CHAPTER IV.

FLUSHING AND VENTILATION.


It is seen from Table No. 13 that if at any time the flow in a circular sewer becomes less in volume than \( \frac{1}{10} \) of the full capacity of the sewer the depth becomes less than \( \frac{1}{2} \) the diameter and the velocity less than \( \frac{2}{3} \) that for a full sewer. If the sewer is small the first condition is apt to cause deposits by the stranding of floating matter on the edges or even in the centre of the stream; if the grade is near the minimum the velocity becomes less than is desirable and deposits result from this cause. But a 6-inch or 8-inch pipe is usually the minimum size employed and is carried up to the last house-connection, from which a quantity of sewage very much less than \( \frac{1}{10} \) of the full sewer capacity is received. In fact there will be in a residence district a stretch of at least 400 feet of 6-inch or 700 feet of 8-inch sewer, even at the flattest allowable grade, which would be filled less than \( \frac{1}{100} \) of its capacity by a rate of 175 gallons per capita, and consequently where deposits are probable. The discharge from any individual house comes usually not in a continuous flow, however, but in spurts of relatively large quantities separated by considerable intervals of time. If we watch such intermittent discharge we will find that when the sewage enters an empty sewer from the house-connection it flows both down the grade and also up it for a short distance. The latter portion
at the end of the discharge also flows down grade, but it has probably carried with it and left at the upper limit of its flow matter which remains there to putresce and perhaps form the beginning of an obstruction. Beginning in the sewer at practically nothing (since most of the initial velocity is destroyed by foaming), the velocity of such discharge continually increases, and the depth decreases, with the distance from the point of entry. This frequently causes the stranding below the house-connection of large floating matter which is introduced from such connection, and although successive discharges may move this matter, each one a little further down the sewer, a long cessation of them may give it an opportunity to become fixed in its position. Discharges from connections higher up the grade will tend to prevent these deposits, two or more discharges occasionally coming simultaneously and uniting their volume; and generally the further any connection is from the upper or dead end of a branch the less the danger of its causing such deposits. In a thickly settled district this danger in the case of 6- or 8-inch pipe becomes very small at a point to which there is tributary 1000 to 1500 feet of sewer. If the district is sparsely settled, however, the danger may exist for many times this length.

Any house-sewer, but particularly a lateral, is liable to partial stoppage at times, due to ashes, sand, or other material introduced through house-connections, manholes, or infiltrating through the joints or other defective places. Unless the velocity of flow is sufficient to carry this matter along it will form deposits in the sewer-invert which must be in some way removed.

There is another class of deposits, composed of mycelial matter, which forms in most house-sewers. This contracts the area of cross-section and may become the breeding-place of micro-organisms; but emits little odor and is readily detached and carried away by a strong flush of water.
To prevent these deposits the only practicable way known is to keep all sewers constantly flowing with a depth at least $\frac{1}{2}$ the radius of the invert, water being introduced for this purpose if necessary, and also to maintain a velocity of at least $1\frac{1}{2}$ feet per second. To remove them the methods employed are either to occasionally turn through the sewer streams of water of sufficient quantity and velocity to dislodge and remove the deposits, or to employ shovels, hoes, "pills," scrapers, or similar appliances to be described in Chapter XV.

The method of prevention, if applied near a dead end, where the sewage flow is minimum in quantity, even in the case of a sewer laid at minimum grade, would require about 47,000 gallons per day for each line of 6-inch pipe and 83,000 gallons for each 8-inch line. These quantities it will usually be impracticable to supply; and were it practicable the addition to the sewage of this amount in each of several branches would compel a large increase in the size of the sewer-mains, and greatly increase the cost of treatment in case this method of disposal was employed. There will occasionally be instances, however, where a convenient stream of water can be utilized to advantage in this way.

It sometimes happens that an old sewer-main or other large drainage-channel is at so flat a grade as to be, in part at least, a sewer of deposit. Flushing can be used to advantage in such a case to stir up and remove the matter deposited. A notable instance of this may be found at Milwaukee, Wis., where 40,000 gallons of lake-water per minute are pumped into the Milwaukee River (the flow of which is largely sewage) for flushing it.

In general a sewer in which there is a continuous flow with a depth of at least $\frac{1}{2}$ the radius of the invert and a velocity exceeding 2 feet will need but infrequent cleaning if legitimate sewage only be admitted. If for any reason or at
any time these conditions be not fulfilled artificial cleaning will probably need to be resorted to.

ART. 21. METHODS OF FLUSHING.

As stated, there are two general methods of cleaning sewers: flushing, and by the use of some kind of scraper or similar tool. The latter usually calls for no special provisions in the construction and will be treated of in Part III. Flushing, however, is frequently accomplished by appliances built into the system, and the principles involved are other than those controlling hand labor; it is therefore necessary to consider it in designing. Flushing may be done by hand, by automatic appliances, or by use of rain-water.

By the first the sewer can be flushed from any manhole, as well as from flush-tanks; by the second from fixed points only, usually the heads of laterals; by the third the flushing-water enters from roofs through all or many house-connections, or in some instances the inlets are so constructed as to store the rain-water from the street-surfaces or from water-courses and flush with periodic discharges of the same.

The secret of successful flushing lies in compelling a large mass of water to move at considerable speed down the sewer. If the sewer be less than 24 inches or 30 inches in diameter water should as far as possible completely fill it, that deposits may be removed from its entire circumference and also that the effect of the flush may be felt far down the sewer. With the sewer flowing full bore at the upper end the depth of the water will decrease as the flushing-wave progresses down the sewer, until at some point below, at a distance varying with the size and grade of the sewer, with the head of water at the upper end and the volume of sewage flowing, the depth and velocity of the sewage will be but little affected by the flush.

The initial velocity will depend upon the head and upon
the facility offered the water for entering the sewer. There should be a free and open orifice at the entrance end, and if possible the angle between the inside of the sewer and that of the manhole or flush-tank should be rounded. Speed is of as much value in flushing as quantity, and with a given amount of flushing-water the more quickly it can be made to pass through the sewer the better. In most cases little if any benefit would result should a faucet be left continuously running in each house in a city, but \( \frac{1}{4} \) of the same amount of water used in a proper way would be of great benefit to the system.

Although for creating velocity the head in the flush-tank should generally be as great as possible, it must be limited by the amount of internal pressure which the sewer can stand without rupture. A few years ago a brick sewer in Washington, D. C., was, on account of insufficient size, put under such a head of water by the run-off from a cloudburst that its upper half was completely severed from the lower and the sewer destroyed, and a similar result might follow from too great pressure of flushing-water. With a pipe sewer this danger is not so great. A head of 6 or 8 feet at the manhole or flush-tank—which is more than can usually be obtained—should not endanger a pipe sewer. Brick sewers as ordinarily constructed should not be filled to a point more than 5 feet above the invert or, for those more than 5 feet in diameter, higher than the crown. In no case should the water be backed up a sewer-line to such a height as would flood any connected cellars.

The flushing-water should move down and not up the sewer, since the effect of the latter would probably be to sweep the intermediate deposits nearly to the upper limit of the wave and leave them there to dam the flow. The interval which should elapse between flushings will vary under different conditions. In sewers where there is a constant
ample flow of water, where stoppages are few and due solely to accident or design of ignorant or malicious persons, flushing need be resorted to only when such stoppages occur. If it is found from experience that stoppages are frequent or that there is a constant depositing of material in the sewers, or if it is foreseen that this will occur from causes mentioned in the previous article, frequent flushings should be provided for.

In the case of a dead end of a house or combined sewer, or one which has but few house-connections made with it, the flushing should be done once in each 24 or at least 48 hours.

Both separate and combined systems have been built and satisfactorily maintained without flushing at any point oftener than two or three times a year. It is probable that this is possible only where there is considerable ground-water entering the sewers at their upper ends, or where the dead ends occur only in thickly populated districts and on grades a little greater than the minimum herein advocated. There is too little definite information on this subject to justify a positive statement as to when, if ever, flushing at dead ends may be profitably omitted. It is advisable so to arrange every house or combined sewer, where the conditions will be those given as favoring deposits, that it can be satisfactorily flushed.

A few experiments have been made on the actual effect of flushing-water in a sewer, chiefly with reference to the velocity and depth of the flushing-water at different distances from the point of entering. Andrew Rosewater found by experiment with a 400-gallon tank at the head of an 8-inch line of sewer discharging 11 gallons per second that at the first manhole, 200 feet below the flush-tank, the water was 6 inches deep and had a velocity of 3.6 feet per second; 200 feet further the depth was 5 inches, velocity 2.8 feet; and 400 feet further the depth was 4 inches, velocity 2 feet—showing the flushing effect to be practically exhausted in 800 feet. Mr. Ogden, in experiments made in Ithaca, N. Y.,
in 1897, found that with discharges from flush-tanks through 8-inch pipes of from .89 to 1.1 cubic feet per second the flow was reduced to 2 inches at 1123 feet from the flush-tank in two cases where the grades varied from .52% to 1.31%, at about 1000 feet in another where the grades varied from 1.02% to 3.14%, and in another where the grades varied from .80% to .89% the depth was 4 inches at 895 feet from the flush-tank. In the first two the sewer was scourcd clean for 529 feet and some effect felt at 819 feet; in the third the sewer was cleaned for 356 feet and the effect slight at 970 feet; in the last the pipe was "disturbed, but not cleaned," at 636 feet, until 600 gallons were discharged, when it was cleaned for more than 636 feet, but less than 900 feet. The other discharges referred to were of 300 gallons each. An interesting series of experiments were conducted and their results plotted by S. H. Adams in England. These appeared to show, as do the above, that 300 gallons is in some cases insufficient to properly flush an 8-inch pipe; also that the effect of such a quantity is felt for about 800 to 1000 feet.*

In flushing by hand the sewer is usually stopped at the down-grade side of a manhole or flush-tank, this is filled to a desired height with water or by allowing the sewage to accumulate in and above it, the gate, plug, or other stopper is removed and the water allowed to enter the sewer under the head due to its height. Where outside water is used for flushing and is limited in quantity another stopper should be placed at the upper orifice in manholes, to prevent a flow up the sewer, and left in until the flushing is over. The stoppers are made of various forms and to act in various ways, and to close the whole or only the lower half or two thirds of the sewer. The water is obtained from different sources and introduced by different methods, a further discussion of which will be given in Part III.

In England the separate system, when first constructed,

* See also Transactions Am. Soc. C. E., vol. xl, pp. 1-30.
was designed to admit to the house-sewers roof-water and drainage from yards, and this method is still followed there to a considerable extent. In the United States the majority of separate systems are not supposed to receive this water. It is argued by advocates of the former practice that the householder should not be required to construct two connections, one for house-sewage and one for rain-water. But the last can be conveniently discharged into the gutter, except in the case of buildings covering a large area, when the cost of the extra drain would be relatively inappreciable.

Another argument for the admission of roof-water is that it is beneficial in flushing the sewer. If it is admitted only at and near the dead ends it will usually be advantageous, but it should not be thought to take the place of all other flushing. The sewers are most likely to need flushing at dry seasons, and this must then be done by hand or otherwise. There is a danger that the presence of these roof-connections will give a false idea that the flushing requirements have been entirely met.

If roof-water is admitted to small sewers throughout their length there is great probability of its gorging the pipes and backing up into connected basements and cellars. In Mount Vernon, N. Y., in 1892 great damage was caused in this way and all roof-drains were at once disconnected; and many similar instances might be cited.

Since the danger is so imminent and the benefits contributed at such uncertain intervals, most American engineers do not advise the admission of roof-water to small sewers.

Sewers are sometimes flushed by connecting their upper ends with convenient streams, or artificial channels filled from such streams, the water being admitted periodically by gates: as at Bern, Wurzburg, Innsbruck, Freiburg, Breslau, Munich, and other cities of Europe; also at Newton, Mass.

Reservoirs fed by streams or springs are used in Munich,
Cologne, Wiesbaden, Frankfurt, Stuttgart, and other cities. At the first-mentioned place large underground reservoirs, one of which is 6 feet 6 inches by 4 feet 7 inches and extends along two blocks, are filled from the Isar River.

Tides are sometimes made use of for this purpose, the water being allowed to rise in the sewer at high tide and being held there by gates until the low tide, when it is released. Ordinarily only the lower reach of the outlet sewer can be thus flushed. A better method in some cases is to hold the water after high tide in a basin from which it is rapidly discharged at low tide into the sewers to be flushed.

As in the case of Milwaukee, already cited, and of Bremen, the flushing-water may be pumped from a lake or river directly to the sewer. This is of course applicable within the limits of economy to very large sewers only, or to a system where a number of dead ends can be reached by a comparatively short line of water pipe.

The water for flushing is sometimes taken from the ocean or other body of salt water; but the salts are thought to decompose the sewage, giving rise to gases and deposits of matter rendered insoluble, and are corroding to any metal-work in the sewers. Hence its use is not advised by most authorities.

**Art. 22. Appliances for Flushing.**

Automatic flush-tanks are in use in a large number of separate systems, but are seldom used for flushing combined or storm-water sewers, owing to the enormous quantities of water needed for that purpose. There have been a great number of devices invented for flushing. Most of those at present used in any considerable numbers are siphons in principle, so arranged that a tank in which they are set may fill gradually up to a certain point, when its contents are dis-
charged rapidly into the sewer. The tanks are made to contain at the time of discharge from 150 to 600 or even 1200 gallons for 6- to 10-inch pipe sewers. For larger sewers larger quantities are provided. The smaller quantities are of little use. No tank should discharge less than 250 gallons at a time into a 6-inch pipe, and correspondingly larger amounts into larger sewers. 500 to 800 gallons discharged into an 8-inch pipe once in 24 hours would be more beneficial than half of that amount at each of three or four discharges during the same time. The tanks should, of course, be water-tight. They are usually built of brick plastered on both the inside and the out, or of concrete with steel rods. Wood or iron could be used, but would not be so durable. They should be so built and arranged that the water may have the greatest permissible head above the sewer when discharging. (For details see Art. 42.)

The water may be conveniently admitted to the tank through a half-inch or smaller stop-cock connected with the street-main by a supply-pipe passing through the tank-wall. This cock is continually left sufficiently open to cause the tank to fill and discharge at desired intervals. If the water is inclined to be muddy at times the use of too large a supply-pipe will result in the choking of it by sedimentation. It should be of such a size that the quantity to be used in the tank will pass through it with a velocity of 2 feet per second or more. Instead of a cock, a small orifice plate is sometimes placed at the end of the pipe, the size of orifice determining the flow.

The discharge-pipe of the tank should be at least as large as the sewer. It would be better to have it a size or two larger and bell-mouthed at the end.

The automatic flushing appliances most in use in the United States are further referred to in Chapter VIII. They
are, most of them, covered by patent, and the prices range upward from about $12 for a tank to discharge 150 gallons through a 5-inch pipe.

Where automatic flush-tanks are not used some engineers have built into manholes at dead ends 2-inch to 4-inch pipes connected with adjacent water-mains and provided with gate-valves, as at Mount Vernon, N. Y., and Newton, Mass. This is probably the most convenient method of hand-flushing and the cheapest to operate. The cost at Mount Vernon was about $40 for each 4-inch branch and connection.

There are numerous methods of flushing by hose, by water-tanks, etc., many of which are described in Part III.

In flushing by rain-water no special appliances are ordinarily used, the roofs and sometimes the yards being connected in the ordinary way with the sewer.

Special methods involving pumping, some instances of which have been referred to, need no description, since the details will vary with each case.


In every sewer there is a space above the sewage filled with air, and this air, it is evident, will generally be far from pure unless kept in motion and frequently renewed. The odor accompanying all sewage, even when there is no decomposition proceeding in the sewer, is communicated to this air, and there will frequently be given off some gases due to putrefaction. This air probably is seldom motionless. It is influenced by the sewage to move down the sewer; it is warmer in winter and sometimes in summer than the outside air, which condition occasions motion when there is communication between the two; it is driven out of or along the sewer by sudden inflows of sewage from house-connections or branches
and sucked in by decrease in the volume of flow; near the outlet the direction and force of the wind affect it, driving it up the sewer or sucking it out; last, and most important, it passes into empty or partly empty house-connections and into proximity to, if not into the air of, connected residences. Herein lies the danger. There is no "sewer-gas" which is deadly to human life, but it is known that air which has been confined in contact with decomposing sewage is charged with "an ever-varying mixture of gases; and of those that are deleterious the more prominent are sulphuretted hydrogen, sulphide of ammonium, and caburetted hydrogen; while ammonia, carbonic acid, and occasionally carbonic oxide derived from leakage of illuminating-gas into sewers are present in more or less large proportions." (W. P. Gerhard, "Sanitary House Inspection.")

The least that can be said of these is that they lessen the vitality and prepare the way for easy conquest by diseases that might otherwise obtain no hold upon the system; they should therefore be excluded from all occupied buildings. The danger due to impure air in dwellings has led the New York Board of Health to conclude that "40% of all deaths are caused by breathing impure air." Playfair asserts that in modern hygiene "nothing is more conclusively shown than the fact that vitiated atmospheres are the most fruitful sources of disease." Death rates have been "reduced in children's hospitals from 50% to 5% by improved ventilation."

While the vitiation referred to in these quotations is not that of sewer-air exclusively, this is included among the causes of it and produces the same effect. Unfortunately the most numerous and fruitful sources of the gases are found, not in the sewer, but in the house-connections or soil-pipes, and consequently not directly under the control of the authorities. The methods necessary to prevent danger from
these sources will be considered under the head of House-connections (Art. 82).

ART. 24. METHODS OF VENTILATION.

It is evident that the danger from sewer-air may be avoided, or at least lessened, in two ways: by preventing the creation of gases, and by preventing the sewer-air from reaching human beings in dangerous quantities or under dangerous conditions. No method has yet been found for perfectly accomplishing either of these aims in practice, but both may be partially attained.

Aside from illuminating-gas most of the objectionable gases are given off by putrefaction, and the prevention of this in the sewers is therefore most necessary. This is best accomplished by the removal of all sewage to the outlet before putrefaction can begin; and here is seen the advantage of daily flushing, cleaning the upper laterals of deposits before they reach this dangerous stage. The use of disinfectants in sewage for this purpose is seldom advisable, both on account of the enormous cost and practical difficulties of applying them and because the various and changing characters of sewage in different cities and from hour to hour may introduce such matter as will combine with any given disinfectant to produce deposits and gases fully as injurious as those due to sewage alone. The presence of objectionable germs in sewer-air is probably occasioned partly by putrefaction and the resulting formation of gases, the germs being thrown into the air by bursting gas bubbles; although splashing is probably the more common cause of this.

To prevent air from the sewer from entering houses two general methods are in use: placing barriers in the house-connection or plumbing, and removing the sewer-air through other outlets. The former is one of the aims of the plumber and is usually attempted by the use
of traps. The latter is effected by natural ventilation by the use of many ventilating devices, in few or none of which has positive action been successfully obtained. A combination of these two methods gives reasonably good results in most cases, a partial obstruction to the air being placed in the house-connection or its branches in the shape of water-sealed traps, and the power of the air to force its way through these being lessened by ventilation.

If the sewer were a tight conduit with no inlets or outlets except through the house-connections and the main outlet the sewer-air must remain constantly unchanged and stagnant, or must find exit and entrance through these house-connections. The first condition is impossible, for the amount of sewage varies from hour to hour and must displace and in turn be displaced by air driven to and derived from some outside source. In case of a sudden discharge of sewage into such a sewer the air will be driven through the only outlets—the house-connections—unsealing the main traps, and the secondary ones also unless these be amply vented. A strong wind blowing up the sewer from the outlet may produce the same result. In addition to ventilating the sewer it is therefore advisable to insure a continuously free air outlet to every soil pipe.

Attempts have been made to constantly remove the air from sewers by either sucking out the foul air or forcing in fresh; that is, by producing a current through the sewer to a given outlet by either the vacuum or plenum process. Both have proved failures as well as very expensive. In no experimental case has the effect been felt more than 1000 feet from the fans or other apparatus, not only on account of the great amount of air in the sewer-main and laterals to be moved, but because the traps in the house-connections were unsealed by the pressure and air sucked from or forced into the buildings, according to the system employed.

The Metropolitan Board of Works, London, concluded,
after exhaustive study of the question, "that the method of ventilation adopted in mines, where there are only two openings to be dealt with (an inlet for the air at one end and an outlet for it at the other), is inapplicable to sewers." This characteristic of a sewerage system renders impracticable all methods of ventilation depending upon one or two ventilators to each line of sewers: such as connecting the sewer-end with a chimney, which would afford little more ventilation than an untrapped soil-pipe at the same point or a special ventilating-manhole.

Many expedients for ventilation have been devised and tried—among them connecting the sewers to street-lamps, where a suction is caused and the gas burned by a constant flame; placing in the crown of brick sewers small perforated pipes connected with "uptake-shafts," expected to cause a continuous removal of the gases; leading pipes from the sewer to special flues constructed in houses, within the body of the walls, adjacent to the chimney, or upon the outside of the house and running up above all windows; leaving the main house-drains untrapped and extending them above the roofs; placing flap-doors in the sewers, opening downward for the sewage, but closed to air, which can escape through openings just above such flaps; placing in the street centre at intervals along the sewer manholes or other ventilating-shafts with perforated covers; connecting the sewers by untrapped pipes with street-inlets at the curb line. In connection with these, charcoal and other deodorizers are sometimes placed at the air-outlets.

There seems to be evidence in favor of the conclusion that the greatest danger exists in the house-connections themselves and not in the sewers, although the latter should be prevented from contributing to this danger. Of many analyses of sewer-air made not one to the author's knowledge has shown a
greater impurity than that in a crowded city street, whether CO₂, oxygen, or bacteria be taken as the basis of comparison. Equally positive proof goes to show that the average house-connection or the adjacent soil near open joints in the same does give rise to dangerous gases. (It is probable that the upper ends of branch sewers, if not flushed well and often, are open to the same charge.) However, a rush of comparatively pure air from the sewer forced through the traps of a foul house-connection is as objectionable as though it itself were polluted, since it forces into the building the impure air existing in such connection. Air outlets to house plumbing should hence be of such capacity and so placed as to give full and immediate passage to all the air necessary to prevent forcing or siphoning of traps.

This fact, that the house-connections themselves are fully as foul as, if not more so than, the sewers should be more generally recognized and better provision made for ventilating them. This is reasonably well done by placing a vent-shaft just above the main trap, continuing the soil-pipe above the roof and venting each trap throughout the house. But a still better circulation of air is obtained by omitting the main trap altogether and permitting the air from the sewer to pass through the house-connection unobstructed. The danger of this air passing the traps on house-fixtures is no greater than that of the soil-pipe air doing the same, and in the majority of cases the sewer air is the less dangerous. Such construction is also of great assistance in ventilating the sewer. If only an occasional house-connection be left untrapped, however, the odors from this may be objectionable, the sewer air being but little diluted by the infrequent openings. But the author knows of no city which makes this method compulsory in all connections where it is not perfectly satisfactory.
FLUSHING AND VENTILATION.

The use of street-lamps as outlets may sometimes be advantageous, but in this country the cities which have tried it have not found it of much value. The use of hollow electric-light poles was tried in Columbus, O., in 1898, but was not found to be worth adopting. The general use of flap-doors in the sewers presupposes a regular flow of air in a fixed direction through the sewer, which investigation has found does not ordinarily exist; but this use may be advantageous on steep grades, where there is a tendency for the air to rise past intermediate ventilating-points to the highest ones. Ventilation through manholes and other ventilating-shafts most, if not all, engineers recommend, although many do not consider these sufficient.

The use of storm-water inlets for this purpose is much opposed by many, who contend that the sewer-air should not be discharged so near to passers-by upon the sidewalk. In fact this same argument is used by a few against ventilation through manholes in the centre of the street. It is probable that the danger from this cause is very slight, if it exists at all, since it is dependent, not upon the gases, which are enormously diluted upon reaching the outer air, but upon the presence of disease-germs in the exhalations, which has been disproven. Moreover, the average catch-basin, even if just cleaned (as this cleaning is ordinarily done), is more offensive than any rightly designed sewer is at all likely to become; and it is extremely doubtful if, in connection with its odors, any contribution of air from the sewer could be detected. For these reasons it seems to the author desirable to connect the sewer with the street-inlets by ventilating-pipes and to place manholes with perforated heads at intervals. Since the latter are apt to be sealed in winter by ice and snow, and in summer by mud, the additional ventilation through the street-inlets would seem to be advisable, particularly if the sewer be
not ventilated through the house-drains. A small amount of snow will not ordinarily stop the openings in a manhole-cover, owing to the warm air of the sewer, but a heavy storm or frozen mud may easily do so.

Since the proportion of air in a small sewer to the discharge into the same is much less than in the case of a large combined sewer, and consequently the effect of a given discharge is a greater compression of, and pressure transmitted by, the air in the smaller sewer, the sewers of the separate system need ventilation or safety-vents even more than do those of the combined. In case there are storm-water inlets to which ventilation-pipes from house-sewers may be led this method may be adopted; but ventilation through untrapped house-connections is probably more efficient. This extra ventilation is very often—perhaps in the majority of cases—neglected, but such omission is undoubtedly attended with danger.

For house-sewers, ventilating manhole-heads and untrapped house-drains; for combined sewers, these with the addition of untrapped street-inlets; and for storm-sewers, manholes and inlets—these, with flap-doors on steep grades, seem to the author the best methods so far devised for ventilation; and without ventilation any system will almost surely become a nuisance and a danger. The aim should be to secure by whatever method the greatest possible number and freedom of communications between the sewer and the outer air; and there is little doubt but that when this is realized the sewer air becomes so diluted and the organic matter floating in it so oxidized as to render it less dangerous and objectionable than the air of a crowded church or theatre. When this is not true the sewers are probably in great need of cleaning and flushing.