SANITARY DRAINAGE.

Sanitary drainage, as we know it in America, has been a peculiarly progressive art. Forty years ago, towns were seweried to get rid of their surface and subsoil waters,—mainly to prevent the flooding or dampness of cellars, and the obstruction of traffic by the accumulations of storm-water. Agricultural lands were drained for agricultural improvement. Houses were drained for convenience. "Sanitary," so far as common speech was concerned, was a word uncoined. Edwin Chadwick, then a middle-aged enthusiast, had barely inaugurated the movement which the world was so slow to take up, which has owed so much of its progress to his sturdy and sustained impulse, and of which, as a hale octogenarian, he is still one of the most lucid, most enterprising, and most effective promoters.

Though till then carried on with little reference to the health of the person or of the people, the drainage of houses and grounds and towns had become a somewhat systematic art. The storm-sewers of the first half of the century constituted the basis of the sanitary drainage which was to follow. The covered creeks and the subterranean waterways of London and other cities, constructed with a widely different purpose, were used for the discharge of a gradually increasing proportion of the offscourings of the population. Following Chadwick's suggestion, the subject of separating this foul flow from the storm-water drainage, after much discussion, obtained a certain amount of practical development. It had elicited much instructive discussion, and not a little acrimonious debate, at the time when the improvement of town sewerage began to receive intelligent attention in America. The first important contribution to this branch of our municipal literature was made by Mr. Chesbrough, who, in 1858, reported to the local authorities of Chicago the results of a careful and critical study of European drainage systems, offering at the same time
a sewerage project for the apparently impracticable swamp area which had been chosen for the site of that city,—a scheme which, for the time when it was projected and the conditions by which it was limited, was a more than notable example of successful and intelligent engineering skill. The same talent applied now to the same conditions, in the light of what has since been learned, would produce a different and better plan, but hardly one so much in advance of the examples in which it originated.

The sewerage of Chicago and Mr. Chesbrough's later work at New Haven and elsewhere, have had a controlling influence on the sewerage systems of the country. Among the best examples of similar work executed by other engineers, may be cited the sewerage of Providence, of Brooklyn, and of the upper part of New York. But, after all, a review of the drainage works of all the cities of the country shows, on the whole, how limited has been the influence of any sanitary suggestion. The drainage systems of our newer towns is generally bad, and those of the older ones is even worse. Taken as a whole, the old peninsula of Boston is a quite complete museum of almost every conceivable mistake and defect in public sewerage. It has some good sewers, but an unusual proportion of very bad ones, as is shown by an illustrated report on the subject made by Eliot C. Clarke, Esq., to the Massachusetts State Board of Health. Philadelphia offers in its older and its best peopled portions much less variety of defect, but an almost universal dissemination of defects of very serious character.

Boston, Buffalo, and a few other large towns are now executing or considering the construction of great intercepting trunk-sewers to keep their foul outflow out of adjacent waters. It would have been more logical if the authorities of those cities had first secured the reconstruction of their interior sewerage systems, and so remedied faults which have a more immediate effect on the health of the people. Certainly, a logical sequence of their present efforts must be an extension to the interior of the town of the principle of purification now being applied to the water front. The influence of the example of England, where the greatest attention has been given to water-carried sewerage, has been most important. The practice of separating storm-water from foul drainage, advocated there some forty years ago, and from that time to this largely adopted, was so obviously a move in the right direction, where circumstances
favor such a system, that it has at last had marked effect in this country, where, indeed, it has received important modification and amendment. Many smaller towns, for which sewerage was recently not thought necessary, are now discussing the propriety of introducing complete works, or are actually carrying them out, advantage being taken in many cases of the greater economy and cleanliness of the separate system. Indeed, this system is being considered for portions of our larger towns in some cases, in others for whole towns. Baltimore, for example, where the existing sewerage works are confined to some dozen miles of storm-water conduits laid in the low-lying parts of the town where surface water used to accumulate, is now actively considering a project submitted by its engineer, Mr. Charles H. Latrobe, for the complete sewerage of the whole city,—over one hundred miles,—on the system of the entire separation of storm-water, as carried out in Memphis. New Orleans has adopted the same system, to be executed when, if ever, it shall be able to procure funds for the purpose.

Ordinary brick sewers, as built from immemorial time, are practically very far from being impervious to water. The original purpose of their construction has usually been to carry away storm-water flowing on the surface of streets and of private property; but one of their most beneficial offices has been found to be the incidental removal of the surplus moisture of the soil,—an effect the influence of which upon public health has always been great. So obvious, indeed, has been the advantage of such soil drainage that, where tightly jointed vitrified pipes are used in heavy soils it is usual, in the best practice, to lay porous draining-tiles in the ditch, or, in practice not so good, as in recent work at Newport, to leave the lower part of the joints of the pipes uncemented, securing in this way, when the ground is saturated, an efficient subsoil drainage. Unfortunately, this method secures also the unintended result of allowing foul sewage to spread itself throughout the soil during dry seasons, poisoning the ground and robbing the heavier part of the sewage of its requisite means of transportation, stranding it as a deposit in the pipes.

The influence of subsoil drainage on the general health of the people, and especially in removing or mitigating fever and ague in malarious regions, has been quite as marked in the case of drainage works carried out in country districts for purely
agricultural reasons. The result of such drainage in England, in districts which were formerly extremely malarious, has been most important and lasting, and it is now the accepted belief on all sides that the sovereign remedy for fever and ague is the complete drainage of all moist land in the neighborhood.

The history of house drainage during the past fifty years is the history of a most rapid and satisfactory progress, from the mere introduction of convenient channels for the removal of what would otherwise have to be carried out of the house by hand, to a process whose intimate relation to the health of the people is universally recognized. It has more recently exhibited a steady growth from the "modern conveniences" scattered throughout the house by the profuse hand of the plumber, with no regard to the effect on the atmosphere of the dwelling, to the "sanitary drainage" which is now so jealously guarded by intelligent Boards of Health, and in which convenience is made secondary to conditions of cleanliness and purity. It is safe to say that we have now the prospect of securing, at an early day, a constant regard for healthful conditions in the introduction into the houses of rich and poor of those appliances for convenient and more civilized living which the whole people is so fast coming to demand.

A review of this progress discloses a remarkable change in public sentiment. Twenty years ago the number of persons who paid the least attention to the sanitary accompaniments of modern living was altogether insignificant. Later, the influence of the pens and tongues of a few enthusiasts, and of far fewer philosophers, began to be felt, and that element of society which formerly expended its enthusiasm on phrenology and kindred "sciences" began to take up sanitary science as a more promising field for the exercise of its energies. This led to the condition which now prevails, when drainage is elevated to a position of undue prominence; when, with few exceptions, all the ills that flesh is heir to are ascribed to wet ground, foul soil, defective drains, and that great bugaboo of them all, "sewer-gas"; when defective ventilation, stove heat, furnace heat, bad food, and worse drink are allowed their little-disturbed sway, the majority of their victims being charged to the account of bad drainage. The capital of the nation is notoriously the place where "malaria" plays its wildest pranks and finds its most distinguished subjects. Its site has defects,
and its saturated soil is undoubtedly most objectionable. But in all the outcry against the malaria of Washington we hear little of the whisky, and the late hours, and the dissolute life to which, probably, a more just estimate would ascribe the greatest proportion of its morbidity and of its mortality.

These remarks are by no means intended to belittle the office of proper systems of drainage in improving the public health, but rather as a precaution against that general disappointment which must follow the demonstration of the patent fact that perfect drainage is not the only requirement of perfect living. With this limitation, too much importance can hardly be attached to the subject; nor can too much earnestness be employed in urging forward every movement which looks to the removal of filth and of undue soil-moisture.

It cannot be pretended that the conditions of sanitary perfection are known; but we may safely claim that the intelligent investigations of the past few years have led to a very important increase of our positive information on the subject. There is no doubt that some of the well-accepted theories of the present day are destined to be set aside by future investigation; but, on the whole, they constitute a very good and reliable foundation for systematic work. They contain a sufficient element of certainty to justify local Boards of Health in establishing rules and regulations, the enforcement of which, whatever their imperfections,—and it is to be remembered that such rules have to be prepared for universal application, not alone for those who desire and are willing to pay for the best work,—cannot fail to bring about a marked improvement in the condition of life of all classes of the people.

The assumed basis for the best present practice,—most of which will probably stand the test of time,—may be fairly stated as follows:

All ordinary domestic waste matters, whether offensive or inoffensive, when first produced, become to about the same degree offensive when putrefied. They also become to about the same degree dangerous, save that some may carry specific germs of disease, which are absent from others. All such matters should, therefore, be removed entirely beyond the house and beyond the limits of population before their putrefaction sets in. The objections attaching to the decomposition of these substances attach in like manner, but in less degree, to such of
their elements as adhere to the walls of the channels through which they are removed; i.e., it is important not only to consider the removal of the great bulk of our filth, but also to guard against evils arising from the decomposition of the adhering particles which mark the course it has followed.

The removal of waste matters by transportation in water has such preponderating advantages over all other systems of treatment,—including the earth closet,—that it is not worth while, for general practice, seriously to consider any other than the water-carriage system. The removal of solid matters in a stream of water requires a sufficient depth in the flow to carry the solids along, and a sufficient velocity to prevent sedimentation. As these elements—depth and velocity—must always work together, the size of the channel through which the stream runs is most important. An amount of water that would fill a large pipe half an inch deep, would fill a sufficiently smaller pipe an inch deep. Ordinary fecal solids are readily transported in water an inch deep, while in water of only half that depth their buoyancy would be too much reduced, and the amount of their surface receiving the impulse of the flow would be too small for their prompt transportation; so that, unless the velocity were so great as to break down the mass, they would remain in the channel. Some of the substances reaching our drains are of too firm a consistency to be broken down by the velocity of ordinary streams, and these often form the nucleus about which fouler things gather to create accumulations. Therefore, it is important, with regard to all drains which do not run full, that their diameter be so restricted as to give the required depth to their flow. There is another consideration of equal importance which must always be kept in view: the velocity of the stream remaining the same, the depth of the flow will be in proportion to the diameter of the pipe and to the quantity flowing through it. Therefore, as the quantity supplied in ordinary house drainage is fixed, the diameter of the pipe must be so restricted that, at the velocity with which it flows,—varying according to the rate of inclination,—the given fixed volume will secure the required depth. It is not, of course, possible to maintain at all times a cleansing depth of flow in any house drain; but it is possible, by regulating the diameter of the conduit in accordance with the volume flowing at the time of greatest use, and with the rate of inclination, to make sure that at some time during the day, and
generally several times during the day, there shall be a sufficient depth of current to wash away what the straggling flow may have left behind.

In those parts of the house drainage where the conduit is filled with water, it is necessary to give, at least at frequent intervals, a sufficiently rapid movement to the whole mass to carry away whatever may have been deposited in these filled portions by slighter discharges. Practically, this observation applies mainly to the case of traps, where a bend is introduced in the course of the pipe to hold water, as a "seal" to separate the air of the outer drain from the air of such pipes as are open to the interior of the house. In this case, velocity has to be given not only to water occupying a portion of the pipe, but to its full contents, so that the diameters of traps should be, other things being equal, considerably less than the diameters of the pipes leading to them and from them.

One of the most serious difficulties met with in practical work is what is known as "siphonage," that is, the sucking out of the water of traps by the rarefaction of the air in the outer pipe, caused by the passage of liquids or air through it or across its mouth. The tendency to siphonage is greater in small traps than in large ones, the same suction being brought to bear on a smaller volume (weight) of trapping water. No satisfactory device of general application has yet been discovered by which this difficulty may be overcome with certainty and without entailing other effects equally to be feared. The present custom exacted or sanctioned by local Boards of Health is to carry a vent pipe from the upper bend of the trap to the open air, so that when the air of a pipe becomes rarefied, the balance shall be restored by admitting air through the vent pipe, leaving the water of the trap undisturbed. Theoretically, this practice has much to commend it; practically, it seems to me to have grave objections, which it will require our best endeavor to remove. Our best hope lies in the devising of some other means for securing a safe trap.

However completely we may succeed in preventing deposits in waste-pipes and drains, we cannot prevent the adhesion to their walls of more or less of the soapy, greasy, and slimy matters carried by their flow. With a perfect adjustment of diameters, and with the proper appliances for frequent flushing, such adhesions may be reduced to a minimum. However small the
quantity so adhering, it is sure to enter into decomposition, and it is well known, or, rather, it is generally believed, that the extent to which such decomposition becomes noxious or innocuous is regulated only by the degree to which fresh air is admitted to it at all times. All waste-pipes and drains must have such a connection with the outer atmosphere as shall insure a supply of oxygen for complete decomposition at all points, and a reasonably rapid dilution and removal of the gaseous products of the process.

Concerning fixtures within the house, it is to be remembered that each additional one constitutes another channel of communication between the air of the house and that of the drain. The possibility of efficient protection at these openings is, at least, so well secured, that we need not hesitate to establish such fixtures as are required for comfort and for reasonable convenience; but there remains just so much question in the matter as to justify the recommendation that a luxurious profusion of plumbing fixtures had better be avoided.

The two vital points still to be settled are: First, an absolutely effective means for maintaining the integrity of traps; and, second, such an arrangement of vessels, traps, and waste-pipes as will insure the complete discharge beyond the house walls of all matters delivered into the waste-pipes without the possibility of their being long retained in traps or elsewhere on their way. Thus far we are at sea as to the first of these requirements. Some endeavor to satisfy it by trap ventilation, and others by the use of mechanical traps, both of which methods, as now carried out, have demonstrable defects. The uncertainty here involved constitutes to-day the chief unsolved problem in the work of house drainage. It is here more than anywhere else that the most skillful and experienced judgment is required in the arrangement of plumbing work.

The water-closet has undergone a transformation since improved drainage began to attract attention in this country, which has brought it within measurable distance of practical perfection. The universal condemnation of the pan-closet by every respectable authority, if we except the Boards of Health of the larger cities,—and there are good reasons for their present inaction,—is secured. Just apprehension as to its dangers is widely disseminated and deeply implanted. Its introduction in new work must soon be prohibited, and its retention
in old work cannot last very long. The defects which are most marked in this apparatus exist in a modified degree in some other closets which still meet with favor; but the march of improvement is entirely in the direction of closets which have no moving parts, which require a very copious use of water without waste, and of which the outlet channels are free from enlargements, or recesses not subject in every part to a thorough cleansing every time they are used. The simplest of these, and in many respects one of the best, is the plain "hopper" with a bent trap below it supplied with such a volume of flushing water as to ensure complete washing. Another common fault recognized and appreciated by all authorities is the supplying of closets by valves directly connected with the house supply. The importance of the interposition of a flushing cistern is getting to be well and generally understood. On the whole, we may say that, so far as water-closets are concerned, the interests of the public are taking care of themselves in a most satisfactory manner. Economy and indifference will necessarily retain in use the great mass of improper apparatus until it shall have worn itself out; but new construction and renewal of old work will in time overcome existing difficulties.

The majority of even the best houses are now very badly drained, and are subject to the production of "sewer-gas" at many points between the outer wall of the house and the fixtures within it. Occupants are generally careless or ignorant of this fact, and the verdict of "my plumber" is still considered by the average house-owner a sufficient certificate of good sanitary condition. Large traps, clogged with accumulations of putrefying kitchen-waste, soapy compounds, fœcal matter, etc., are still the rule rather than the exception. Defective pipes and more defective joints, involving often the escape of drainage drippings, or of drainage exhalations, exist very widely. Most drains still run under the cellar-floor, and such drains are almost invariably very faulty. All of these things, however, are slowly being changed, and the change is, practically, always in the right direction. In some cases where the local sewerage is very bad there is doubtless a certain amount of contamination of houses by the gases resulting from decomposition in the sewer. Few modern sewers, however, are seriously open to this charge, and proper ventilation of soil-pipes is, when accompanied with good plumbing work, a sufficient protection against danger from this
cause, when the cause exists. The important lesson to be taught is that most of our sewer-gas is home-made. Bacterial growth in sewers is a newly-mooted subject, of which the moot ing is thus far the only real progress; but this is real progress.

In the sewerage of towns all will admit that great advances have been made within the period under consideration. The better works referred to on a previous page may be regarded as the models on which construction is generally planned. In execution the best plan often fails of proper carrying out, because of the not yet entirely obsolete ignorance and stupidity of the newly-elected sewerage committees of local governments, and because of the almost universal misconception of the meaning of the word "economy," coupled with a notion that public works are always most cheaply and most honestly executed when let by contract to the lowest bidder. The only economy in works of this character, especially as they are forever hidden from view, is to be sought in absolutely faithful and excellent construction with the best attainable material. The extra cost of building sewers in the best manner is not worth a moment's consideration as compared with the wastefulness and grave sanitary danger which usually attend lowest-bidder construction.

I am a firm believer in the superiority, under most circumstances, of the separate removal of house-drainage through small vitrified pipes; but I believe that large brick sewers properly arranged and constructed are—bacterial growth apart—better and safer, as they are also vastly more costly, than pipe sewers, as these are usually laid. It is true that brick-sewers leak and frequently contaminate the soil; but the ooze from their walls is of much less consequence than the direct delivery of a stream of sewage at every joint with improperly laid pipes. I believe, of course, that the system that I have carried out at Memphis and elsewhere, of using very small, tightly-jointed pipes, thoroughly washed out once or twice a day by automatic flush-tanks connected with the water supply, is as much better than other systems as it is cheaper; but I believe, nevertheless, that perfect workmanship is better, from a sanitary point of view, than a perfect plan. The demonstration of the truth of these convictions afforded by good examples of work executed in this country during the past ten years, cannot fail to have its influence on future sewer construction, and we may regard our future in this respect as well assured.
The importance of the removal of the water of saturation from the soil in and about the house, and generally in malarious districts, is becoming better and better understood, and malaria must ere long become practically obsolete in the older settled portions of the United States, as it already has in its old haunts in England.

In studying the difficult questions involved in the ultimate disposal of sewage, the public has yet to appreciate the importance of immediate removal. Of course even the freshest and most recent sewage ought not to be delivered where it can contaminate adjacent streams or bodies of water; but real contamination is very greatly in proportion to the degree to which sewage has been permitted to decompose on the way from the fixtures in the house to the outlet of the main sewer. As in the house, so in the town, complete removal before decomposition should always be the rule. When water-carried waste matters are delivered in this fresh condition, a very large proportion of their organic constituents is consumed by fishes, and the lower order of life and the decomposition of such matters as float in the well aerated upper portion of the water is complete and rapid; but the rule must, in time, prevail, that no sewage shall be delivered into stagnant waters, along shores, into harbors, or into streams, which carry it past other communities which would suffer from its ultimate decay.

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