish the flush for a W.C.; the cistern supplying a W.C. should be entirely distinct; the only other use it may be put to, is to supply the flush for a urinal, or the flush (not the draw-off cocks over,) for a housemaid's slop-sink. In neighbourhoods where the W.C. flush is restricted by the Water Company, the use of water-waste preventing cisterns, (of which there are several manufacturers,) supplied from the main house cistern, is often to be advocated. Such cisterns, I believe, nearly all work with a pneumatic syphon action, one action flushing the cistern practically empty, which has again to be refilled by a ball-cock, before another flush is available. The quantity of water such cisterns are generally made to hold is, I believe, two gallons, which is the limit allowed by the regulations of most of the London Water Works Companies.

Such a flush is, perhaps, small enough, and people may do well to await the refilling of the cistern, and supplement the first by a second flush.

I recommend the use of these cisterns, especially in connection with schools or servants' W.C's, for, when once the flush has been started, it cannot be arrested:—thus, careless people who generally release the ordinary lever immediately they have pulled it, before anything like

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an adequate flush has passed, will, when one of these cisterns is used, of a necessity cause a W.C. to be well flushed, if they only just pull the lever. The supply pipe from the cistern to the W.C. is often too small; it should be at least one inch in diameter, but a larger diameter than this is preferable.

It is, in some cases, valuable to place, at some point in this supply pipe, a screw down stop-cock, so that the water may be turned off from the W.C. in the event of repairs, &c. All cistern overflow pipes should be of larger diameter than the pipes which supply the cistern, and should discharge direct into the air through an external wall of the building as a warning pipe.

In concluding I would recall part of the evidence of Mr. Rogers Field, B.A., M. Inst. C.E., at the meeting of the sanitary section of the Society of Arts, in 1880. He related how one of his clients (in whose house a death had occurred from diphtheria) wrote, "I tell every one there was formerly always a bad smell about the closet, but now if I want fresh air, I pay it a visit." Is there any reason to prevent any householder having his W.C. in a similar state of sanitary perfection? In this chapter I have not given illustrations of the various W.C.'s and appliances I recommend, for I think it unnecessary, as I am sure the various manufacturers will willingly and courteously show any intending user, not only illustrations, but the actual apparatus as used.

CHAPTER VI.

THE URINAL, SINKS, ETC.

The Urinal with Flushing Rim—Inspection Cap to Traps—Automatic Flushing of Urinals—The W.C. may be arranged for use as an Urinal—The Slop Sink—Housemaids' and Butlers' Sinks—Bell Trap—Enamelled Earthenware Sinks—The Space beneath Sinks—The Gully Trap.

Two other sanitary appliances may be connected to the soil pipe, besides the W.C., viz. the urinal and the housemaid's slop-sink. Leaving the latter for discussion later on, the former may at once command attention. In the majority of cases, the ordinary lip white ware urinal, with a good flushing rim, will be found to give satisfaction.

Immediately beneath the urinal basin the trap should be fixed, and the good sanitary principles and design of the syphon form of trap, known as the "P" trap, made in lead, by Messrs. Dent and Hellyer, recommend it.

This trap is of true syphon form, and has fixed in its base (see Fig. 7), a brass cap, which screws into a brass socket, soldered in the bottom of the lead trap, forming, with the aid of a little red-lead, a sound, water-tight joint.

This cap is for the purpose of cleaning or clearing the trap, and is consequently very appropriately termed the inspection cap. The waste-pipe from this trap should be carried through an external wall of the house into the open air, and made to discharge into a gully trap, which, in its turn, should discharge through a short branch drain and opercular channel into the channel of the main house drain, in a manhole or turning chamber. It is well to choose for this purpose a gully trap which has also a bath or a lavatory waste pipe, or both discharging into it. If it is quite impossible to discharge an urinal waste pipe over a gully trap, and if an urinal is really indispensable, then the waste pipe may be joined to the soil pipe or

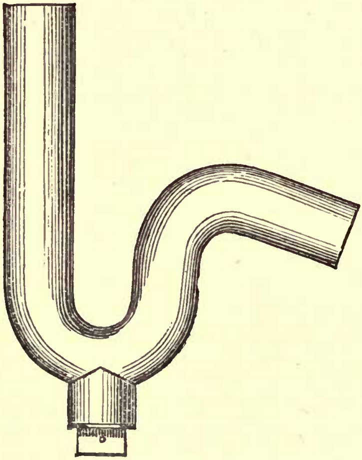


FIG. 7.

the connecting soil pipe, so as to discharge into it. Every urinal should be supplied with its flush by a flushing cistern, in my opinion; and for schools, clubs, and public buildings, an automatic flushing cistern is always to be advocated.

However, in the majority of private houses, I consider an urinal to be almost unnecessary, as a W.C., properly arranged with a lift-up seat and lead safe, may fulfil the office; thus there will be one sanitary appliance less in the house, an object always desirable when attainable. For certain pertinent reasons I have not explained the conclusions arrived at, which suggest the above recommendations. Other kinds of urinals are made, but in my opinion they cannot lay claim to any advantage over the one above described, when fitted in the manner suggested, and will probably be found more expensive.[1]

A slop sink may be described as a basin, with a flushing rim fitted with a P or S trap, which should be made to discharge into the soil pipe. This appliance should be treated as a W.C. entirely, and I consider one should never be fixed if possible to do without it, as a W.C., if properly

[1] Since writing the above chapters, a trap that has excited considerable notice, as a substitute for a "P" trap (shown in Fig. 7), is the Anti-"D" trap, one designed by Mr. Hellyer, of the firm of Messrs. Dent and Hellyer, and it will be seen by the diagram, Fig. 7*a*, that the outlet of the trap is of rectangular form, and of larger diameter than the bottom of the trap, and the main feature claimed

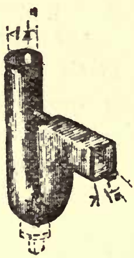


FIG. 7A.

in regard to this trap, is that it is not so liable to be "unsealed" by either momentum or syphonage, a fact no doubt indisputable. However, it must be remembered that in such a trap there are angularities, and where such occur there is more liability to deposit than would be in the case of Fig. 5, and frictional resistance must be increased by such angularity.

arranged with lift-up seat and lead safe, very well fulfils the office of a slop sink for the pouring away of slops. If one is necessary, those made by Messrs. Geo. Jennings and Co. of Lambeth will be found to be as good as any. Sinks generally in the past have been sanitary appliances which, paradoxically, have been most insanitary ones, often having been a source of ventilation to the drains, admitting sewer gases directly into the house. Housemaids' and butlers' sinks should be carefully disconnected from the drains by having similar traps fitted underneath them, and their waste pipes discharging over a gully trap in a similar manner as recommended for the urinal above. Owing to the numerous small particles of solid matter which necessarily pass down the waste pipe of a scullery sink, the excellent form of trap recommended for the butler's sink and urinal is scarcely suitable, as such a trap would too frequently become choked. The patent bell trap, made by Messrs. Geo. Jennings and Co., will be found to be the most satisfactory form of trap for trapping the waste pipe of a scullery sink; and, as in the case of the above sinks, the waste pipe should be made to discharge over a gully trap. On no account should any other form of bell trap but the one above mentioned be used, and that one only in conjunction with the waste pipes of scullery sinks. To the old form of bell trap there are many objections, the chief, perhaps, being that when the grating covering it is removed, or should the bell of it become broken, the outlet to the waste pipe or drain is no longer trapped. Further, the form of it is such as to readily admit of a collection of filth. Again, the quantity of water which constitutes the seal of such a trap is so small, that it is soon dried up by evaporation, and consequently, when such traps are used for trapping drains carrying off the surface water of areas, &c., the seal of them becomes dependent on the state of the weather, and after but a few days without rain, the seal of these traps will be found so much evaporated that the drain is no longer trapped. Messrs. Jennings and Co.'s trap is also open to this last objection, and hence, in my opinion, it should only be used in conjunction with the waste pipes of scullery sinks, down which water is frequently being passed, to replenish the seal of the trap. Their trap is so constructed that the grating may be entirely removed without the trap being in any way interfered with, thus the grating may be taken up and solid matter removed.

Sinks very suitable for the use of the house or scullery maid, are now constructed of enamelled earthenware, the four corners being rounded instead of angular, thus not affording such a good harbour for dirt, and the glazed surface will not so readily allow of dust, &c., adhering to it. Butlers' sinks are generally made deeper than these earthenware sinks are constructed, and are generally wooden ones lined with lead;[1] the outlet of the sink to the waste pipe being closed by a brass plug (of the same diameter as the waste pipe), fitting in a socket with a grating, so that the sink can be filled with water for the purpose of washing glass, &c.

A housemaid's sink may be fitted with a similar plug and socket, or a brass grating alone may be used. The space underneath sinks should not be enclosed by a casing, but left open, in order to prevent a refuge being provided for the accumulation of dirt and rubbish.

Before proceeding further it may be well to speak of the gully trap, to which so much reference has been made in this chapter.

The gully trap is an excellent form of trap consisting

[1] Butlers' sinks are now made in white glazed stoneware and china.

of a small hopper, discharging through a bent outlet pipe, together with it forming a syphon form of trap, much of the more solid matter discharged into it being deposited at the bottom of the hopper, so that it can be cleared out at intervals; it is constructed of glazed stoneware, and the glazing admits of any fat or grease which may adhere to the sides of the hopper being easily washed off. This trap was no doubt suggested by the filthy dip trap of the past, and now some stoneware traps termed gully traps are sold, which somewhat assimilate the dip trap; care should be taken to avoid these, and a gully trap selected

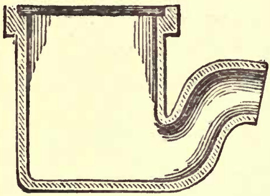


Fig. 8.

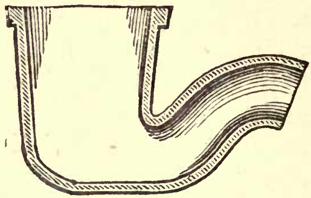


Fig. 9.

having an easy bend at the junction of the hopper with the bent outlet pipe, which pipe itself should have its bends easy.

One of the best gully traps made is that supplied by Messrs. Bailey and Co., of the Fulham Potteries, and termed Field's gully trap.

Every gully trap should be covered with an iron grating, in order to prevent stones, &c., entering them.

Figs. 8 and 9 show a bad and good form of gully trap.

There are other appliances which should be made to discharge over a gully trap, but these must be treated of in another chapter.

CHAPTER VII.

THE LAVATORY, RAIN-WATER PIPES, BATH, ETC.

The Tip-up Lavatory Basin—Rain-water Pipes—Their Joints—The Rain-water Shoe—The Bath—The Safe—The Safe Waste Pipe—The Area of same—The Outlet from Bath—The Bath Waste Pipe—The Overflow Pipe—Cisterns—Dustbin—The Portable Iron Dustbin.

AT the conclusion of the preceding chapter, a good form of gully trap was illustrated, and previously the method in which this trap should be made to discharge into the main house drain was explained; always when possible this method should be adopted. It now remains to refer to the other few appliances, the waste pipes of which should be made to discharge over a gully trap; these may be summed up in the lavatory, rain-water pipes, and the bath.

A gully trap should also be used to receive the stable drainage, but it may be well to leave this till the stable drainage is under discussion in a later chapter.

It is a matter of opinion as to what kind of lavatory basin should be used. In my opinion the convenience of the tip-up basin, made by Messrs. Geo. Jennings and Co., commends its employment.

It is maintained in some quarters, I believe, that in the course of time, the hopper into which the soapy contents of the basin are tipped, becomes coated with filth, and engenders foul gases, but this objection may be over-ruled, I think, when the ease with which the hopper may be cleaned is taken into consideration.

Of course in any case where careless negligence is allowed to prevail, the result must be filth with its consequences; if any sanitary appliance were never cleaned, the same consequence would result, and the chambermaid's office become almost a sinecure.

The hopper in question should have fixed immediately beneath it a similar trap (Fig. 7) as recommended for the urinal in the last chapter, and when the lavatory is on the ground floor, the waste pipe from the trap should be made to discharge in a like manner over a gully trap, as before recommended, in connection with this trap.

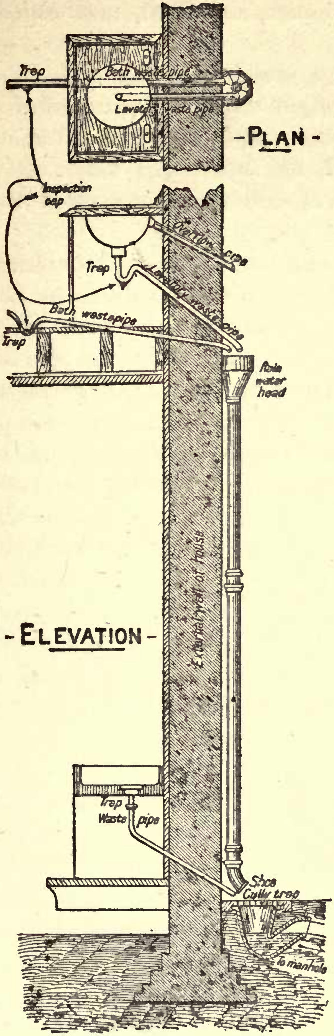
Should the ordinary basin with the brass plug be adopted, the disconnection should be just the same, and of course then the above trap should be connected to the basin itself immediately under it, the waste pipe from the trap being carried through an external wall of the house to discharge over a gully trap as above.

The ordinary basin should have an overflow pipe taken from just beneath the rim of the basin, and such a pipe is best carried through an external wall, so that it can discharge into the air as a warning pipe.

It is now almost always the custom to fix rain-water pipes made of cast-iron with socket and spigot joints.

The sockets, when the pipes are fixed, should be filled with spun yarn and red-lead, which should be well caulked home. All rain-water pipes should discharge through a short bent pipe, termed a shoe (see bottom of rain-water pipe, Fig. 10), over a gully trap.

In the past, it has been the practice to connect the rain-water pipes actually to the main house drain, with the joints above referred to totally devoid of any filling



whatsoever; thus, these pipes have filled an office which should never be demanded of them, namely, the office of ventilating pipes to the main house drain, the foul gases flowing up them, and passing out at any unfilled joint, in many cases almost immediately beneath a window.

Rain-water pipes should, without exception, be disconnected from the main house drain, by being made to discharge over a gully trap, as shown in Fig. 10, and on no account should a rain-water pipe be fixed inside a house, but against an external wall of the house.

That very important

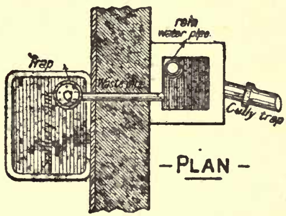


Fig. 10.

and luxurious sanitary appliance, the bath, now claims attention.

Baths are made in various metals and materials, but probably those ranking amongst the first in superiority are the copper and iron ones; and whilst the former are perhaps to be preferred, the latter are more often employed owing to the great difference in cost of the materials, &c.

A similar "lead safe" as that recommended in connection with the W.C., only in length and breadth an inch or two greater than the length and breadth of the bath itself, should be fixed beneath the bath, as a safeguard against damage to the ceiling, &c., below, in case of an overflow.

From this safe a waste pipe should be carried through an external wall of the house to discharge into the air so as to give warning in the event of overflow of the bath. It is as well to close the end of such a pipe outside the house with a copper flap, in order to prevent a draught of air flowing into the house.

Such a pipe should be of an area (I refer to baths with hot and cold water supply pipes) somewhat exceeding the area of the supply pipes combined. In older kinds of baths it has been the custom to make the outlet for the waste water serve as the inlet for the fresh water, the result being that hair, soap-suds, and dirt, not having been entirely washed away from the immediate neighbourhood of the outlet, are again forced back into the bath on the fresh water being admitted to fill it.

The supply pipes should have inlets to the bath entirely apart from the outlet, and the waste pipe should have fixed in it a valve known as a "Quick Full-way Bath Waste Valve," such as is made by Messrs. J. Bolding and Sons, which firm holds one of the foremost positions amongst those firms who supply baths and bath fittings.

As in the case of the lavatory waste pipe, soap is apt to be deposited on the internal face of the bath waste pipe, which, on decomposing, becomes offensive, therefore this pipe should have a trap fixed in it, and of a similar kind to that advocated for the lavatory, only the inspection cap should be fixed on the side of the trap instead of underneath it, as the trap's close proximity to the floor would ill admit of the cleansing of the trap by the cap if so fixed. (See Fig. 10.) A bath waste pipe should be at least two inches in diameter.

Of course, when a bath is fixed on or about the level of the ground, the waste pipe may be made to discharge immediately over a gully trap, but when above the ground level, it should be made to discharge into a rain-water head and pipe as shown in Fig. 10.

The waste pipe of lavatories or housemaids' sinks, fixed above the ground level, should also be made to discharge in this manner. All baths should have an overflow pipe, which should be of the same area as the waste pipe of the safe, over which the overflow pipe may be arranged to discharge.

A mistake often made calls for remark, that of fixing overflow and safe waste pipes, of about the same size only as one of the supply pipes; thus should a bath be inadvertently left when being filled by both supply pipes, and an overflow result, considerably more water is being passed into the bath than the overflow pipe is capable of carrying off, the result inevitably being damage to the room below.

Such pipes should be of an area somewhat exceeding the area of the two supply pipes combined—I say exceeding, because it must be remembered that in most cases the water is supplied to the bath at a greater pressure than that at which it will pass from the bath.

I have already in a former chapter referred at some length to cisterns, but there is one point in connection with them that calls for comment; it is the pernicious custom of fixing them in and under floors; when so fixed, they are liable to become the receptacle of much dirt through the floor boards, &c.

They should be fixed when possible in positions easily accessible of examination, and should be carefully covered, and periodically cleaned out.

Perhaps the few remarks it is proposed to make with reference to the dustbin, will be deemed irrelevant to the subject of these chapters, but as the dustbin plays such an important part in the removal of refuse of a house, and has such a great sanitary bearing in a habitable building, I may be pardoned for adverting to it.

No dustbin should be built against a wall of a house; it should be distinct and apart from the dwelling, being removed as far as possible from it, consistent with its convenient use.

It should be the care of the housekeeper to see that it is regularly emptied, and the internal walls of it being coated periodically with neat lime mixed with water, is to be strongly advocated.

Quite recently, owing to illness in a large house in Kensington, my opinion was sought with reference to the sanitary state of its drainage arrangements. On arriving at the house, a most unpleasant stench was observable, apparently arising from the area below, which no doubt was caused by the unemptied dustbin. In my opinion the drainage arrangements were not responsible for the illness, and the dustbin probably was — although, of course, one could not say for certain such was the case. The doctor, however, was strongly of opinion that the illness arose from sewer or some such gases.

The portable galvanized iron dustbins now made, will be found an admirable substitute for the old-fashioned buildings from a sanitary aspect.

Fig. 10 will be found to refer to some of those appliances alluded to in the last chapter as well as those mentioned in this.

CHAPTER VIII.

STABLES.

The Nature of Stable Sewage—Flooring—Stable Channels—Special Flushing of same—The fall of Stable Floors—The Coach-house.

It has been customary in the past to give but little consideration to the drainage of stables, but in these more enlightened days, when sanitary reform is becoming—although but to a very slight extent—more recognized, people are commencing to realize that foul gases are capable of dispensing injury to both man and beast.

Owners of valuable horses are very gradually beginning to pay that necessary attention to the drainage arrangements of their stables, which no doubt not only decreases the yearly account of the veterinary surgeon, but preserves and prolongs the lives of costly horses.

Similarly as it is the successful endeavour of sanitary reform to exclude sewer gases and to remove as speedily as possible all sewage from the house, so it should be from the stables; the consideration of how best to do this will be the object of this chapter.

It must be borne in mind that the sewage matter from the stables is of a very different kind to that which is passed down the main house drain from the various sanitary appliances in the house, and that small pieces of straw in large quantities, and contaminated with sewage matter, with which they have come in contact, pass into the main house drain.

Again, it must not be forgotten that such straw, and even the sewage itself discharged from stables is liable to be deposited, and the greater the length of drain through which it has to pass, of course the greater will be the accumulation of deposit, on the sides of the main house drain, after being discharged into it from the branch drain receiving the stable sewage, owing to the fresh water flush, as usually employed in the cleansing of stables, (even in the best practice,) not passing down the drains in one body, so to speak.

In the event of there being such deposit, (which would not be washed away probably until a flush from a W.C. came down the main house drain, which might not be before some hours after,) it is patent that it must tend to lessen the sweetness of the main house drain, and therefore, in my opinion, the branch drain conducting the stable sewage to the main house drain should be made to discharge into it as near the syphon trap as possible; that is, such a branch drain should discharge, when possible, through an opercular channel, (as before described for branch drains,) into the straight open channel of the main house drain in the disconnecting manhole.

At the head of this branch drain a gully trap should be fixed, immediately outside an external wall of the stables, into which the stable sewage should be passed.

Fig. 11 explains the method recommended for adoption —only one stall is shown, but this, no doubt, will suffice for a clear explanation.

The stable bricks, known as bevelled adamantine clinkers, when set in Portland cement mortar on a bed of concrete, form an admirable flooring, and if these be not used, care should be taken that a good hard flooring is made.

A main channel should be laid along the foot of the stalls, (see Fig. 11,) and from it a branch channel should run up the centre of each stall or loose box.

A class of channels for this purpose, which have earned for themselves much commendation, are the iron ones made by Messrs. Cottam & Co., termed by them the "Claremont pattern"; these are so made that when placed level on the top they have the necessary fall to rapidly empty, but in addition to this the top can at any time be removed and the channels may be swept and cleaned out.

It is well, however, not merely to trust to the fact that these channels may be cleaned as above, but each of the branch channels should have introduced into it at its upper end a fresh water supply pipe, with a full-way screw down stop-cock situated just under the manger, so that a stable hand can daily "flush down" the channels by turning the cock.

A similar pipe and tap should be fixed at the head of the main channel so that it may also be "flushed" through to the above-mentioned gully trap, into which it should discharge, being carried through an external wall of the stables for that purpose.

The cistern which feeds the flushing pipes should be fixed high up, for of course the greater the altitude the better the flush will be.

The arrows shown in Fig. 11 indicate the direction in which the floors of stables should be made to fall, but care must be exercised that the fall given be not too great, for if this is so a horse is unable to rest properly.

From the head of the stall to the main channel about three inches, and one and a half inches for each side will suffice.

The floor of the coach-house may have a slight fall to a gully trap in the centre, which should be made to discharge through a branch drain and opercular channel also into the disconnecting or other manhole or chamber.

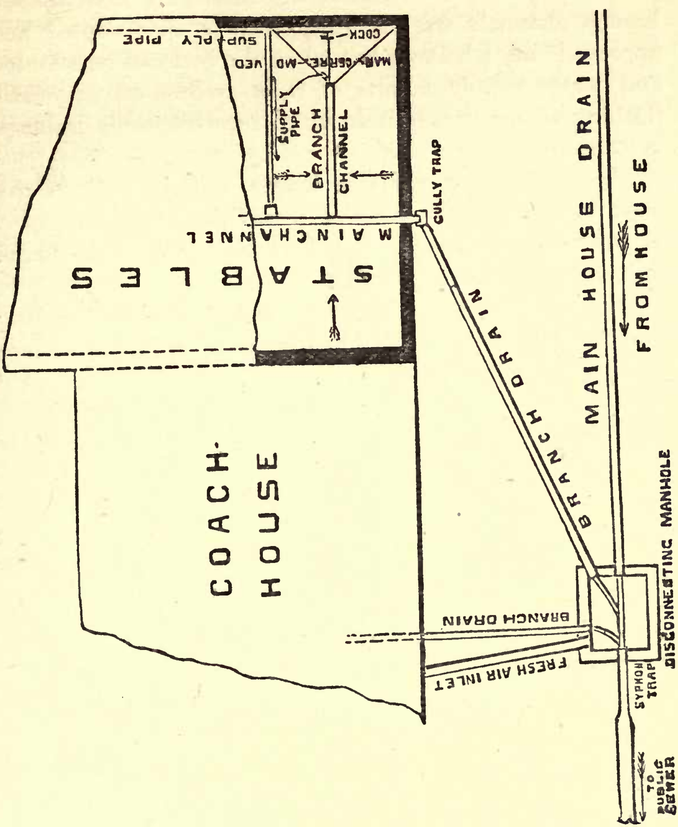


FIG. 11.

Such a gully trap will be found convenient when carriages are being washed, &c.

Stables should be well lighted and airy, but not draughty.

The method above described of discharging the main and branch channels over a gully trap is an accepted and approved one, I believe, but when the cost can be afforded and water supply admits of it, a system of automatic flushing of the branch drain which receives stable drainage is to be advocated.

Those who have valuable horses will do well to pay heed to the sanitary mode of their living, and the outlay in the proper drainage of their stables will not be found to have been money ill spent.

This portion of my subject has not produced a long chapter, but I think the importance of it justifies there being one wholly devoted to it.

CHAPTER IX.

DISPOSAL OF SEWAGE.

The Rivers Pollution Prevention Act—The Cesspool—The Float Indicator—The Overflow Pipes—Removal of Solid Residue—The Straining Chamber—The Position of the Cesspool—Surface Disposal—Shuttle and Flap Valves—The Objection to the Discharge of Crude Sewage on the Ground—Sub-Irrigation—Bed for Sub-Irrigation Pipes—Contour Principle of Irrigation—Sewage Meter Tank—Sewage Sick—Setting out Ground on the Contour Principle—Herbage grown on Sewage-fed Land—Tape-worm—Ventilation of the Connecting Drain.

In the preceding chapters it has been my endeavour to show the best method of collecting the sewage from the various appliances in the house and from the stables, and how to dispose of it to the public sewer, which being done, it passes into the hands of other people, and out of the control of the designer of the house drains. The disposal of the sewage from the public sewer is a subject to which a series of articles might be entirely devoted, and it is hardly one that comes under the present heading at all, being a subject to be discussed under that of "Main Drainage," rather than under the present title, so that it will not be considered here at all, it being only the duty of the engineer designing a good system of house drainage, when the house drains are to be discharged into a public sewer, to see that such drains are properly "disconnected" from it, &c., as described in earlier chapters. But it often happens, in the case of country residences, that there is no public sewer into which the sewage can be discharged, and then it devolves upon the householder or landlord to dispose of the sewage. Properly to discuss the question of how to do this, would require a small volume, no doubt, but I trust in the limit of this chapter to treat on two or three of the best methods for this purpose.

Cases sometimes occur, when a smaller residence has not sufficient land to admit of a system of irrigation being carried out, and in such a case the cesspool is the only resource left, for it must be borne in mind that since the passing of the Rivers Pollution Prevention Act of 1876, crude sewage may no longer be passed into any river or stream.

The very mention of the word cesspool is to some people like the holding of a red lamp to a locomotive driver on a railway, but a cesspool of proper size and design, and properly "disconnected" from the main house drain, when carefully attended to, is not nearly the offensive and dangerous thing so many people think. It should be noted that I am not advocating the use of a series of cesspools, the one emptying into the other and so on, but only of one cesspool of peculiar design, and that only when the land belonging to a house is so limited as to prevent the sewage being evenly and shallowly distributed over the ground from the drains, at a suitable distance from the residence. The cesspool of the olden days, a mere hole dug in the ground, from which the liquids percolated into the earth, and in which the solids disintegrated, was superseded by an excavation, in which a sort of brickwork sump or tank was constructed, from which an overflow pipe is conducted to the nearest ditch, which of necessity becomes horribly fouled.

Such a tank is rarely, if ever, water-tight, and percolation

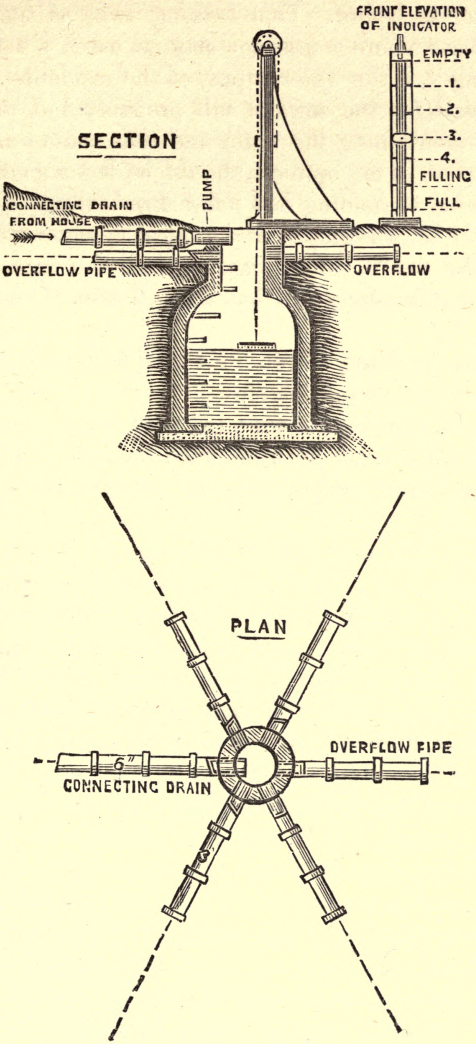

FRONT ELEVATION OF INDICATOR
EMPTY
1.
2.
3.
4.
FILLING
FULL
SECTION
PUMP
CONNECTING DRAIN FROM HOUSE
OVERFLOW PIPE
OVERFLOW
PLAN
6"
CONNECTING DRAIN
OVERFLOW PIPE

Fig. 12.

takes place as before. This soaking away of the sewage, in such cases where a cesspool may be used, is a source of grave danger, if the water-supply of the residence is drawn from a well, for the sewage will probably find its way to the strata containing the water and thus contaminate it.

A cesspool, in my opinion, should be but a small receptacle capable of holding but a few days' sewage discharge, and should be constructed of a conical or some other form, so that the top is much smaller than the base, in order that when it is nearly full but a small area of the sewage is exposed.

The bottle shape shown in Fig. 12 is such as will, I think, be found very successful.

When the residence is supplied with water from a well, and a cesspool must be used, such an one should be of water-tight construction, cement mortar and concrete being used.

In such a case no overflow pipes should, in my opinion, be employed, and a suitable pump should be used to lift the sewage, which should be distributed by a trough over the garden, and the householder, who will find he has thereby a valuable source of manuring, should insist on this pump being used with such regularity that the cesspool is never allowed to so fill, that the sewage rises above the level of the outfall of the connecting drain. To enable the master of the house to tell by a glance whether the cesspool is nearly full or not, it is advisable to arrange a counterbalance float-indicator, as shown in Fig. 12.

When a house is supplied with water from public waterworks, then overflow pipes radiating from the cesspool may be fixed, and each of these may consist of about three lengths of glazed stoneware pipes, continuous from which for some feet may be laid a land drain of agricultural drain-pipes.

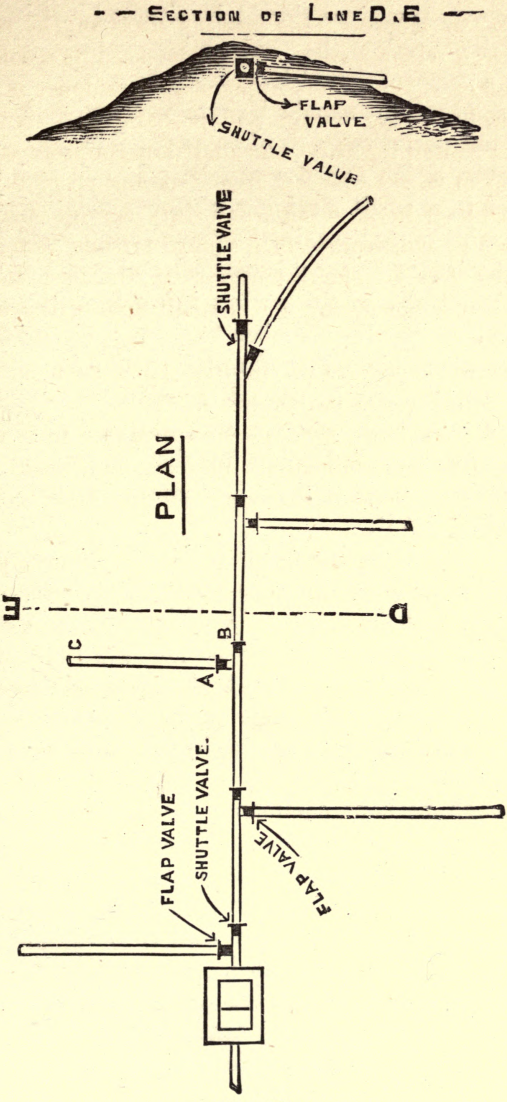

SECTION OF LINE D.E
FLAP VALVE
SHUTTLE VALVE
PLAN
SHUTTLE VALVE
E
D
A
B
C
SHUTTLE VALVE.
FLAP VALVE
FLAP VALVE

FIG. 13.

These overflow pipes should be situated just below the level of the outfall of the "connecting drain."

Such a cesspool should be covered by a large grating.

The solid residue should be removed, and the cesspool cleaned out periodically, as often as possible.

However, if the expense can be afforded, and the fall admit of it, a small straining chamber may be situated, with advantage perhaps, in the "connecting drain" immediately before the cesspool is reached, and grilles or gratings of iron, or formed by thick wires in an iron frame, should be placed across the chamber to form a strainer and to intercept the solids. This chamber should be water-tight, and the bottom may be formed by an invert with concrete rendered over with cement, and, at the end where the "connecting drain" leading to the cesspool is fixed, a gutter may be made of the same "sweep" as the drain and discharging into it.

The solids thus intercepted should be scooped out periodically and as often as possible, and having been distributed over the ground should be dug into it.

The straining chamber may be similarly covered as the cesspool. It should be noted that this chamber should be considerably smaller in cubic contents than the cesspool into which it discharges, say about one-third of the size of the cesspool.

Although, perhaps, common sense would nearly always so dictate, yet it is incumbent on me to point out, that a cesspool should always be situated as far from the residence as possible, and with this admonition the subject of cesspool disposal may be left, and that of discharging sewage direct on to the land discussed.

When the lands of a house are of sufficient acreage to admit of the sewage being conducted some 300 or 400 yards at least from the residence, crude sewage is sometimes distributed direct from the "connecting drain" over the ground by placing branch drains (running out at the surface) at intervals in the main line of drain, and in each of these branch drains close to the junction a flap-valve is situated, and in the connecting drain immediately below each branch drain a shuttle valve is fixed.

By these valves the flow of the sewage may be directed on the ground at any of the branch drains desired, and, of course, the more numerous these are the more equally the sewage may be distributed.

In this method of disposal it is necessary for the ground to fall rapidly away from the main line of drain; and of course if ground can be found which admits of a fall on both sides of it, so much the better.

Perhaps a sudden and sharp gradient is to be desired, for it will admit of the branch drains running out to the surface sooner than with a gradual fall.

Reference to Fig. 13 will no doubt assist in explaining the method referred to.

A portion of the main line of drain is shown with some of the branch drains.

Supposing the shuttle valves are open and the flap valves closed down to A, which is open, then sewage can flow freely to that point, and if the shuttle at B be dropped into its seat, then the sewage will of course be directed so as to flow through the open A, and through the branch drain and over the ground C, and to enable the sewage to be more widely dispersed, little gutters may be cut in the ground in the direction it may be desirous to distribute the sewage.

When this branch drain at C has been in use a little time, and the ground is barely covered with sewage, then the valve A should be shut and B opened, and another pair of valves and branch drains brought into use.

The discharging of crude sewage over the ground in this way is, however, objectionable, for the solids are apt to be lodged on the roots or leaves of vegetables or herbage, and for obvious reasons the distribution of sewage in the state it leaves the house must be offensive, if only to the eye.

The straining, therefore, of the sewage is to be advocated, and to effect this a straining chamber similar to the one already recommended in connection with the cesspool should be fixed, having its position in the main line of drain at a point just before the irrigating ground is reached. This chamber may be constructed in a similar manner to the one forming part of Fig. 15, which will be referred to later in this chapter.

When a straining chamber is used the master of the house must make it his imperative duty to see that it is regularly cleaned out about every second or third day, as in that time decomposition of sewage may commence and danger arise.

If two strainers be employed, the bars of the one nearest the irrigating ground being of much narrower gauge than the other, then of course more solid matter may be caught than with one alone, and when this matter is very offensive it may, when scooped out, and before being dug into the ground, be mixed with dry earth, which will be found a very good deodorizer. The small amount of solid refuse caught by the strainers in two or three days, even from a large mansion, will be a matter of surprise to many.

The shuttle and flap valves mentioned above are not illustrated here, for they will be found well represented in the catalogue (Figs. 8—11) of Messrs. Henry Doulton & Co., who make them.

The method of sewage disposal known as sub-irrigation must now claim attention.

Sub-irrigation can undoubtedly be best employed when there is only liquid sewage to be dealt with from cottages and small houses, the grease and fat from larger dwellings being found to soon choke the irrigation pipes, and if such a method be adopted for disposing of the sewage from a large mansion, and also when water-closets are used, the sewage should be strained before reaching the irrigating ground.

The process of sub-irrigation is somewhat similar to the method just described for distributing sewage over the

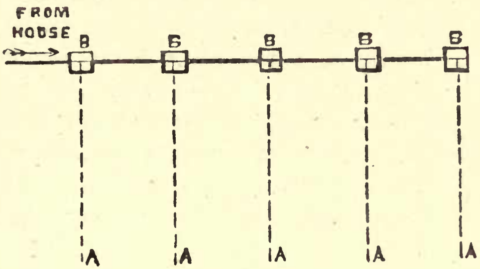


Fig. 14.

surface of the ground, only of course the branch drains are entirely underneath the ground.

A flushing tank similar to the one shown in Fig. 5 (Chap. IV.) should be placed about the head of the main house drain, and the liquid sewage discharged from it down the drain and through the syphon trap to the irrigating ground.

When this is reached branch drains, as shown at A, Fig. 14, composed of "butt-joint" pipes, should be laid with a slight fall from the connecting drain about 9 in. or 12 in. under the surface of the ground.

Chambers marked B, Fig. 14, may be constructed at the head of the branch drains in which valves are situated for the purpose of directing the sewage down any particular branch drain for the more equal distribution of the sewage.

Thus the sewage being forced down a branch drain finds its way out at the butt-joints, floods the subsoil, and by capillary attraction, &c., feeds the vegetation.

It will be found, however, that in time the pipes forming the branch drains require to be cleaned, and it is therefore wise to lay them on a permanent bed, which may be made with half-round drain-tiles laid to a suitable and slight fall. The pipes can then at any time be dug up, cleaned and relaid on this bed; but if a permanent bed be laid, it will hardly be found necessary to remove all the pipes for cleansing, as a few, removed at intervals, will admit of the ones left having a rod passed through them to clear them. Of course there is the objection to this system of disposal, that everything is not well in sight, and all the pipes cannot be freely and readily examined, and the danger that a careless householder might not have the subsoil drains frequently enough cleaned, with the result that they may choke and the sewage "back-up" through the syphon trap into the disconnecting manhole.

Sub-irrigation is most adapted to residences which have not sufficient ground attached to them to admit of surface irrigation being performed, but yet have more than absolutely entails the use of the cesspool, and where the fall of the ground will not admit of surface irrigation.

It behoves me to write of one other mode of surface disposal which has been much practised by some of the civil engineers who have made house drainage a speciality.

It is the practice of discharging sewage over an irrigating ground laid out on what is known as the contour principle.

The sewage passes down the connecting drain from the

SEWAGE METER TANK.

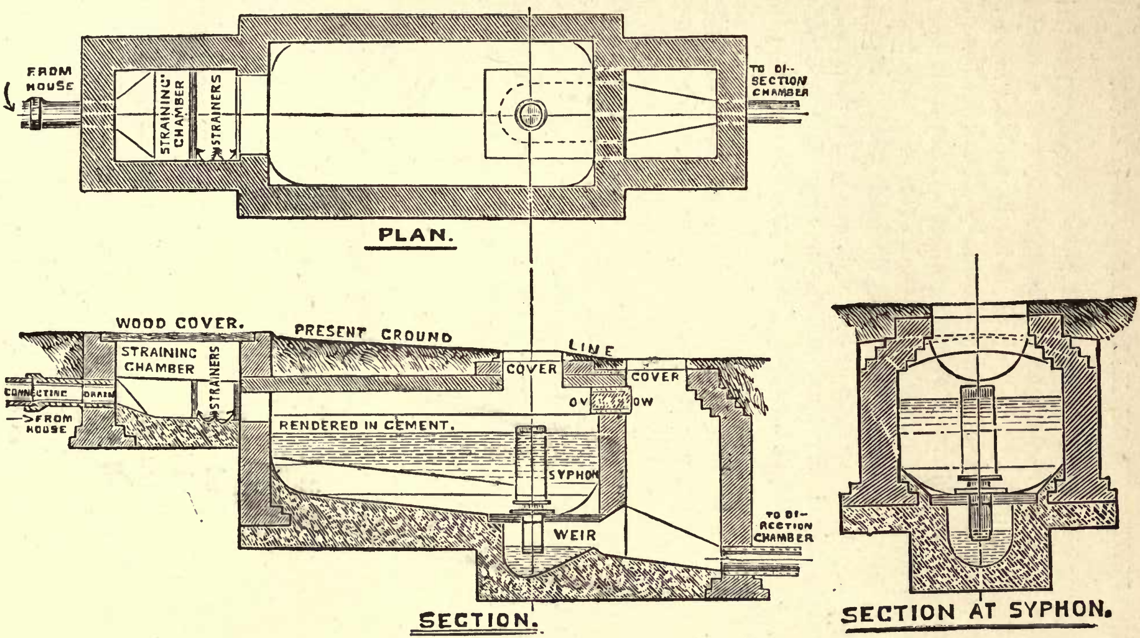


FIG. 15.

disconnecting manhole, and just before reaching the irrigating ground, flows into a receptacle termed a sewage meter tank (see Fig. 15), which is really nothing more or less than the flushing tank shown by Fig. 5, Chap. IV., on a large scale, with a straining chamber, the tank being constructed in brickwork, rendered over smoothly inside with cement; it is, therefore, deemed unnecessary to again explain the action of the syphon. When the sewage rises to about the level shown in Fig. 15, the syphon acts and discharges the sewage with a rush to the irrigating ground.

Referring to Fig. 16, it will be seen that the pipe from the sewage meter tank to the irrigating ground enters what I will term, to facilitate explanation, a "direction chamber," in which the sewage may be directed either by the use of paddle valves or by a piece of turf or a little clay, either to the right or left, or straightforward over the irrigating ground. The necessity for being able to discharge the sewage over various portions of an irrigating ground is, that after sewage has been allowed for some time to flow over land (even when it does so intermittently, as referred to hereafter), it may become too much charged with sewage, or what is called "sewage sick."

By Fig. 16 it is my attempt to partially illustrate an imaginary ground laid out on the contoured system, which may aid explanation of the following text—

A piece of land falling away slightly from the "direction chamber" should be selected.

The engineer should then "range" a straight line across the ground, being a production of the centre line of the drain running from the sewage meter tank to the "direction chamber." Lines some 30 ft. apart should be set out parallel to this line, and lines similarly equi-distant apart should also be set out at right angles to the above line.

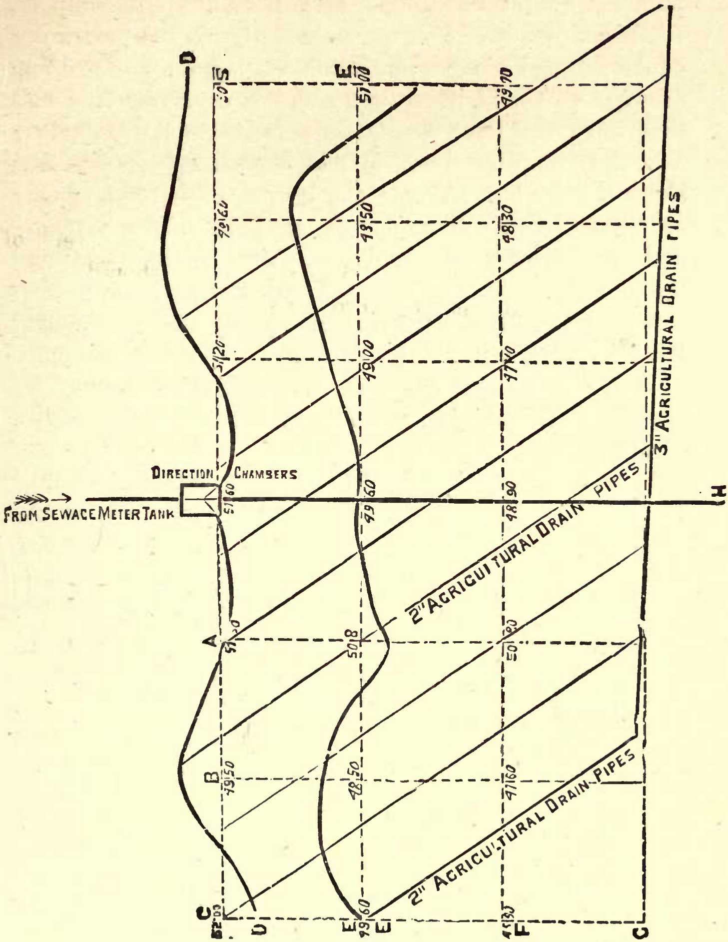


FIG. 16.

These rectangular lines are shown by the faint dotted lines in Fig. 16. Levels should then be taken at the various points of bisection of these several lines.

Thus a line can be found across the ground at practically one level, and along this should be dug a sewage carrier (a grip about 3 in. deep by 5 in.), but of course it is well that it should have a scarcely perceptible fall on either side away from the drain, so that the sewage can just flow along the carrier. A stop can be placed (a lump of clay or piece of turf will suffice) at any point along a carrier, and the flow of sewage will be arrested at that point, and the carrier gradually filling will overflow, and the ground can thus have the sewage more equally distributed over it down to the next carrier.

It is a most difficult task to explain clearly on paper the system in question, and I must claim the indulgence of my readers.

It will be seen by Fig. 16 that the first carrier (DD) nearest the "direction chamber" is carried along at the level reading 51·30 at the point marked A on the line DD; thus a departure up the ground has to be made at the point B, to find a similar reading (or nearly so), the actual reading at this point being too small, namely 49·50, and similarly a departure down the ground is made at C to find the proper reading, it being at this point too great.

Carriers may be dug across the ground about the points F and G, and that portion of the ground brought into use, when the portion nearer the "direction chamber" tends to become sewage sick, or it is necessary for it to lie fallow, &c. A carrier should be cut straight across the ground to H, down which the sewage can be made to flow from the "direction chamber," and directed along any of the carriers situated at E, F, or G.

Agricultural pipes may be laid a foot or so under the irrigating ground, as shown in Fig. 16, to enable the sewage to be more rapidly and evenly distributed in the ground.

The difference between the two methods of surface disposal herein described is, that in the case just dealt with, ground that is nearly flat can be employed, and the distribution is intermittent, whilst in the former case (Fig. 13) the ground must have a considerable fall, and although intermittent disposal may also be employed, yet this may tend to force the sewage too rapidly (considering the severe fall generally necessary in such cases) over the ground, with the result that the bulk of it rushes to the lowest point on the land, without having effectually irrigated the highest portions.

In the case of the contoured ground, the sewage is forced over the ground by the sewage meter tank, and more evenly spread, and the intermittent action of the tank admits of the sewage soaking into the land, and the pores of the soil becoming aërated; for otherwise the pores of the earth might become clogged by the sewage slime, which, forming a deposit on the ground, would prevent nitrification, and lend encouragement to putrefaction at the surface of the ground.

Thus the value of even and intermittent distribution can be seen, and such distribution should not take place oftener than once a day.

Irrigation grounds should be planted with roots, &c., that have a tendency to rapid absorption of liquids, and osiers will be found to imbibe sewage with great avidity, and are therefore frequently used.

Of course, the more porous the soil is constituting an irrigating ground, the better; but sometimes land practically impervious to water, such as clay, is only available; then such ground should be dug up to a depth of a few feet, and then burned and broken up, which will enable the sewage to get away. An acre of land will be found sufficient to act as an irrigating ground for a very large mansion indeed.

Thus far it will be seen that it is most desirable that sewage should be intermittently distributed over a light loamy or sandy soil, at a distance of some hundreds of yards from a residence, and when this is properly done, experience seems to show that there is no danger (or little) of a nuisance or epidemic being caused by so doing; but yet the greatest care must be taken that cattle are not allowed to eat too soon of herbage which has been fed with sewage, and that the cabbage, or what not, similarly manured, is not placed on the table till a suitable time has elapsed since sewage was distributed on the ground where it has been grown.

We have it on medical authority that danger may arise from the consumption by cattle of vegetation which has been flooded with sewage; for instance, in the case of herbage to which has been applied sewage containing fæces from a patient with tape-worm, danger may exist.

We learn that a man suffering from tape-worm evacuates thousands of ova of tape-worm with his fæces, and some of these eggs are apt to stick to the herbage, and thus be eaten by a bullock.

In course of time every ovum consumed by the bullock is capable of creating a cyst (measle) in the flesh of the animal, thereby producing measly beef, and if such beef be consumed by the human being in an inefficiently cooked condition, each cyst is liable to create a tape-worm in the human body.

It would thus appear that the question to be solved is, How long will such eggs when clinging to the vegetation retain their germinating power? The following quotation is from the translation by W. E. Hoyle, M.A., M.R.C.S., &c., of "The Parasites of Man," by Leuckart; referring to the proglottides (a worm consists of a head and dozens of proglottides, each proglottis being a procreative segment containing thousands of ova, and capable of breeding such ova), he writes:—

"It is not yet possible to tell how long this potency can be retained; the period will doubtless vary with the environment; while Gerlach was able to infect a pig with decaying proglottides of tænia solium five weeks old.

"In an experiment I made, the eggs of tænia cœnurus had lost potency after lying in water for eight weeks.[1] This follows more rapidly when the eggs are kept dry. Haubner reports having ineffectually fed a sheep with tape-worm eggs which had been kept dry for fourteen and for twenty-four days, and I have had similar experience in which eggs exposed to an August sun had lost their power of germinating after four-and-twenty hours."

It would seem, therefore, from the foregoing that dryness and heat are essential to the effectual and ready decay and death of these ova, and that in this country, even in the hottest weather, the herbage should stand at least from three days to a week without having sewage administered to it before cattle are allowed to graze on it, and in the colder and more humid months at least three weeks or a month; and further, it can be gathered that no vegetables (for human food) should be fed by sewage, except such as will have to undergo the process of cooking.

[1] Davaine, on the other hand, asserts that he has "kept eggs of tænia solium and tænia serrata in water for years, living and unaltered."—(Mem. Soc. Biolog. t. III., p. 272, 1862.)

I have not, in this article, at all entered into the question of the chemical treatment of sewage, for it is generally accepted—in the case of house drains where there is no public sewer to receive their discharge—to be unnecessary, and although so frequently adopted in the disposal of the sewage collected in public sewers, I believe I may add that the fact that the sewage created in country mansions may be distributed over land, as above described, in its crude state (when such distribution is properly attended to) without danger or nuisance, is established by practical experience.

In all cases where possible, the disconnecting manhole should be well removed from the house, as pointed out in an earlier chapter, and when the land admits of it, the irrigation ground (as explained in this chapter) should be several hundred yards from the disconnecting manhole, by which it is patent a great length of "connecting drain" is entailed.

This connecting drain must be thoroughly ventilated, and should have along its length "inspection manholes," situated about every 150 feet (counting from the "disconnecting manhole"), which should be covered with large iron gratings; and whenever there is a change of direction, a turning chamber should be employed, which may be similarly covered so as to act as a ventilator, and practically as a substitute for a manhole (see earlier chapters).

The length of connecting drain between the syphon trap and the first of these inspection manholes or turning chambers should be ventilated by a pipe being carried up from a large T branch (with the branch vertically, or nearly so, upwards), situated immediately on the connecting drain side of the syphon trap. This pipe should be finished off a little above the ground level with an iron grating of an open area rather larger than the area of the pipe. Such a pipe for ventilation should also be used, in a similar position near the syphon trap, when the connecting drain discharges into a cesspool.

I cannot close this article without acknowledging my great indebtedness to Mr. T. Nichols, Assistant Director, and Professor Bell, of the Natural History Museum, for the kind assistance and courtesy afforded me in my research into the question of parasites, &c.

CHAPTER X.

CONCLUSION.

The Preparation of Schemes for House Drainage—Maxims—Rules for Housekeepers.

A MORE appropriate title for this chapter would be, perhaps, "Review," for the intention herein is to review shortly what has already been written in the preceding chapters, in order that certain deductions may be made as to some of the more salient points to be remembered.

Both text and illustrations of these articles must, of course, be taken to a great extent as typical only, as for different buildings the organization of the drainage arrangements will vary, and no scheme of drainage should be prepared without the aid of the draughtsman.

A plan should always be prepared, and in many cases a section showing the fall of the main house drain is of great value.

It is, I believe, very often the custom for builders to drain a house, and afterwards prepare a plan, showing what has been done; but how much better a scheme might be produced if a plan of the house were always consulted and a project designed on it before the works were commenced, the drainage arrangements being prepared in accordance with design and method instead of being placed in any position hazarded by conjecture at the site, and suggested by the false conception that the "main house drain can be very well laid here, and a branch drain can be run satisfactorily there," &c.

From these articles certain rules may be gathered, and the following maxims founded on what has gone before may be advantageously followed.

The main house drain should always be carefully "disconnected" by a good form of trap from the public sewer, irrigating ground, &c. The main house drain and all branch drains should be laid in absolutely straight lines, change of direction being effected by turning chambers only. The soil pipe should be carried up as a ventilating pipe (and of one area throughout) to a point well removed from all openings in the house or its roof, and should assume when completed a truly vertical line, if possible.

The joints of all pipes should be air and water-tight, the greatest care being observed that all superfluous cement is wiped out from the barrel of the pipes in the case of joints made with cement.

A fresh air inlet should be situated in connection with the main house drain, on the house side of the trap which "disconnects" the house drains from public sewer, &c., and it should be fixed near this trap, so that fresh air may flow through the entire length of the main house drain and up the soil and ventilating pipes which form a foul air outlet.

W.C.'s are preferable that retain water in the basin, for the reception of a discharge from an user.

A good form of trap should be fixed immediately under every W.C. Urinals and housemaid's slop sinks should never be fixed, if it is possible conveniently to do without them, and when fixed should always be properly trapped, the latter being treated as if a W.C. Waste pipes of sinks, baths, and lavatories should be as short as possible, and suitably trapped.

All branch drains should be trapped at their head by a good form of trap.

Cisterns should be fixed so that they can be easily examined or cleaned out, and should be carefully covered.

Stable floors should have channels, with loose covers, laid in the flooring, and these channels should be capable of being flushed, the flush passing to a trapped branch drain, the trap of which should be situated, when possible, outside the stables.

If a cesspool is used, it should be smaller at the top than at the base, and should be capable of receiving only two or three days' sewage discharge from the residence. The connecting drain from the trap at the disconnecting manhole to the irrigating ground or cesspool (when there is no public sewer to receive the sewage) should be well ventilated.

As few sanitary appliances as possible should be fixed in a house, consistently with convenience.

Holders of residences drained on the principles advocated in these chapters should see that the housekeeper observes the following rules:—

"Once a week the brass plugs of all sinks and lavatories should be placed in the sockets, and the sinks and lavatories filled with water; the plugs should then be withdrawn, so that a good flush can pass through the waste pipes and traps of the sinks and lavatories in order to scour them.

"The bath should also be filled up with water, which should then be released, with a similar object in view.

"The basins of all W.C.'s should be cleaned daily, and

A.—Signifies gully trap into which scullery sink discharges; this also receives discharge from rain-water pipe, which may have the bath, housemaid's sink, or lavatory discharging into it.—[See Fig. 10, Chapter VII.]

B.—Signifies gully trap into which pantry sink discharges, and which might also receive the discharge from a rain-water pipe, into which a sink, bath, or lavatory might also discharge.—[See Fig. 10, Chapter VII.]

C.—Signifies gully trap receiving discharge from stable channels.

D.— ,, ,, ,, in coach-house flooring.

E.— ,, ,, ,, receiving discharge from lavatory; and may also receive discharge from similar rain-water pipes at A and B.

F.—Signifies fresh-air inlet. G.—Signifies branch drain.

H.—Fullway screw-down stop-cock and fresh-water flushing supply pipe.

R.W.P.—Rain-water pipe.

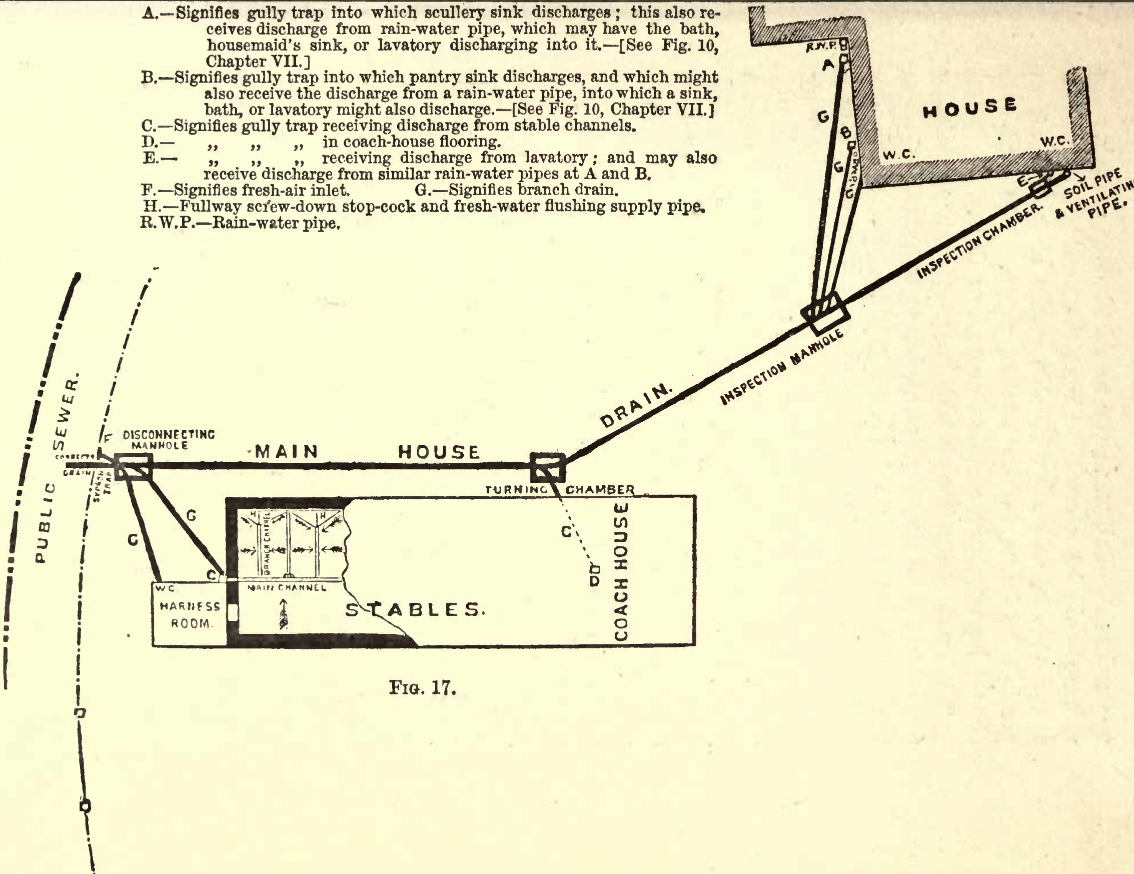


FIG. 17.

the underside of all W.C. seats scrubbed once a week. No refuse should be deposited about the premises except in the dust-hole, and all vegetable refuse should as far as possible be burnt in the kitchen range. The dust-hole should be regularly emptied every few days.

"A good contractor should be employed periodically (at intervals of six months at least) to generally clean the manholes, syphon and gully traps, &c., sweep the drains, &c. Also to remove the inspection cap of sink and bath traps, and clear such traps, and to coat the dust-hole internally (unless of iron,) with neat lime mixed with water. Further to clear out all cisterns at least once a year, though preferably oftener."

In the past it has often, I believe, been the practice of architects to design a house completely, without any regard having been bestowed on the drainage arrangements, and when the carcass has been completed, or nearly so, then the consideration of the drainage arrangements has been entered upon, and the result is that the soil pipe has but rarely formed the head of the drain, as it should do. W.C.'s have been placed in any convenient position left by the previous situation of other rooms, and generally the architect has said with regard to the drainage arrangements—"Oh! here is an excellent place for a W.C., a lavatory can be fitted here, and then we can put the housemaid's sink in that corner," &c. &c.

In the designing of a house, one of the first thoughts of an architect, after having found the suitable plot of ground, and the class and plan of house having been roughly decided on, should be as to how the proper drainage may be effected. A well-designed house should have its drainage arrangements so disposed that the soil and ventilating pipes form the head of the drain, and the main house drain should be as straight as possible, and the branch drains as short as can be, the W.C.'s being situated so that two of the walls are two of the external walls of the house.

Fig. 17 gives a hypothetical scheme of drainage, in which it will be seen that a fresh current of air can freely pass through the main house drain and up the soil and ventilating pipes.

It will be seen in this particular case a change of direction has been made in the main house drain, and this is done in order to illustrate the use of the turning chamber.

It will be observed that every branch drain can be easily and freely examined, and that every W.C. is situated so that two of its walls are two of the external walls of the building in which it is placed.

The diagram will, I think, in most other respects be self-explanatory, in connection with the reference.

Little more is left for me to add; to one fact, however, not generally recognized, attention should, perhaps, be drawn, this fact being that it is not so much the endeavour of specialists in house-drainage to do away with the foul gases generated in sewers, &c., as it is to render such gases as innocuous as possible; for as long as nature produces sewage matter, foul gases will emanate therefrom.

In these chapters it has been my chief object to point out what should be done, rather than what has been done so badly in the past. Those who are desirous of learning defects in house-drainage arrangements, will consult with advantage the excellent pictorial guide, *Dangers to Health*, by Mr. T. Pridgin Teale, M.A., Surgeon to the Leeds Infirmary, which as regards defects proper is admirable, and from practical experience (although I have not, perhaps, met personally with quite all the examples given by him), I can quite believe every case is truthful and unexaggerated.

In closing these chapters, I trust that those whose eye they meet will say with me, "Quod erat faciendum," and I would that I could say, "Quod erat demonstrandum."

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