Lecture VII.

The Ventilation and Cleaning of Sewers.

No city in the world has spent so much as London upon this subject. The reports of the Metropolitan Board of Works give a complete history of their experience, from which the following abstract is gathered. The original method of ventilating their sewers was by the "gully gratings" or inlets at the sides of the street. These were efficient so far as ventilation of any kind could help the wretched condition of these old, half-choked receptacles of filth. But, as may readily be imagined, they became sources of great annoyance to foot-passengers, as well as to the adjacent residents, so that while the sewers themselves have recently been made "self-cleansing," these openings near the sidewalks have been trapped as fast as others were made in the centre of the street, by building shafts for that purpose, with perforated covers. During the period of transition, however, from the former filthy condition of their sewers to their present comparatively clean condition, through judicious reconstruction, various complaints arose from certain localities, on account of the bad odors arising from these new vent-holes. This subject has given rise to a prolonged investigation by experts, who experimented during a period of several years upon various devices for alleviating or entirely removing the source of complaint. But the system of frequent vents in the centre of the streets has never yet been abandoned, simply because no other device has yet been found adequate to take their place. We learn from the report of 1865 that the subject of the ventilation of the sewers was referred to a committee who were then experimenting upon the ventilation of the Southern Outfall Sewer by artificial draught, created by furnaces in Woolwich Dockyard. This committee employed Sir J. Bazalgette and other experts, and finally made a report in 1872, giving a review of all the various methods that had hitherto been adopted in the metropolis. They stated that the amount of success attending these various methods "was variable, depending on the local circumstances of each particular case." In short, no one method
was shown to be generally applicable, and most of the expedients tried were found to have an effect that was only palliative, even for the locality where it seemed best adapted to the circumstances there existing.

Among the experiments tried, a large class were with the view of deodorizing and disinfecting the gases which escaped from the street vents. The device which attained the largest measure of success in this direction was that of suspending charcoal, spread upon gratings, one above the other, in the vertical shafts above the sewer, through which the air must pass while moving upward on its way to the open air in the street. So long as this charcoal remained dry and loose, it worked well, and afforded considerable relief in certain localities. Its use was adopted by Liverpool and various other towns, in a similar manner and with similar results. Various patented devices were applied for holding and exposing this charcoal in a manner which should least obstruct the passage of the air, while keeping it free from dirt and water falling from the street, and giving the largest facility for renewal when it became clogged. Such renewals were frequently found necessary in most places, in order to keep the apparatus in efficient condition. This involved considerable cost and trouble for attendance, besides the outlay for the apparatus itself. Moreover, the Board states, in summing up the whole subject, that although the results were sufficiently favorable to warrant the use of charcoal in some of the air-shafts which were sources of annoyance and complaint, it was found that their use was attended with no little inconvenience; for the charcoal obstructed the exit of air through the shafts, thereby causing such an accumulation of bad gases in the sewer as to endanger the safety of the men whom they sent to work in them. "It therefore became necessary that such vents should be cautiously and not generally applied."

Experiments were also made by disinfecting or deodorizing the air from the vents by use of acids and of chlorine gas generated in the shafts by apparatus placed there for the purpose. Although a partial relief was had in some cases, the variable nature of the foul gases to be dealt with prevented this method from being adopted, except in certain limited cases where peculiar circumstances existed; so that such a method could be but very partial in its application, and could never become general.

The plan of ventilating the sewers by air-flues connected with the furnaces and shafts of factories and other buildings was tried in some localities south of the Thames, and the effects was considered benefi-
cial by the residents of the immediate neighborhood. But the good
effects were confined to a small district in each case, and it was
doubted whether any large portion of the noxious gases evolved was
actually consumed by this method, for this reason, viz.—the vacuum
produced by the artificial draught was inevitably supplied by the air
entering the sewer through an immense number of openings in the
close vicinity of the locality where the exhaust draught was applied,
so that the air drawn out from any part of a long sewer near which
a furnace was applied was to a large extent replaced, not, as was
desired, by the offensive gases from distant parts of the sewer, but by
pure air rushing down through the numerous small openings near the
furnace, leaving the more remote places uninfluenced. For this
reason, also, the method used in mines, where there are only two
openings to be dealt with, is inapplicable to sewers. Moreover,
where the chimneys used were not public property, the owners of the
factories or furnaces objected to such connections being made with
their chimney shafts, while in many parts of the city no such factories
existed. In order to provide chimneys and furnaces, especially for such
localities, and maintain them in blast, a very large cost would be in-
curred for a remedy that would at best be confined in its action to a
very small district in each case, for reasons given above.

The plan of ventilating sewers by pipes carried up the outsides of
houses, which we have hitherto discussed and objected to, was also
tried in London to some extent, but was condemned because of the
reasonable objections of the owners of the buildings, and “in conse-
quence of the liability of the gas to descend into the chimneys and
windows of such houses.” The Board tried an experiment in the
east end of Southwark Street, by erecting an ornamental ventilating
shaft, in the centre of the thoroughfare, with refuges and lamps, and
the extension of this system to other localities was discussed. Its
adoption was estimated to cost from £200 to £300 in each case, ac-
cording to the position and depth of the sewer, exclusive of the cost
of maintenance. If this system were to be largely extended, it was
found that the details must be varied to suit the local peculiarities
which must be considered and provided for in each case, which would
involve a separate study for each locality, and prevent the possible
diminution of cost by a repetition of the forms of the appliances to
be used. In short, it was found that every new case must be tenta-
tive in its nature, and therefore not susceptible of having any accu-
rate estimate made of its cost. The only principle settled upon as
capable of a wide and successful application was that of flushing the
sewers with such a copious supply of water that the decomposing substances clinging to their sides or flowing through them should be largely diluted and carried away before sufficient time should be given for the generation of noxious gases in any considerable volume. To accomplish this result, frequent flushing would be needed, during periods of drought; but during periods of rainy weather the natural influx of water might sometimes take the place of flushing, especially in a climate like ours, where rain in the summer months frequently falls in large volumes during a few hours. The Committee of the Metropolitan Board were requested to continue their investigations, treating each case as the local circumstances might indicate. Four years more were spent in experimenting, but with no result, except that the various devices tried were found to give various degrees of success in various localities, as before. In 1876, the committee reported a sort of digest of their conclusions, as expressed above, giving them in a concise form.

CLEANSING OF SEWERS.

The inclination of sewers is generally governed more or less by the topography of the surface; but in flat districts, where the fall is limited by Nature, a sewer must, in order to be self-cleansing, have an inclination that will secure a velocity of at least three feet per second in small pipes, and of two and one-half feet in larger sizes. Where this cannot be obtained without pumping, pumps are often applied, which by lifting the sewage to a sufficient height enable us to conduct it farther from the city, and to a point of discharge which is more eligible than could be found nearer. If the large sewers are not self-cleansing, arrangements must be made for ample flushing at frequent intervals, and perhaps also the removal of sand by hand, which must be taken out through the man-holes. The heavier part of the road detritus is generally intercepted by pockets or catch-basins at the inlets under the curb-stones; but in heavy rains the water does not remain long enough in these pockets to deposit the finer silt, which is therefore very likely to be deposited within the sewers themselves. The modern forms for sewers with small, narrow inverts are much less likely to collect deposits than the older forms or circular sewers; yet the latter are sometimes adopted, as in Chicago, for lack of height below the street level, to develop the oval form. This is admissible for such sewers as are generally half filled, or more, with their ordinary flow, and in that way more likely to be kept clean by scour. In order to favor the velocity of flow, and guard against check-
ing it by all possible means, great care should be taken that all inlets and junctions should be at an oblique angle. Rectangular junctions are always found to produce eddies and favor deposit, whether the inlet is applied on the side or top of the sewer. The ordinary house inlets are provided for by Y branches in pipe sewers, and by special branch blocks in brick sewers. Where sewers join at street-corners, those on either side the main should be curved around to approach parallelism before joining, and come together in a bell-mouth. The invert should be prolonged in a tongue beyond the point where the sides join, so as to guide the current as far as possible to a parallel course. Inverts of stone-ware are now made, and are superior to brick for two reasons. They not only resist the abrasion of sand for much longer time, but being made hollow, afford a channel for the ground-water, which is often a great convenience during construction in wet ground. This means of draining the soil-water, if adopted for permanent use, does not keep it so well separated from the sewage as may be desirable, for the sewage would almost inevitably leak into such ducts. Junctions are often made at man-holes, and many reasons favor their being so made, for convenience of inspection and cleaning out. In order to avoid the checking of currents which are inevitable when such junctions occur at a considerable angle in man-holes, Latham and other writers advise stepping down some six inches or more at the man-holes to accelerate the flow. (See Fig. 3.) Wherever there is sufficient fall to allow this and at the same time retain slope enough to keep up the proper velocity in the sewer, there may be no objection to such a course; but where there is no fall to spare, as may often be the case in flat districts, the loss of head by the ordinary man-hole junction ought to be avoided. This loss of head is partly due to the sudden change of direction of the current by bringing in the branch sewers at right angles with the main, and this can be avoided by a previous curvature of these branches near the man-hole. But a good deal of loss arises from the contraction of the vein of the current in entering the sewer as the water passes out of the man-hole. This can be remedied in a large degree by rounding off the corners, where leaving the man-hole, like a small
bell-mouth, to conform with the vein of contraction. The method of stepping is advocated as an assistance to ventilation, it being alleged that the air in passing into the man-hole is by this step deflected upward, and finds a readier exit through the top of the man-hole into the street. But in practice I cannot attach much value to this consideration. This suggestion, whatever it may amount to, must depend on the supposed momentum of the air, which would tend to prevent it from rising and throw it across the man-hole, if built without a step; but the velocity of the air, when at its greatest, can never be so great in a sewer provided with a number of man-holes, as to allow of any momentum being acquired by the air which would produce any practical result. Moreover, if the air is to be poured out at every man-hole, where is it supposed to come from? If from the lower end of the system, near the outfall, the quantity of air so entering any sewer could, if all diverted upward, readily find exit at the first man-hole that it encountered, leaving no current to go beyond. The fact is, I imagine, that air is drawn in at all the man-holes of a district whenever a heavy rain-fall is running off, as the water subsides, and again every evening, as the amount of sewage flow due to the working hours subsides to the night flow; and flows outward at all of them when the fluid contents are increasing from similar causes operating in the opposite direction. Whatever currents through the sewers are due to winds outside are influenced by the air entering at any point on the windward side of the town where the wind pressure accumulates by being confined between walls or otherwise, and goes out again on the leeward side of the town where it finds the least resistance.

The flushing of sewers by intermittent flows or artificial methods is often found necessary to keep them clean in a district having a limited fall. Various methods are pursued for this purpose, suited to the local circumstances. Where streams of water are found at hand, they afford the best means of flushing, and provision can be made for using them by laying conduits and building tanks for that purpose. But where no such streams exist, the sewage itself is often dammed back by a gate till a considerable length of sewer is filled, or nearly filled, when, the gate being suddenly opened, the restrained water rushes along, and scours the sewer for a considerable distance. These gates are sometimes made to be operated by hand, requiring the presence of an attendant, and sometimes made to work automatically, by the height of the water. In conducting all flushing operations, care must be taken to guard against the flooding of houses by impounding
sewage to too great an extent, and at the same time to use a current of sufficient volume and force to wash all the inside of the sewer. There is in all sewers a film of organic matter in a slimy condition, clinging to their sides, consisting chiefly of putrid, greasy refuse, emitting a very foul smell, and therefore not a desirable material to retain. Rain-water may assist in flushing sewers very materially, but as it is extremely intermittent in its action, some more reliable source is often needed, by which the process can be repeated at will and at certain intervals, found by experience to be required in any particular locality. It is usual to begin flushing at the lower end of a district and work back. Each successive discharge will generally be carried quite through the system in this case, unless large deposits have been allowed to accumulate through too long neglect, which may stop on the way and need following down the line by more water. Tanks are sometimes provided at the upper end of small pipe-sewers, to discharge automatically, when filled. If these are made to hold the sewage, a sufficient height is rarely obtained in flat districts to enable the tank to be filled without setting back the sewage to an inconvenient extent into the house-drains. It is better to use rain-water, brook-water, or water from the mains that supply the town, in such cases. It not only washes the sewer better than sewage, but avoids all chance of setting back the sewage in house-drains, for the tank can in that case be made entirely independent of the sewer, except while they discharge, which is done through a pipe at the base of the syphon at a similar level. The automatic syphon of Mr. Rogers Field of London is often used in England for this purpose, especially for flushing house-drains. The best form of syphon for sewers is the annular one (see Fig. 4) composed of two concentric tubes, one inside the other; the inner tube forms the long or outlet end of the syphon, the outer tube being sealed at the top. The air is readily expelled from the syphon by a very small stream of water, if this can be made to fall through the air in the inner tube, instead of trickling down its sides, for which purpose a funnel-shaped mouth is provided at its top. The inner tube must dip in water at its lower end or outlet, before

![Figure 4](image-url)

_Figure 4._ PLAN.

_Figure 4._ SECTION.

_Figure 4._ FIELD'S FLUSH TANK 'ANNULAR SYPHON.'
the air can be expelled; for which purpose a basin is constructed for
it to dip in. If kept thus sealed all the time, however, the syphon
would keep delivering the water as fast as it comes into the tank,
which would defeat the object. It is is important, therefore, to allow
the air to enter the syphon after discharging the tank. This is ac-
complished by applying a small syphon to empty the little basin in
which the lower end of the large syphon dips. This small syphon
is readily charged by the rush of water while the large one is in ac-
tion, and as soon as the tank is emptied the small syphon draws the
water off from the discharging end of the large one, and both are
empty. As soon as the tank fills up, the first quart of water that
overflows through the large syphon seals its lower mouth, and as this
overflow continues, it is made to drop clear of the sides of the tube
by the funnel-shaped appendage at its top, which turns the water into
the centre of the tube. The small syphon is best when made of lead,
which is a metal that suffers but very little change in such situations.