THE PRINCIPLES AND PRACTICE OF HOUSE-DRAINAGE.

IT is proposed to make this paper a simple and direct statement of some positive knowledge, and of more confident belief, about the drainage of houses. It is not addressed to that indifferent public which sees a good deal of nonsense in the theories of all reformers. It is not addressed to plumbers, who, as a rule, are little attracted and less influenced by what anybody says whose working years have not been given to plumbing work. It is not even addressed to architects and engineers, who, whatever their own convictions, so often find it necessary to compromise with their mechanics and with their clients, and to be content with such improvements as it seems under the circumstances judicious to insist on. It is addressed to that limited class that is willing to learn, and with whom a promising suggestion becomes a fruitful germ; to the few who will agree with its teachings, and to the more who will take its propositions into earnest consideration without the intention, and often without the result, of agreeing with them. Where they can be avoided, alternative suggestions will not be made. If there are two ways of doing a thing, one right and the other only not wrong, the right way alone will be recommended. There is usually but one best way, and all that is to be considered here is purely and simply the best way of improving the drainage of a human habitation, and of maintaining its good sanitary condition.

GENERAL PRINCIPLES.

THE house and the ground under and about it, and the air with which it is filled and surrounded, should be as dry and as clean as the best constant effort can make them. To this end, the most intelligent care and the most earnest attention must be given to all details of construction, and, no less, to the details of maintenance. No house, however perfect its original condition, can remain in perfect condition if subjected to the deteriorating influences of even ordinary carelessness. Many a palace is a pig-pen in its hidden recesses; and where the light of day and the eye of a scrupulous housekeeper are withheld, there will those enemies of the human race, dirt and damp and decay, surely make their stand. The whole range of cubby-holes, dark cellars, uninspected closets, and those spaces about pipes and fixtures which are screened from observation and withdrawn from the reach of care by the pernicious carpentry to which the plumbing art is so closely wedded, are, all of them, places to be suspected and to be as far as possible abolished. Where dark places must be maintained, they should be the chief objects of the householder's care. It is a wise old sanitary saying that "where daylight cannot enter the doctor must."

Houses that are perfect, even in the general arrangement and construction of their sanitary works, are extremely rare. Those which, having begun perfect, continue so under daily occupation, are still more rare. So true is this that it is sometimes asked if it is, after all, worth while to encounter the additional expense and the constant attention that perfection demands; whether, indeed, the world has not got on so well in spite of grave sanitary defects that it is futile to hope for an improvement corresponding with the cost in money and time. The most simple and the efficient answer to this is that the world has not got on well at all, and is not getting on well; that among large classes of the population one-half of all the children born die before they attain the age of five years; that those who come to maturity rarely escape the suffering, loss of time, and incidental expense of unnecessary sickness; that the average age of all mankind at death is not one-half of what it would be were we living under perfect sanitary conditions; that one of the chief items of cost in carrying on the world, to say nothing of the cost of burying those who die, is that of supporting and attending the sick and helpless; that another great item is the cost of raising children to or toward the useful age, and then having them die before they begin to make a return on the investment; that the great object of a well-regulated life is to secure happiness for one's self and one's dependents, an aim which is crushed to the earth with every death of wife or child or friend. There is a sentimental view, no less important, which need not be recited, but which is sufficiently suggested to the minds of all who have had to do with the sanitary regulation of houses by the frequency with which their services are called into requisition only when the offices of the undertaker have been performed. No cost and no care would be too great to prevent the constantly recurring domestic calamities which have had their origin, and which have found their development, in material conditions that a little original outlay and a constant and watchful care would have prevented.

The objects to be attained in the drainage of a house and of its site are, first, to remove all causes of excessive dampness; and, second, to provide a means for the water transportation of organic wastes to a safe point of disposal, in such a way as to prevent decomposition on the premises, and so as to exclude from the house all air which has been in contact with these matters after their discharge into the drainage system.

The means for accomplishing these ends are of two distinct sorts: one allied to the drainage of agricultural lands, the other to the flushing of gutters.

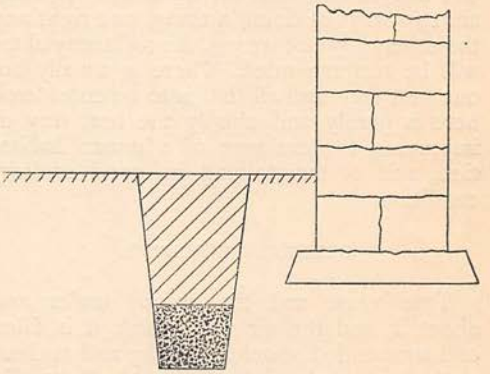
FOUNDATION AND CELLAR.

THE first in order of execution, and although not first in importance, still of absolute importance, comprises the means for preventing undue dampness of the interior atmosphere, or of the walls, of the house by an actual inflow of water, by an exhalation of watery vapor from the water contained in the soil, or by a soaking of the foundation. In the case of city houses occupying the whole width of the lots on which they stand, this drainage is necessarily confined to the cellar and foundations, and, as a rule, the water to be drained away can be delivered only into a public sewer,— though there are frequent exceptional cases where, by piercing an impervious stratum of clay or other material, an outlet may be gained into a porous stratum of gravel or sand below. Wherever the site is on a deep and naturally well-drained bed of sand or gravel, the question of drainage as a means for removing soil-water does not present itself. But here another very serious difficulty is to be encountered, having a different sanitary bearing, but of no less sanitary consequence. This relates to the protection of the house against exhalations from the ground,— not of moisture, but of the atmospheric impurities of the subsoil.

In the case of a country house, or of a town house standing in the center of a considerable area, it is often the most efficient means for securing satisfactory drainage to apply a very thorough system of underdraining to the whole area about it and for some distance away, by laying different lines of tile drains, not necessarily under the house at all, but so as to surround it on all sides from which water flows toward it, and in all cases at a depth several feet below the level of the cellar-bottom. It is seldom, even where a spring is struck in digging the cellar, that such drains, surrounding the site of the house, will not entirely divert the water. In this drainage of large lots, the character of the outlet is of secondary importance. All that is needed is that it shall be low enough for the free discharge of the flow of the drains, and, if it be a sewer, that these descend toward it with a sufficient fall to prevent foul water from setting back into the porous drains in the case of a gorging of the sewer at a point near the house.

In the drainage of a city house occupying the whole width of the lot, the same system is to be adopted, save that the drains, instead of being so placed as to surround the house and cut off water approaching it, must perforce be placed under or near the foundations to receive such water as may have reached its actual site. Here the question of outlet becomes a very serious one. If the discharge must be into a sewer, then some special means must be adopted for preventing the return of the air of the sewer to the subsoil under the house.

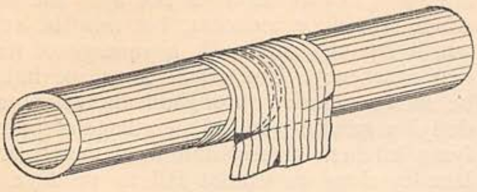
In the construction of these drains two courses may be pursued with perhaps an equally good result. One is, after having excavated the ditch and cleared its bottom of all loose dirt, to fill in to the depth of a foot



GRAVEL DRAIN, UNDER CELLAR FLOOR, NEAR FOUNDATION.

with sand or gravel,— and even fine sand will answer the purpose. The other is, to use agricultural drain-tiles, preferably of the smallest size, say an inch and a quarter in diameter, laid at the bottom of a well-graded trench and continued to the point of outlet. Where tiles are used, the joints should be wrapped twice around with strips of muslin drawn tight. This makes a perfect collar, holding the tiles in line, and affording much the best protection that has yet been devised against the ingress of sand or silt, which usually finds its entrance at the lower part of the joint, flowing in with the water which rises with the general water-level and flows off over the floor of the tile.*

Where tile drains are used, it is a mistake to marry them to other materials. Tile alone or gravel alone will make a very good drain,



TILE DRAIN, WITH MUSLIN JOINT.

— tile and gravel together not nearly so good when permanence is considered. Tiles should be laid on the bottom of a perfectly graded ditch, and should be compactly imbedded in the heaviest loam that is found in excavating. When covered to the depth of a foot, this clay should be well trodden down, so that if the tile could be taken out, leaving the earth undisturbed, we should find a complete matrix, or nidus, which had clasped it firmly at every point. The old marvel, How gets the water in? is too long for discussion here. I beg the reader to take the word of an old drainer that it does get in — and get out — perfectly.

The large pipe drains with wide joints, often with fractures giving access to vermin,— no less than the "box drains," "French drains," "blind drains," and various other antique devices for getting rid of soil-water,— are costly, cumbersome, and in the long run, inefficient, owing to their liability to obstruction. The amount of water that can ever be collected as a constant stream, except in the case of a very copious spring, even in very wet foundations, is extremely slight. A sand seam in the natural soil one-fourth of an inch thick is generally sufficient to carry it; and it is such seams, carrying water in this manner, which usually produce our subterranean and surface springs. A tile an inch and a quarter in diameter will carry more water than can usually be collected for a constant flow from the subsoil of half an acre of ground. A body of sand or gravel ten or twelve inches wide and of equal depth cannot be so compacted, provided clay and loam be kept out of it, that it will not afford a free outlet for all the water that can reach it under these circumstances from the soil of an ordinary lot. As a rule, the tile will be found to be much cheaper than the other material. It is better always that the depth of the drain should not be less than three feet below the level of the foot of the foundation. The more rapid the descent the better, but even two inches in a hundred feet, with perfect grading, will remove a very large flow. Indeed, if the drain has no fall, or even if it be depressed in places, provided it have a good and unobstructed outlet and well-protected joints, its surplus water will be discharged as soon as the general level of the water reaches the level of the overflow point. Where the water is to be delivered to a sewer, I should in any case recommend the making of the outlet drain, or a part of it, with sand or very fine gravel. I should at least make a break ten feet long in the course of the drain, and fill this with such material,— fine enough not to allow the free transmission of sewer air to the drains under the house, which a continuous tile drain would afford. I am aware that this recommendation is radically different from what has generally been set forth; but it long ago commended itself to my judgment, and has proven in practice to be entirely successful.

It is a usual custom to connect the underdrains of a house with the drain carrying the foul water, and to connect with them, also, the rain-water conductors from the roof. In view of what we now know of the ease with which the contained air of the subsoil may be contaminated, it is of the utmost importance, where the best results are sought, to deliver the underground water itself by an independent line guarded with absolute completeness against the possible invasion of foul air. Nowhere within the house, nor, indeed for some distance outside of it, should even the rain-water conductors deliver into this system.

By the means just described, the actual superabundant water of the soil may be removed. In connection with the foundation and cellar, two things else demand attention. The first is the carrying up of dampness through the foundations into the walls of the house, and the exhalation of watery vapor, which, in the case of a heavy soil, however well drained, is of considerable amount. These difficulties attach chiefly to clayey ground. The next is the entrance into the house of the aërial exhalations of the soil. Even a clay soil contains a large amount of air, and under different circumstances, such as changing barometric pressure, the rise and fall of water in the soil, and the action of winds, producing a strong draught in chimneys, this air enters the cellar and the house. The difficulty increases greatly as the soil grows more porous and becomes

* This use of muslin is patented, but it is hereby dedicated to the public to the extent of its use under or within the foundation-wall of buildings.

more dry. For example: A pile of stones broken to the size of road-metal contains a very large amount of air,— how large we could determine by filling its voids with water and measuring its quantity. Every wind that blows, every change of temperature, every rise of water into the mass, drives out or changes a portion of this air. If at the bottom of the heap there lay a mass of carrion, its stench would be almost as perceptible as though the stones were not there. A bed of such stones sufficiently large and sufficiently compacted would make a dry, firm, safe foundation for a house,— in many respects an excellent foundation. But if the atmosphere of the house were not separated from that of the interior of the mass of stones by something much more effective than even the usual cellar-bottom concrete, and if the carrion were putrefying beneath, the state of things would not be the worst possible only because the obvious offensiveness resulting from the putrefaction with the free interchange of atmosphere between the house and the foundation would insure the immediate removal of the difficulty.

This mass of broken stone, with its putrefying carrion below and its human habitation above, is only an exaggerated illustration of what exists universally over wide ranges of country. Houses are sometimes built on coarse gravel. Here the atmospheric interchange is almost as free as in the illustration given. Sometimes the gravel is finer and mixed with sand which, imposing by friction more resistance to the movement of the air, limits the interchange, but interchange to the extent of free inhalation and exhalation always goes on. Nothing can prevent this from being active when chimneys are drawing strongly, while the house is sealed against the outer air; when, indeed, as is so often and so widely the case on light soils, the whole practical ventilation of the house — that is, its intake of air — is from the ground under it, often flowing through and enriched by the various familiar fumes of ill-kept cellars.

The putrid carrion, it is true, we do not find in such concentrated condition as to produce an insufferable stench; but let us examine the case of a certain village. It is not necessary to name it. There is not a State in New England in which many of its parallels may not be found, and, indeed, there is hardly a village in the whole country built on a porous soil where corresponding conditions do not exist. The village that I have in mind was built on a flat deposit of gravel intermixed with very coarse sand, lying nearly level and extending in depth about fifteen feet to the permanent level of the adjacent tidal waters. It was a considerable village throughout the first half of the century; then it began to expand into an important railroad town. It has now a large population and much wealth. It has a water supply, and "all the modern improvements," —all except sewers. Its disposal of household waste of all kinds is not *upon* the soil, which would be indecent, but *into* the soil, which has the supposed advantage of hidden indecency. The result must inevitably be such a diffusion throughout the whole underlying ground-work of the village of putrefying kitchen grease, and fecal matter and laundry slops, as cannot fail to produce in the whole atmosphere of the gravelly earth a condition of marked contamination. Even in the milder season, however free the interchange between the air in the ground and the air over it, the air of so much of the ground as lies under houses cannot be by any means ideally perfect. When the interchange between the outer air and the ground is cut off by frost, and when cellars and wells form almost the only means of communication, then the condition is only infinitely worse.

This description may seem at first reading too sensational, and dwellers on light soils will point with satisfaction to the relatively low death-rate that their communities furnish as contrasted with that of dwellers on damp clay soils, where this atmospheric interchange is much less active. This is no fair response. The death-rate is comparatively low under these circumstances, not because of, but in spite of, the almost universal breathing of products of putrefaction as exhaled by the soil into the house. Could this element be withdrawn, it cannot be questioned that the death-rate, and in larger degree the sick-rate, on the lighter soil would show a much greater contrast.

The practical question now arises, how to meet this difficulty? If proper sewers were once provided, an absolute suppression of all vaults and cesspools would suffice to secure the early purification of the ground, for the bacteria of putrefaction — those universal scavengers — would soon make away with the existing accumulation. How far their action may modify the ill effects of the constantly renewed underground filth we have as yet no means of knowing. If we are wise we shall take the benefit of the doubt and cut off the supply of foul material.

Sooner or later we shall secure, by sewerage and a compulsory use of the sewers, the complete purification of the subsoil. In the meantime the individual householder who has an anxious thought as to the condition of his individual house, and who is now living subject to the influences of an evil due to his neighbors' many cesspools more than to his own single one, seeks some means to protect himself against enemies which his neighbors are willing to disregard. He will find his best protection in isolating his house in the most effective way from the ground in which it is founded. There is a common belief that stone walls laid in mortar, and cellar floors covered with a few inches of concrete, effect such isolation. This is not the fact. Concrete floors and granite walls are as sponge to the penetration under slight pressure of atmospheric currents. To what degree walls and concrete floors filter out the impurities of the air passing through them, we do not know. Not knowing, we will not trust. One of the safest materials for a cellar-bottom, and for the exterior packing of foundation-walls, is a clean, smooth, compact clay, one which may be beaten into a close mass, and which has a sufficient affinity for moisture always to maintain its retentive condition; for, when used in the damp atmosphere of a cellar or about a foundation, it seems to constitute a good barrier to the passage of impure air. In the cellar it may, of course, be covered with concrete for cleanliness and good appearance; but six inches of clay well rammed while wet will impede the movement of air to a degree with which ordinary cellar concrete can furnish no parallel. Where clay is not available, a good smearing of asphalt over the outside of the foundation-wall, and a layer of asphalt between two thicknesses of concrete for the cellar-bottom, will afford a complete though more costly protection. Asphalt used in substantially the same way, especially if in connection with a solid course of slate or North River bluestone, in the foundation above the ground level, will prevent the soaking up into the structure of the moisture of a heavy soil.

The matters above touched upon are seldom discussed in works on house-drainage, except so far as the mere removal of surplus soil moisture is concerned, but their importance is not likely to be overestimated. There may be good grounds for the opinion of those who think that many of the minor ailments to which the race is subject, and some of its more serious ailments as well, are due, not to the influence of an excess of filth in any form, but to the influence of an excess of moisture acting often on a little filth, or on a little organic waste which would not be classed as filth at all. Such ailments prevail more especially in houses in which mold is prevalent, which on being closed soon acquire a musty smell, and in which stuffiness is a natural condition,— houses where a general and all pervading slight dampness is to be detected. This dampness may belong to the structure rather than to the climate; for there are dry houses at the sea-side and damp houses on the mountains. The soil has an influence over the interior climate of the house, which is even stronger than external atmospheric conditions. Positive knowledge does not carry us very far in this direction, but the experience and observation of the world, especially where intermittent fevers and neuralgia prevail and where an ailing condition and low tone are the rule, have indicated very clearly that the wisest course for every man who would make his home perfectly healthy would be to separate it as completely as possible from all interchange of air or moisture with the ground on which it is built.

FOUL DRAINAGE.

ANOTHER and even more important branch of house-drainage has come into general use within a comparatively short time. This is now attracting quite all the attention that is its due. Knowledge concerning it is advancing steadily, and on the whole satisfactorily. Mistakes have been made during the past dozen years even by the best of those who have had to do with it. Such mistakes have from time to time become recognized, and they have been remedied, until we are now approaching something like a fair understanding of the fundamental requirements of house-drainage. Perhaps it would be too much to say that the practice of the art keeps anything like even pace with its principles. Neither the common usage of the best plumbers nor the average requirements of the boards of health of cities show any very considerable improvement over what was done in the better work of some years ago, save in better workmanship. Leaky joints in iron pipe, though still by no means uncommon, are less frequently found since attention has been given to testing joints under pressure. In the best work the thorough ventilation of soil-pipes, furnishing an inlet as well as an outlet for the movement of air, is now generally adopted. Another step in advance is marked by the abandonment or the much better construction of drains laid under cellar-bottoms.

The greatest step of all — the step which insured wide public benefit — was taken when municipal boards of health became so generally, so almost universally, interested in the subject of plumbing regulations. These bodies have nearly everywhere established an effective control over all new work done, and often over the amendment of old work. The main point being gained, that all such work is to be executed according to rules and under such inspection as will secure the observance of the rules, it is only a question of time when the rules themselves shall be perfected.

As they stand, these plumbing regulations permit some things which they will hereafter prohibit, and they require some things which they will hereafter, perhaps, not permit. In the latter category is the back ventilation of traps, and in the former the use of "pan" water-closets, of fresh-air inlets at the level of the sidewalk, and of bends, cowls, and caps at the top of the soil-pipe.

However, in spite of all their imperfections, the establishment of such regulations, and the rigorous enforcement of their requirements under actual inspection, have marked the greatest progress that has been made for a long time past. It is to be remembered, in criticising these regulations, that they are necessarily made suitable for universal application. They are a very inadequate guide for the arrangement of the plumbing work of a large and elaborate house; but they do constitute an invaluable guide and safeguard for work of a cheaper sort. The poor tenant, who was formerly at the mercy of his landlord, is now protected by a system which must inevitably prevent the continuance of the infamous jobs of the cheap plumber of a few years ago.

THE WRITER'S OWN OPINION.

It is no part of the purpose with which this paper is written to discuss, even in a general way, the different methods and processes of house-drainage, nor the various theories and opinions by which these are influenced. It will be assumed that the reader will be satisfied to find here only the writer's own opinion, and the grounds on which that opinion is based. I shall therefore confine myself to saying what I advise doing, with the reasons therefor.

I advise, above and before all, that in every house, large or small, the *amount* of plumbing work be reduced to the lowest convenient limit; that there be not two sinks or water-closets or bath-tubs where one will suffice for reasonable convenience; that under no circumstances shall there be a wash-basin or any other opening into any channel which is connected with the drainage system, in a sleeping-room, or in a closet opening into a sleeping-room. I should confine all plumbing fixtures on bedroom floors to bath-rooms; and, if possible, I should give each bath-room exterior ventilation, but I should never locate it against an outer wall unless I could give adequate protection against frost, for the liability to danger from the freezing of waste-pipes, traps, etc., is greater than the liability to danger from an interior location, if the fixtures are all of the best sort, and if the room itself is sufficiently ventilated.

I should always, so far as possible, place the bath-rooms so nearly over each other on different floors, that they could all be connected by short waste-pipes with one vertical soil-pipe; and if bath-rooms or water-closets were required on all floors or on any floor in different parts of the house, I should serve each set with its own vertical soil-pipe, avoiding any considerable horizontal run, such as is at times resorted to in connecting fixtures at different points on different floors.

I should try to have every part of the plumbing work fully exposed to sight. It is occasionally necessary to run a soil-pipe or other waste-pipe in a position where it ought to be concealed; but I should, when I could, avoid such situations, and when possible I should resort to some frank decoration of the pipe rather than to its concealment behind a casing.

Wherever pipes pass through floors in going from one story to another, I should make an absolutely tight blocking of the channel. As generally arranged, the soil-pipe and other pipes run through bungling openings in the floor concealed behind carpentry of one sort or another, and the pipes themselves are boxed in so that the whole system constitutes a free run-way for vermin, and a free channel for the diffusion from cellar to garret, and between floors and behind partitions, of whatever foul air an ill-kept cellar and closet-fixtures may produce. The diffusion throughout a steam-heated and ill-ventilated house of the floating results of hidden decomposition is apparent to a fresh nostril in many a "first-class house." There is no minor item connected with house-drainage that is productive of such an obvious improvement in the atmosphere of the rooms as the shutting off of this means of intercommunication.

I should use only extra-heavy soil-pipe, or pipe at least with extra-strong hubs, so that the lead calking can be driven so tightly home as to make leakage under any pressure absolutely impossible.

I should try to avoid the placing of plumbing fixtures of any sort in the cellar of a house, unless they could be so arranged as to deliver into a soil-pipe or drain not concealed under the floor. In exceptional cases, where an underground drain is necessary, I should not follow the regulations and lay a mason-work trench with a movable cover, so that access to the pipe could be gained at pleasure. I should have the pipe laid in an open trench, and so thoroughly calked that under a pressure equal to the height of one story not a drop should escape at any joint; and then, a safe conduit being secured, I should inclose it in a concreting of the best cement, inclosing it so completely and so securely that if the iron should rust out and be washed away, the cement itself would constitute a safe channel.

I should make it a chief aim to secure for all needed fixtures the greatest simplicity, and for all their waste-pipes the greatest absence of complication. I should use sinks without grease-traps, bath-tubs without inaccessible overflows, wash-basins free as far as possible from fouling places, and water-closets without valves, connecting rods, or machinery. Such restriction would limit very materially the range of selection, and would lead to discarding many things that are now in common use. This suggestion is a radical one, and it will fail of acceptance in many most respectable quarters. There can be, however, no question as to the propriety of expressing one's firm convictions in the most distinct way. What I am endeavoring to convey is not the well-known average opinion of engineers and sanitarians,— only my own opinions. These may be entirely wrong; but they are the outgrowth of the best thought that I have been able to give to the subject, and it must be conceded that no harm will result to the health of the people if they are carried out in practice.

The main purpose of house-drainage, as we now understand it, is to remove all such wastes of domestic life as are suited for transportation in running water with the greatest completeness and with the greatest attainable safety. To secure this object, the drainage system must be so constructed as to carry away, completely and immediately, everything that may be delivered into it; to be constantly and generally well ventilated; to be frequently and thoroughly flushed; and to have each of its openings into the house guarded by a secure and reliable obstacle to the movement of air from the interior of the drain or pipe into the room. It is no longer a question of "sewer-gas." Wherever the offensive exhalations designated by this term exist, wherever the effluvium of putrid waste may be detected, there is inevitably defective arrangement, or defective workmanship, or both. It is no longer to be considered the best policy to shut off sewer-gas from the house by confining it to the sewer. The true course should be to seek the seat of the evil and to remove its cause. The foul air in a defective sewer or in a defective house-drain — and it is more often in the latter — is invariably the result of the accumulation and retention of filth,— its retention for a long enough time to allow it to enter into putrid decomposition. There is but one proper way to cure it: that is, to prevent the accumulation. Such removal is to be secured only by thorough flushing, either by a copious stream accompanying the discharge, or by frequent periodic washings sufficient to sweep all deposits away. No flushing will prevent some sliming of the pipes, but good ventilation will take care of this.

All drains, soil-pipes, and waste-pipes should be absolutely tight, not only against the leakage of liquid, but against the leakage of air; they should be so reached, in every part, by a flushing stream of one sort or another, that deposit and accumulation will be impossible; they should be as thoroughly ventilated in every part as the safety of the water-seal will permit. The exterior drain, and ultimately the sewer into which it delivers, should have the same general characteristics, it being understood that the freest possible ventilation is to be given to both sewer and house-drain, by the admission of air from without and the delivery of air to the open sky, without the possibility of its entering the house at any point, in any manner, or at any time. All fixtures should be so trapped that this exclusion of the air of the drain shall be assured, but at the same time in such a manner that at each use of every fixture all the filth that it delivers shall be carried completely away, the trap being immediately refilled with fresh water.

Such are the leading sanitary requirements of house-drainage. These being secured, it is a matter of little sanitary consequence whether the fixtures themselves are cheap or costly, simple or elaborate, ornamented or plain. As, however, these appliances are devoted to the meaner uses of the household, good taste would indicate that their most appropriate "elegance" is to be secured by making them and their belongings as simple as possible, and as inexpensive as the securing of the best results will allow. They should be conspicuous, if at all, by their purity and cleanliness.

Having thus set forth the general principles that should govern the construction of the drainage work of houses of all classes, we may next consider its details.

(To be continued.)

George E. Waring, Jr.

THE PRINCIPLES AND PRACTICE OF HOUSE-DRAINAGE.—II.

DETAILS OF THE WORK.

THE MAIN LINE.

In arranging the details of house-drainage the main line is always first to be considered. It begins at the sewer, or flush-tank, or—in barbarous instances—at the cess-pool; passes through the house by such a course as may be indicated by a judicious compromise between directness and convenience, past the location of the highest fixture that is to discharge into it; then it passes out through the roof for free ventilation.

TRAPS ON MAIN DRAINS.

The question of a main trap between the house and a public sewer has been much discussed, and is still determined by no rule. There should always be such a trap between the house and a flush-tank or a cess-pool. I am inclined to the belief that there should not be such a trap in the case of discharge into a sewer, unless it be especially foul. If it is only a great cess-pool, holding the accumulated deposits of a street or larger district, or if its interior atmosphere is at all comparable in offensiveness with that of a cess-pool, then a trap will be necessary; but if it has such an atmosphere as will admit of the entrance of workmen, and if its contents are carried forward in its current with reasonable completeness, I incline to the opinion that, even if no other house connected with it aids in its ventilation, it will be better that the single house under consideration should be connected without a trap.

I have reached this conclusion slowly and in opposition to the opinion of many of the best engineers. The objection ordinarily raised against the practice is that by it "the sewer-gas is laid on" to the house; that contagious diseases existing in other houses connected with the sewer will communicate their infection directly to any house not so cut off; and that, as a matter of common policy, one man alone should not ventilate a sewer that is used without ventilation by neighbors. There are two arguments against this, and they seem to be controlling ones. (*a*.) The purpose to be secured is the greatest practicable purity of the drains and pipes of the particular house, and, while it is true that a trap will shut off the air of the sewer, it is also true that the trap itself, unless the course of the drain is very steep and its flushing very copious, may not only form a seat of decomposing filth, but will so set back the flow as to cause a deposit of foul material for some distance along the house side of the drain. If the sewer is not extremely offensive,—more offensive than a critical investigation made a few years ago showed most sewers in New York city to be,—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 the immediate seat of decomposition in and behind the trap will continue active. (*b*.) All the cry about sewer-gas being "laid on," and about the intercommunication of diseases from one house to another by means of the sewer, is the outgrowth of a condition that is now hardly tolerated, and that certainly is not contemplated in this paper. In the older work, there was either no ventilation whatever to the drainage system, or it was very inefficient. The water used, though perhaps not less in amount then than now, was not so used as to secure a good flushing effect, while the stability of traps was then little thought of. Pressure of any sort being brought to bear on the atmosphere of the sewer, foul air escaped into house-drains and found no other means of relief than by forcing traps or by working its way out at defective joints. Under such circumstances, the argument in favor of the trap was a strong one. Now, house-drain and soil-pipe are tight, ventilation is very free and complete, the effect of a pressure on the air of the sewer is not to be feared, traps are reliable, and, in the best work, joints are absolutely tight. Under such conditions the safeguard supposed to be furnished by the exterior trap is not needed,—assuming always that the sewer is a reasonably clean one. Its condition will always be improved by the ventilation furnished by the untrapped drain.

FRESH-AIR INLETS.

In the case of country houses, not discharging into sewers, the trap is a necessity.

Wherever a trap is used, there must be on the house side of it an inlet for fresh air. There can be no real ventilation of the drainage system if it is open only at its top. A bottle cannot be ventilated by removing its cork, nor will a chimney draw if it has no opening at the bottom. A copious inlet for fresh air, working in conjunction with a wide opening at the top of the soil-pipe, will insure a free movement throughout the whole system that will accomplish an adequate ventilation, not only of the main channel itself, but, by the diffusion of gases, of *short* branches connecting fixtures with it. Most of the directions given in sanitary journals and books for the arrangement of fresh-air inlets, especially in cities, seem to have been made without due regard to their liability to become obstructed by rubbish, and especially to become entirely closed by accumulations of snow. Many such inlets in New York, at the edge of the pavement or at the face of the curb, are sometimes blocked for days together in bad winter weather. Becoming obstructed from any cause, their efficiency stops, and for the time being the security that they should afford is withdrawn. There is really no good reason for placing this opening at a distance from the house. I have never known of annoyance resulting from the inlet pipe being brought out at the face of the foundation wall, preferably, of course, not too near to windows and doors. With well-flushed pipes, the constant though often slow movement of air through them so reduces the offensiveness, which a few years since was thought to be inevitable, that, although there might be a slight outward puff when closets or baths are discharged, no annoyance results.

MATERIAL AND CONSTRUCTION.

WHETHER the soil-pipe passes through or under the foundation of the house, unless the wall be old enough for all danger of settlement to have passed, it should be carried through an arched opening to prevent its disturbance if settlement does occur. In any case, the iron pipe should be continued for nearly or quite a full length (five feet) outside of the foundation wall. It may be continued farther with advantage. Although thus laid in the ground and used as a drain, iron pipe is not, like earthenware pipe, imperishable; still the greater certainty of tightness and correct grading, if due only to the better class of workmen by whom it is done, is a strong argument in its favor. After reaching solid ground that has not been disturbed in excavating for the foundation, *a carefully laid and rigidly inspected* earthenware drain is to be preferred. After the drain passes inside of the foundation wall it is better, where it is not necessary to connect with fixtures in the cellar, that it should be carried in full sight, along the face of the cellar wall or suspended from the floor-beams, to the point where it is to turn up as a vertical soil-pipe. This is advisable because here, as much as anywhere else in the house, it is important to be able to inspect the joints, and to know always the condition of the work. If, however, it should be necessary to make connection with a water-closet or other fixture in the cellar, it is better that the main channel should run under the floor to or near the location of such fixture, in order that all or nearly all of its length may constitute a part of the main line, thoroughly flushed and thoroughly ventilated, like the rest of the system. If there are several vertical soil-pipes, it will suffice, of course, if one of them is carried down for the cellar connection, and the others can be carried together above ground and connected with the main line before leaving the house. A branch only ten or twelve feet long, running to a servants' closet in the cellar, even if provided with adequate upward ventilation, is not likely to keep in nearly so good condition as it would if carrying also the discharge of closets and baths above. Wherever it becomes necessary to lay the drain under the cellar floor, I should *not* counsel the following of the usual recommendation to lay an iron pipe in a mason-work trench, with a cover that may be removed for inspection, as before set forth. It should be protected as hereinafter described.

THE SOIL-PIPE.

IT is a generally accepted rule, and a good one where space suffices, to use no short turns—technically, "T branches" and "quarter bends." Two one-eighth bends, or a Y branch and a single one-eighth bend, give a more gradual and therefore better change of direction. So, in the attachment of water-closets to vertical soil-pipes, it is usual and better to make the connection with Y branches. Where space does not suffice, however, a half Y answers a sufficiently good purpose, and even a T branch (right angles) is less objectionable than it was when flushing was less copious than it now is. The soil-pipe throughout its whole length, horizontal as well as vertical, should be so secured with hangers and clamps or hooks and with supporting posts that it will be rigidly fixed in its position. From the beginning of the work, every joint should be made with a view to being tested under hydraulic pressure. If the work-man has this in view, the test will generally discover few leaks. As ordinarily made, especially where the whole circumference of the pipe is not easily accessible to the calking tool, a test will almost invariably disclose serious leakage. In every case the test *should* be made, and every semblance of a leak should be calked until thoroughly tight under pressure. In making this test, the simplest way is to close all openings into the pipe with disks of india-rubber compressed between two plates of iron forced together with a screw. Such plugs can be fastened so tightly as to hold a head of fifty feet. There is no special advantage, however, in applying this force; for if joints are to leak at all, they will leak usually under a head of a few inches, and always under a head of a few feet. It is generally most convenient to test the vertical pipes story by story, the plugs being inserted through the water-closet branches. Another satisfactory test which may be applied after all fixtures are attached is made with an air-pump and pressure-gauge, such as gas-fitters use. If the gauge stands firm even under a slight pressure for an hour together, the work may be accepted as tight. The principal drawback is that, if the work is not tight, it is much more difficult to locate a slight leak than when the water test is used. I think it may be accepted as a well-grounded rule that no prudent owner should receive and pay for his plumbing work until all of the iron waste-pipe has been tested, by one or the other of these methods, under the personal observation of the architect or his plumbing expert. There is probably no occasion to fear that work once made tight will develop leaks for many years, the tendency to rust after a time, even with tar-coated or enameled pipe, being rather to close such slight leaks as may exist.

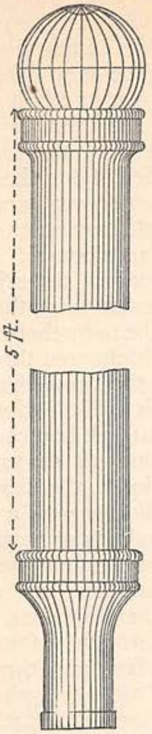
The fear has sometimes been felt that sand-holes and slight imperfections in cast-iron soil-pipe may lead to the permanent injury of the work. Ordinarily, this is not a real danger. Where pipes have been tested before erection by being filled with water in single lengths and rejected because of slight leaks, it has been found that a few hours later such leaks have become entirely closed with rust. Doubtless a rust closure is a permanent one.

There are two grades of soil-pipe known to the trade, "common" and "extra-heavy." If common pipe has sufficiently strong hubs to stand heavy calking, *and if the outer and inner circumferences are concentric*, there is no reason why it may not be trusted for very long service; but it is difficult to maintain the core in a perfectly concentric position, and even in the best pipe there is generally a slight difference of thickness between one side and another. A very slight difference is a very serious matter in common pipe. In extra-heavy pipe, unless the eccentricity is very obvious, even the thinner portion will be thick enough for safety. This thicker pipe, however, is sometimes weakened by air bubbles in the mass. To detect these, the whole pipe should be tested by sharp hammering over its whole surface.

In ordinary work in private houses, a diameter of four inches has been adopted as sufficient for the soil-pipe. So far as the mere water-way is concerned, this diameter is ample, even when roof water is admitted from very large houses. Indeed, for most cases a diameter of three inches will furnish a sufficient water-way; then, again, the smaller the pipe the more thoroughly it is flushed by the stream discharged through it. There is, however, another consideration that is important. The siphonic action, or suction, produced upon lateral branches by the discharge of water through the main shaft, is in inverse proportion to the diameter of the pipe. The sudden discharge of a water-closet using three or four gallons of water through the three-inch soil-pipe might, under favorable circumstances, produce an almost complete vacuum in the branches. The same volume flowing through a four-inch pipe would have a less effect, and through a five-inch pipe still less. Practically, where there are no fixtures higher than the fourth story, and where the admission of air from the top of the soil-pipe is very free, four inches may generally be regarded as a safe size.

VENTILATION OF THE SOIL-PIPE.

The upward extension of soil-pipe for complete ventilation is a matter of much importance, and one that has been considerably bedeviled by invention. Experiments instituted to demonstrate the utility of different caps or ventilating cowls have not yet been carried to a complete scientific result; but they have sufficed to establish two important points. One is, that every ventilating cowl of whatever kind, and of whatever effectiveness during positive winds,—when no cowl is needed,—is invariably an obstructor of the movement of air during calms or under light winds; also, that every deviation from the straight line obstructs the current. Therefore, the cap or bend or cowl, one or another of which is almost always used, is of no real utility in a high wind, and is an absolute obstructor at other times. The best result will always be obtained by running the soil-pipe straight up to a certain elevation above the roof,— more or less according to the exposure,—and leaving it entirely open at the top. To prevent the intentional or accidental introduction of obstructing objects, it is a good practice to insert, and to secure, into the open mouth the ordinary spherical wire-basket that is used to keep leaves from obstructing the outlets of roof gutters. The other point is, that a universally effective increase of the movement of air is secured by increasing the diameter of the pipe at its upper end. Theoretically, the lower down the enlargement begins, and the greater it becomes at the top, the better will be the current produced. Practically, it seems to suffice to increase the diameter of the single upper length of pipe. This is most conveniently done by using an "increaser," from four inches to six inches, just under the roof, and to set a length of six-inch pipe at the top.


THE TOP FINISH OF A SOIL-PIPE.

The owner and the architect, and all who are interested in securing good work, should bear constantly in mind the importance of making this main channel for ventilation and for drainage absolutely and permanently good from bottom to top. This being assured and tested, the various fixtures or plumbing appliances may be connected with its branches.

THE WATER-SEAL AND OTHER TRAPS,

CONSTITUTING one of the most essential elements of plumbing work, have for some time past occupied the careful attention of all who are interested in the improvement of house-drainage. Few who have applied their ingenuity to the subject have failed to invent and patent a "sewer-gas" trap. I took out a patent for a trap of this sort myself some years ago,—probably one of the least successful of the whole list. The best of the efforts of others, thus far, have been only measurably successful. I am still using one or two of them in my own work, because they are passably good, and because nothing else has offered that seemed better. The successful accomplishment of the object in view offers probably the most hopeful field to which sanitary inventors can now turn their attention. Devices intended to meet existing difficulties have not all been confined to the form and construction of the trap itself. Much the most widely recommended and successfully enforced effort to meet the difficulty has been to supply what is known as the "back ventilation" of traps. Having known of the early failure of this device, before it was generally recommended to the public and taken up in the compulsory regulations of health boards, I have never been able to look upon it with favor. There is no doubt that under many circumstances it does good, but I believe that *on the whole* it does more harm.

Not only as confirming my own view, but as an illustration of very thorough and careful experimental work, attention may properly be called to an investigation carried on for the City Board of Health of Boston, by J. Pickering Putnam, Esq., an architect of that city. These investigations have been set forth quite fully in illustrated communications to the "American Architect," which papers certainly mark a very important step forward in sanitary literature. The deductions to be drawn from these investigations are these:

While a sufficient vent-hole at the crown of a trap will prevent its contents from being withdrawn by siphonage (suction), insufficiency in such an opening, resulting from whatever cause, defeats the purpose for which it was made. Insufficiency may be due to several things. (*a*.) The opening may originally be made too small. (*b*.) It may, and very often does, become reduced in size, or entirely closed by the accumulation of foul matter thrown into it during the use of the trap. (*c*.) As its efficiency is due entirely to the admission of air fast enough to supply the demand for air to fill the vacuum caused by water flowing through some portion of the pipe beyond the trap, it is not only a question of having an opening large enough to admit the air, but of having an adequate current led freely to the opening. As the opening is into a portion of the drainage system that is unprotected by a trap, it cannot, of course, communicate with the interior atmosphere of the house; it must be connected by a pipe either with the open air outside of the house, or with the air of the upper part of the soil-pipe, above all fixtures. The ability of this pipe to transmit air in the volume required depends on its size and on its directness. A one-inch pipe, one foot long, for example, may admit air fast enough, while a longer pipe of the same diameter, or a smaller pipe of the same length, would not do so. One or other of the defects above indicated may very easily defeat the object, and, in so far as the opening may be decreased by the accumulation of waste matters, the object, which is fully secured while the work is new, may be permanently defeated by a condition that occurs after a little use. What seemed originally to be adequate security may become untrustworthy in time.

Then, again, the trap to which such back ventilation is applied depends for its efficiency on the permanence of its water-seal. A water-seal which has no other exposure to the air than it gets under ordinary circumstances, will not be so reduced by evaporation as to lose its value for a considerable period; but with back ventilation, a current of air is established through the pipe in the immediate vicinity of the trap, and evaporation becomes more rapid, destroying the seal by removing the water in a very short time. It was an unsealing due to evaporation that first caused me to discard the method. I believe, most firmly, that when the system of back ventilation, as now practiced, is applied to all the traps of a house, the destruction of the seal by evaporation will be much more to be feared than it would be in the same set of traps by siphonage only if not vented.

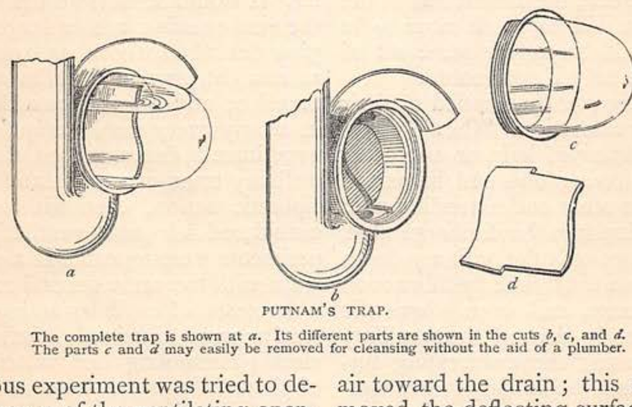
Traps are also frequently emptied of their water by capillary attraction. When a rag, a bit of string, a matting of hair, or any other porous substance having one end immersed in the trap, has the other end extending over the bend and leading into the discharge pipe, traps having a seal of only the ordinary depth may be emptied in a short time by this action alone. In other cases, and even where the traps are considerably deeper, the capillary material, by increasing the evaporating surface, greatly increases the liability to evaporation in the presence of the current of air produced by the venting-pipe. While, therefore, this capillary action is not an infrequent source of the failure of a trap which is not ventilated, it is also an aid to the destruction of the seal when it is ventilated.

Mr. Putnam's experiments were conducted in logical order. He first demonstrated that the air rushing through the trap to supply a vacuum caused by a flow in the piping beyond carries the water with it as a matter of course. Some of this water, striking against the walls of the trap, is thrown back to its original position, so that the whole volume of sealing-water is rarely removed with a single motion, whatever the form of the trap. However, he found that, sooner or later, under a sufficiently continued movement of air, the whole of the water, even in a deep trap, might be so withdrawn as to break the seal permanently. The time required for this depends very much upon the number of surfaces of the wall of the trap tending to throw the water back into it. It was found that, of the common traps, the ordinary "pot" or "bottle" trap offered the greatest obstacle to siphonage. It was assumed that "the severest test for siphonage to which a trap could possibly be subjected in practice would be that which would be sufficient to siphon out an eight-inch pot-trap or a ventilated S trap constructed in the usual manner." The apparatus used was strong enough to destroy in one second the seal of a one and one-quarter inch S trap, having a one and one-quarter inch vent-opening at the crown, having a one and one-quarter inch smooth lead pipe, sixteen feet long, connected with it, and to siphon out an unventilated pot-trap eight inches in diameter, having a seal four inches deep. It was shown by this apparatus that a reduction of diameter of the vent-pipe, or an increase of its length, lessened the stability of the trap. It made a marked difference whether the pipe was straight or was bent into a coil three feet in diameter. It would seem from the description that the vent-opening was as large, and the vent-pipe described above as large, as short, and as straight, as would ordinarily be found in practice; and it was shown that the seal was, in nearly every case, easily destroyed. The experiments demonstrated that none of the ordinary traps can withstand a not unusual siphonic action, even with what would be considered adequate ventilation. These experiments were repeated in a great variety of ways with the same general result.

In tests of capillary action, the following results were obtained: Strips of hair-felt, closely resembling the matted accumulation of short hairs which forms so large a proportion of deposit in traps and pipes, were used, having one end immersed in the water of the trap and the other hanging over the bend. Other materials were similarly used. The result of the experiments, as affecting the question of ventilation, is thus set forth:

"To test the loss by capillary attraction on ventilated S traps, as compared with the loss on the same where unventilated, an S trap having a seal of four and five-eighths inches was arranged as before with jute, half filling the trap. With a trap attached to the waste-pipe, and connected with the drain in the ordinary manner, but unventilated, the loss by capillary attraction was as follows: In the first five minutes, one-half inch; in the first forty-five minutes, one inch; in twenty-four hours, three inches; in three days, three and one-quarter inches; in four days, three and three-eighths inches. Thereafter no perceptible change took place. It made no perceptible difference whether the basin side of the trap was opened or closed, showing that evaporation in an unventilated trap is practically almost imperceptible. The experiment was then repeated on the same trap ventilated at the crown into a cold flue, with the following result: in one hour, one and one-eighth inch had been removed; in five hours, one and seven-eighths inch; in twenty-two hours, two and a half inches; in two days, three and one-quarter inches; in three days, three and a half inches; in four days, three and three-quarters inches; in five days, four inches. Thus the loss continued at the rate of about one-quarter inch a day by evaporation, after the outer end of the jute mass had entirely dried up. This rate of evaporation was nearly double *what it would have been had it not been assisted by the capillary attraction.* From this we see that ventilation greatly increases the danger arising from capillary attraction, often rendering the latter dangerous in cases where, without ventilation, the seal would not have been broken." tendency of the current thus produced is to carry the sealing-water with it. In a perfectly smooth curved trap the removal of the water may be complete and almost instantaneous; in traps of irregular form, where the water in its course strikes against the wall of the trap, it is thrown back or deflected from its course; when so thrown back a portion of the water is still carried on by the current of air, but another portion falls away from the current and resumes its position in the trap. If a sufficient number of deflecting surfaces are presented in the course of the current of air, the whole of the water, after a certain portion of the seal has been removed, is retained, and the complete unsealing of the trap cannot occur.

Mr. Putnam's trap, the form of which is illustrated herewith, stands, in its normal condition, entirely full of water. Under strong siphonic action about one-half of this water follows the



PUTNAM'S TRAP.

The complete trap is shown at *a*. Its different parts are shown in the cuts *b*, *c*, and *d*. The parts *c* and *d* may easily be removed for cleansing without the aid of a plumber.

Another curious experiment was tried to determine the influence of the ventilating opening in retarding the flow through the trap by friction. The retardation was found, as a general result, to be about thirty per cent. This is, of course, a reduction to that extent of the power of the stream flowing through a trap to overcome the tendency to form deposits.

PUTNAM'S TRAP.

As an incidental result of his experiments on siphonage, Mr. Putnam, by gradual stages, arrived at the invention of a trap which seems to be a practical one, and which, subjected to tests that were sufficient to break the seal of any ordinary trap even with fair back ventilation, maintained its seal undisturbed. The theory followed is this: Siphonage is due to the rapid movement through the trap of air driven in by atmospheric pressure, to fill the partial vacuum formed by the withdrawal of air from the pipe beyond the trap by the inductive effect of flowing water; the first air toward the drain; this amount being removed, the deflecting surfaces of that portion of the apparatus thus emptied suffice to rob the air-current of its spray, and under no test that has yet been applied, with an open-topped soil-pipe, can the seal be broken. The interior of the trap is well exposed to view, and the arrangement for cleaning in case of need is simple. The trouble of an occasional unscrewing of the glass cap to remove an obstruction would be a very small price to pay for the absolute security which Mr. Putnam seems to have achieved.*

This trap or something like it may probably come into universal use for wash-stands, baths, and laundry-tubs,—for urinals, also, where separate urinals are used. For water-closets it cannot take the place of the exposed trap of which the bowl constitutes one arm. For kitchen and pantry sinks I believe my own own device is better.

I have been using for some years past one form or other of mechanical trap, usually Bower's or Cudell's. They seem to be the best

* Since the above was written, I have tested Mr. Putnam's trap, finding it effective, in withstanding siphonage, and substantially self-cleansing. It seems to me the best trap that I have seen.

heretofore available, but they have never been entirely satisfactory. If the Putnam trap is not the success that I expect, these perhaps will remain our best resource for a time. Whether compelled by local law to ventilate traps or not, I should not depend on ventilation in the conviction that the simple S trap, as ordinarily constructed and as ordinarily ventilated, is totally unreliable.

PLUMBING APPLIANCES.

CONCERNING patented apparatus, it is proper for me to explain the fact that in the following pages, among other things, I set forth somewhat in detail inventions of my own, which are patented, and by the sale of which I should profit. Such a course is naturally open to criticism, and such a position is always one of embarrassment. It is the usual course to describe the various appliances, mentioning one's own only incidentally, and this would doubtless seem to many persons to be the proper one for me to pursue.

It seems to me on reflection, however, that the only justification for the writing of this paper is to communicate to the public the best advice I have to offer. My attention has been given for many years to details of house-drainage as a matter of business, not of philanthropy. I have had occasion to study closely, and to adopt and discard, one after another, a long series of plumbing appliances,—things that have come up and gone down in the rapidly improving art which ten years ago was an extremely crude one, and in which perfection has as yet by no means been attained. I might describe this succession of improvements, and indicate the quality, promise, and defect of each. Such information may be found, by those who desire it, very well set forth in the rather copious modern literature of the subject. The space at my disposal here would hardly suffice for a bare cataloguing of plumbing improvements. My own devices were in no case invented with a view to securing a valuable patent, nor for any purpose but to improve my own professional practice. The few of these devices which have approved themselves to my later judgment, and which I am now introducing in my work, I have patented to secure an incidental commercial advantage. I shall therefore describe them without hesitation and without further comment, treating them exactly as I treat such of the inventions of others as commend themselves to my judgment. I shall trust to the good sense of the reader not to misunderstand my motive.

Special appliances for carrying out the plumber's art in the drainage of houses are to be numbered by hundreds. Invention has taken advantage of a growing demand for the attainment of additional security against the invasion of drain-air, and has literally run wild. "Sewer-gas" has been made to do full duty as a cause of public alarm. The shops and the catalogues and the professional papers and books are full of an embarrassing variety of all manner of devices. Many of these inventions are great improvements on their predecessors, but many are their predecessors under new names and with new complications. Few of them have been made with regard for what seems to be the most imperative need of the work — simplicity. We should especially seek the greatest possible simplicity, not only in detail but in general scheme. While the market offers a separate vessel for each possible separate use, the wisest course seems to be to reduce the number of vessels and to concentrate the various uses as much as may be. For example, I should, wherever possible, avoid the need for urinals, slop-sinks, and hoppers, by constructing the water-closet in such a manner as to supply all of these demands in a convenient and acceptable way, thus securing incidentally the most frequent change of its trapping-water and the most frequent flushing of its outlet. The urinal is almost invariably the most odorous vessel in the house. The slop-hopper is generally a receptacle for rags and rubbish, in a dark, out-of-the-way, uninspected closet; and the sink for drawing water is, in less degree, open to similar objection. With a self-closing faucet for drawing water, there need be provided for the protection of the ceiling below only such simple means of outlet — like a safe-pipe opening through the ceiling of the basement or into a sink or a water-closet cistern — as will carry the slight drip that may come from an accidental leak. Ordinarily there is no serious objection to arranging to draw water through the bath-cock, if this is placed, as it should be, at the top of the tub.

Objections to this concentration of uses, and to the abolition of a separate vessel for each separate use, are confined mainly to trade journals, published in the interest of manufacturers and plumbers whose profits it is thought might be affected by the reduction. Their argument is that cost is secondary to ample convenience. While it is important to avoid unnecessary cost, the economical argument is the least of all the reasons for what is here proposed. The real and controlling argument is based on the great advantage of having the fewest possible points requiring inspection and care, and to secure the most frequent possible use of every inlet into the drainage system. Reasonable convenience being always kept in view, three water-closets in an ordinary house are much better than half a dozen; and the same principle holds throughout the whole range of plumbing appliances.

WASH-STANDS.

STATIONARY wash-stands, where they should be used at all — in bath-rooms and lavatories mainly — should, like all other fixtures of the kind, have the space under the slab fully exposed to view, so that the trap and all pipes may be seen at all times, and so that neither by accident nor by stealth may there be created the hidden untidy condition which is almost universal with the tight, unventilated inclosed spaces generally used. The basin itself as now constructed has a hidden overflow which it is very difficult, if not impossible, to cleanse, and it has generally either a plug and chain to close its outlet, or a side plug operated by a knob above the slab. Both of these are wholly objectionable. The links of the chain and the ring and attachments of the plug become fouled with soapy matters, and it is difficult to cleanse them. Practically they are generally nasty. To shake a filthy chain in a basin of clear water would be a very untidy preliminary to ablution. This is substantially what we do when we let water with some force directly into a basin in which a dirty chain is hanging. The side plug *seems* to be much nicer; it is really less nice. There is a befouled waste-pipe leading from the outlet to the plug, in communication with a slime-coated overflow channel rising above the plug. This pipe it is practically impossible to cleanse. Its filth is constantly undergoing decomposition. Whenever the bowl is emptied it becomes filled with air; when the plug is closed and the bowl is filled, this air is driven in bubbles with some violence into the bowl. Not infrequently flakes of the sliming matter come with it. The only really cleanly device that I have yet seen is what is known as "Weaver's Waste," where the plug fits closely into the outlet, forming part of the bottom of the basin, and is opened by being raised from below. It does not get over, and it may slightly aggravate, the objection to the hidden overflow; but it does enable us to wash in a clean vessel. I am now experimenting with a small fixed basin which is simply an earthenware funnel without plug or overflow. At its top stands a movable wash-bowl to be filled from the supply-cocks in the usual manner. The bowl is emptied by pouring its contents into the funnel. That this will prove a practical success is not yet demonstrated.

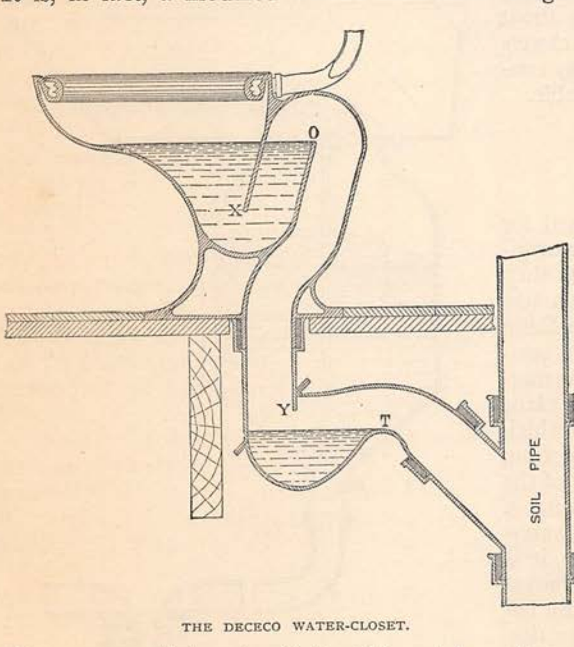
WATER-CLOSETS.

WATER-CLOSETS have naturally been the subject of more ingenuity, and of more argument, than anything else connected with the whole subject of house-drainage. It is hardly necessary at this late date to say anything to the limited public which reads on such subjects about the absolute inadmissibility of the almost universal pan-closet, which is still the great favorite of landlords and of builders, and which, in spite of its complication and intricacy, is still, owing to the great demand for it, sold more cheaply, and therefore more widely, than any other. It is enough to say that those who care for safety in drainage works will neither adopt it in new construction nor retain it where it already exists. It is not, and it cannot be made, a safe water-closet. To a greater or less degree, the objections to it hold in the case of every other closet in the market which has anywhere in the course of its outlet anything of the nature of a valve or moving part.

It is not an overstatement of the universal conviction of skillful sanitarians to say that the range of unexceptionable water-closets is limited to such as have a free water-way from the bowl to the soil-pipe, depending for their trapping, and in some cases for their holding of a bowlful of water, on an elevation of the overflow point. These may be classed in a general way as "hopper" closets. The simplest form of this closet is a funnel-shaped vase reaching from the floor to the seat. At the bottom it is connected with an S trap, having a depth of seal generally of from three-fourths of an inch to an inch and a half. This is a cheap and good utensil for the commoner uses. It is made of earthenware or of enameled iron, and in its best form its rear portion is nearly or quite vertical. What is known as the "short hopper," made of iron or of earthenware, has a shallow bowl, with a trap rising at its side and entirely above the floor.

Pursuing the plan already announced, to avoid anything like a cataloguing of plumbers' supplies, and referring to what has already been said about my own inventions, I give herewith, as an illustration of the better class of closets, a vertical cross-section of the Dececo closet with its trap and discharging siphon. In this closet I have tried to overcome the objections to the mechanical or valve closets, while retaining the advantages of a deep bowlful of water for the reception of deposits and the suppression of odor. It has a seal about four inches deep, a depth of water of nearly seven inches, disposed in the most useful way, and a sufficient submersion of the main part of the bowl. While it is possible under strong siphonage to reduce the depth of its water considerably, it is not possible, under any conditions that can occur in practice, to break its seal, the rising limb being sufficiently large to give an adequate passage to a continuous stream of air without removing the water to such a point as to unseal the trap. It has the further advantage that its seal is in full view and is always under control. When it *seems* to be right it *is* right.

The peculiar operation on which it depends for its discharge is due to the use of an outlet weir below the floor, which is the invention of Mr. Rogers Field, an English engineer. It is, in fact, a modified Field's flush-tank.



THE DECECO WATER-CLOSET.

The outer or discharging limb of the siphon reaches down into the weir-chamber. The depth of seal is the distance from the surface of the water in the bowl to the top of the intake X, and this is regulated by the height of the overflow point O. The closet is supplied with water through an ordinary flushing-rim, connected with a service-box or cistern overhead. The cistern is operated by a pendent pull. When the pull is drawn down, a copious supply of water flows into all parts of the bowl through the flushing-rim, washing it completely and raising the level of its water rapidly. The surplus overflows at O faster than it can be discharged over the weir-top T, without rising so high as to close the opening at Y. This closure shuts off the air in the siphon from the air in the soil-pipe, with which it is ordinarily in communication. The water flowing through the long limb of the siphon, in an irregular stream, carries the air with it, and there is soon established a strong siphon action, which continues until the water in the bowl descends below the top of the intake X. Then air is admitted at this point, and the flow through the siphon is checked. The discharge at T continuing, the water in the weir-chamber soon falls sufficiently to allow air to enter at Y and empty the siphon. The contents of that part of the siphon between X and O fall back and establish an immediate hydraulic seal at the intake. The service-box is so arranged that after the main supply is stopped a small stream continues to be discharged into the bowl until it is filled to the height of the overflow point.

It was evident from long and successful experience with Field's flush-tank, that the principle on which this closet is constructed is a perfectly correct one. It has undergone few changes since its original construction three years ago, and the several hundred closets now in use are invariably satisfactory. So far as I can see, it accomplishes perfectly every purpose for which a water-closet, slop-hopper, or urinal is required. In practice, it uses at each operation over two and a half gallons of water, which gives a thorough flushing to the soil-pipe and drain, while it has the great advantage of sending a good part of its discharge through the soil-pipe in advance of the foul matters, lubricating their passage through the whole drainage system. Although this considerable volume of water is essential to its complete efficiency, the closet may be emptied by pouring into it suddenly less than two quarts of water. A large pail of slops thrown into the closet as rapidly as possible fails to overflow it, and barrels of water might be poured through it in succession as fast as the three-inch outlet can discharge it.

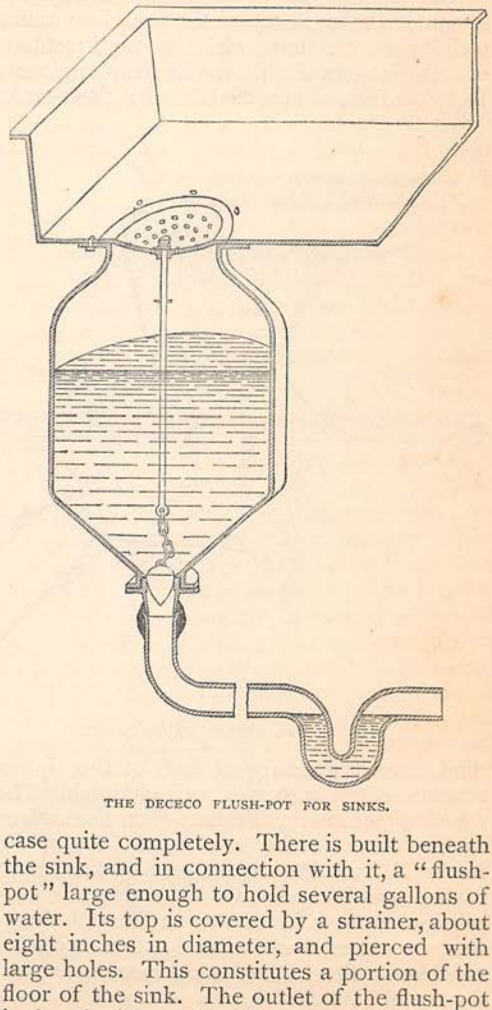
The setting of water-closets in the best manner is most easily secured when hopper or other plain closets are used. By the best manner, I mean such setting as requires the minimum of carpentry, preferably nothing whatever but a single well-finished hard-wood plank with a hole through it, resting on cleats at the sides and hinged to be turned back out of the way. It is better that there should not even be a cover to the hole. The entire closet, inside and out, should be as thoroughly exposed to view, to ventilation, and to perfect cleansing as possible. If the floor and back and side walls be covered with glazed tiles,— preferably white,— so much the better; but a cheap and satisfactory setting is secured by a slate flooring with hard-wood finish around the sides. Even oil-cloth on the floor, and the ordinary base-board and plaster at the sides and back, answer a very good purpose; the great thing is to have a perfect exposure to sight and air. The costly housing-in of the closet by a close seat and cover and a close riser in front may serve a very good purpose as an ornamental piece of cabinet-work, but this too often covers a condition of things that no fastidious housekeeper would knowingly tolerate. Sloppage, leakage, and the tainted air rising through the irregular holes left for the soil-pipe, unite to make this space untidy and in every way objectionable. Some sort of housing-in is necessary with closets which have machinery about them, but the whole class of hopper closets may be entirely free from anything or any condition to make such concealment desirable.

SINKS AND OTHER DETAILS.

KITCHEN and pantry sinks are used for the discharge of matters which in their original condition are not offensive, so that they are, in the popular estimation, of much less serious consequence to the sanitary condition of the house than are water-closets. This temporary different condition, however, of the matters which they receive, very soon gives place to a similar condition of the matters which they have discharged. After a little retention, putrefaction sets in, and the refuse food of the sink becomes as offensive and objectionable as does the digested food of the water-closet. In the one case as in the other, it is very important to secure a complete removal of all foul matters well beyond the house before putrefaction. The liability to detention and deposit is much greater in the case of the sink than in the case of the closet, for the reason that, with much less flushing, there is discharged through its waste-pipe a considerable amount of heated and temporarily liquefied grease. This grease passes the strainer of the sink and is unnoticed, but, as it cools along its course, it attaches itself to the sides of the pipe in constantly increasing accumulations, until the channel is often nearly or quite obstructed. It is by no means pure grease that is thus attached. In its congelation there are involved particles of highly putrescible matters, and the ordinary kitchen-sink waste-pipe is the seat of a constant decomposition,— mostly beyond the trap, and for this reason not especially noticeable.

Not to get rid of the putrefaction, but to prevent the obstruction of the pipe, there have been invented various forms of grease-trap, having for their purpose the hardening of the grease under conditions which will allow it to be removed. These grease-traps would answer a better purpose than they do if we could depend on their being regularly attended to; but so long as water will flow from the sink, servants will give themselves but little trouble about such accumulations.

I have employed a device that has now been in considerable use for several years, which seems to meet the requirements of the



THE DECECO FLUSH-POT FOR SINKS.

case quite completely. There is built beneath the sink, and in connection with it, a "flush-pot" large enough to hold several gallons of water. Its top is covered by a strainer, about eight inches in diameter, and pierced with large holes. This constitutes a portion of the floor of the sink. The outlet of the flush-pot is closed with a plug like a wash-basin plug, which is attached to a spindle rising through the strainer. The outlet is connected with the drain by a small pipe, having a common trap, which is useful only during the short periods when the plug is withdrawn. Ordinarily the outlet stands closed. Water thrown into the sink flows through the strainer, leaving all coarser substances to be brushed up and *burned in the range*.* Little by little, the flush-pot becomes filled, and during this slow process most of the grease becomes congealed. When it is nearly full the water can be seen, even before it reaches the strainer. Then the spindle and plug are raised and held up until the gurgling of air through the trap indicates that the pot is empty. Then the outlet is closed and the filling begins again. The strainer and spindle may be lifted out together, exposing the whole interior of the flush-pot, which may thus be given a daily cleansing and kept in as good order as any iron vessel in the kitchen. The theory of the success of this apparatus is very simple. There is absolutely nothing running through the waste-pipe except during the moment when the flush-pot is being discharged, and then the whole mass flows with such force as to carry everything with it.

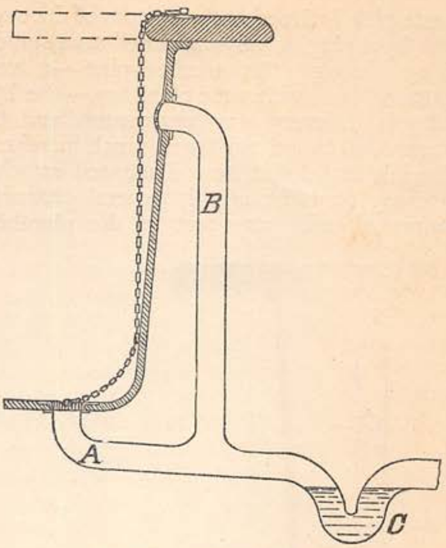
At my own house, having occasion to inspect the main drain (diameter three inches), I found that neither a copiously supplied water-closet nor a bath-tub had such flushing effect as had the discharge of the flush-pot in the kitchen. Its flow filled the drain more than half full with a stream of good velocity.

OVERFLOWS.

OVERFLOWS, intended for the safe removal of surplus water from bath-tubs, wash-bowls, etc., are necessarily on the house side of the trap. They are practically never reached by a strong flushing stream, and their walls accumulate filth and slime to a degree that would hardly be believed. They constitute the nastiest element of modern house-drainage of the better order. Perhaps they are not a serious source of *danger*, but they are, more often than any other part of the plumbing work, except the urinal, the source of the offensive drain-smell so often observed on first coming into a house from the fresh air.

In the stationary wash-basin as at present arranged, there seems to be no easy way to get over the difficulty, a difficulty which of itself should be a sufficient reason for excluding these fixtures from sleeping-rooms. The basin overflow is objectionable for substantially the same reason that the bath-tub overflow is objectionable, though perhaps to a slighter degree owing to the smaller surface exposed to the accumulation of deposits.

The concealed overflow of the bath-tub may, fortunately, be dispensed with, and in this case the difficulty inseparable from the



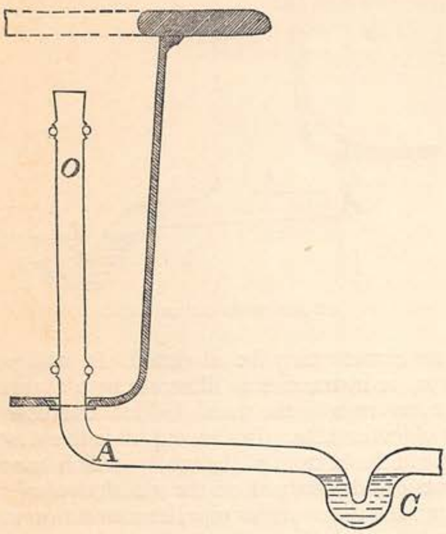
HIDDEN OVERFLOW OF BATH.

arrangement may be obviated. It will, perhaps, be instructive to illustrate by a diagram the reason why the usual hidden overflow is so objectionable. In this cut, A is the waste-pipe at the bottom of the tub, by which its contents are discharged on the withdrawal of the plug. B is the overflow pipe, its connection with the tub being through a perforated screen. C is the trap by which the waste-pipe is shut off from the drainage system, and which has incidentally the effect of retarding the flow of water through the waste-pipe. If we suppose the tub to be filled to the level of the overflow and its waste-plug to be removed, the water will immediately rise in the overflow pipe to very nearly its height in the tub. It is of course impregnated with the impurities of the water in the bath. Furthermore, the lighter particles of organic matter flowing through the waste will, some of them, rise by their levity into the overflow pipe. The water rushes up into this pipe with much force, but it descends only very slowly as the level in the bath descends, so that at each operation there is a tendency to deposit adhesive matters to the walls of the pipe. What is so deposited decomposes and escapes little by little in a gaseous form through the perforated screen into the air of the room. The amount of these decomposing matters is somewhat increased, though probably not very much, by floating particles passing through the screen when the overflow is performing its legitimate function.

This is the simplest statement of the proposition, and this is perhaps the least objectionable form of hidden overflow. Where the

* This simple cremation of the worst elements of house-garbage costs no money and little trouble. It solves one of the difficult domestic problems.

waste-pipe is closed at the bottom of the overflow by a plug or valve attached to a spindle rising through the overflow-pipe,—a very favorite device with some plumbers,—the difficulty is in every way aggravated and the amount of fouled surface is much increased. The inherent defect here illustrated attaches to every overflow of this general character connected with any part of the plumbing



STANDING OVERFLOW AND PLUG FOR BOTH.

work. In the case of a bath-tub it may very easily be avoided, as shown in the next diagram, by doing away entirely with the overflow-pipe B and its perforated screen, and using for the closure of the waste-outlet A, as a substitute for the ordinary plug, a pipe fitting into the outlet and rising to the height desired for the water in the bath. If the upper end of this pipe be given a trumpet-shaped opening, its capacity will be increased. Unfortunately, such a substitute for the ordinary overflow is not applicable to wash-bowls as now made. It may be made available for pantry sinks if the pipe can be so placed in a corner as not to interfere with the proper use of the vessel. If its universal adoption for bath-tubs could be secured, a very wide-spread source of mild nuisance would be done away with. Fortunately, it is far cheaper than any arrangement for which it is a substitute. It is one of its incidental uses that it enables us to get rid of the dirty chain attached to the ordinary bath-plug. Weaver's waste, which is one of the best devices for closing the outlet of an ordinary wash-basin, is also arranged for the bath. In neither case does it in any respect modify the objection to a foul overflow.

STOP-COCKS need no especial notice in this paper, except in connection with bath-tubs. Most, if not all, of the English earthenware bath-tubs imported into this country, and many even of the planished, copper, and enameled iron tubs made here, are furnished with an ingenious device for delivering the supply near the bottom of the tub in such a manner as to mix the hot and cold water at the delivery and to admit the supply with little noise. The last may be an advantage. The first may be perfectly accomplished by delivering the hot and cold water through a single nozzle at the top of the tub in a convenient position for drawing water for other uses. There are doubtless many cases where the bottom delivery of the supply may be free from sanitary objections, but they are fewer than would be supposed, and it seems strange that the frequent serious objection to the arrangement should have been so generally overlooked. This bottom delivery is substantially a cock for drawing water, and all who use such cocks for filling wash-bowls must have noticed a frequent indraft of air when the cock is open. Water being drawn from the lower part of the supply-pipe, the head in the upper part is annihilated, and if a cock is opened the water falls in the supply-pipe, air rushing in to take its place. The indraft of air is not of much consequence, but the indraft of a pipeful of dirty water from a bath-tub does not suggest a pleasant modification of the quality of the water-supply of the house. In this case, as in many others, an apparent mechanical improvement, securing only incidental benefits, should be discouraged. In my judgment the only perfectly safe and satisfactory arrangement for baths thus far devised is one by which the water is drawn through a faucet above the water-line, and by which the outlet is closed by a stand-pipe serving as the *only* overflow of the tub.

LAUNDRY TRAYS, as they are now almost universally arranged, are hardly to be regarded as a conspicuous element of the sanitary works of a house. There are few cases in which we find anything about them that is seriously objectionable. With them, as with sinks, water-closets, and wash-basins, it is best to avoid all unnecessary carpentry. It is, of course, best that they should be made of some other material than wood,— either slate, cement, or earthenware. Earthenware tubs, supported on galvanized iron legs and surrounded by a simple border of hard wood, seem to ask for no improvement.

AN EXAMPLE.

SIMPLICITY in house-drainage and a marked contrast to the multiplication and complication so often found in the better class of houses, are illustrated in the case of a very fine and costly house of which I am now superintending the plumbing work. It has in the basement one kitchen-sink with the flush-pot, and four laundry-tubs. The main soil-pipe runs under the basement floor near both of these; it is of extra-heavy iron, leaded and tested under pressure to absolute tightness. It is then, so far as it lies below the floor, completely encased in Portland cement mortar, and this, again, in well-made concrete; it turns up near the laundry-tubs, and near the ceiling it receives a branch pipe coming from a lavatory on the first floor, twenty-five feet away; it then passes through the floor and receives the waste of the flush-pot of the pantry sink; rising to the ceiling, it receives the waste of a bath-tub and wash-stand on one side, and on the other the waste of a Dececo water-closet and wash-stand; passing through the next floor, it receives the wastes of the fixtures in the servants' bath-room,—a straight hopper closet and bath-tub and a wash-stand; above the ceiling of that room its four inches size is increased to six inches, and it passes with this larger diameter a short distance through the roof, its top being closed by a large wire basket inserted in the hub of the six-inch pipe; the branch pipe under the ceiling of the cellar is connected with a Dececo closet and a wash-stand in the lavatory, and is continued up, without other connections, to its increaser and a six-inch top joint through the roof. This is the full complement of the drainage appliances which, in accordance with modern ideas, it was thought necessary and wise to introduce into a house which, even five years ago, would have had twice as many closets and baths, and at least four times as many wash-basins, to say nothing of two or three urinals and one or two house-maid's sinks. The whole cost of the work to be done, including all water-supply and heating, and the outside connection with the sewer of six roof-water conductors, is just about one thousand dollars. Under the old method, supposing the same material and workmanship to be used, and considering the long lateral waste-pipes and hot and cold water and circulation pipes of the different baths and basins, the cost would hardly have been less than twenty-five hundred dollars. The saving of cost effected is, in my judgment, of much less consequence than the simplicity secured.

In the foregoing remarks, it has by no means been attempted to give full directions for the guidance of house-drainage work, but rather to set forth certain points for the information of house-builders. The plumber is, and, with the general public, will long remain, the final authority in the decision of all questions arising. The better plumbers—those who keep themselves intelligently informed as to improvements in their art—will be a very useful authority; all plumbers, when brought face to face with the average householder, are a masterful authority, and their control is generally complete. The information given in these two papers may, now and then, either aid them to better judgment, or enable their clients to modify their practices in some important respects.

George E. Waring, Jr.

THE DREAM OF DREAMS.

"We are such stuff as dreams are made of."

BEHOLD an image of the dream of dreams;—
  A child woke in a meadow garlanded
  With many a flower, the tired bee's balmy bed
  And nectarous feast; oft-interlacèd streams
Through green leaves smiled with blue, alluring gleams
  Of liquid light; the birds sang overhead,
  And on the land the lavish sun-god shed
The gold wherewith his Eldorado teems.
But when, grown gray, the child, with weary feet,
  Pressed near the meadow's heart, to take his rest,
  Song lulled, intoxicate with odors sweet,
An earthquake shock uptore its bloomy breast,
  And lo! a gulf! fierce blasts of poisonous heat,
  And all that beauty by black death possessed!

C. T. Dazey.