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THE ANITARY CONDITION IN CITY AND COUNTRY DWELLING HOUSES.

BY

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CONSULTING ENGINEER FOR SANITARY AND AGRICULTURAL WORKS.

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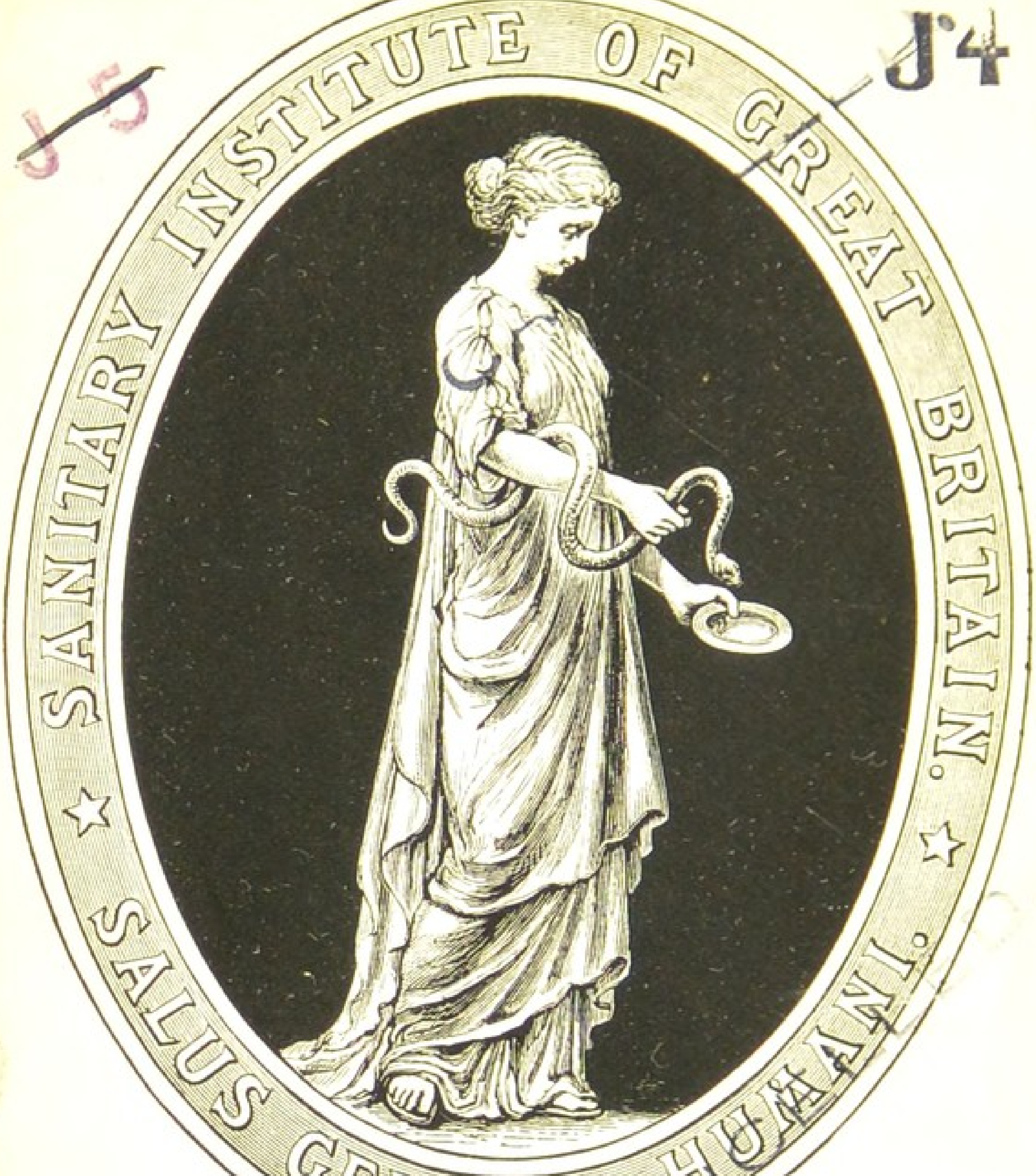

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PREFACE.

THE papers reproduced herein were prepared to be read before the American Public Health Association, and the Public Health Association of New York.

It has been thought unnecessary to modify the form in which they were first presented.

The paper on Country Houses led to a lengthy correspondence in the *American Architect and Building News.* This correspondence is reproduced nearly entire, as affording the best presentation of my own views on the subject, and as meeting objections which are likely to arise in the minds of those who have given it only casual attention.

G. E. W., JR.

NEWPORT, R. I., *June*, 1877.

THE

SANITARY CONDITION

OF

COUNTRY HOUSES.*

THE sanitary defects of the average country-house are due to ignorance. Had the architect who built it been stimulated to learn what is required for a perfectly healthful condition, he would of course have been, in every case, vigilant to secure it. Did the physician know, except in a vague and theoretical sort of way—that is, did he fully realize—the degree to which the ailments he contends against, and which he should be vigilant to prevent, are diseases due to removable causes connected with the construction and arrangement of the

*A paper read before the American Public Health Association, at its meeting in Boston, 1876, by George E. Waring, Jr.

dwelling, he would insist upon a reform.

Did the householder himself know the extent to which his own efficiency and the health and lives of his family depend on an observance of the less obvious sanitary requirements, he would demand that both architect and physician should inform themselves as to the needs of his house, and should secure the fulfilling of those needs.

By far the greatest number of country-houses are farmhouses, laborers' dwellings, etc.; and these are not less subject to sanitary criticism than are those of the better class, though their defects are mainly of a different character, and relate more to the grounds about the house and to its water-supply, and to the condition of its cellar, than to the arrangement of its interior drainage. Indeed, in nearly every case, these houses have no interior drainage at all; and such reformation of their character and condition as is needed, will be sufficiently indicated in considering the better houses. Unhappily, so far as the occupants of these farmhouses and cottages are concerned, there is little hope that any considerable improvement will soon be undertaken, or indeed that any thing we may say here will be heeded.

Until we can convince the country physician that his most important obligation to his community lies in a supervision of the conditions under which it lives, it is hardly worth while to waste breath upon the average members of that community. We may accumulate evidence as to the fatal effect of prevalent carelessness and filthiness in the cellar, and in the soil about the house, until we are tired of making quotations; and, for every instance that we bring forward, of a death from typhoid fever traceable to the use of poisoned well-water, the farmer will produce a hundred cases of persons who have always used water from wells standing in barnyards or close to privy-vaults or cesspools, without suffering.

The action of poisoned water is less

direct than that of a well-aimed rifle; and its effect, where there is any effect, is slower and less obviously connected with the cause than in a case of poisoning by arsenic. We can hardly hope to convince the common man of his error, and induce him to spend money, and to put himself to considerable personal inconvenience, to reform a state of affairs which has existed all his life-time, and which he believes to have answered well with him and with his fathers.

To his mind, typhoid fever, diphtheria, and the whole list of zymotic diseases, are afflictions sent by an inscrutable Providence for some hidden purpose of discipline; and he believes it his duty to bear meekly, if sorrowfully, the chastening to which he is subjected. He is still far from accepting the idea that his discipline may have for its direct purpose his regeneration in this very matter of hygiene. In their unvarying operation the laws of health (which are not entirely inscrutable) strike both the just and the unjust, and these laws are disciplinary, or not, according as we meet their requirements with intelligent obedience, or bow blindly and ignorantly before them. Typhoid fever does not come to us as a punishment for Sabbath-breaking, nor for profane swearing, but as a punishment for the one sin which brings us within reach of its scourge—the sin of unwholesome living. Then, too, sinners though we are, in this regard, it touches us so slightly—only here and there a case—that we are led, not precisely to run the risk of chances which we appreciate, but to remain placidly unconscious that the law is in operation about our own houses, awaiting only the due assembling of the conditions which bring its action to bear upon our own persons.

The great mission of enlightenment, which has been so well entered upon by this Association, began its effective operations with the educated classes of society. Especially has it engaged the attention of the two professions to which I have referred. Within the range of these professions, the questions of healthful building and healthful living especially lie. From above, the enlightenment will be extended downward, until, in some millennial future, the merest cottager will understand the degree to which his health depends on the cleanliness or filthiness of his domicile.

In like manner, it is obvious that our efforts to secure an improvement in the construction and care of country-houses, must be first addressed to the more intelligent classes, and that they must work their way by example, among the poorer and the less informed. Let us consider therefore, by way of illustration, the case of an elaborate country-seat, built with a determination to secure every luxury and every comfort, every convenience and every safeguard, that the most skilfully applied modern art can compass; a house to which that compound adjective so dear to the American heart may be applied in every department from garret to cellar—a house where every thing is "first-class."

If we examine the old mansions of our grandfathers, or go back still further, to the seats of the nobility of past centuries in England, and compare our modern houses with these, we shall realize what enormous strides have been taken in the improvement of many elements of our building. Among other things, the modern mind has at last fully accepted the fact that a wet cellar is dangerous, and is to be, in all cases, and under all circumstances, avoided or abandoned. We are still indulgent, and perhaps not very improperly so, of an occasional inroad of storm-water, which subsides within a few hours; but a cellar with standing water is, at least very generally, *felt* to be an impossible accompaniment of healthful living. By hook or by crook, we manage to get a drain away from the lowest point of every cellar dug in soil that *retains* water after heavy rains. We understand very well—in the case of the better houses, perfectly well—the importance of dry walls, at least of dry interior walls. When we build in brick or stone, our opposition to absorbed moisture seems to stop at the point where it is no longer injurious to wall-paper and paint; but we do secure, almost universally, by the intervening air-space, a separation of the wall next to which we live, from the wall through which exterior moisture penetrates. We have learned how to warm our houses more uniformly; and we realize, in far greater degree than our fathers did, the importance of abundant sunlight.

But here, I fear, so far as health is concerned, the improvement of our building ceases; or, as we pursue our investigations, we come to a point where it seriously retrogrades. In the matter of ventilation, our better-built houses are usually very defective. In our hot-air furnaces we burn anthracite coal, separated from the air-chamber only by cast iron, which is, especially when heated, extremely porous to carbonic oxide. We thus introduce an element of unhealthfulness throughout the whole house, which constitutes, as compared with the influence of the open fires of our ancestors, a very serious defect. These influences affecting the wholesomeness of the air we breathe, are serious; but they are far less so than is our miserable system of house-drainage.

Half a century ago, in houses of the better sort, the most active prejudice existed against the use of any form of indoor conveniences; and in spite of the often dangerous exposure to the weather, and of the universal stifling foulness of the out-house, no one thought, except in case of serious illness, of permitting defæcation within doors. Partial invalids and delicate persons must perforce subject themselves to an injurious exposure. The objections to this old system were extremely grave, not only on the score of comfort, but greatly also on the score of health. The introduction of the water-closet marked a real advance in our apparent civilization; and the general system of an interior water-supply and drainage, with the agreeable accessories of fixed wash-bowls, baths, laundry-trays, butler's sinks, etc.—of what the house agents call "all the modern conveniences"—have made life easier and more luxurious. In certain ways, too, they have added important sanitary benefits.

But in freeing ourselves from the prejudices of our fathers, and in gaining these marked benefits, we have exposed ourselves to dangers which are all the more grave because of their hidden and almost universally unsuspected character. It is by no means necessary that the introduction of modern plumbing-appliances into a house should be any thing but advantageous; but unfortunately, so little is popularly known of the sanitary requirements which should govern the work, while the influence of defective works upon the health of the household is of such a hidden character, that, in securing comfort and convenience, we have, in almost every instance, introduced a real element of danger.

We leave to the plumber, who, except in the rarest cases, is only a skilful mechanic, the entire control of the most important part of our house-building. It has recently been suggested that there is an opening for a new industry among professional men—a new profession, where instructed sanitarians may find profitable and useful employment, in taking the control of this very important branch of house-building and inspection ; a profession which should apply itself to the important art of preventing diseases. It seems to me that a much more practical method for attaining the desired end would be to induce the architect who builds the house at the outset, and the physician who has in charge the preservation of our health, after we move into it, to qualify themselves to perform the functions indicated, and to add to their present work the most essential branches of sanitary engineering and sanitary inspection.

In a certain sense, the sanitary

question reaches into a field where all is uncertainty and speculation; but enough is already known concerning the relation between neglected or improperly controlled filth, and the health of those who live subject to its influence, and enough is also known of the simple means by which all danger may be avoided, to make the prevention of diseases, arising from this source, practically certain.

Indeed, the effort to be put forth relates far less to the instruction of the architect and the doctor, in the very simple details of sanitary improvement, than it does to impressing upon them the importance of applying these details as one of the very first of their professional duties.

The precise methods of causation, and of propagation of cholera, diarrhœa, dysentery, typhoid fever, diphtheria, cerebro-spinal meningitis, neuralgia, and the minor range of malarial fevers, it is the province of the physiological investigator to determine. These questions are involved, if not in mystery, at least in a certain amount of uncertainty; and doctors disagree radically as to the "germ" theory, and as to the manner in which epidemics are introduced into new localities. Fortunately we need not, in this connection, consider these moot questions; for doctors by no means disagree as to the influence of neglected filth in either initiating or propagating all diseases of the class referred to. It is a matter of small consequence to the average householder, who cares nothing for the general sanitary bearings of the question, whether typhoid fever is propagated by germs, or by some agent as yet unknown. He does care very much, or at least he would care very much, if he thought any thing about it, that the condition of his house shall be in every respect such as to insure, beyond question, the perfect safety of his family. He does not, it is true, realize the fact, which we fully appreciate, that his costly and finely finished water-works are a source of danger. He has trusted to his skilful architect to make sure that he is guarded against unhealthful influences from this source, as effectively as he is guarded against exposure to the weather. He has no time to devote to this part of his work; but he feels he has given it into hands fully competent to direct it, and he takes no further thought or trouble about it.

Unfortunately, so far as the question of health is concerned, he has, as a rule, trusted the work to an artist, rather than to a sanitarian; for the architect, however competent to plan the general arrangement of the house, and to make it, without and within, beautiful, attractive, comfortable, and convenient, is—like the average owner—too often either ignorant of or indifferent to the requirements of the sanitary laws, as recently developed.

The owner takes possession of his new home, and subjects his family to unseen and unsuspected influences, which are quite likely, sooner or later, to manifest themselves in one form or other of ill-health. He then calls to his assistance a physician, who, if we take an average representative of the profession, has sat at the feet of an old Gamaliel, and has applied himself far more to the art of healing, than to the art of prevention. In the slight ailment, or in the grave sickness with which he has to deal, he is skilful, useful, and efficient; but surely, physicians themsleves will confess that, as a class, they too seldom seek for the cause of ill-health in conditions which are so universal among their patients, and which obtain to such a degree in their own homes, that they are apt to be disregarded. He naturally looks to some unusual condition, or to some unusual exposure.

Indeed, it is hard to realize that conditions under which the human machine so generally works perfectly and easily, may, under certain circumstances, become the very conditions for the causation of diseases. If we can get doctors and builders to *realize* the absolute, vital importance of controlling the conditions under which we live, we shall have done our best work. Mr. Brown and Mr. Jones and Mr. Robinson—practical men, engrossed in the management of their affairs, and with a long-cherished antipathy to theory and innovation—will pay very little attention to what we may say in this hall, or to any thing we may write; but they will listen to the advice of their physicians, and in building, they will follow the least sanitary suggestion of their architects. Constant dropping will wear away even the stones of their indifference; and we shall, in time, secure a reformation of the whole community. But our earliest effect is surely to be produced by our influence over their professional advisers, who will, I trust, not misapprehend the spirit in which we venture to remind them of this vital and too little heeded element of their duties.

Let us come now to the specification of our charge against the modern country-house. It stands, we will suppose, upon nearly level land of a nearly impervious character; but ample provision has been made for the drainage of its cellar. Not far away from it, are cisterns and a well, each of which is in communication with the force-pump in the kitchen. This is provided with a twin cock by which water may be drawn from one or from the other at pleasure. Under the roof is a large tank, holding more than a day's supply; and this, filled by the force-pump, furnishes all of the water needed for constant tap at every point. Near the middle of the house, one above the other on the different floors, are placed the bath-rooms with water-closets and stationary basins—in the middle of the house, to be safe from the frost of more exposed positions. The attempted ventilation of these rooms is often only by a window into a closed well, or through a small register in the wall, opening into a small rough flue in the chimney, throttled from bottom to top with projecting bricks and lumps of mortar.

The real ventilation is through the constantly open doorway into the interior passages of the house. In each bed-room, or in a closet attached to each bed-room, there is a stationary wash-basin, with its supply of hot and cold water. Under the staircase in the main hall, and often with no ventilation at all, are the conveniences of the master of the house himself. The butler's pantry has a sink connected with the main outlet-drain by a generous pipe. The kitchen sink has the same connection, and so have the laundry-trays, which, together with the servants' closet, are often near the level of the cellar-bottom—near the zero point of the drainage system.

The house has been built by contract; and a plumber, whose specification has related chiefly to the weight of pipe that he shall use, and to the character of finish of the basins and bowls, and their faucets and plugs, has been left to the exercise of his own discretion as to the arrangement of all the hidden parts of the work. His job is a satisfactory one, if the tubs and trays and sinks and basins have the proper neat look, and if an abundance of water is everywhere supplied, and everywhere flows readily away. For an outlet he has been provided with two cesspools; the first one, tightly cemented, has a trapped overflow; the second, receiving the overflow of the first, is built with uncemented walls, with a view to the percolation of its contents into the soil.

For a time every thing works well; the clean new outlet-pipes perform their office satisfactorily, and the clean soil about the leaching cesspool performs its purifying work completely. The house is acceptable in every way; and its happy owner congratulates himself that he has secured all that modern art and knowledge can give him.

Let us examine this house after it has been a few years in occupation, with a view to studying its actual sanitary condition. We will disregard, as foreign to our immediate subject, the flood of injurious carbonic oxide which its registers pour into its interior, and the said lack of ventilaton which the substitution of the furnace, for the open fire, has inflicted. We will say nothing of the pressure of soil-water against the absorb ent cellar-wall, nor of the damp emanations from the undrained, heavy ground around the house. Let us confine ourselves only, and strictly, to the questions of water-supply and drainage.

The well, although perhaps not very near the leaching cesspool, and the now foul soil surrounding it, may get its water through some stratum of gravel which carries the ooze of this cesspool; or it may penetrate a permeable stratum, or a seam in the underlying rock, which brings it into communication with other cesspools or privy-vaults far or near. These impurities are not perhaps enough to produce an obvious effect, while the water in the well is high, and holds back the water in the soil as the land-water in the beach holds back the salt tide; but, when the supply fails, in time of drought, then the demand on the well is replaced by a flowing-in from the foul earth, and the impurities are concentrated to a dangerous degree. Or perhaps the dejections of a patient ill with typhoid fever, or other disorder of the bowels, have entered the stream oozing from the cesspool to the well. In either case, disease may follow.

Warned by the frequent reports of diseases originating in this way, the master of the house has given strict and frequent orders that under no circumstances shall water from the well be used except for cooking; but some of the inmates, the servants especially, preferring the sparkling water of the well to that of the cistern, bring the pump into communication with the former; and now and then the whole supply of the house, for a longer or shorter time, is taken from this source. Indeed, if there is a well in communication with the house-supply, it is simply impossible to prevent the use of its water from time to time.

The tight cesspool into which the drainage of the house discharges is of course hermetically sealed, that there may be no possibility of its emanations tainting the air. It is connected with the outlet of the soil-pipe by the best vitrified pipe, carefully laid. This pipe, for part of its course, runs through soil that had been excavated and refilled at the time of building; through soil, that is, which is sure to settle as time goes on, bringing the weight of the whole mass lying above the pipes so to bear upon them as quite surely to move them enough to open their joints, allowing more or less of their contents to soak away into the ground. Sooner or later this leakage penetrates the foundation-walls, and taints the air of the cellar.

A strong, well-constructed four-inch soil-pipe descends from the trap of the highest water-closet, usually in a straight line, to the ceiling of the cellar, and passes in a straight course, and with a regular descent, to the point of outlet. It has been securely strapped to the floor-beams of the cellar, making it quite certain that a deflection in the main floor of the house, of even an eighth of an inch, will tear it loose from its attachment with the closet, and leave a little crevice for the escape of its gases, and of those formed in the cesspool.

The importance of ventilating the soil-pipe having been recognized, a one and one-half inch lead pipe, leading from its highest point, has been carried out through the roof, closed over at the top to prevent the admission of obstructions, and perforated with a dozen little holes to give egress to the pent-up gases. This is not *ventilation:* it is only *venting*, only the relieving of pressure,—an important office, but by no means a sufficient one.

The closets on every floor are of that ghastly foul sort which hold in a lower unventilated chamber nearly all that is admitted to them, save the water alone, until the solid matters, by decomposition, are enabled to pass away in a stream which was insufficient to flush them away as solids. The traps of the lower closets—too little air being supplied through the small venting-holes above the roof—are often emptied by siphon action, where a strong flow is rushing through the pipe from the emptying of a bath on a floor above.

To economize the work, traps under the wash-basins are frequently omitted, an introduction of the waste-pipe into the trap of the water-closet being deemed sufficient, even where the communication is by means of a long and nearly horizontal waste-pipe.

In time, all the foul contents of the cesspool, and the foul slime of the soil-pipe, having been for years producing acrid gases, the leaden traps under the closets, and the horizontal leaden connection-pipes have become more or less honeycombed; and here and there openings have appeared in the pipes. These being in their upper sides, where the usual plumber's inspection for leakage does not detect them, they remain unsuspected, and they go on year after year pouring out into the house their poisonous exhalations.

The influence of even very small openings of this sort is far greater than would be believed. I was recently told of a household in New York which had long been a reliable source of income to its attending physician. Upon his death, a younger doctor, an enthusiastic sanitarian, succeeded him. He soon became convinced that the illness that had so long prevailed was due to emanations from the drainage-pipes of the house. Plumbers were employed to make a thorough inspection, and they reported everything in perfect order. The cases of disease kept occurring; and a sanitary inspector from the Board of Health examined the house, and found no defect. The character of the recurring ailments indicated so clearly a foul drainage cause, and no other, that the physician finally applied himself to a minute inspection of every part of the work.

On the waste-pipe under a wash-basin in a room communicating with the nursery, he detected a very slight oozing of moisture, so slight that he did not feel sure that it existed until he found that it moistened tissue paper laid over the spot. The most rigid scrutiny developed no other leak. This pipe was taken out, and a new one substituted; and, although he or his predecessor had been called to attend some member of this family almost weekly, for a dozen years before, he was not called again for eighteen months—and then only because of the stork.

If any thing is certainly known with reference to the house-drainage question, it is, that in an unventilated system of pipes, the foul matters which they contain enter into a putrefactive decomposition which produces poisonous, or at least injurious, gases; and, if any thing is clear to the common comprehension, it should be that pipes of a corrosible material—like lead—made by human hands and subject to the defects of all human work, containing, day and night, corrosive and injurious gases of this character, are dangerous inmates of any inhabited house.

Not only do these gases find their escape through defective joints, through perforations of old pipes which they themselves have destroyed, and through traps whose sealing-water has been sucked out by a flood rushing past them in the soil-pipe; but they have, as has been clearly shown by the experiments of Dr. Fergus of Glasgow, the power of passing almost unretarded and unchanged through the water seal-traps upon which we have so long depended with confidence.

Given the cesspool and the soil-pipe charged with injurious air, it is simply impossible that under our ordinary methods of arrangement this air can be prevented from mingling with that of our imperfectly ventilated sleeping-rooms and living rooms. Every safeguard that modern experience has suggested should be applied from the beginning to the end of the system, to make sure that, whatever may be the character of the aeriform contents of the pipes, they shall be strictly barred from escape into the house, and that every means shall be adopted to cause their escape into the free air above it.

Not only this, but every means should be taken to prevent the formation of these gases, and thus to gain the double security of their non-existence in their worst form, and against their entering our houses in their modified form.

And, first, for the prevention: Poisonous sewer-gas is a product of the obstructed decomposition of organic matter in the absence of light and of a sufficient supply of oxygen. In its most dangerous form it is believed to have but little odor.

If the decomposition takes place with exposure to a sufficient supply of common air to furnish the oxygen needed for a more complete decomposition, the gases produced, although often more offensive in their odor, are not only less dangerous to health, but the more thorough decomposition is believed to be accompanied by a destruction of the germs of disease. These gases have in a much less degree, if they have it at all, the power of decomposing lead pipes. In other words, this worst enemy of those who live in modern houses may be entirely or quite disarmed by the simple means of supplying common air to all parts of the drainage system.

To provide this immunity, so far as the main artery of our works is concerned, it is quite necessary to substitute for the paltry vent-pipe so generally used, a pipe of the full size of the soil-pipe itself, running with the least and the fewest angles possible, quite up through the top of the house, and provided at its summit with a good ventilating-cowl. We must also admit at the lower end of the pipe, a sufficient supply of air—as copious as the danger of freezing in winter will allow—to feed the suction cowl, and thus keep up a good circulation throughout the whole length of the pipe. The effect of this ventilation should be made to extend as far as possible throughout the branches of the system; and with a view to this the water-traps, which, although they are not the most effective appliances in the world, are still sufficiently useful to be retained, should be placed as near as possible to the waste outlet which they are to protect. Where the outlet of a wash-basin, for example, is untrapped until the water-seal of a distant closet is reached, it becomes in time smeared for its whole length with the accumulated soap and filth of repeated ablutions; and these, although they are not what we recognize as fecal matters, are still organic matters of the same chemical character, and they produce in their decomposition, although in much less quantity, the same sort of gases.

Let every trap, then, be as near as possible to the beginning of each waste-pipe, and let the main soil-pipe be entirely untrapped, so that, as far as may be, every outlet drain in the house shall be in free communication with a thoroughly ventilated main channel. This secured, we may rest content in the belief that, so far as lies in our power, we have prevented the formation, anywhere within our drainage-system, of gaseous emanations which can be iujurious to health.

The next step is to make sure that while we have, so far as is possible, disarmed our concealed but ever-present enemy, we bar every avenue to his nearer approach. He may perhaps no longer be dangerous: but we can never be quite sure of him, and he would be an offensive and disagreeable visitor. As a first step, in the place of strapping our soil-pipe to the beams of the cellar-ceiling; let us set a stout post, bearing upon a firm foundation, directly under its bend, and so prevent the possibility of its settling a single hair's breadth. In this way we may keep a well-made joint with the water-closet trap perfectly tight. As a next step, we must either abandon all of our plumbing appliances, save only the necessary water-closets, and return to the old basin and pitcher, and the sponge bath, or we must provide for *the absolute shutting off of every overflow and waste pipe* which is now separated from the drainage-system only by an ordinary water-trap.

The water-seal is a trap in more senses than one. Dr. Fergus found all gases with which he experimented, to pass freely through its sealing water-ammonia passing through and reacting upon litmus paper in fifteen minutes. Furthermore, in cases where the trap is not frequently used, the evaporation of the sealing water leaves it open for the passage of air from the drain directly into the rooms. These defects are constantly present, even in the case of waste-pipes which are not subjected to pressure from the confining of their gases. Wherever there is such pressure, the evil is of course greatly aggravated.

The unquestioned advantages of a free supply of pure water in wash-bowls and bath-tubs on every floor of the house, can be safely secured only by some system which shall overcome their great defect, which far outweighs their advantages—the defect of affording a possible inlet to sewer-gas into the interior of the house. As at present constructed, it is safe to say that there is not a butler's sink, nor a bath-tub, nor a wash-bowl in use, which is not to a greater or less degree subject to this criticism.

The only safety is to be sought in supplying a self-closing stop-cock to every waste-pipe or overflowed-pipe, so arranged that it can be kept open only while it is actually held open by the hand. Any device for fastening it open during the convenience of the user, would only result in its being neglected, and left open when it should be closed. To those who have given no thought to this branch of the subject, it may seem a super-refinement of criticism to make this sweeping objection to an appliance of modern life which is in almost universal use in town and country; but I believe it to be susceptible of proof, that of all the causes of the various zymotic diseases which occur in our otherwise well-appointed houses, by far the greater majority have received their filth-born impulse from poisonous gases escaping through the overflow and waste pipes of wash-bowls, bath-tubs, etc.

Surely no one who has given attention to the details of plumbing can escape a certain sense of hazard, when he finds himself an occupant of a friend's guest-chamber, whose white marble fixed wash-basin whispers to him, the whole night through, of the hidden horrors of which it is the decorated outlet.

With a means for drawing water on each floor and with a closet-bowl through which to dispose of slops, the labor of attending our old friends, the bowl and pitcher, is not serious; and such an arrangement offers absolute security against a defect which has thus far not been remedied.

I have sufficiently indicated the very simple improvements that are needed in connection with the water-supply and drainage of that part of the house which is occupied by the family. The kitchen sink makes no slight demand upon our consideration. Its outlet offers a passage, not, it is true, for fecal matter, but for every sort of organic substance from which fecal matter is derived; and which may supply, on its decomposition, precisely the gases which are generated in the ordinary soil-pipe. It does not carry the germs of disease—assuming that there are germs; but its scraps of food, etc., are, on the other hand, mixed with congealed grease, which covers them to a certain degree against the access of oxygen, and tends to make their decomposition especially foul. Add to this the serious difficulty, that the congealing of the grease has a tendency to obstruct the waste-pipe, and lead to leakage and subterranean overflow of a serious character.

The methods for remedying these disadvantages are well known, and may be easily applied. The leading safeguard in the whole matter, here as else-where, is to be sought in the free ventilation of the waste-pipe at a point as near as possible to its source, and in the introduction of an efficient water-seal and grease-trap.

We come now to the method of finally disposing of the liquid waste of the house. Any one who has had much experience in the investigation of defective works must have reached the conclusion that those cases are really few in which even the defective methods adopted have been executed in any thing but a defective way. The sanitary formula of Hippocrates, "Pure air, Pure water, and a Pure soil," is violated hardly less often by the earthenware drain without the house than by the waste-pipes within it. A vitrified earthenware drain laid on a firm foundation, and connected at its joints with good cement, is as perfect an apparatus for conveying foul liquids as we can well conceive of; but far too often the cementing of the joints is much less than perfect; and in almost a majority of cases, the pipe at some point rests upon new filling, which, by a settlement of a single half-inch, is quite sure to open a crevice at the joint, through which the trickling filth escaping from the house may find its outlet. In every case where it is necessary to pass through any thing but the original unbroken and solid earth, the excavation should be carried down to the undug bottom, and filled to the grade of the drain with well-compacted concrete. Either do this, or else substitute a stout iron pipe wherever new filling has to be crossed, however firmly this may have been packed.

Having a pecuniary interest in the success of the flush-tank invented by Mr. Rogers Field, one of the leading sanitary engineers of England, I have some delicacy about its advocacy here; but perhaps the fact that I have taken this interest in its introduction is the best evidence of my faith in its value. This tank is simply an apparatus for accumulating the trickling flow of liquid waste to the amount of twenty-five or thirty gallons, and then discharging it rapidly by a siphon which is brought into action automatically. The accumulation then escapes in a rapid and cleansing stream, sweeping every thing before it through the outlet-drain. During the accumulation the grease is congealed and separated.

The tank should be so arranged as to receive the kitchen waste, and whatever other liquid it may be convenient to deliver to it, but not the waste from the water-closets. This should enter the drain farther down its course; and any deposit it may leave, will be swept forward by the action of the stream from the flush-tank.

The disposal of the liquid wastes of the house is one of the most serious elements of our subject. In the town, where we have a public sewer which may be depended upon for removing whatever we deliver to it, however defective this may be in the eyes of the public sanitarian, the problem is solved so far as the house-holder is concerned. He may easily make such a disconnection of the air-channel which brings his soil-pipe into communication with the public drain, as to insure himself against any danger from this source of poisoned air.

But in the case of a country-house, where a large amount of liquid is to be disposed of, and where there is a serious danger that we may contaminate the source of our drinking-water, or render the air about us impure, too much attention cannot be paid to the securing of a perfect method.

So far as I know, there are but two permissible devices in use. One of these, and the most objectionable, is an absolutely tight cesspool, well ventilated and accessible for inspection and cleaning, but from which not one drop of liquid can filter away into the soil—care being taken to empty it in such a way as to produce the least possible offence. The other is the system recommended by Mr. Moule, the inventor of the earth-closet, for the disposal of the liquid through permeable drains lying within reach of the roots of plants, and in the well-aërated surface soil, whereby the foul off-scourings of the household may be largely consumed and purified by vegetation, and be destroyed by effective oxidation.

This system has long been used in a small way, in many places in England, always with perfect success; and it has, during the past six years, served its purpose most effectively at my own house in Newport, where every drop of vaste water has, I am confident, been purified and consumed by the soil underlying less than one thousand square feet of lawn. Indeed, so well am I assured of the efficiency of this system of subsoil irrigation, that I am now applying it for the disposal of the entire sewage of the village of Lenox, Mass., where a flush-tank, having a capacity of five hundred cubic feet, will periodically deliver its contents through a system of about ten thousand feet of two-inch tile lying twelve inches below the surface, and which has an uncemented joint at every foot of its length.*

I am frequently asked whether the earth-closet does not offer a solution of the house-drainage question. Having been for years its enthusiastic advocate, and realizing as well as any one can its great value in the hands of those who will give it a little intelligent care—having no other system, and desiring no other, for my own house—I am still compelled to say that, in the case of the ordinary householder, the water-closet is to be preferred. Indeed, I will go a step farther, and say that, now that I know by experience how effective is the method of subsoil irrigation used in connection with the flush-tank, were the question of a system for my own house to come up again, I should adopt the water-closet, as requiring less attention, and as being in some respects more neat.

* Since this paper was prepared, the Flush-Tank and absorption field at Lenox, Mass., have been thoroughly tested, and their working has been all that could be desired.

The field for the earth-closet is an enormous one, and one which it should be the earnest endeavor of all sanitarians to aid it in occupying. It covers all those cases where the water-closet cannot be used, or where it would be subjected to the abuse of ignorant or careless persons. Its value for schools, for all manner of public charitable institutions, and especially for farmhouses and country-houses which are not supplied with water, and where invalids must expose themselves to inclement weather, cannot be over-estimated.

My limited time will not allow me to consider, as I should be glad to, the broad and important question of the removal, by underdraining, of the soil-water from retentive lands forming the lawns and gardens of country-houses; and I believe that the day has passed, when it is necessary to say a word before such an Association as this, on the subject of that crowning abomination, the old-fashioned vaulted privy. We still accept it as an evil which has too much headway for us to stop it at once; but those of us who have not been misled into the fallacy of believing that the "odorless excavating apparatus" has made its continuance permissible do not need to be reminded again of its entirely uncivilized character, and of the unhealthful influences that it must inevitably and in every case exert.

THE

SANITARY CONDITION

OF

CITY HOUSES.*

A SUITABLY built, suitably arranged, and suitably surrounded city house is probably the safest of all human habitations; but a suitably built, suitably arranged, and suitably surrounded city house is probably the rarest of all human constructions.

The country house gets, from its isolated position, a full bath of sunlight, and a free circulation of pure air, which counterbalance many of its customary defects. But in spite of this, its defects are often pronounced; and deleterious influences arising from soil exhalations

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* A paper read before the Public Health Association of New York.

and from improper disposal of wastes are in its case often very serious.

A city house with an absolutely impervious sheet of concrete between its cellar and the underlying ground, with impervious cellar walls, with due protection against the rising of damp through its foundation, and with a sufficient circulation of fresh air through its cellar, is practically isolated from any source of danger connected with the ground over which it is built. The earth in front of it is covered with pavement, protected against undue saturation by its abilty to shed rain ; and the earth behind it is either covered in like manner with close pavement or has its exhalations filtered by the vegetation of its grass-plat—so that, supposing the whole area in its neighborhood to be protected in like manner by the belongings of other houses, there is little to fear from a malarious condition of the ground. Supposing every house in the neighborhood to be thoroughly well protected in the way indicated, it might stand over a pestilential swamp without much danger.

It is no argument against this assertion, that such of the houses with which we are familiar as stand over the site of an original pond or swamp are subjected to malarial diseases, because the usual manner of construction has left them without the necessary protection against ground exhalations. Probably to a certain extent the freest and best-drained soil acquires in time, from the character of the early occupation of town-sites, a certain degree of fouling which the absence of vegetation, and the crowding of houses, so thickly as to exclude sunlight and the circulation of air, allow to become dangerous; and there is frequently an undue amount of ground moisture which affects foundation walls and cellar bottoms as these are usually constructed. The extent to which the unwholesome influence of the ground air and moisture from the soil is felt by the occupants of town houses varies, of course, very much according to the original character of the ground. Where the ground is dry and sweet there is little to be apprehended. The ordinary ventilation of the cellar, which comes from careless workmanship, is generally sufficient for safety; but in proportion as the dampness or foulness increases, in just that proportion careless building becomes dangerous.

We know very well, from a difference in salubrity between houses standing on proper sites and houses standing on improper sites, that this influence of soil emanations is serious; probably, so far as the usual slighter malarial ailments are concerned, this soil influence is the most serious with which we have to contend. At the same time the debilitating effect of the exhalations referred to—headache, neuralgia, loss of appetite, intermittent fever, etc.—take a far lighter hold upon the popular imagination than do the often fatal diseases which are produced by bad air of another sort. The low condition and consequent susceptibility to infection which the malaria of damp soil produces doubtless aggravate very seriously the dangers arising from the other source; that is to say, persons enfeebled by exposure to malaria would often succumb to infection, when a robust and vigorous person would withstand it.

Mankind has been too long accustomed to living in the face of threatening infection, and has been too long educated in the belief that all fatal disorders are to be accepted as the chastening work of God's inscrutable purpose, for us to hope that the average man will at once realize the degree to which his life and health are dependent upon the manner in which he controls the circumstances and conditions of his living. Happily, it is coming to be well recognized that typhoid fever, diphtheria, cerebrospinal meningitis, and various grave disorders of the bowels, are the crop produced by planting in the system certain floating impurities of the air, whose action is as direct, under favorable circumstances, as is that of the spores of *penicillium* in producing a crop of mould when planted on the surface of a damp boot. It is not necessary to discuss here the merits of the "germ" theory. It will hardly be disputed that, whatever we may call the agent of propagation, there is an active agent peculiar to each disease. If we plant cowpox we grow cowpox, if we plant small-pox we grow small-pox, if we plant typhoid we grow typhoid; and so on throughout a long range of diseases whose limit is not yet defined.

Whatever our seed, our crop depends greatly upon the soil in which it is planted. In the case of a vigorous, active person, of strong constitution, and living under wholesome conditions, it may fall on sterile ground and be lost, while the same seed sown in the blood of the weakly may produce its fatal crop with certainty and abundance.

It is largely in connection with the influence of the constitution upon liability to infection—in addition to the minor disorders and discomforts resulting from the rising of swamp malaria and the conditions which produce fever and ague and neuralgia---that we have to consider the importance of excluding the ground air from the house. It is probably but rarely in city building that there remains in the subsoil such a degree of foulness as to produce typhoid fever and similar diseases; but the instances where a liability to fall before their attack is produced by this sort of unwholesomeness are by no means rare.

The causes of grave infection are precisely the same in the city that they are in the country, and they grow in both cases from improper protection against the emanations from the organic filth which is a necessary product of all human life. In the country it is perhaps less often by the fouling of the air than by the fouling of the water that these diseases are spread. In the city, the water supply coming from an untainted source, the infection is almost invariably through the medium of the air which we breathe.

We are very far from possessing such accurate knowledge of the conditions of decomposition which favor the multiplication of the germs of disease, or the production of such a condition of the air as produces disease, that it can be demonstrated with scientific certainty that under such and such conditions typhoid fever will be produced, and under such other its production will be impossible. It is a case where we have to accept purely circumstantial evidence.

No analysis of the water-closet drainage which oozed into the Broad Street pump in London, demonstrates to us that germs of cholera were communicated to its reservoir; but it *is* known that a water-closet whose outflow reached that well was used by a cholera patient, and that within a week more than five hundred persons, scattered over one of the best parts of London, and even as far as Richmond Hill, whither they had fled to escape the plague, but whence they sent to this pump for water, were killed by cholera; the only possible communicating link between the individuals of this scattered multitude being that they drank this water.

We know by frequent observation, that persons living in houses into which poisonous gases are poured through the honeycombing of lead soil-pipes, or the inefficiency of wash-basin traps, are liable to fall sick with diphtheria or typhoid fever. We know that when the defective pipe has been removed and a tight one substituted for it, or when the faulty baisin outlet has been closed, such diseases cease. We do not know precisely what condition of the air escaping from the imperfect pipe is necessary to produce the disease. Therefore, all that is said concerning this branch of the sanitary subject, is to be taken as the sum of empirical knowledge, and as being in so far unscientific that our deductions are not susceptible of clear demonstration.

Let us set aside the question as to the manner in which zymotic diseases originate, and assume that it is demonstrated that they are frequently caused by improper drainage, and by the admission of drain air into living-rooms. Taking this as a starting-point, we find two most serious questions to be considered:

1. How shall we keep out of the house the influences arising from the ground beneath it and beside it, which tend to produce a low condition of health, and to create a susceptibility to zymotic poisoning?

2. How shall we protect ourselves against such infection as comes to us from within or without the house, as a result of improper methods for the public and private disposal of the wastes of the body and of the household?

Concerning the injurious ground air, it may be assumed, however serious the difficulty, that it may be nearly or entirely remedied by a thorough draining of the soil below the level of the house cellar, by making the cellar-floor, the foundation-walls, and the pavement and walls of basement areas, hermetically tight; and by providing for the complete, even if very slight, ventilation, of the cellar itself. This is recognized on all hands, at least so far as the cellar wall and foundation are concerned, as being necessary to the best building In time it will come to be absolutely required by public authorities who have the regulation of the way which builder's work must be carried out.

That the importance of this complete separation of the house from the ground under and about it is by no means popularly regarded as essential, our daily observation proves. Those contractor-built rows of cheap houses, built by the block and sawed off in sixteen-foot lengths to suit the demand, which have covered so many hundred acres of this city, are built almost invariably without the least regard to the influence of the soil below them upon the health of those who are to live within them. That strictly American adjective, "first-class," which makes every degree of badness acceptable to the ambitious mind, has its requirements fully satisfied by a certain conventional expenditure about the front and the entrance door of the building, by high ceilings, and in these latter days by a judicious touch of "Queen Anne" joinery and paper-hanging. The house may be the veriest rattle-trap that ever trembled over the site of a recent swine-yard; there may be the freest racing-ground for rats from garret to cellar; it may have twenty openings in its drainage system, which are separated from the street sewer only by ineffective and often inoperative water-seal traps; its foundation walls may leak, and its cellar may often hold stagnant water. With all these defects, and with all the "scamping" of its work, which are evident to the practised eye, if its experienced builder has had the shrewdness to give it that touch of cheap finish which makes it "first-class," he may count on a price that will make his operation a good one. Should he be able to add the taking recommendation that the house has been built "entirely by days' work," it matters little that it was the days' work of apprentices and bunglers.

One of the almost universal defects of New York houses is strictly fundamental. The proportion of houses of the costlier sort that would bear a rigid inspection as to the efficiency of their cellar-floors, foundation-walls, and areas, must be extremely small. The gravity of this drawback is sufficiently understood by all who know the prevalent ailing condition of the women and children whom these houses shelter.

Much more serious, when measured by the death and pain that it produces, though hardly more so with regard to its effect on the health and efficiency of the people, is the question of disposing of the household wastes.

Men living in widely scattered communities find it easy, in their rude way, to get rid of the organic refuse that they produce, without serious injury to their health. As houses are made tighter and are more gathered together, the trouble increases with regard both to the waste of each household as reacting upon its own members, and to the influence that it may have upon the members of other households. When men gather together into closer built towns, they bring with them at first the institutions of the village—the vault in the back yard, the leaching cesspool, and the slop-gutter. The methods of life implied by the use of these systems are accompanied by defects of construction and ventilation which give a high death-rate. It may be questioned whether, with a public supply of good water, there is any great amount of actual poisoning occasioned by such disposal of filth. Indeed, the statistics of health in Philadelphia show an exceptionally small death-rate in those districts where the slop-water of the house is carried away through surface channels, and where the gutters at the sides of the streets are almost constantly running with soapsuds and kitchen sink waste. The untidiness suggested by this custom makes it one of the first efforts of the dainty and fastidious to hide such matters out of sight, by passing them away in cover-ed channels.

Human ingenuity has been able as yet to devise no system for the disposal of all manner of liquid waste which is at once so inoffensive, so invisible, and so healthful, as a well-arranged system of water-carriage removal. The unfortu-nate thing about it all is that it is easy to meet the requirements of the fastidious by such a development of the system as is, from a sanitary point of view, the worst possible. Marble-top wash-stands with silver-plated fittings, decorated china closet-bowls, planished copper baths set in cabinet work of hard wood, stationary trays in the laundry, and the brightest and handsomest workman-ship wherever the plumbing is visible throughout the house, are too often—in-deed it is hardly extravagant to say almost universally—the outward mani-festation of most pestilential hidden dangers.

Art can hardly achieve more in the way of luxurious appointments than is compassed by all of these details in a modern house of the best sort. The character of their finish has much to do with the estimate that the intending purchaser or tenant puts upon the house he examines, and they are the subject of some of the most minute of the architect's specifications. When we consider the interior construction and arrangement of the hidden system to which they belong, we approach a part of the subject concerning which the purchaser, the architect, and the tenant, are too often ignorant and indifferent. Nor do the dangers which belong to the modern house drainage system cease when we pass the limit of private work, and come to the public sewer to,—and from,—which the house drains lead.

The sewer and the drain meet one imperative requirement of the community. They are hidden from sight, and their processes are not offensively manifest, as are those of the slush-bearing surface gutter.

It is often assumed, perhaps because of the name given to the air of which we hear so much and which is so widely destructive,—"sewer-gas,"—that the difficulty lies entirely or chiefly in the public sewer, and that we have only to improve the character of this, or so to detach our private system of drainage from it as to prevent the transmission of its air.

It is probably true that no city of its age can rival New York in the defective condition of its brick sewers. They are too often badly planned, badly built, and badly kept, and they do unquestionably produce a vast amount of disease and death. We can by no means, however, charge them alone with all or nearly all of the harm that is done; for so far as the production of dangerous gas is concerned, the waste-pipe of the house itself, smeared from top to bottom with the foulest organic matter, putrefying under the worst conditions, and with frequent variations of temperature caused by the entrance of hot and cold water, is at least a brave rival of the worst street sewer.

The lack of ventilation of even the best sewers of New York and of American cities generally, makes it important that we shut off as completely as possible the communications between the air that they contain and the air of our soil-pipes. Were these sewers well made and properly ventilated, the suggestions about to be offered concerning the soil-pipe might be materially modified; but circumstanced as we are with reference to the public sewer, we must arrange to use it only as a means for getting rid of our liquid outflow, and must provide for our security against injury from its poisonous gases by a proper construction of our own *cloaca minima*; that is to say: we must have no more to do with the public sewer than is absolutely necessary, treating it as a deleterious outside influence against which safeguards must be adopted.

There are still very many houses in all our cities in which lead soil-pipes are used. The experiments of Dr. Fergus of Glasgow have demonstrated in the clearest way the great susceptibility of lead to the corroding influences of the foul gases arising from organic decomposition. He cites a great number of instaces in which even after a few month's use the action of these gases upon the material of the soil-pipe has perforated it through and through, and in some cases completely honeycombed a considerable area of its wall. This effect is produced by gases and not by the foul water, as is proven by the fact that the perforations are always at the upper side of the pipe, and never on its lower side, where the water flows. It occurs along the upper side of horizontal and oblique pipes, and especially at the upper side of a bend, as in front of a trap; for the reason that the lightness of the gas causes it to lie chiefly against these parts of the pipe. The perforations being at the upper side of the pipe, they are not manifested by the leaking out of water, as the conduit is rarely filled. Often where it is horizontal or oblique, it serves only as a gutter, its upper side being largely eaten away.

Even the smallest perforation may become a source of the most serious danger; a mere pin-hole may permit the escape of such an amount of air from the pipe as to poison the atmosphere of a large room. The apertures formed by corrosion, however, are rarely so small as pin-holes, and they are not infrequently large enough to admit the finger.

In modern practice it is almost universal to use for the soil-pipe and the larger branch-wastes, cast iron in the place of lead. This material is not susceptible to perforation from the action of its contained gases; but, as drainage works are constructed, it is often fed by numerous waste-pipes of lead, which come to it from bath-tubs, wash-basins, butler's sinks, laundry trays, and urinals, and even the water-closet usually has a trap or a connection pipe of lead. All of these leaden connections are subject to the same liability to corrosion as is the lead soil-pipe itself; and in one sense they aggravate the danger, from the fact that perforations occurring in them are more likely to discharge gas into sleeping-rooms or into the more frequented parts of the house.

The especial adaptation of lead to the construction of these minor waste-water channels because of its flexibility, and of the ease with which it is jointed, make it almost necessary that it should be used; but, as plumbing-work is generally constructed, it is used with more or less risk.

The old soil-pipe was invariably a tight one, and was generally separated from the connection with the sewer by a trap. The air it contained was not only extremely foul, but it was subject to expansion on the admission of warm water, and from the production within it of the gases of decomposition. This expansion *must* be relieved; and it invariably is relieved under such circumstances, by the forcing of that one of its traps which has the least head of water to be overcome. The air in a street sewer is generally subject to more or less expansion from the same source, and to compression by the entrance of large volumes of storm-water, and by the blowing of strong winds against its outlet. The pressure in this case finds its relief by forcing the weakest house-drain trap, and the weakest trap between that house-drain and the interior of the house.

It has for some time been usual in all complete plumbing-work to relieve the soil-pipe by carrying a small "stench-pipe" from its upper part, out through the roof of the house. This is generally a pipe not more than 1½ or 2 inches in diameter; and in order to protect it against the admission of rubbish from above, it is either domed over, and perforated with a number of small holes, or its upper end is bent so that its outlet shall be turned downward. Where this pipe is not so long and crooked as to offer considerable resistance by friction, and where the perforations at the top are sufficiently large and numerous, it serves a good purpose in relieving the pressure of expansion. Under quite unfavorable circumstances it will still, probably, be easier, for the pressure to relieve itself through this stench-pipe, than through any water-trap ; and in so far as the danger comes from this cause, it is an effective device.

The more recent investigations into the nature of sewer-gas seem, however, to have demonstrated that in its poisonous condition it is the product of an obstructed decomposition ; of fermentation, which Pasteur aptly calls "life without air." The atmosphere within the soil-pipe does not contain sufficient oxygen to supply the continuous decomposition, which is thus checked until the oxygen which it requires is supplied by constituents of the organic matters themselves—a process which leads to a radical difference in the resultant gases. Instead of being a thorough destructive oxidation of the material, it becomes a putrefying decomposition, producing foul smelling and dangerous results.

That part of the soil-pipe which carries the waste of the butler's pantry and the kitchen sink, is more or less charged with melted grease, which coats the accompanying particles of food and of filth, and so shelters them from the action of the air, giving the same pernicious character to their decomposition.

The most important improvement in house-drainage that has been made is the comparatively recent one which has grown out of our better knowledge of the true character of the decomposition taking place in the soil-pipe. It has for its objects—and it accomplishes these objects perfectly—the reduction of putrefactive fermentation to the lowest minimum, and the complete and immediate dilution of the gases which the slight remaining putrefaction does produce. It consists in creating throughout the whole length of the soil-pipe a constant supply and a constant movement of fresh outer air-

Except for the danger of freezing in cold climates, the best way to accomplish this purpose is to admit a small air-pipe—one inch in diameter will be sufficient—at the lower end of the soil-pipe, at or near its passage through the house-wall, and the continuing of the soil-pipe itself, full bore, up through the roof of the house, furnishing it with an efficient cowl, to increase its draught.

In climates so cold that even this small direct admission of air would be dangerous, the pipe through which it comes may pass for a greater or less distance under the ground, or inside of the cellar, to raise the temperature of its air above the freezing point. With a good draught in the soil-pipe itself, enough fresh air may be admitted through even fifty feet of one-inch pipe.

Fludder's modification of the system is even more complete and effective, and its adoption will add little to the cost of the best plumbing work.

Fludder not only carries the soil-pipe through the roof, but he also carries another pipe of the same size from the upper side of the soil-pipe where it is about passing the foundation wall, along the ceiling of the cellar, and up through the kitchen-chimney flue—the only flue in the house that is sure always to be heated. The course of the air in this case is down the main soil-pipe, and up the kitchen-chimney ventilating flue. It secures a large volume of air—there cannot be too much—and the all-important constant circulation. A valuable adjunct of this system is a damper or valve in the main soil-pipe, above the highest closet connection, which ordinarily stands open, but which being connected with the pull-up lever of each closet, is closed when this is raised. The construction of the closet is such that when it is being emptied, there is no trapping water between it and the soil-pipe. When the handle of the closet is raised, its first effect is to close the valve in the soil-pipe, and its next to open a free passage between the water-closet and this pipe. While the closet is thus open, it affords the only inlet for air to supply the draught for the ventilating flue. When the handle is released, the closet seals itself with water; the valve in the upper part of the pipe is opened, and the free circulation is re-established. Should the amount of cold air admitted by this system be enough to cause a closing of the soil-pipe with gathering frost, this very closing will prevent the further admission of air, and the warmth of the house will soon melt away the obstruction; which, be it understood, is at a high point in the soil-pipe, where it is not likely to do harm, as it would do at its lower end.

Where a ventilating cowl is to be used to maintain a draught, it is important to consider its kind. The present movement, both here and in England, is in favor of some form of mechanical device by which the action of even a slight wind shall increase the suction by mechanical means, whenever a slight wind is blowing. It is more important that the current through the soil-pipe should be constant, than that it should be rapid; and these mechanical cowls, of which Banner's and the Archimedian are good examples, offer a certain obstruction to the flow when at rest. In baffling winds Banner's cowl especially may easily cause a back draught.

Whatever may be best for smoke-flues, nothing has yet been devised which is so good for soil-pipes as the old "Emerson" ventilator, of which the patent has run out, and which therefore lacks the advocacy of liberal advertising. This cowl increases the draught with every wind that blows, and in every eddy; and when the atmosphere is at a dead stillness, it offers no obstruction to the flow.

The soil-pipe being properly constructed and duly ventilated, the only further practical improvement in the waste drain system seems to lie in making its branches, which lead from bath-tubs, wash-basins, etc., as short and as large as practicable, so that they may partake, by the transfusion of gases, of the purer condition of the air in the soil-pipe itself. It will not always be possible to ventilate each of these pipes independently, though this is always desirable; but with a ventilated soil-pipe and large, free waste branches, we need fear no serious tainting of the air that they contain.

Did the limit of this paper suffice, it would be well to consider the construction and location of water-closets; but I must confine myself to the simple question of the proper ventilation of the apartments in which they stand. Unfortunately, it is rarely practicable, as our houses are arranged, to give them an open outer window; but they surely require some more efficient means of ventilation than a small hole in the wall more than half closed by the air-bothering network of a register, and leading into a small flue choked and obstructed from bottom to top with rough lumps of intruding mortar. The ventilation of these apartments would be materially improved by the use of shafts of six-inch earthenware pipes smoothly jointed, discharging well above the roof, and protected by an elevated cap against the entrance of rain water.

There is a somewhat active modern crusade against the stationary wash-bowl; and as stationary wash-bowls are ordinarily arranged, the crusade is certainly justified. At the same time, the convenience of these appliances, and the degree to which they augment the luxury of an abundant water-supply, and a good drainage system, are so great that it is worth an effort to retain them. A stationary wash-basin anywhere within the house is, under its existing conditions, in danger of becoming a channel for the influx of sewer-gas; and even were our drainage pipes and sewers so carefully arranged as to reduce the production of foul gases to the minimum, it would still be most important to remove the possibility of the entrance of drain air anywhere within the house.

I trust that I may be excused for

mentioning a device of my own for accomplishing this purpose. It consists in supplying wash-basins, bath-tubs, butler's sinks, kitchen sinks, and all vessels, except water-closets, by which a water-supply is made useful, with a plug that closes the main outlet from below, so that any pressure of gas instead of forcing it open shall force it more tightly shut, and so arranged that it must always remain closed, except when held open by the hand; and in putting a stop-cock in the overflow pipe, worked by the same handle that works the stop-cock of the supply-pipe, so that when the supply-pipe is open and the overflow may be needed, this latter shall be open also; and that when the supply-pipe is closed, the overflow pipe shall be completely closed as well. With this arrangement it is impossible that there should be the least connection between the air of the drainage system and the air of the room; the usual water-trap seal below the basin, worthless though it is as a permanent reliance, suffices for protection during the short time required to fill the vessel.

Aside from its danger, the usual wash-basin is objectionable, as being something less than fastidiously nice. If it has a plug and chain, these become soiled with dirty water, and are not thoroughly cleansed before the next use. If the waste plug is operated by a handle rising through the slab, there is a considerable length of pipe between it and the bottom of the basin, which is sure to be coated with a slime of soap and dirt, with which the next filling of the basin is materially fouled.

These latter defects are removed by my device, and by the recent invention of Wheaton, of Dayton, O. If, by the use of any of these improvements, the entrance of sewer-gas is prevented and the dirty outlet chain or slime-coated open outlet pipe is got rid of, I see no reason why the most liberal extension may not be given to the use of all manner of vessels to be filled from the public water-supply.

There are many minor details that might with advantage be alluded to did time permit—such as the objections to long horizontal waste-pipes; the importance of having these waste-pipes trapped only at their upper ends, delivering at their outlets into a freely ventilated soil-pipe; the increasing importance of ventilating waste-pipes in proportion as their length increases; the necessity for delivering the ventilation of foul pipes at such points as will prevent their outflow of air from being involved in the back-draught of unused chimneys; and all the long detail of house ventilation; and the pregnant subject of the poisoning of the air by the carbonic oxide produced by the burning of anthracite, which Dr. Derby demonstrates in his valuable monograph on "Anthracite and Health;" together with the effect on health of that foul smelling effluvium which comes from the heating of organic dust by steam-pipes, and which makes an unventilated, steam-heated room so disgusting to the unaccustomed nostril.

These are relegated to a secondary position because, like the necessity for free sunshine in all inhabited rooms, they are less obviously connected with the question of life and death than is the matter of drainage pure and simple, and are therefore less likely to engage immediate attention.

Interest in sanitary improvement will naturally first apply itself to the more serious causes of fatal and distressing disease; but once awakened it will pursue the whole range of the subject, and will, let us hope, not abate until it has compassed a perfectly wholesome condition in every department, and has secured to all, what all have a right to demand, an entirely safe human habitation.

FLUDDER'S SYSTEM

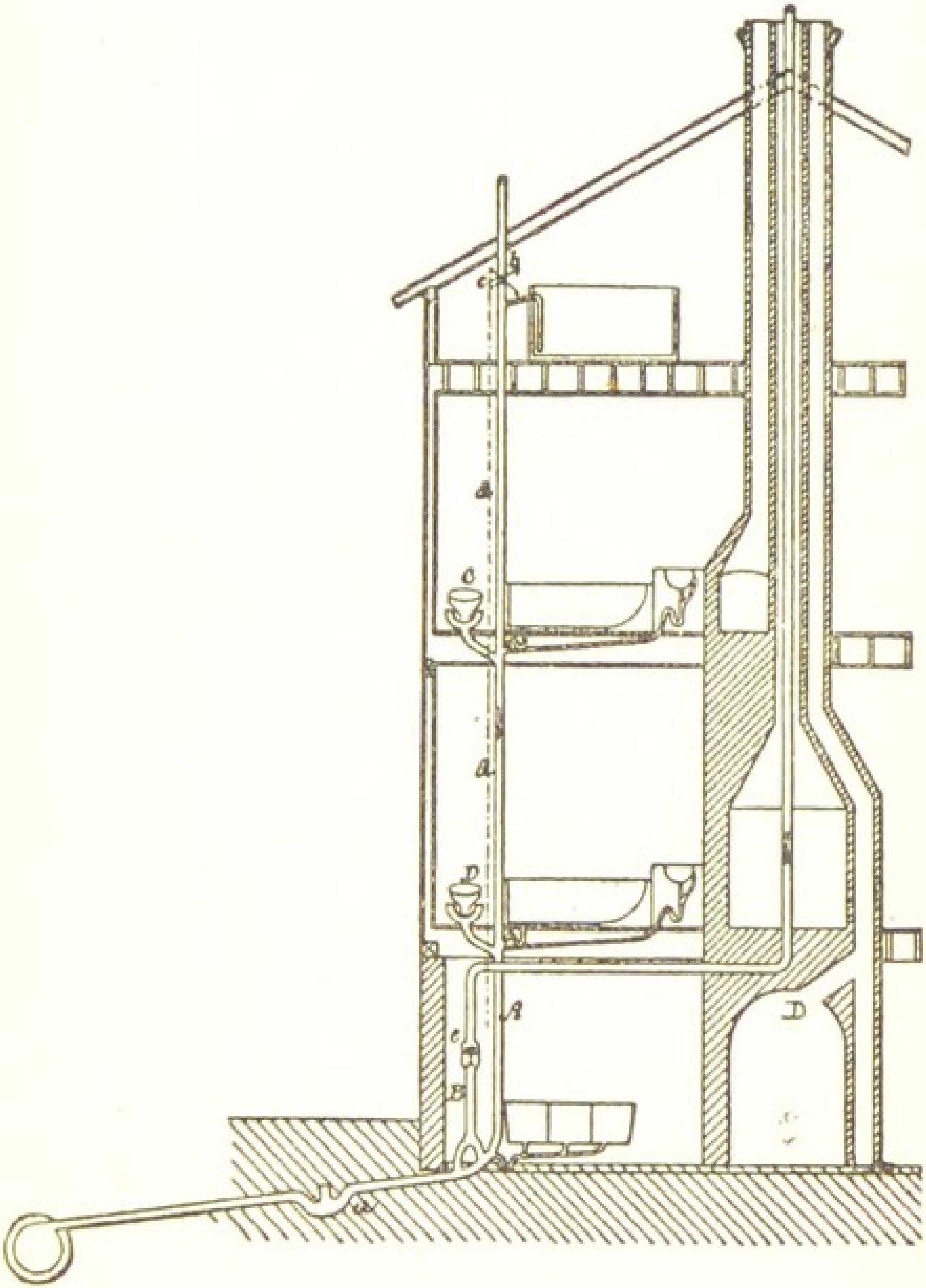
FOR THE

VENTILATION OF SOIL-PIPES.

THE accompanying illustration shows a new system for producing a circulation of air through the soil-pipe of a dwelling-house, which seems to overcome some objections to the method now generally adopted. Its purpose is to secure a constant *downward* current of fresh air through the pipe, thus providing a sufficient amount of oxygen to carry the decomposition of the foul matters remaining within the pipe, and the foul sliming of the inner surface, to such a point of completeness as shall prevent the formation of poisonous gases.

Another effect secured is the creation of an inward draught, whereby the tendency of the gaseous contents of the soil-pipe to escape through water-traps, etc., is reduced, while imperfections in the pipe would be likely to become inlets rather than outlets — fresh air entering them at these points, instead of foul air escaping.

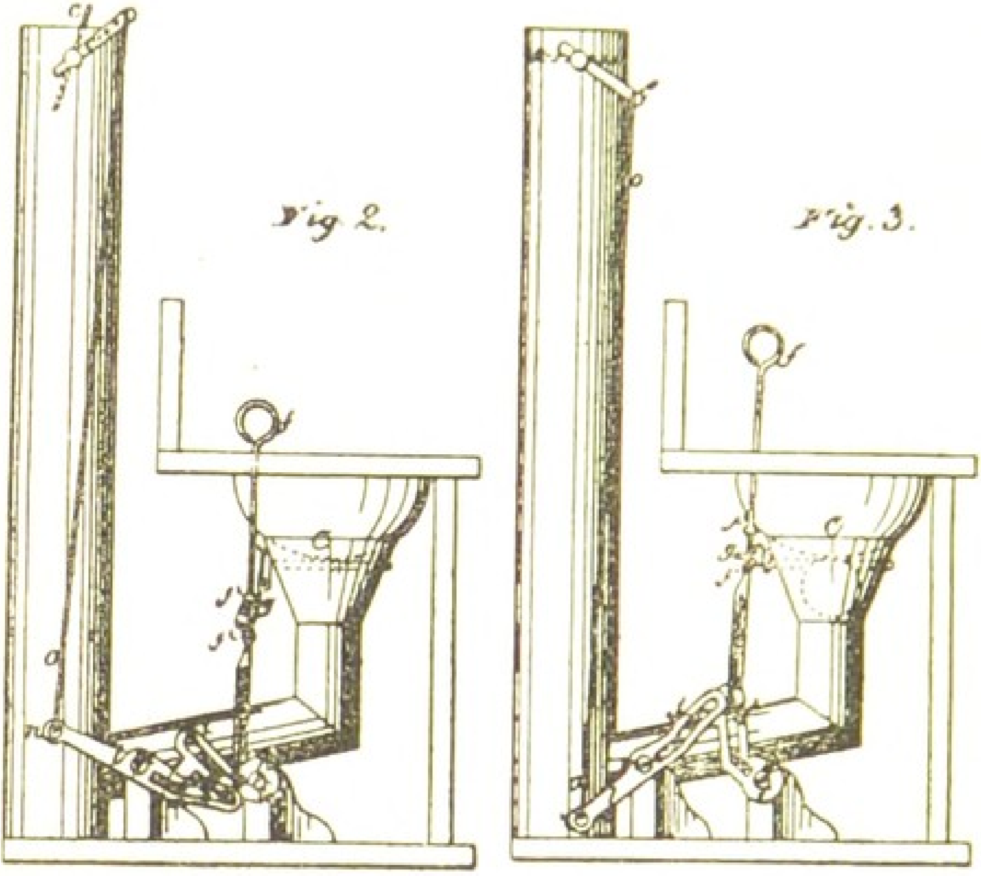
Referring to the diagram, "A" indicates the soil-pipe descending from without the roof through the house and the cellar, and passing on to the sewer. At the point "*a*," outside the house, it is



trapped in such a way as to prevent air from being drawn from the sewer. At its lowest point in the cellar, below the junction of the waste-pipe from the laundry trays, another pipe "B" of the same size with the soil-pipe, or preferably somewhat larger, is connected with the soil-pipe by two legs; the purpose of this double connection being to prevent a downward draught on the pipe "B," by the flow of water past its mouth. The pipe "B" rises to the ceiling of the cellar, and crosses to the line of the kitchen chimney — the kitchen chimney, because this is the only one in the house which can be depended upon to be kept constantly warm enough to create an upward current. It then turns upward, and passes through the kitchen flue to a point well above the top of the chimney, preferably considerably farther above than the diagram shows.

For cold climates, there is an additional arrangement for reducing the area of the air inlet.

So far as described, this arrangement must lead to a constant descent of air through the pipe "A" to its point of junction with the pipe "B," and an ascent through this latter to the point of escape above the chimney. For this purpose alone the arrangement is probably the best that has been devised; but its further features, concerning the attachment of the water-closets, are no less worthy of commendation. These closets "C" and "D" are connected with the soil-pipe by untrapped outlets, although the bowls of the closets are separated from this outlet by an ordinary water-seal tilting-pan. It is assumed, and probably correctly assumed, that the movement of air down the soil-pipe would create sufficient friction to keep up a constant movement in the air contained in the short outlet-pipes, and in the receiving-chambers below the closets; enough so to prevent any injurious stagnation. By an ingenious device, the lever which tilts the sealing-pan when the closet is used is attached to another lever connected by bell-wire with the damper in the upper part of the soil-pipe. In its normal condition this



damper stands open. When the handle of the water-closet is raised, its first effect is to close the damper, and thus prevent the supplying of air from the summit of the soil-pipe; its further movement tilts the sealing-pan, and discharges the contents of the closet into the soil-pipe. As soon as the sealing-pan is open, the demand for air to feed the draught of the ventilating pipe in the chimney-flue can be supplied only through the closet; a downward draught is established, which is sufficient to carry with it all odors, and entirely to change the air of the receiver and branch-pipe below. There being no trap in the branch-pipe, the contents of the bowl are flushed immediately through into the soil-pipe, instead of remaining to decompose, as they do in the bend-trap now almost universally used. The handle being released and allowed to fall back, the first effect is the closing of the water-seal; and this is immediately followed by the opening of the damper, which re-establishes the current from above the roof. In the diagram the damper in the soil-pipe is shown at "*b–c*," and its connection with the closets by the line "*d–d*." It is immaterial how many closets are used. Each one has its independent connecting-wire leading to the damper; and when any one of these is drawn taut, closing the damper, the wires connected with the other closets simply fall slack.

Should it not be expedient or advisable to carry the upward air-pipe through the kitchen chimney, it may pass independently through a high point of the roof, and be furnished with a good ventilating cowl, for maintaining a constant current. At "*e*" there is shown a chamber or enlargement of the pipe, containing a wind-wheel. by which (through a glass at one side of the chamber) one may see the effect and constancy of the current. For experimental purposes this may be very well; but for practical use it is of no value, and it must have a certain, even though very slight retarding effect upon the current—due not only to the power required to move the wheel, but to the disturbance of flow resulting from irregularity of form. "D." indicates a method for ventilating the cellar, which is quite independent of the main device. This may also serve for a smoke flue for the laundry.

EXTRACTS FROM CORRESPONDENCE

IN

"The American Architect and Building News,"

ON THE

DISPOSAL OF THE LIQUID WASTE

OF

COUNTRY HOUSES.

CORRESPONDENCE.*

DECEMBER 16, 1876.

I HAVE followed with much interest the series of articles you have published on "The Sanitary Condition of Country Houses," the subject being one to which I have given considerable attention.

It approaches, but does not quite reach, one of the points involved, which is of so much importance, that I venture to ask for its consideration in a subsequent paper. The question I refer to is that of the disposition of sewage from a country house, where there is no town drainage available, and *where the grounds surrounding the house are level* (which, by the way, is the usual condition in country towns). To simplify the consideration, let it be supposed that there is a street

* "T." is HENRY R. TOWNE, Esq., of Stamford, Conn. "B." is JAMES BAYLES, Esq., of New York City. "W." is the writer of the foregoing pages.

water-supply, so that contamination of springs is not to be guarded against; that the house is provided with water-closets, sinks, etc.; that the waste-pipes are all connected with a four-inch iron soil-pipe, and that the latter passes through the basement wall, from three to four feet below ground, to avoid frost. Now, given the above conditions, how far must the sewage be carried from the house, and how shall it then be disposed of?

Obviously the character of the soil is an important element; and I would suppose, therefore, the two most ordinary cases, (1) where the soil is of gravel, porous; and (2) where it consists of clay, not porous. It should be remembered, also, that the soil-pipe necessarily leaves the house at a depth which precludes the subsoil irrigation system of Mr. Moule.

The conditions I have supposed are such as will apply to the majority of residences in small towns and suburban villages, as well as to many country houses; and you can do no more useful service than by indicating the proper treatment of this problem, which perhaps on account of its difficulty, is one but very lightly touched upon in most treatises on sanitary engineering.

T.

DECEMBER 23, 1876.

IN the communication published in your issue of Dec. 16, a question is raised as to the disposal of the liquid wastes of houses which stand on level ground—the usual condition in country towns. Mr. Towne thinks that the directions contained in my address before the American Public Health Association do not quite reach this point.

I see no escape, in the case of such houses, from the necessity for making the conditions conform to the requirements. Certainly the requirements cannot be made to conform to the conditions. The production of liquid wastes which are sure to endanger health if not properly got rid of, is a necessary part of the economy of every household. So far as I know, there are only five systems by which this liquid can be treated.

1. By discharge through an open surface gutter to a distant open vat, or waste corner of the grounds. This is the most offensive system, and the one least likely to be adopted by persons who are at all nice in their ideas of decency; but it is not necessarily dangerous to health, if the final deposit is at some distance from the house. If the gutter is kept well slushed out, the decomposition at the distant terminus will have its foul emanations so diluted by the air before they can reach the windows as to be innoxious — save for their smell. Happily the sense of decency will prevent the adoption of this tolerably safe but entirely nasty expedient.

2. By discharge into a leaching cesspool. This is the most dangerous system yet devised, especially for houses not supplied with water from public works.

It is also a system which public opinion and public authority must soon prohibit. The covert poisoning of the ground from which the water-supply of a whole neighborhood is taken, and from which the "ground air" rises into and around human habitations, will not much longer be permitted. So far as the house itself is concerned, there exists the further defect of a constant formation of sewer-gas in the cesspool, which has no outlet save back through the pipe leading from (and to) the house — a channel of communication which no form of water-seal trap can close.

3. A tight cesspool; not simply a "cemented" cesspool, but one which is known to be, and is sure to remain, absolutely tight. It is possible to make such a cesspool as this, but it is not usual; and it is possible, but it is still more unusual, to ventilate it so that the formation of poisonous gases need not be feared. In its most perfect condition it is subject to the necessity for frequent emptying; and is sure to be at best only a mitigated

nuisance, ready to become a source of real danger whenever its impervious wall is accidentally made pervious, or when its ventilation fails from any cause, or when its proper emptying is neglected, or when a sudden storm causes it to overflow, or to set back into the house-drain. Under the best circumstances and conditions, such a cesspool may be permitted; but when the householder himself is not constantly vigilant and attentive—even anxiously so—it may become a cause of serious mischief.

4. By discharging into a public sewer. If this is well contrived, well constructed, *and well ventilated*, it offers the best solution of the problem, so far as the individual householder is concerned.

5. By discharging the liquid waste of the whole house (through suitable flush-tanks and settling cisterns) into a system of sub-irrigation-pipes as described in the paper which suggested Mr. Towne's letter. Where the public sewer is not available, I regard this as much the best device of all.

I see no escape from such conditions as the above paragraphs indicate as necessary under one system or the other. With a public sewer, the soil-pipe may of course leave the house at a depth of four feet or more. If the tight cesspool is to be used, it may be placed so far under ground that the same depth will be admissible; but my advice would usually be against providing for any such accumulation of putrefying filth. The sort of gasometer that the dome of such a cesspool would furnish, ought not to be an adjunct to any habitation.

If the sub-irrigation system is to be used, then the grade must be made to conform to it: that is all there is about it. The soil-pipe cannot leave the house at a depth of four feet below the level of the ground to be used.

Fortunately this is not necessary. The *ground* may freeze to a depth of four feet; but a soil-pipe drain carrying the warm outflow of the house would not freeze at a depth of two feet, probably not at considerably less than that. My own house-drain is only two feet deep, and has remained unaffected when the ground was frozen solid nearly five feet deep. My irrigation-drains have worked perfectly in the coldest weather, at a depth of one foot. My flush-tank stands mainly above ground, outside of the house, and is only protected by a one-inch board "dog-house" packed with leaves.

These facts indicate that much less depth is needed than Mr. Towne suggests. And the fact is that very few places, even in villages, are *level:* there is usually a slight fall, and a slight fall is all that is needed. Whatever is needed *must* be furnished either by raising the house, by lowering the ground, or by adjusting the level of the pipes to suit the conditions. Ordinarily a little skill and ingenuity in such matters will suffice to accomplish this. I have not as yet met a case where there was any serious obstacle to be overcome.

W.

JANUARY 13, 1877.

MR. WARING'S reply to my query as to the best mode of disposing of the sewage of country houses which stand on level ground, is interesting, but by no means exhausts the subject.

Of the five systems Mr. Waring enumerates, the first, second, and third, are practically excluded from consideration by him on account of their objections, and the fourth (the use of a public sewer) is excluded by the conditions supposed in my query, so that only the fifth (the sub-soil irrigation system of Moule) remains; and to this Mr. Waring nails his colors with the remark that if the grade does not admit of this system it "must be made to conform to it: that is all there is about it."

This position I think is hardly tenable, however, for in many places the grade is uncompromisingly and provokingly level, and *cannot* be altered, as, for instance, in such districts as Central New Jersey, where in some towns and villages the grade does not vary twenty inches in the whole place, let alone within the bounds of an ordinary house-lot of say fifty by one hundred and fifty feet. In such cases the sewage *could*, of course, be collected in a tight cesspool, thence pumped into a raised flush-tank, and then discharged into subsoil irrigation pipes: but this plan is too expensive, both in first cost and in operation, to admit of general application, and is moreover open to the objections Mr. Waring makes to tight cesspools. And thus, *for flat grounds*, system number five is also in many cases excluded.

If the question of cost be ignored, there is little difficulty to the engineer in dealing with the problem we are considering, under any conceivable circumstances; but it must be remembered that cost is almost invariably an important if not a controlling element, and the question therefore is: How, at reasonable cost, can we secure the best result?

Now I believe that where, as I have supposed, there is a street water-supply so that we need not fear contamination of drinking-water, the leaching cesspool *properly used* may, notwithstanding its conceded objections, be our best reliance. The conditions under which it may be resorted to, I conceive to be as follows: It should be located as far from the house as possible, but not less than fifty or sixty feet, and should be carried to a depth of at least four or five feet below the mouth of the discharging sewer. Its diameter (as dug) for an ordinary dwelling-house should be at least ten feet; and its walls of large, loosely fitted stones, should be "drawn in" from a point just above the sewer outlet as quickly as practicable, so as to form a dome entirely covering the cesspool, above which, to the ground level, the excavation should be filled in with clean earth in which vegetation should be encouraged.

Before closing the cesspool, two four or six inch pipes of lead or galvanized sheet iron should be laid in place, one reaching down almost to the level of the sewer, and the other starting from the apex of the dome. These pipes should be led below ground to some convenient point, and then carried to an elevation of at least eight or ten feet above ground, and then capped with ventilating cowls, the one leading from the top of the cesspool having a cowl so constructed as to create an upward current in the pipe, the other having a reversed cowl, like a "wind-sail," which will force air downward into the cesspool. By this means we prevent any pressure within the cesspool or sewer from the formation of gases of decomposition, and also provide for a circulation of air within the cesspool which will constantly dilute and carry away the gaseous impurities.

In laying the sewer or drain from the cesspool to the house, the precautions which Mr. Waring suggests should be taken to secure tight joints and a solid bed; a good running trap should be inserted not far from the house and the iron soil-pipe from within the house carefully connected. Within the house, the soil-pipe itself should be independently ventilated by carrying its upper end out through the roof, and making an opening in its lower end in basement to complete the circulation. One or the other of these openings must be connected with the kitchen flue (in which there is always a fire), and the other with the outer air. Thus equipped, we have a system which is at least safe against the entrance of "sewer gas" by the ordinary channels. The existence of any pressure within the soil-pipes and drains is guarded against, and the system of ventilation provides for the constant dilution and removal of gaseous products of decomposition whether produced in the cesspool or soil-pipes.

The remaining sources of danger are from impure "ground-air," and the vitiation of the local water. The latter is admitted as a fact, and the plan under discussion is recommended only where the water-supply is brought from a distant and untainted source. The former only need therefore be considered. Now, assuming a moderately pervious soil at the level of the bottom of the cesspool (and without this the cesspool soon becomes practically a tight one,) the purely fluid part of the sewage will probably travel a long way, indeed—*will mingle with the subterranean streams which exist in almost all localities.*

But it should be remembered that all of this sewage is usually enormously diluted with water, that we have provided for the removal of its more volatile constituents, and finally that the liquid portion in flowing away passes through what we may regard as a huge filter which washes out and retains the remaining organic constituents. So long as the surrounding soil is able to decompose and absorb the matter thus committed to it, no danger accrues. In the course of time, however, the capacity of the surrounding soil is exhausted; and the gases resulting from the decomposition of organic impurities begin to rise, unpurified and noxious, through the upper strata of the soil.

At first the absorbent and disinfectant powers of the latter will disarm the enemy; but ultimately the impure air and gases we have so much cause to dread will reach the surface, and mingle with the outer air. But when this is the case, are we any worse off than under the "subsoil irrigation" system? With that *all* the decomposition occurs at the surface of the ground, and dependence is placed on vegetation and free admixture of the air to neutralize its effects. But why are not the same means to be equally relied upon for neutralizing and dispersing the products of decomposition which may occur at a greater depth below the surface? Probably these products are diffused over a much greater area of ground on reaching the surface than they would be under the other system, and are already diluted and partially disarmed for harm.

One caution should be observed, however, where this plan is followed, particularly where the cesspool is not well removed from the house; namely, to guard against any possible rising of emanations from the ground *within the house*, by having well-cemented cellar walls and floor (or, better still, in addition to these, an open area around the house); but this precaution is one that ought to be observed with any system, and in all houses.

In conclusion let me say that the above plan is only suggested for houses "which stand on level ground," and which have a safe and abundant water-supply. For more favorably situated cases, better plans, no doubt, are available; but for the case I have supposed, I have seen none suggested by which at moderate cost equal safety can be secured. But in this correspondence I have been a seeker after knowledge, not an expounder of it; and I shall be glad to learn of better plans than that I have suggested, if such there are.

T.

JANUARY 27, 1877.

MR. TOWNE instances the case of a house standing on level ground, such as prevails in the villages of Central New Jersey, and suggests the course to be pursued where the character of the surface makes it impossible to secure the requisite fall for the use of sub-irrigation drains. He supposes the case of "an ordinary house-lot, say fifty by an hundred and fifty." Let us suppose, by way of illustration, that the rear fifty feet of such a lot is to be used for the disposal of sewage by underground land-drain pipes. One of the conditions of the success of the system is that the slope shall not be too great. In arranging the sewerage of Lenox, Mass., where a large volume will be distributed, I have taken a fall of one in three hundred, or four inches to one hundred feet. For a private place where the wastes of a single household are to be accommodated, and where the flush-tank would not discharge more than from thirty to fifty gallons at a time, it would be better to have a fall of one in two hundred, or six inches to one hundred feet. More than this would be too much; and were the slope greater, I should propose to lay the lines on a course diagonal to the inclination of the land. The reason for this is, that if the inclination is greater, the flow runs too rapidly to the far ends of the lines, instead of leaking out more equally at each joint of its course.

To provide a fall of one in two hundred on the rear fifty feet of a level lot, would require a slope of only *three inches*, which could be made by handling an average depth of one and a half inches over the whole, or only about three hundred cubic feet of earth—an amount less than the ordinary modifications in grade of any tolerably finished house-lot. Indeed, a part of the slope required could be given in the drains themselves, as there probably would be no disadvantage in making them a little more or a little less than twelve inches deep at their ends.

I trust that this explains my statement that there is no practical difficulty in arranging for the application of this system, even on level ground. Of course, provision must be made to deliver the soil-pipe, or the outlet of the flush-tank, at a point sufficiently high to reach these drains; but there is not the least difficulty in doing this. The question of cost, so far from being "ignored," is a leading argument in favor of the irrigation-drain system; for in no other way, even on level ground, can the problem be so cheaply solved.

Mr. Towne's suggestion for a leaching cesspool is simply inadmissible. I am confident that no sanitarian, who has kept himself at all well informed of the progress of knowledge on this subject would permit the use of this device. The suggestions for the construction and ventilation of such a cesspool are practical and good in their way; but the objection to it is radical, and cannot be overcome. There are many conditions where, so far as the immediate occupant of the house is concerned, no harm may be done; and of course in the country, where the excavation is made at a distance from any probable future house site, there is less to be said against it. But in any congregation of houses in a town or village, the public authorities should strictly prohibit any such fouling of the earth.

If the soil is so tight that there is no leaching, then, however loose the wall, there is no escape of the liquid. If through sand, gravel, porous strata, fissures in rock, or any other means of escape, the liquid soaks away, we may be quite sure that it will carry with it to greater and greater distances as time goes on, and, as the soil becomes foul, it will retain the objectionable or dangerous ingredients. Deep down in the earth, away from the action of the atmosphere, we lose the effect of the cleansing oxidation of the air, and of the action of roots, which are the best agents in purifying all manner of sewage. In fact, the objection is a radical one.

We cannot safely retain on our

premises a putrefying mass of organic filth ; and our own safety, and the safety of the community, require that we shall not pour this filth into unknown subterranean recesses, from which it may taint the water of the wells and the ground-air under houses.

Mr. Towne suggests the cementing of cellar floors as a safeguard against the rising of foul air into the house. To accomplish this end, such cementing must be absolutely tight, and the same tightness must be given to the surrounding wall. Both of these conditions are important to the best building, but they are often neglected for the sake of economy. So far as the drainage question is concerned, they would cost much more than would the adoption of the irrigation-drain system, even including the slight modification of grade that this might make necessary.

Mr. Towne asks, Why are we worse off with the exhalations from leaching into the deep soil (and under our houses) than with the irrigation system where the whole of the decomposition takes place close on the surface of the ground?

Precisely because of the difference between a decomposition taking place in the absence of fresh air and roots and the rapid and destructive process which these agencies insure. The most serious evils may result from the putrefaction of organic matters stored in large masses, or closely covered from the air. The same materials consumed by the concentrated oxygen of aerated earth, especially when an active vegetation stands ready to take up the results of the decomposition, produce no hurtful result. W.

FEBRUARY 3, 1877.

THE communications printed in a recent issue of your journal, from Mr. Waring, jun., and Mr. Towne, discussing the drainage of houses on level ground, have raised a question of great interest, and I ask permission to say a few words on the same subject.

There are situations and conditions which render practicable the system of house-drainage preferred by Col. Waring, which disposes of the liquid waste of the house by means of flush-tanks, settling cisterns, and irrigation-pipes. I have employed this system, somewhat modified, in draining my own country house, which stands on high ground, and has a sloping lawn of more than a hundred feet width, in the best position for the accommodation of irrigation pipes. I do not believe, however, that the system is one which admits of general adoption, nor one which will meet the requirements of most householders living within the narrow limits of town or village lots. Even where practicable, it does not seem to me to possess the theoretical excellence which is claimed for it. In summer, when evaporation is rapid and vegetation active, it is possible that the organic matter in the waste of a house would be taken up and assimilated by plants as rapidly as it could decompose in the soil; but I am not quite sure that even this is true in all soils.

I have watched very carefully the workings of the system in my own grounds; and while the lines of drain-pipe are laid within eighteen inches of the surface, which is quite even, I have failed to discover any indications of a more rapid or luxuriant growth of grass or weeds near the pipes than remote from them. If, however, it be conceded that the system works well in summer under average conditions, I fail to see that my buried pipes are much—if any—better than a leaching cesspool during the winter months, when the ground is frozen and vegetation dormant.

During this time the ground surrounding, and particularly that underlying the pipes, becomes charged with impurities which it cannot dispose of in a legitimate way. Long before they can be appropriated by growing plants, thawing snows and heavy soaking rains carry these impurities deep into the soil where the plants cannot reach them.

In a light, porous soil there is nothing to hinder these accumulations of six or seven months of each year from working down until the soil is saturated and our own or our neighbors' wells polluted. We have, in the Northern States, only about five months of warm "growing-weather;" and in my judgment, draining into the soil during the other seven months means pollution of the soil.

From a careful study of the problem of house-drainage in unsewered neighborhoods, I am satisfied that the tight cesspool system is the only one which is practicable. I have many times during the past few years had occasion to recommend a plan of drainage which has the advantage of adaptation to all the conditions I have yet encountered in practice. It is neither an invention nor a discovery; but in these matters the attainment of good results is of much more consequence than novelty or ingenuity in the means employed. I contract with a responsible mason to build a cesspool as "tight as a bottle." The price depends somewhat upon circumstances; but as I select my mason and give him to understand that he is to estimate honestly on the cost of first-class materials and workmanship, and not as a competitor for a contract to be given to the lowest bidder, the price is usually reasonable and the work always good.

When there is plenty of room, I put the cesspool from fifty to sixty feet from the house; when the lot is small, I put it as far away as I can. In shape the cesspool is much like an old-fashioned coffee-cup; its size, taking an average, is five feet diameter at top, and six feet deep. I cover this with a stout platform, removable at will, from the middle of which rises a wooden chimney ten or twelve inches square in cross section, and three to five feet high, capped with one of Mr. Baldwin Latham's charcoal ventilators, or with a device embodying the same principle. At one side of the platform I set a pump—any one of several makes is adapted to the purpose—and run the suction-pipe down to the bottom of the cesspool. This pump is a permanent fixture, and is always ready for use. The house connection is made in the usual way; but I have no traps at any point on the line of the main waste or soil pipe, or the house-drain proper. The soil-pipe is carried up of one size from the foundation wall to and through the roof. The branch waste-pipes are of course trapped; but I take the precaution to use traps which cannot lose their seals from any cause except evaporation. The danger to be apprehended from the absorption and transmission of cesspool gases by the water-seals of such traps is obviously very slight, at most. With the house-drainage system open at both ends, no accumulation of gases at any point where they can be held under pressure is possible.

When the cesspool is full, it can be emptied in any way most convenient. In a town or village where an odorless excavator can be ordered, it may be emptied by lifting out the ventilating chimney, and dropping the suction-pipe of the apparatus through the hole in the platform. If the householder must attend to the work himself, he can do it in one or two ways, according to circumstances. In summer, if he has a garden, he may employ it for surface-irrigation. He can make a trough by nailing two boards together at right angles, and, putting one end of this under the spout of his pump, let the other end rest where the water will do most good. By providing two or three such troughs made of long boards, he can irrigate a garden of considerable extent, and as frequently as may be needed. The organic matter already partially decomposed will be at once taken up by the plants; and the water is quickly absorbed by the dry surface soil, to be given off again in evaporation. In the winter, or in places where irrigation is not needed for the fertilization of a well-kept garden, the contents of the cesspool must be pumped into tight vessels of some sort, and carted away. A short piece of rubber tubing attached to the spout of the pumps, and half a dozen kerosene-barrels with tight-fitting bungs, will give the householder an odorless excavator of his own.

Concerning the views expressed by my very intelligent friend, Mr. Towne, I can only say that, in my judgment, the leaching cesspool system is the worst which can be employed under any circumstances. I lately visited a town in which this system is carried out *par excellence.* The town is built upon a limestone formation, which is full of cracks and fissures; and, to dispose of any thing in the shape of waste, it is only necessary to dig down twenty or thirty feet, until the limestone is reached. Even privy-vaults empty themselves. The town has a water-supply drawn from sources not reached by the pollution of the soil; but within three years it has had two epidemics of typhoid fever, and is never free from sickness of unmistakable zymotic origin. We must not forget that, in pouring sewage into the soil, we are poisoning it for the future, near and remote. Coming generations will suffer, even if we do not, the consequences of so reckless a disregard of the precautions which the experience of centuries has shown to be essential to the avoidance of conditions prejudicial to the public health.

B.

NEW YORK, Jan. 22, 1877.

MARCH 10, 1877.

I WAS much interested in the courteous responses of Col. Waring and Mr. Towne to my letter on the drainage of country houses, published in your issue of Feb. 3, and regret that I could not find time for an immediate reply.

I cannot wholly agree with Col. Waring's views respecting the absorptive and oxidizing power of the soil, without taking certain well-defined exceptions to his very general conclusions. A full discussion of the points at issue must be more appropriate to the columns of an agricultural journal than to one devoted to architecture; but as architecture and drainage are of necessity closely allied, the subject possesses a practical interest for a very large proportion of your readers.

In my judgment, formed after some observation, the adaptation of the soakage system to house drainage depends upon a variety of conditions, primarily upon the character of the soil. If I attach more importance to the action of vegetation than Col. Waring does, he attaches more importance to the powers of the soil and its contained oxygen than I do. In his communications published in your issue of Jan. 27, he speaks of the "concentrated oxygen of aerated earth." I have never found any satisfactory evidence of the fact that oxygen is concentrated in the soil. Oxidation is unquestionably promoted by looseness of the soil; but this same condition favors the escape of gases resulting from the decomposition of organic matter, and those most productive of disease are not, so far as I know, appropriated by vegetation. In assuming that the character of the soil is of secondary importance as concerns the efficiency of the soakage system, Col. Waring seems to contradict himself. Very little air permeates a stiff clay soil, as he practically admits. Heavy clay soils do not in themselves exert a stronger absorptive action than porous soils The absorptive powers of clay are only manifest when it is finely divided, as when burned or intimately commingled with the looser components of a light loam.

The experiment of straining dung-liquor through soil does not prove much, if anything, as regards the subject under consideration. The solid matter is simply removed by the ordinary process of filtration, and under the combined influence of heat, moisture, and air, it would quickly ferment. That "organic matter once seized upon by the soil is never again given up in an unchanged condition," is not, I think, established. I know of one case where carrots planted in ground fertilized with material freshly removed from an old privy-vault, were wholly unfit for food. Washed clean and cut with a knife, they were unhealthy in appearance and offensive in smell. As to the "unyielding grip of the interior surfaces of the soil to prevent added organic matter from working downward," I fear there is some room for doubt. It is certainly difficult to reconcile the proposition with the fact that the roots of plants follow the deposition of organic matter, and, as in the deepened soil of the Mapes' farm in New Jersey, extend to twice the depth usually reached by the roots of such plants in stiff soils, manifestly because the manure had worked down as the depth of the soil was increased.

There is a limit to the absorptive powers of every thing. Even charcoal has its limits, although its powers are to some extent self-renewing. So it is with the soil. When the surface is ice-bound there is little opportunity for aeration. If unfrozen below, it is likely to be sodden from preceding rains, and under such circumstances the destruction of organic matter by oxidation would proceed but slowly.

That sewage can be discharged into the soil continuously, without ultimately polluting it to considerable depth and beyond the reach of the oxidizing influence of the air, I cannot believe. It is no uncommon thing to find deep wells polluted by impurities carried down from the surface. The water of wells sunk near barnyards is often unfit for use, even when the danger of contamination by the flow in of unfiltered surface-water is effectually guarded against. On this point the experiments of Dr. Lissauer, as translated from *Deutsche Vierteljahr schrit* in the Proceedings of the Institution of Civil Engineers, are not without interest. The results of fifty-one experiments to determine the absorptive power of soils point to the following conclusions, among others :—

"1 The liquid entering the pores of the soil displaces the air or liquid previously present, forcing the former up wards into the atmosphere, and the latter downwards into the subsoil or effluent water.

"2. In order that the effluent water may not be directly polluted by the sewage liquid, the maximum supply of the latter must not be more than can be taken up by the pores of the soil.

"3. Dry, loamy soil absorbs more than peaty soil and gives up less, whilst dry sandy soil, on the contrary, absorbs less and gives up more. Consequently a loamy soil, though it absorbs a large quantity of liquid, can seldom be irrigated; whereas a sandy soil, though it absorbs but little, may often be irrigated.

"4. The looser the soil, the easier water-courses are formed in it, and therefore the less can its maximum power of absorption be approached: otherwise the sewage liquid might penetrate the subsoil before the whole of the ground had been saturated.

"5. In order therefore that the effluent water may be protected from pollution, it is especially necessary that the absorptive power of the soil should be known; but the determination is of no value unless it be made in a sample in which the natural position of the particles of earth has been undisturbed."

I have no desire to place myself in a position of antagonism to the system favored and defended by Col. Waring in his several communications. I consider it good, but like all good things it probably has its limitations. It rests with the engineer and the architect to intelligently determine what these are.

In Mr. Towne's letter, I find some statements which indicate that he has reasoned from imperfect data. The consumption of water in cities is certainly no standard by which to judge the consumption per head in country houses depending upon wells and cisterns; and I refer him to Col. Waring's last letter for an estimate, which, though very liberal is more nearly correct. As regards cesspool capacity, it must, of course, depend somewhat upon circumstances. A nine-hundred-gallon capacity is by no means an arbitrary standard. Speaking generally, it is safe to say that the smaller the cesspool the better, inasmuch as it requires to be emptied the oftener. The conservation of filth under conditions favorable to the exercise of its power for mischief is never desirable. Eternal vigilance is the price of good health; and I have yet to see a drainage system applicable to isolated country houses which can be left to take care of itself without sooner or later becoming a nuisance and a danger. I should never drain roofs or carry storm-water from any shedding surface into a cesspool which also received the house-waste; and the danger of overflow from this cause need not be taken into account.

B.

MARCH 24, 1877.

MR. BAYLES intimates that the reasoning contained in my last communication was predicated on "imperfect data," for the reason that "the consumption of water in cities is certainly no standard by which to judge the consumption per head in country houses depending upon wells and cisterns;" and he refers to Col. Waring's estimate as more nearly correct. My statement gave an average consumption per head per day of thirty-eight gallons; while Col. Waring's (in referring to a case in which "there is no public water-supply") was thirty gallons. But by reference to my letter of Dec. 16, 1876 with which this discussion commenced, Mr. Bayles will learn that the question therein proposed was that of "the disposition of sewage from a country house, where there is no town drainage available, where the surrounding grounds are level, and *where there is a street water-supply.*" On these data I maintain that my reasoning was correct; and, indeed, my own observation is to the effect that where there is an abundant water service, the average consumption per head is usually much more than thirty-eight gallons daily.

The problem I originally suggested is one of great importance; but I think it has been somewhat lost sight of in some of the recent communications. In my own limited experience I know of four towns, the populations of which range from 3,000 to 10,000, in which a public water-supply has been introduced for years without any corresponding provision for the removal of sewage. Indeed, even the city of New Haven, which has long had a water-supply, was only efficiently sewered within the past eight years.

Without discussion I will concede that these conditions are intolerable, that a sewerage system should be contemporaneous with a water service, and that the introduction of the latter should in many instances be legally prohibited unless accompanied by the former; but this does not alter the fact that in hundreds of places, precisely these most objectionable conditions obtain, and probably will obtain for years to come. The question I have asked is, How, under these conditions, *and at moderate cost*, can the average house-holder make himself most secure against zymotic diseases originating from decomposing sewage?

Mr. Bayles adds other pertinent objections to those I have previously made against the irrigation system urged by Col. Waring as so universally applicable; and I think it must be conceded that this system cannot be extensively relied upon *for use on private grounds* of small extent, particularly in our Northern States. At the risk of appearing too confident in my own judgment, as opposed to that of persons who have made a much more thorough study of this subject than I have been able to, I will say further, that the alternative system to which Mr. Bayles has committed himself—viz., the use of tight cesspools—seems to be equally inadmissible, for the reasons stated in my letter published in your number of 17th ult.

This is eminently a case in which it is easier to make objections than to give advice; but the subject is one, the importance of which, although but little recognized, cannot be over-estimated; and I sincerely trust that its discussion in your columns may lead to a better solution of it than has yet been offered.

T.

APRIL 14, 1877.

I TRUST that your readers are not tiring of this discussion, for—unlike Mr. Bayles—I think it quite as appropriate, even in its agricultural details, to an architect's as to a farmer's paper. The question as to the action of the soil, and of the air which it contains, upon organic impurities added to it, is equally important whether we are considering the effect of this action in preparing food for plants, or in removing conditions dangerous to health. It has its sanitary side, and so claims the attention of the architect—the practical sanitarian.

It is to be understood that what I propose is not a "soakage" system, but something that stops so far short of saturation that in an extreme case, as per my communication, only about one volume of liquid is added, per day, to over three hundred volumes of earth. The importance attaching to the soil as an agent of disinfection is due to its known powers of absorption and to the oxidizing effect of its contained air. "Satisfactory evidence of the fact that oxygen is concentrated in the soil" is to be found in the recorded testimony of many investigators in the field of agricultural physics.

Prof. Johnson, of New Haven, says:* "The soil, being eminently porous, condenses oxygen. Blumtritt and Reichardt indeed, found no considerable amount of condensed oxygen in most of the soils and substances they examined; but the experiments of Stenhouse and the well-known deodorizing effects of the soil upon fæcal matters leave no doubt as to the fact. The condensed oxygen must usually expend itself in chemical action. Its proportion would appear

* How Crops Feed, p. 218.

not to be large; but being replaced as rapidly as it enters into combination, the total quantity absorbed may be considerable. Organic matters and lower oxides are thereby oxidized. Carbon is converted into carbonic acid, hydrogen into water, protoxide of iron into peroxide. The upper portions of the soil are constantly suffering change by the action of free oxygen, *so long as any oxidizable matters exist in them.*"

Schubler says:* "The earths possess the remarkable property of absorbing oxygen gas from the atmospheric air, a phenomenon pointed out many years ago, by A. von Humboldt . . . . This property of the earths is confirmed almost without an exception, provided they be employed for this purpose in a moist state." In the experiments which he instituted, exposing one thousand grains of different earths for thirty days in vessels of fifteen inches cubic contents (15 inches of air containing 3.15 inches of oxygen) he found that sandy loam

* Journal Royal Agricultural Society, vol. i., p. 197.

absorbed 1.39 inches of oxygen, clay loam absorbed 1.65 inches and garden mould absorbed 2.60 inches.

This looks very much like concentration. All authorities agree in ascribing this power of condensing oxygen (and other gases) to all materials very much in proportion to their porosity. As charcoal is very porous, this is usually taken as an illustration. Voelcker says:* "It [charcoal] possesses the power, not only of absorbing certain smelling gases, sulphuretted hydrogen and ammonia, but also of destroying the gases thus absorbed; for otherwise its purifying action would soon be greatly impaired. It is very porous, and its pores are filled with *condensed* oxygen to the extent of eight times its bulk.

"We have, therefore, in charcoal oxygen gas (which supports combustion or lights fires) in a condensed or more active condition than in the common air which we breathe. Hence it is that organic matter in contact with charcoal is so rapidly destroyed. The beauty of

* Latham's Sanitary Engineering, p. 236.

charcoal is that the destruction takes place imperceptibly, and that its power of burning organic matter is continually renewed by the surrounding atmosphere so that it is a constant carrier of atmospheric oxygen in a condensed state in its pores. The oxygen that acts on organic matter and burns it up is speedily replaced, and the process goes on continually. Hence it is that a comparatively small quantity of wood or peat charcoal is capable of destroying a very large quantity of organic matter."

Johnson, after describing and illustrating this action of porous substances, says :* "The soil absorbs putrid and other disagreeable effluvia, and undoubtedly oxidizes them like charcoal, though perhaps with less energy than the last-named substance, as would be anticipated from its inferior porosity." Jamieson says,† "All porous bodies which offer a considerable surface to gases act like charcoal." Saussure says that charcoal absorbs nine and a quarter times its

* How Crops Feed, pp. 170, 171.

† Journal Royal Agricultural S'y, vol. xvii., p. 448.

bulk of oxygen. Prof. Way says:* "The reason that the sand accelerates the fermentation of the urine is no doubt this: all bodies possess a surface attraction for gases, and of course therefore for common air. This attraction, *which enables them to condense a certain quantity of air on their surfaces*, is in direct relation to those surfaces." Way filtered sewer-water through six inches of soil. In two and a half hours he collected half a gallon, which he analyzed. It contained no potash, "no ammonia or nitrogen in any form." The original liquid contained over three hundred grains to the gallon of "organic matter and salts of ammonia." He found the *absorption* to extend to a weight of sewage-water *more than equal to the weight of the soil.* This, be it remembered, was an instantaneous mixture, with no opportunity for a constantly renewed oxidixing action.

That the soil absorbs the products of the decomposition of organic matter,

* Journal Royal Agricultural Society, vol. xi., p. 366 *et infra.*

and carries the decomposition to completeness, no chemist would question. This action is the basis of the efficiency of the earth-closet. In my own experiment, an analysis of the earth and ashes used in earth-closets for six years (probably ten times over) showed that practically all of the eight hundred pounds of solid dry matter estimated to have been deposited during the six years was destroyed by oxidation as completely as it would have been by actual burning in a furnace.

The investigations of Way and Thompson fully determine the *retention* of impurities by the soil—an action which they ascribe largely to the double silicates.

The porous condition of the soil does *not* favor the escape of gases. On the contrary, in the case of the earth-closet, dry and porous earth completely arrests the escape of gases, as is demonstrated both by the absence of smell, and by the absence of chemical reaction. If the quantity of decomposing matter is large and concentrated, gas may be formed in such volume as to force its way through, but *exhalation* does not occur. It is not claimed that the gases which are most productive of disease are appropriated by vegetation, but that they are destroyed by chemical action—by oxidation.

The report of Dr. Mouat, on the effect of the use of the earth-closet in the government institutions of India in time of cholera, is conclusive, at least so far as this disease is concerned.* All recorded evidence as to the use of the earth-closet in stopping the spread of disease is to the same effect.

I believe that I only "seem" to contradict myself. Loose soils are more freely permeated by atmospheric air and heavy clays are more retentive of organic impurities presented in solution. The air in the loose soil oxidizes, and the double silicates in the clay have other chemical action. There is air in all soils sufficient to care for the small amount of impurities discharged by a single house-

* Twelfth Report of the Medical Officer of the Privy Council, pp. 104, 105.

hold throughout the mass, underlying twenty-five hundred feet of surface; and there is clay enough to have an important effect even in what is called sandy loam.

The absorptive powers of clay are manifest to chemical tests even when solid lumps of it are penetrated by solutions of nitrogenous matter. I think my statement, that "organic matter once seized upon by the soil is never again given up in an unchanged condition," is the statement of an established fact—with the limitation that after the soil is *saturated*, it cannot "seize upon" new supplies until the first supply has become chemically changed. On the Mapes' Farm in New Jersey—where, by the way, I was a pupil in 1853—the manure was *ploughed* down, and the deposition of organic matter in the subsoil was mainly due to the decomposition of the roots of crops, which (like clover) have the power of deep penetration. In the clay subsoil of the richest and oldest garden, we find no evidence that organic matter has ever "worked down" into it; on the contrary, we know that, as "organic" matter, it does not do so even in nearly pure sand or gravel.

Of course "there is a limit to the absorptive powers of everything"—a limit to everything, in fact,—but that limit in the soil is, in my opinion very far beyond the needs of the case in hand. So, too, the "some extent" of the renewal of absorptive power is more than enough for the purpose. I believe that wells are polluted by filth flowing through porous strata and rock-fissures, not by filth that has once been fairly *absorbed* by the soil.

The quotation from Lissauer applies to *excessive flooding*, not to the limited discharge of sub-irrigation drains. Paragraph (1) seems not opposed to my theory; (2) applies obviously to much greater flooding than is contemplated, as the effluent water at Merthyr Tydvil (less than one-tenth as much land—loose and gravelly at that—as I have recommended being used per head) remains pure after the filter-bed has been used for several years. (3) All soils can be irrigated (with sewage?), but heavy soils may not be so profitably irrigated because they part with their water so largely by evaporation, and thus lose heat. (4) We do not propose to tax the one-hundredth part of the "maximum power of absorption." (5) The limitation of our volume makes this inapplicable to the discussion. Of course the system of sub-irrigation has its limitations, but it is a vast step ahead of any cesspool system.

If the experience of the world is of any value, it is proven that the tight cesspool, which Mr. Bayles advocates, conserves filth under the conditions which are the *most* "favorable to the exercise of its power for mischief." Even eternal vigilance will not stop the putrefaction of its contents. With some experience and observation in such matters, I do not hesitate to express the opinion that the sub-irrigation system may be more nearly left to itself than any other I know about.

I can only answer Mr. Towne's question by repeating the opinion before given— that the sub-irrigation system is much the simplest, the safest, and the best; and that its cost is really trifling, even where the water from the kitchen sink, and laundry trays in the cellar, has to be lifted with a pump to the level of the drains. He accepts, apparently, without question, the wrongly based objections of Mr. Bayles, and says, "I think it must be conceded that this system cannot be extensively relied on *for use on private grounds*, of small extent, particularly in our Northern States." To offset this, I can point to instances of success on such grounds in such localities, especially to my own, which has worked *perfectly*, winter and summer, for seven years. I have never heard of a case of failure. These examples, supported by the arguments given above, must sustain the claims of the sub-irrigation disposal of liquid house wastes, or those claims cannot be sustained by my advocacy.

Since writing the above I have found in an editorial of the *Agricultural Gazette* (London), of March 19, the following:

"The astonishing power of an aerated and porous soil and sub-soil (our knowledge of which we owe to Dr. Frankland) may be trusted a great deal more than engineers appear to trust it. Mr. Norman Bazalgette labored hard the other evening to prove that Merthyr filter-beds had done nothing like the work which Dr. Frankland had declared them capable of doing. But the answer to his criticism, which was given in the subsequent discussion, seemed to us complete; and as upon it rests the safety of the cheaper method which in the agricultural interest we recommend, we reproduce it here.

"At the close of his clear and conclusive argument on this subject, Dr. Frankland put the matter thus: 'I have analyzed the effluent water from the Merthyr filter-beds when only 230 people radined on to them per acre, and again when 500, and when 1,250 people were draining on to them per acre; and, deducting and discounting the dilution by the subsoil water, in the first case it was thirty times as clean and as pure as it needed to be; in the second cases it was purified seventeen times more than enough; and in the last case, it was still three or four times purer than was necessary. Is it unreasonable, then, to believe that those filter-beds could have cleansed sufficiently or even more than enough the sewage of three or four times as many as the greatest of these numbers, if only the work had been given them to do?'

"Now we contend that the work was given them to do, and that they did it." Then follows an explanation of the irregular distribution of the sewage over different parts of the ground, showing that although each area of about one acre received its due proportion of sewage, "the quarter of the plat which was next to the carrier had its full work to do from the first and till the last of its six hours' period; but it often was not till two or three hours had elapsed, that the quarter farthest from the feeder was even fairly wetted. And thus it was that while it may be true enough, that it was only the sewage of 20,000 people that was dealt with by the twenty acres of filter-bed at Troedyrhiew—being at the rate of 1,000 people per acre—yet at least one-half, probably much more than one-half, of that beautifully purified effluent water must have come from areas of the filter-bed, which were being watered at the rate of 2,000, 3,000, or 4,000 people per acre."

My recommendation for the use of soil for the purification of household sewage was based on a calculation of only 175 people per acre. It is proper to explain that when Dr. Frankland says, that the water was made "thirty times as clean and pure as it needed to be," he means thirty times purer than the Rivers' Pollution Commissioners' standard of fair potable water.

W.

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