THE VENTILATION OF PUBLIC SEWERS

BY

JOHN S. BRODIE

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CHAPTER I.

INTRODUCTORY.

THE subject of the proper ventilation of sewers and drains, although well understood and practised by the Ancient Romans, as shown by the remains of the Coliseum of Rome and other public buildings of that era, may be considered to have gradually arisen in this country after the general introduction of systems of sewerage consequent on the almost universal adoption of the water-carriage system of sewage removal, about the middle of last century.

In most of the principal towns there had been in use for many years large sewers, or, more strictly speaking, culverts, chiefly used for the conveyance of surface water, and in the majority of cases built for the purpose of enclosing what had previously been natural watercourses or streams. Those primitive sewers, if ventilated at all were indirectly so by means of the water-shoots or gullies, covered by wide iron gratings, provided for conveying surface and slop water from the road surfaces and channels into the sewers. It is perhaps unnecessary to say that, until about the year 1830, none of these gullies were trapped in any way.

In 1848 an Act of Parliament was passed creating a General Board of Health. This Board was the first sanitary authority ever created by law in any country. The Board of Health was reconstructed in 1854, and again in 1858, and was finally absorbed in the present Local Government Board, created by an Act of Parliament in 1871.

Between 1830 and 1840 about 900 gully traps had been formed in surface-water gullies or "shoots" in the Metropolis, with the inevitable result that, the sewer vents being closed up, nauseous emanations began to issue from the sewers in places where they were least welcome.

It is therefore not surprising to find, in 1852, the Board of Health, acting on the advice of their engineer, Mr. Henry Austin, C.E., suggesting openings being made from the sewers to the centres of the roadways, for the purpose of relieving air or gas pressure in the sewers, and thus inaugurating the surface ventilator as we now know it.

In 1858 some experiments were made under the direction of Sir Joseph Bazalgette and Colonel Haywood, engineers respectively to the Metropolitan Board of Works and the London City Commissioners, with a furnace in the clock tower of the Houses of Parliament for the purpose of ascertaining its influence in ventilating the main sewerage system of the Metropolis. The results obtained were not considered satisfactory, as the radius within which the sewer air was influenced by the furnace was found to be very small.

Since the latter date many investigators have devoted both time and energy to the subject of sewer ventilation. Many inventions have been tried and even patented, some with a view to force fresh air into the sewers, others trying to exhaust foul air from them, while many attempts have been made to deodorise or purify the escaping sewer air before it gets out into the atmosphere.

Up to the present time, however, little real progress has been made in the direction of uniform success in the solution of this difficult problem.

CHAPTER II.

IS THE VENTILATION OF SEWERS NECESSARY?

BEFORE proceeding to the discussion of the problem of sewer ventilation, two preliminary questions may first be considered, *viz.* :—

1st.—Is the ventilation of sewers necessary at all?

2nd.—If it is, why?

All who are familiar with the usual open grids in the centres of carriageways in towns and other populous places, and in country roads under which sewers are laid, are aware of the occasional puffs issuing from them of evil-smelling currents of foul air. These offensive smells are usually at their worst at the latter part of a prolonged spell of calm or droughty weather. They are, again, most noticeable at early morning or evening. There can, of course, be no question as to the offensive nature of these smells, however sanitarians may disagree as to whether they are dangerous or not.

Then it is a too familiar experience to most people that, notwithstanding the much-abused intercepting traps between the house drains and the public sewers, the water-seals of such traps are often forced by the back pressure of the air or gas in the public sewers, especially in the case of unoccupied houses, and a full current of sewer gas is conveyed into the entire system of the house drains, to the great discomfort of the dwellers therein if occupied, and to the danger to health of new-comers into previously empty dwellings. Moreover, the house-hunter frequently beats a precipitate retreat if a "smell" is felt in inspecting a prospective residence, and property has been known to remain an undue time before being occupied entirely from this cause, to the loss of the owner.

But one of the best and most convincing practical reasons that ventilation *is* necessary is the study of the many replies from towns all over the country to the question put by many municipal officers to their brother officials in other towns: "Have you received any complaints as to offensive smells from sewer ventilating grids?" The replies are painfully and unanimously in the affirmative.

The second question is much more difficult to satisfactorily answer.

In considering this question, it is desirable to bear carefully in mind the distinction between "sewer air" and "sewer gas." "Sewer air" may be considered offensive in degree only, and may vary from being imperceptible to smell, or almost so, to that of a most obnoxious description, and is due to the foul-smelling liquids and solids passed into the sewers, and not necessarily, or even usually, to any deposits, stoppage or delay of sewage in passing down the sewers in consequence of insufficient gradients or defective construction of the sewer itself.

"Sewer gas," on the other hand, is always offensive, and is caused by the putrefaction of the contents of the sewer. This putrefaction is in consequence of the sewage matter being "held up" either by the gradients of the sewer being so flat as to prevent the sewer from being self-cleansing, or from a badly laid sewer, in which the gradients may in some places be either reversed (a not uncommon occurrence), or the materials and workmanship of which the sewer is made, whether pipes, brick-work, concrete, or iron, are so defective as to impede the free flowing of the liquid sewage. In any of these cases the sewer becomes really a sort of elongated cesspool, in which the sewage tends to undergo a chemical change or decomposition, and as there is an almost total absence of oxygen to assist decomposition, the result is putrefaction, with all its accompanying offensive emanations. As Professor Bostock Hill has well said: "Gas is formed, and the bubbles of this gas burst and take up into the atmosphere micro-organisms in the sewage."

Now, no amount of ventilation will make a sewer that is in itself defective, either by improper alignment or unsound construction, whether of materials or workmanship, satisfactory. If the sewer itself is defective, by far the best and most economical and satisfactory method of dealing with it is to take it up and re-lay it on proper principles. Any scheme of ventilating a defective sewer will only end in disappointment, and the Author wishes to avoid at the outset any misunderstanding on this point.

It has been said that perfectly-designed and properly laid or built sewers require no ventilation. This is one of those apparently smart, but really fallacious, statements which sometimes carry a great deal more conviction than they are entitled to. But the fact remains that even perfectly-designed and well laid sewers require proper ventilating arrangements to make them work satisfactorily.

On the other hand, there are not wanting authorities of undoubted capability and sincerity who maintain that it is a mistake to provide either inlets or outlets for the admission of fresh air to, or the extraction of foul air from, public sewers. The advocates of non-ventilation of sewers contend :—

1st.—That it is only necessary to thoroughly ventilate the house drains and soil pipes by means of full-diameter ventilators carried above the level of the roofs of the houses, and by all other provisions necessary to render the admission of drain air to the house impossible.

2nd.—That every house drain must be cut off from the public sewer by a sufficient intercepting trap.

3rd.—That with the adoption of the above two conditions it is unnecessary to ventilate the public sewer—that is, to provide intentional inlets and outlets so as to encourage air currents continuously and regularly throughout the sewer.

4th.—That it is better to "bottle a smell" than to dilute and so "purify" it by spoiling a large bulk of pure air in the atmosphere.

5th.—That there are better ways of dealing with sewage emanations than by forcing them down the throat of the "man in the street" by mixing them with the atmosphere we breathe.

6th.—That the only logically correct course is to confine foul odours to their proper place, the public sewer.

7th.—That provided the houses are properly disconnected, little or no ventilation of the public sewer is required.

8th.—That the more fresh air is drawn or forced into a sewer the more foul air will there be emanating at other points, contaminating the atmosphere, without in any way benefiting the sewer or its tributaries.*

Although much attention has been given by Parkes, Meredith, Notter, Parry-Laws, Andrewes, Rideal, Horrocks, and others in this country, and by Flügge, Gärtner, Prausnitz, Rubner, Soyka, Von Rózahegyi, Kirchner, and Alessi on the Continent, as to the nature and injurious effects of sewer air and sewer gas, it is to be regretted that no absolutely clear and reliable conclusion has as yet been arrived at as to whether or not disease is really spread by means of the emanations of foul air from sewers.

* "Journal of the Sanitary Institute," vol. xx., p. 617.

Analytical and Bacteriological Investigations on Sewer Gas.

As already stated, many eminent chemists and bacteriologists have experimented on the air and gas from sewers.

As might have been anticipated from a gas given off such a heterogeneous compound as ordinary town sewage, many varying results have been obtained by different investigators, as shown below.

Dr. Letheby, in 1868, found the air in a City of London sewer, ventilated and fitted with charcoal for deodorising the escaping gases, as follows:—

Nitrogen	79·96 per cent.
Oxygen	19·51 ,, ,,
Carbonic acid	0·53 ,, ,,
Ammonia	Mere traces.
Marsh gas	Mere traces.
Sulphuretted hydrogen	Mere traces.
	100·00

Dr. W. J. Russell, in September, 1870, analysed the air from the Ranelagh sewer at Paddington, ventilated by open shafts, and found:—

Nitrogen	78·81 per cent.
Oxygen	20·79 ,, ,,
Carbonic anhydride (choke-damp)	0·40 ,, ,,
	100·00

The average composition of atmospheric air by volume is:—

Nitrogen	78·49 per cent.
Oxygen	20·63 ,, ,,
Aqueous vapour	0·84 ,, ,,
Carbonic acid	0·04 ,, ,,
	100·00

In 1882 Dr. Soyka, of Munich, in a communication to the "Deutche Vierteljahrsechrift für öffentliche Gesundheitspflege" discussing the influence of sewer gas as a factor in the spread of epidemic diseases, concludes:—

(1) The positive proof of a connection between sewer gases and the spread of epidemic diseases is wanting.

(2) The majority of the experiments hitherto made lead us to conclude that the spread of epidemic diseases is entirely inde-

pendent of sewer gases, and that those towns or parts of towns provided with sewers are more favourably circumstanced, as evidenced by their sanitary conditions, than the same towns before the drainage was commenced, or the districts which are still undrained.*

In 1893-4 Mr. J. Parry-Laws, F.I.C., and Dr. F. W. Andrewes, D.P.H., presented two reports to the Main Drainage Committee of the London County Council. The first report (1893) was by Mr. Parry-Laws on "Sewer Air Investigation"; and the second report (1894) was jointly by Mr. Parry-Laws and Dr. Andrewes, on the "Result of Investigations of the Micro-organisms of Sewage."

In the first report Mr. Parry-Laws arrived at the following conclusions:—

(1) "The mircro-organisms in the sewer air related to the micro-organisms in the air outside, and not to the micro-organisms of the sewage."

(2) "In the air, both within and without the sewer, the forms of micro-organisms present are almost exclusively moulds and micrococci; the micro-organisms of sewage, on the contrary, are for the most part bacilli."

Mr. Parry-Laws adds: "The whole of my results point unmistakably to the conclusion that the principal, if not the only, source of micro-organisms in sewer air is the air without the sewer, and not the sewage; and they also tend to prove that there is very little ground for supposing that the micro-organisms of sewage, *in the absence of violent splashing*, become disseminated in the sewer."

In the second (joint) report Mr. Parry-Laws and Dr. Andrewes arrived at the following results:—

(*a*) "That a considerable increase in the velocity of the air current does not produce an increase in the number of micro-organisms found in the sewer air."

(*b*) "That practically no micro-organisms are given off from the walls of a pipe sewer which has been empty, and open to the air at both ends, even for so lengthened a period as twelve days."

(*c*) "That the results certainly tend to show, contrary to a generally received opinion, that putrefaction of organic matters in a liquid contained in a 9-in. pipe does not disseminate microbes in the air superjacent to the liquid." †

* "Proceedings of the Institution of Civil Engineers," vol. lxviii., p. 350.

† "Journal of the Sanitary Institute," vol. xvi., p. 143.

Dr. David Arthur, in a paper contributed to the 1894 Congress of the Institute of Public Health, disagrees with the conclusions arrived at by Messrs. Parry-Laws and Andrewes. Dr. Arthur shows:—

(1) That with an in-current more micro-organisms are contained at the bottom of the ventilator than are to be found in the outside air.

(2) That with an out-current they are more in evidence at the outlet than in the air in the sewer, or, should rain have fallen, in the external atmosphere.

(3) That the reason for micro-organisms being constant in sewer air is that there is going on continuously a "giving out" and "taking in" of these minute bodies, those that are found forming the balance.

(4) Claims to have succeeded in finding the micrococcus ureæ, along with either the *B. coli communis* or the *B. typhosus*, which Mr. Parry-Laws could not find, and therefore laid stress on their absence as demonstrating that micro-organisms are not given off in sewers.

(5) That dangerous bacilli may creep up the damp face of the ventilator walls, there to multiply, and eventually come away with the spores of moulds, to be disseminated in the outside atmosphere.

In 1896, at a meeting of the German Association for the Preservation of Public Health, held at Stuttgart, Dr. M. Kirchner, in the unavoidable absence of Dr. Fränkel, opened a discussion on the "Danger of Sewer Gas as a Means of Spreading Infectious Diseases," and stated that:—

"Parkes, Meredith and Notter in England had insisted on the serious action of sewer gases escaping into houses, and that typhoid fever was one of the principal diseases attributed to these causes. In contradistinction to these views, the majority of writers on hygiene in Germany maintain that sewer gases are incapable of disseminating typhoid fever or other infectious diseases; and in support of these conclusions Dr. Kirchner alluded to the investigations in Germany of Flügge, Gärtner, Prausnitz, Rubner and Soyka.

"In 1881 Soyka demonstrated by statistics that cities provided with sewers were not in any way more liable to the attacks of diseases such as typhoid fever than those wholly undrained; on the contrary, from the statistics of towns which had recently been sewered on the modern system the mortality from typhoid fever had diminished, and that in those parts of the towns where the sewerage was defective the cases of typhoid fever were more frequent and more severe than in those quarters which were well drained. The conditions at Dantzig and Munich, among other towns, before and after the introduction of drainage were recorded as pointing to the opinion that the provision of proper drainage is the best method of reducing the death rate from typhoid fever.

"From the discoveries of Pasteur and Koch and their pupils, Dr. Kirchner considers that a correct knowledge has now been gained of actual disease germs, and of the best means of withstanding them. Any given disease can only occur when the known organism recognised as the active agent of the same has acquired vitality. In the absence of the typhoid bacillus there can be no typhoid fever; and where there is no cholera-vibris there can be no cholera. The gases caused by putrefaction, however poisonous they may be, cannot produce infectious diseases of the above kind. Certain of these pathogenic germs which may enter the sewers mixed with fæcal matters and soiled water do not find in them very favourable conditions for their existence, and that for the most part these organisms lose their virulence in sewage water. By the sewer gas theory it must be assumed that certain of these infectious germs are capable of floating in the air, and of thus entering into dwellings. But Vägeli has shown that this is not possible, and he has proved that these germs can neither ascend into the air nor be given off from moist surfaces; and in the air of sewers, moreover, bacteria have been ascertained to be invariably present in small numbers; indeed, frequently such air is absolutely free from such organisms."

From the results of the above investigations Dr. Kirchner is of opinion that there is no proof of there being any connection between sewer gas and the spread of epidemic diseases.*

In 1904 Dr. S. Rideal, D.SC., F.I.C., in a note submitted to the Royal Sanitary Institute at the Glasgow Congress,† states the results of some investigations made by Dr. Oliver, of Harrogate, and himself into the influences of various gases on blood pressure, and also on some experiments made by himself on the influence of sewer gas on the arterial blood pressure of workmen exposed to the air of the Lupus-street sewer, London, on December 18th, 1893.

* "Proceedings of the Institution of Civil Engineers," vol. cxxv., p. 472.
† "Journal of the Royal Sanitary Institute," vol. xxv., p. 596.

In the experiments made with Dr. Oliver, Dr. Rideal noticed that carbonic acid in proportions of 10 to 20 volumes per 10,000 has a very marked effect on the arterial blood pressure, causing it to rise from the normal of 100 mm. of mercury to 115 to 120, and even 130 mm.; but that on the removal of the carbonic acid the pressure at once returns to the normal.

"Carbonic bisulphide, similarly, increases the blood pressure temporarily, whilst ammonia has a depressing influence.

"Carbon monoxide resembles carbonic acid, but much smaller quantities are detected by this test.

"In no case, however, did any of these gases produce a permanent alteration of blood pressure. The pressure quickly returned to the normal on the subjects leaving the experimental room, except in the case of carbon monoxide, when the recovery was somewhat delayed.

"At the Lupus-street sewer, however, the sewer gas behaved differently. The carbonic acid was determined simultaneously at different parts of the sewer, and found to be 9·0, 9·3, and 9·7 volumes per 10,000.

"Three sewer men who had been accustomed to work on the sewers for some years were exposed for over three hours to the sewer gas, and their arterial pressures, on coming to the surface at noon, instead of being normal, were 115, 115, and 112 respectively, and their blood pressures did not fall to the normal for over half-an-hour's exposure to fresh air.

"Seven men who had not been exposed to any sewer gas during the day, and who had an average arterial pressure of 100 mm. of mercury, then went down the sewer for about half-an-hour. On returning to the surface their average pressure was found to be equal to 113 mm. of mercury, so that the sewer gas even for a short time caused a considerable rise in the arterial pressure. In addition to this alteration, it was further noted that the hands were red, showing congestion of the capillaries; that the veins were reduced in size, or were not apparent; and that the pulse rate was accelerated.

"It is therefore evident that exposure to sewer gases, even for a short time, increases the blood pressure, and, unlike carbonic acid, the increase of pressure so produced remains for a considerable period after the cause is removed by exposure to fresh air.

"It is possible that this continuance of high pressure after exposure to sewer gas may be attributable in part to the presence in it of carbon monoxide; but these experiments seem to indicate that some other factors must be contributing to the phenomenon."

Professor Thomas Oliver, M.A., M.D., LL.D., F.R.C.P., in a "Harben" lecture to the members of the Royal Institute of Public Health in November, 1905, says:—

"That fresh sewage, when free from pathogenic organisms, however objectionable it may be, is not causative of disease, but when stagnant it gives off foul emanations, the effect of breathing which may be headache, sore throat, and a sense of tiredness. The vital resistance is reduced, so that the individual becomes more liable to microbic disease than he otherwise would. There is a wider-spread danger than that due to the entrance of sewer gas into the sleeping room of a particular dwelling. During the stagnation and fermentation of sewage in drains the moist air, on rising to the ventilation outlet, meets there the colder external air and becomes misty, and is condensed. In the droppings thus formed pathogenic germs are entangled, and since these may be wafted some distance they are in the aërial spread of the disease." *

Major W. H. Horrocks, M.D., D.SC., R.A.M.C., in a Paper† read before the Royal Society on February 7, 1907, on "Experiments Made to Determine the Conditions under which 'Specific' Bacteria Derived from Sewage may be Present in the Air of Ventilating Pipes, Drains, Inspection Chambers, and Sewers," describes a set of recent experiments made on sewage taken from the main sewer at Gibraltar.

Group 1 of experiments were made to determine whether specific bacteria are ejected into the air by the bursting of bubbles at the surface of sewage.

The results appeared to show (*a*) that, independently of air currents, bacteria will not be ejected to a height of 4 in. by the bursting of infected bubbles, and (*b*) that bubbles rising through stagnant water may eject bacteria, which will be carried away by currents of air passing over the surface of the fluid.

Group 2 of experiments were made to determine whether bacteria dried on the surfaces of pipes are likely to be separated and carried by currents of air passing through the system.

In the result it was found that currents of air produced by the passage of sewage which was free from *B. prodigiosus* through horizontal pipes carried up dried particles of *B. prodigiosus* in

* "The Surveyor," vol. xxviii., p. 576.

† "Journal of the Royal Sanitary Institute," vol. xxviii., p. 176.

vertical branch pipes which had been previously saturated with a rich emulsion of *B. prodigiosus* and afterwards dried.

Group 3 of experiments were made to determine whether specific bacteria are ejected into the air of drains, sewers, etc., from sewage flowing under normal conditions.

A system of 6 in. diameter pipes were arranged with a 6-in. disconnecting trap, and an upright ventilating pipe 6 in. diameter and about 6 ft. in height, on the supposed house side of the trap, thus reproducing nearly the ordinary conditions of house drain connections. Three gallons of sewage, containing typhoid bacilli, was allowed to flow down the drain on the house side of the trap, and collected from the drain on the sewer side of the trap, at a velocity not exceeding 3 ft. per second, when numerous typhoid germs were found in the upright ventilating pipe, and some at a height of nearly 12 ft.

A similar experiment to the above, but with the disconnecting trap removed, was made, when typhoid germs were again found at a height of nearly 12 ft., thus showing that special bacteria can be ejected from flowing sewage independently of the resistance to the flow by the disconnecting trap.

Group 4 of experiments were made to test the value of the disconnecting trap as a means of protecting a house drainage system from specific bacteria present in the air of the sewer into which the house drain discharges.

The apparatus employed consisted of pipes arranged to represent a sewer, on which is placed a vertical sewer-ventilating pipe. Connected to this sewer is another length of pipes representing a house drain, on which is fixed a disconnecting trap close to the sewer, with the usual house drain upright ventilating pipe on the house side of the disconnecting trap. Sewage inoculated with *B. prodigiosus* was then allowed to flow at a velocity not exceeding 3 ft. per second through the pipes representing the sewer, when typhoid germs were found in the sewer ventilator, but none in the house drain ventilator. The experiment was repeated, and during the flow of the sewage the trap was repeatedly flushed with 3 gallons of sewage, but still no microbes were found on the house side of the trap.

The disconnecting trap was then removed, when inoculated sewage was made to flow through the sewer as before, and every five minutes a 3-gallon flush was passed through the house drain. Under these conditions typhoid germs were found in the ventilating pipes of both house drain and sewer.

These results appear to show that a disconnecting trap prevents microbes present in the sewer air from passing into the house drainage system.

Further experiments made on actual drainage systems at Gibraltar, including the military hospital, confirmed the results obtained above.

Summarising the results of his interesting experiments, Major Horrocks claims to show that:—

1. Specific bacteria present in sewage may be ejected into the air of ventilation pipes, inspection chambers, drains and sewers by:—

(*a*) The bursting of bubbles at the surface of the sewage.

(*b*) The separation of dried particles from the walls of pipes, chambers and sewers.

(*c*) Probably, the ejection of minute droplets from flowing sewage.

2. A disconnecting trap undoubtedly prevents the passage of bacteria present in the air of a sewer into the house drainage system.

3. An air inlet, even when provided with a mica valve, may be a source of danger when it is placed at or about the ground level.

By way of contributing toward a correct answer to the above question, "Why is it Necessary to Ventilate Sewers?" the Author has taken a short list of five well-authenticated cases, out of a great number available, of sewer poisoning.

One of these is the well-known King's Norton case, where it was found, after a careful hearing of all the facts of the case, that the death of a prominent resident was due to sewer gas, and the unfortunate Local Authority were cast in heavy damages.

The other four cases are a few typical instances, out of a large number, of the danger incurred by workmen in the discharge of their duties as sewer cleansing men from inhaling the noxious air in the sewers, three out of the four cases unfortunately resulting in loss of life.

SEWER GAS ACCIDENTS.

1.—KING'S NORTON.

Smith and Others v. *King's Norton Rural District Council*, Birmingham Assizes, August 5th, 1896.

This was an action for alleged negligence on the part of the Rural District Council, resulting in the death of a brother of the

Lord Mayor of Birmingham from blood poisoning, caused by the escape of sewer gas from one of the Council's sewers, owing to a defective ventilating shaft. Verdict against the defendant Council for £3,500.

2.—DUBLIN.

On Saturday afternoon (May 6th, 1905) several men at work on a sewer were overpowered by gas, and one of them succeeding in crawling out to give the alarm, a policeman, Patrick Sheehan, and a car-driver named Fitzpatrick, went to the rescue. Two men were got out, but later the rescuers themselves were in danger. When, with the help of the fire brigade, all were eventually got out, the gallant policeman was found to be dead, while one of the workmen died the same evening.

3.—SUTTON, NEAR BIRMINGHAM.

Two men were at work in a main sewer on Friday last (April 20th, 1906) at Sutton, near Birmingham, when an explosion occurred. Both were badly injured, the windows of the houses in the vicinity shattered, and the sewer grating lid hurled a distance of 40 yards, several pedestrians having narrow escapes.*

4.—ROTHERHITHE, LONDON.

William Freak, a sewer flusher, was suffocated by poisonous gases in one of the London County Council's sewers at Rotherhithe on May 18th, 1905.†

5.—SOUTHWARK, LONDON.

Half-a-dozen men had a very narrow escape from death in a Southwark sewer on Friday afternoon (January 18th, 1907), and were only saved by the active intervention of the members of the London Fire Brigade. The firemen descended into the sewer, and the six men, one after the other, were brought to the surface. One, however, was so completely overcome that he had to be dragged to the manhole by ropes. The men were removed to the hospital, and all, with the exception of one, had sufficiently recovered by the evening to proceed home.‡

From an unprejudiced consideration of the above actual results of breathing sewer air or sewer gas, it would appear that no reasonable doubt can exist as to the danger of breathing air or gas from sewers.

* "The Surveyor," vol. xxix., p. 466.
† "The Surveyor," vol. xxvii., p. 4 (*Supplement*).
‡ "The Surveyor," vol. xxxi., p. 108.

It may, however, be assumed that all investigators are in agreement on the following points :—

(1) That there *is* danger to health, and even life, from poisonous emanations from sewers, whether sewer air or sewer gas.

(2) That the thorough and effective ventilation of sewers is essential in obviating the danger arising from these emanations.

By section 19 of the Public Health Act, 1875—which recites: "Every Local Authority shall cause the Sewers belonging to them to be constructed, covered, *ventilated* and kept so as not to be a nuisance and injurious to health, and to be properly cleansed and emptied"—the duty of properly ventilating the public sewers is a legal obligation on all the sanitary authorities in this country.

PAST AND PRESENT METHODS OF VENTILATING SEWERS.

All methods of ventilating sewers in use during the last fifty years may be broadly separated in three general divisions—*viz.* :

(1) Ventilation by natural air currents,

(2) Ventilation by artificially-produced air currents,

(3) Deodorisation of foul sewer air or gas before it is discharged into the open air,

and it will be convenient to consider the subject under the above headings.

CHAPTER III.

VENTILATION BY NATURAL AIR CURRENTS.

THE natural ventilation of sewers may range from the almost total absence of any organised system of sewer ventilation, such as prevails intentionally at Bristol and a few other towns, to an elaborate and well-considered system of low-level inlet openings, and high-level outlet openings, as at Leicester and other places, by means of high columns either attached to adjacent house property or street ventilating shafts.

Ventilating Gratings at the Surfaces of Roads.—As already stated, the first openings from the surfaces of the roads into the sewers were made under the direction of Mr. Austin about the year 1852, and were placed at the top ends of sewers, and otherwise at long intervals of 200 to 300 yards apart. Then followed the long reign of the late Sir Robert Rawlinson, K.C.B., P.P.INST.C.E., at the Local Government Board as its first Chief Engineering Inspector. Sir Robert inaugurated his appointment as Chief in 1871 by drawing up and publishing "Suggestions on Town Sewering and House Draining; for the Instruction of Engineers and Surveyors to Local Boards." An extract of these "Suggestions," as revised to 1878, is given in the Appendix, page 83.

Although, in the light of the experience gained by sanitary engineers since that time, the suggestions then made may appear to many as somewhat obsolete, still, without doubt, the main principles upon which sewerage systems should be carried out were correctly laid down by Sir Robert, and the advances made since then have been in the development of details rather than in any fundamental improvement in general principles.

It is interesting to notice, in the last paragraph but one of the "Suggestions," that "Wherever a trap is placed on a sewer or drain there should also be means for sewer and drain ventilation provided to relieve such trap." If this suggestion had been always acted on by the Local Government Board many of our present troubles as to "sewer smells" would never have arisen.

Paragraph 5 of the "Suggestions" is one of the views tenaciously held by Sir Robert, that when the surface ventilators of a sewer were complained about, then his remedy was to "put in some more."

Figs. 1 to 4 show the type of manhole with side ventilating shafts recommended by Sir Robert, and carried out in many towns.

Charcoal baskets were recommended to be inserted in the aperture between the manhole proper and the side ventilating shaft. These charcoal baskets were soon found to be of comparatively little benefit in purifying the escaping gases, and were quickly done away with. The covers over the manholes were, of course, airtight, and those over the ventilating side shafts were

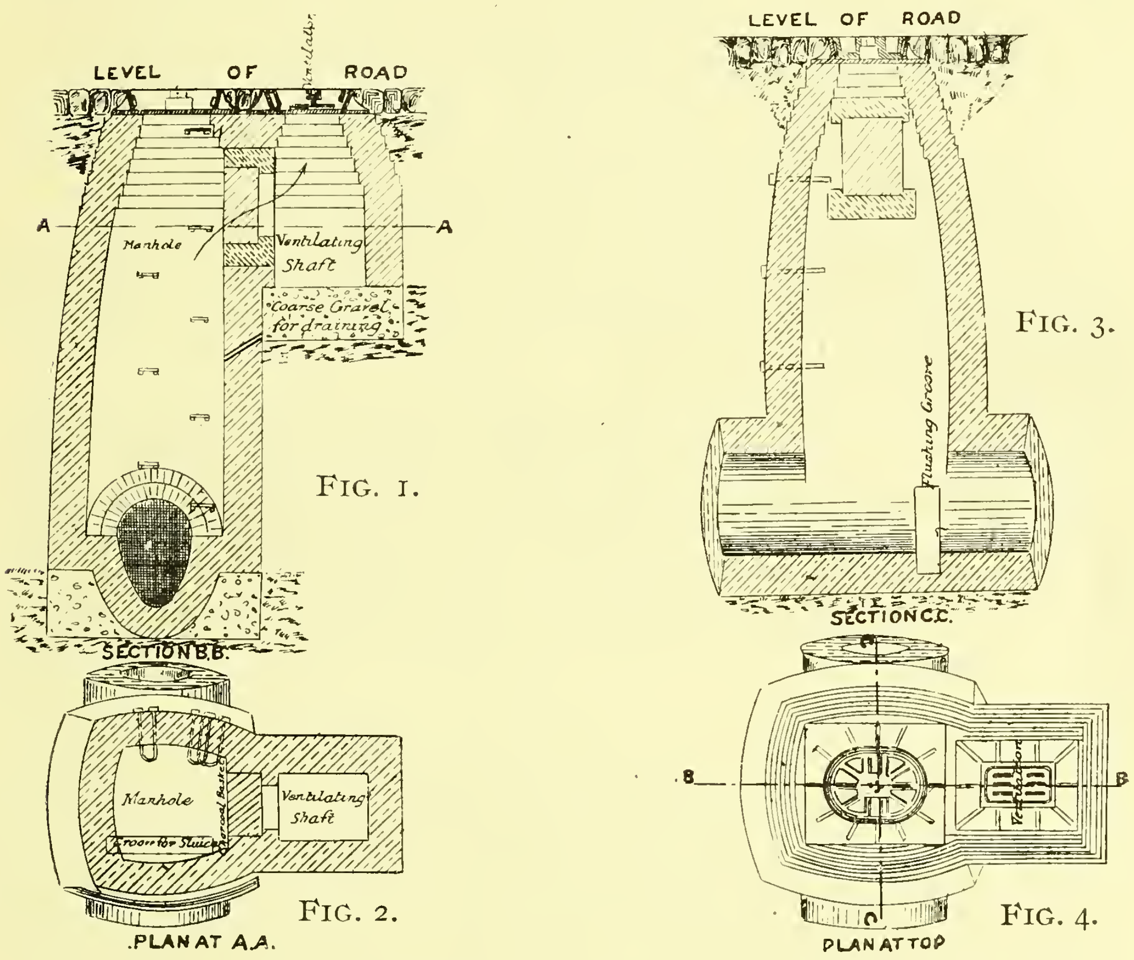


FIG. 1. FIG. 2. FIG. 3. FIG. 4.

MANHOLE AND VENTILATING SHAFT ON BRICK SEWER, 1878.

open and hinged, so that the sludge and dust could be readily removed from the bottom of the pit by the road scavengers as often as was necessary. It will also be seen that a sluicing groove was made at the bottom of the manhole, in order that the latter might be used as a flushing chamber when required.

Very soon it became the practice to ventilate sewers in a more thorough manner by providing manholes at short distances apart for giving access to the sewers from the road surfaces and "lampholes" at every change of direction of the sewers between manholes. These manholes and lampholes were provided as close together as 40 yards in some cases, but the usual practice now is to space them at from 60 to 100 yards apart, and frequently with lampholes in between.

The manholes are generally made of brickwork set in cement mortar, circular in form, and about 3 ft. in diameter, with proper channels and benches at their bottoms, parged with cement mortar, and finished at the street level with a hinged grating to allow the foul air to escape into the open air.

Lampholes were placed between manholes at change of direction, and were usually made of 9 in. to 12 in. diameter stoneware socket pipes, surmounted by a cast-iron hinged grid on a level with the surface of the carriageway in the street.

For a long time, indeed up to within the last few years, the system of sewer ventilation by means of manholes and lampholes with perforated grids at the level of the carriageways was almost universal in this country.

So long as sewers were connected directly to house drains, which were themselves usually ventilated with an upcast shaft or pipe ventilator—"surface ventilation," that is—ventilating grids at the surfaces of the carriageways were found to give reasonable satisfaction, although well-founded complaints were from time to time made, and were in nearly every case traceable to local or special causes which could in almost every case be easily and satisfactorily removed.

But with the general introduction of the intercepting trap, originally invented by Mr. W. P. Buchan, of Glasgow, in 1872, and the issue of the Local Government Board's Model By-Laws in 1877, practically compelling the use of that trap by all sanitary authorities, by which the house drains, ventilators, etc., were aërially cut off from the main sewer, the ventilation of the sewers not unnaturally underwent a very serious change for the worse, as in many cases the conditions of ventilating the sewers had been thereby completely altered, if not radically disorganised.

Surface ventilators, which up to the introduction of the intercepting trap had been largely, if not entirely, inlets for fresh air to the sewers, now began, in the cutting off of the house ventilating pipes, to act chiefly as outlet vents from the sewers, whether of air or gas.

It is not surprising, therefore, to find that early in the eighties many towns had forced on their attention the unsatisfactory state of many of their street surface ventilators, and that a general practice was then setting in to close the surface grids, and to seek permission from owners of property as near to the closed grids as possible to erect pipes or shafts against gable ends of buildings, etc., so as to convey the foul emanations from the sewers and discharge them into the open air as high above windows and chimney tops as practicable.

In April, 1880, Sir Robert Rawlinson, in a discussion at the Institution of Civil Engineers, urged that the health of a district depended :—

1st. — Upon the proper arrangement of the sewers.

2nd.—Upon the proper ventilation of the sewers.

3rd. — On the effectual cutting off of house drains from all direct communication with the sewers.

High Shaft with Surface Grate Ventilation.—In February-April, 1885, the late Mr. G. R. Strachan, then Surveyor to the Vestry of Chelsea, made some experiments on sewer ventilation by down-draughts from cowls.

The sewer experimented on was in Jubilee-place, Chelsea, and was egg-shaped, 3 ft. 9 in. by 2 ft. 6 in., about 206 yards in length, with a capacity of 4,300 cubic feet, laid at a gradient of 1 in 100. At its lower end it joins the main sewer of the Metropolitan Main Sewerage System, and at its upper terminates in a "dead" end. Near the lower end a head wall was built, and under it a dip-trap to pass the sewage out. All the entering drains were fitted with back-flaps.

Near the centre of the sewer a 15-in. pipe was inserted at springing-level, and connected to a shaft fixed against the side of a house, surmounted by a lobster-back cowl 15 in. in diameter at the mouth and 9 in. diameter at the throat at a height of 32 ft. above the road. Similar shafts were erected at the upper and lower ends of the sewer 22 ft. and 31 ft. in height respectively.

Anemometers having been fixed where the shafts were connected to the sewer, a series of experiments were made extending over forty-four days, which showed that, with an average wind velocity of 12 miles per hour, air entered the sewer at the average rate of 140 cubic feet per minute, replacing foul air with fresh every thirty-one-and-a-half minutes, or 46·6 times per day.*

In 1888, the late Mr. W. Santo Crimp, then Surveyor to the Urban District Council of Wimbledon, made some valuable

* "Proceedings of the Institution of Civil Engineers," vol. lxxxiv., p. 362.

experiments as to the velocity and direction of air currents in sewers.

The experiments extended over twelve months, and showed that, while the temperature of the external air varied from 34·75 deg. Fahr. in February, when the sewer air was 42·30 and the sewage 44·75, to 59·10 in August when the sewer air was 57·75 and the sewage 55·65, yet that the differences of temperature had little or no apparent effect on either the direction or the velocity of the air in the sewer.

On the other hand, Mr. Santo Crimp found that the action of the wind was both powerful and direct in its influence on both the velocity and direction of the sewer air currents.

The sewer experimented upon was one of the 12-in. branch pipe sewers at Wimbledon, about 620 lineal yards in length, with a total rise of 100 ft. and gradients varying from 1 in 8 to 1 in 100, laid at an average depth of 10 ft., laying nearly N.W. and S.E., its upper end being nearly N.W. and its lower S.E. Consequently winds from the N.W. blew over the sewer in a downward direction, and from the S.E. in an upward direction, while winds S.W. and N.E. blew across the sewer but from opposite directions. It should also be stated that there was an abundant foliage of trees on the line of sewer experimented on.

The result of the experiments showed that the velocities of air currents in the sewer were almost in direct proportion to the wind velocities outside, and that *upward* currents were produced by winds blowing from S.E. to N., and downward currents from winds S.S.W. to N.W., or roughly in the direction of the sewer itself.

Mr. Santo Crimp also found that, in the course of the twelve months over which his experiments extended, fully one-third more air passed *down* the sewer than what passed *up*.*

High Shaft Ventilation Only: Surface Gratings Closed.—Mr. Mawbey, on entering upon his official duties at Leicester in 1889, "found that for some time past it had been the practice there to use none but closed covers in the construction of all new public and private sewers, including the new main sewers then in progress"; also "that on December 6th, 1889, in accordance with his recommendation, the Highway and Sewerage Committee directed him to continue the practice of putting up pipe shafts where complaints were made of surface ventilators; and on

* "Proceedings of the Institution of Civil Engineers," vol. xcvii., p. 383.

October 13th, 1890, it was agreed that any very offensive ventilators complained of should be at once closed, and that this practice had since, from time to time, been acquiesced in up to the time of his Report (July, 1899)."

Concluding his most able and interesting Report, Mr. Mawbey says: "The system of surface grid ventilation has been well tried in Leicester, and has been found a fruitful source of nuisance and strenuous complaints from the public." (See Abstract of Report, page 105 of Appendix.)

An example of a high shaft ventilator recently erected by the Author to ventilate a large tide-locked sewer chamber at Blackpool, 16 in. in diameter and 65 ft. in height, is shown at Figs. 13 and 14 (page 30).

Mr. James Mansergh, reporting in March, 1898, on the offence caused at Cambridge by the escape of sewer gases through the sewer ventilators, says: "My first recommendation is that where a surface ventilator is offensive, a careful inspection should be made to ascertain if there is any special reason for the offence. If any is discovered it should be corrected if possible. If the investigation shows no special cause, then a column or shaft should be erected, and the surface opening *closed*." (See Abstract of Report in Appendix, page 91.)

Somewhat curious in this connection is a Report by Sir Alexander Binnie to the London County Council (July, 1898) on Sewer Ventilation.

As the result of a Conference of the Engineers and Surveyors of the various Vestries and District Boards in the County of London three resolutions were passed, which may be briefly summarised as follows:—

(1) That the closing of sewer ventilators only increases the evil, and that a diminution of the evil is to be found in the multiplication of the ventilators at frequent intervals.

(2) That in connection with the fixing of any interceptor hereafter on a main house drain, a ventilating pipe from the sewer side of the interceptor be carried up the front, side or back of the house, and that the outlet drain from the interceptor shall not be flap-trapped in sewer unless required by the Sanitary Authority.

(3) That pipe ventilators up buildings, or otherwise where possible, should always be adopted in addition to surface ventilators. (See Report, page 92 of Appendix.)

These resolutions are obviously somewhat destructive of each

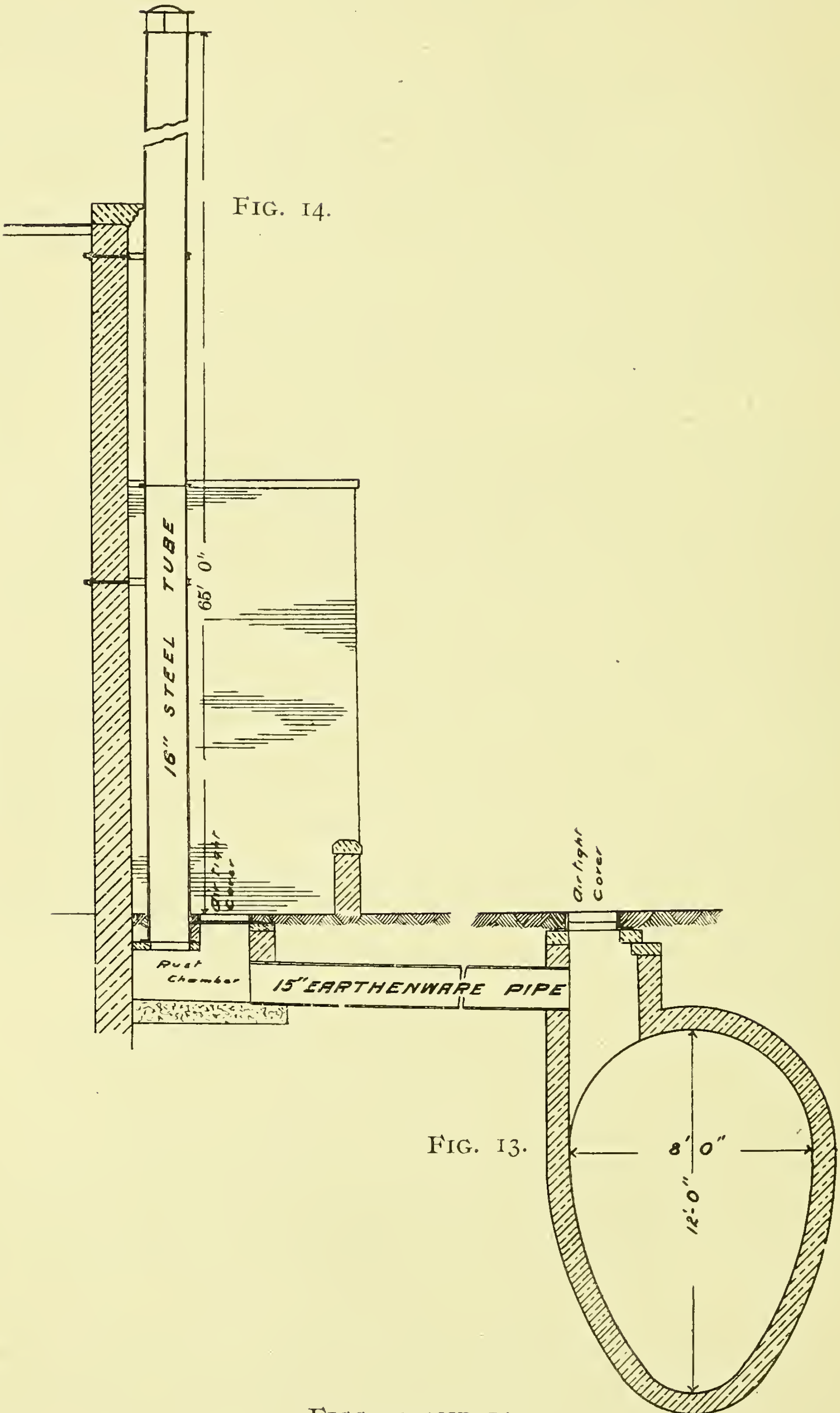


FIG. 14.

FIG. 13.

FIGS. 13 AND 14.

VENTILATION OF TIDAL SEWER CHAMBER AT BLACKPOOL.

other, and are evidently a compromise on the conflicting opinions expressed at a Conference of Metropolitan Surveyors held at the Westminster District Meeting of the Incorporated Association of Municipal and County Engineers on February 18th, 1898, one week before the meeting referred to by Sir Alexander Binnie.*

In December, 1898, Messrs. Taylor, Sons & Santo Crimp reported on the condition of the public sewers at Bristol. It must, of course, be borne in mind that the Bristol sewers are not intentionally ventilated at all.

They state: "The necessity for ventilating sewers can only arise from two causes—danger to sewer men, and danger of forcing the intercepting traps of private houses." They cannot recommend the Council to ventilate the sewers at a cost of £40,000, as they "are certain that the ratepayers in the vicinity of each ventilator would rebel against its existence, and a pressure which would be found to be irresistible would be brought to bear upon the Council, which would lead to the closing of the ventilators."

The City Engineer (Mr. T. H. Yabbicom) and the Medical Officer of Health also reported to the same effect. (See Abstracts of Reports, page 92 of Appendix.)

In March, 1899, the Borough Surveyor of Maidstone received twenty-two replies from various towns in respect of Sewer Ventilation.

Query 1.—Have you adopted upright shafts for Sewer Ventilation?

Eighteen replied "Yes"; three replied "Partly"; one (Bristol) replied "No."

Query 5.—Are the manhole covers in the streets open or closed, and do you receive complaints of nuisance from them?

One replied "Open"; seven replied "Proportion Open"; seven replied "Closed"; thirteen replied "Closed, or being gradually closed."

(See Tabulated Return, page 95 of Appendix.)

In June, 1899, a valuable contribution towards the solution of the problem of Sewer Ventilation was made by Mr. R. Read, ASSOC.M.INST.C.E., Borough Surveyor of Gloucester, in a Paper read before the Association of Municipal and County Engineers. Mr. Read is uncompromising in his opposition to the intercepting trap, and the point of his Paper is to the effect that it is only necessary to return to the *status quo* previous to 1877 and the

* "Proceedings of the Association of Municipal and County Engineers," vol. xxiv., p. 62.

introduction of the interceptor trap. In other words, to abolish the latter altogether would be to provide a perfect remedy for all complaints in regard to offensive gases from sewers except such as are directly due to badly designed, or originally defective, or inefficient supervision and working of sewers. (For Abstract, see page 101 of Appendix.)

In August, 1899, Mr. James Lemon, M.INST.C.E., in his Presidential Address to Section 2 (Engineering and Architecture) of the Sanitary Institute's Congress held at Southampton, said: "There is a great deal to be said in favour of open gratings in the centre of the streets, but they are liable to be closed by the near householder or the Local Authority, and therefore are not reliable. I have come to the conclusion that properly designed shafts should be provided so that the air in the sewer may be changed as frequently as possible; some of the shafts will be inlets and some outlets, but in any case a diffusion of the sewer air will take place." *

Dr. T. Orme Dudfield, Medical Officer of Health of Kensington, obtained replies from thirty-one towns *re* Sewer Ventilation in March, 1900.

To the question: Are the sewers ventilated by gratings in the road? twenty-six reply "Yes"; one replies "No."

To the question: Are the sewers ventilated by shafts carried up private houses? nineteen reply "Yes."

To the question: Are the sewers ventilated by shafts formed in lamp columns? nine reply "Yes."

(See page 109 of Appendix.)

In January, 1901, Mr. H. Gilbert Whyatt, Borough Engineer of Grimsby, presented a Report to the Town Council on the subject of the Ventilation of the Sewers of Grimsby. Dealing in a very thorough manner with his subject, Mr. Whyatt arrives at a number of important conclusions, among which are:—

(1) Does not recommend that the intercepting trap should be abandoned, in view of probable defects in house drains.

(2) The majority of the surface ventilators have been complained about, and orders given to close them.

(3) The policy of closing grids without providing other means of egress for the foul air only results in greater foulness of the sewer air and forcing traps in the near neighbourhood.

* "Journal of the Sanitary Institute," vol, xx., p. 379.

Mr. Whyatt's Committee, on his advice, finally agreed to the following recommendations:—

(*a*) The closing of manhole grids complained of in the past, and erecting vent shafts instead.

(*b*) Vent shafts to be placed at syphons and flaps in sewers.

(*c*) Vent shafts to be placed at dead ends of sewers.

(*d*) Where manhole grids are complained of in future, to be closed on condition that property owners give facilities for erecting vent shafts.

(*e*) Vent shafts to be placed on sewer side of each intercepting trap at expense of owner.

(For Abstract of Report see page 121 of Appendix.)

In February, 1902, Mr. T. de Courcy Meade, City Engineer of Manchester, reported that he had received information from sixty towns in the United Kingdom, and from eight towns in Canada and the United States, and he made the following among other recommendations to his Council, when a Sub-Committee was appointed to go into the whole matter:—

(1) That a systematic course of ventilation should be put in hand over the whole of the 1,700 miles of sewers belonging to the city.

(2) That upcast shafts be erected in suitable positions, with surface ventilators as inlets for fresh air.

(3) That the ventilating shafts be periodically examined and painted, and the rust pockets at the base of the shafts regularly emptied.

(See Abstract of Report, page 123 of Appendix.)

In July, 1902, Mr. H. Gilbert Whyatt, Borough Engineer of Grimsby, collected replies from *forty-nine* towns to the following questions:—

(1) Have you abandoned surface ventilation of sewers?

Twenty-eight towns replied that surface ventilation had been entirely, or was being gradually, abandoned, the cost being defrayed out of current revenue; nine towns replied that surface ventilation had been, or was being gradually, abandoned, the cost being defrayed out of loans sanctioned by the Local Government Board; seven towns replied that surface ventilation had not been abandoned; four towns replied that surface ventilation had never been adopted by them; one reply confidential.

(See Tabulated Replies, page 124 of Appendix.)

In September, 1902, Mr. Councillor W. F. Dearden, M.R.C.S., L.R.C.P., D.P.H., Chairman of a special Sub-Committee of the Manchester City Council appointed to consider the whole question of the effective ventilation of the sewers of Manchester, contributed a Paper on "Sewer Ventilation" at the Congress of the Sanitary Institute held that year at Manchester. After enumerating the various systems of ventilation in use as shown in sixty replies from towns in the British Isles, and eight from towns in Canada and the United States, which his Committee had invited in respect of Sewer Ventilation, Mr. Councillor Dearden expressed his opinion that there was not sufficient evidence available as to the real nature of sewer air, and especially as to its dangerous properties. Before, therefore, spending a large sum of money on sewer ventilation, estimated at from £200,000 to £300,000, the Corporation of Manchester had decided to make further bacteriological experiments as to the character of sewer air emitted from the surface grids.

(See Abstract, page 127 of Appendix.)

On January 31st, 1903, a meeting of the Midland District of the Association of Municipal and County Engineers was held at Birmingham, at which the only subject for papers and discussions was that of "Sewer Ventilation."

Six valuable and interesting papers were contributed, and a most instructive discussion was afterwards held.

The papers were contributed by the following authors: Mr. T. Caink, City Engineer, Worcester; Mr. R. Read, City Surveyor, Gloucester; Mr. W. J. Steele, Deputy City Engineer, Bristol; Mr. A. W. Cross, Surveyor, King's Norton Urban District Council; Mr. H. H. Humphries, Surveyor, Erdington Urban District Council; Mr. C. Chambers Smith, Surveyor, Sutton Urban District Council.

Briefly summarised, the results of the above able contributions to the study of the subject under discussion may be stated as:—

MR. CAINK concluded "that the solution of the problem lay, as far as the prevention of nuisance was concerned, in checking the rapid discharge of sewer air from the ventilators; or in other words, in *transmitting as little air as possible from the sewers* consistently with affording such relief as will prevent the pressure in the sewers rising appreciably above that of the atmosphere." This object is accomplished by the use of Mr. Caink's regulator, which is also a kind of filter or deodoriser.

MR. READ considered that the abolition of the intercepting trap and the consequent full use of the house drain ventilators would be the best means of ventilating the sewers.

MR. STEELE was of opinion that no sufficient evidence was as yet available that the ventilation of sewers is either necessary or desirable.

MR. CROSS believed in producing induced currents of air by means of water spray.

MR. HUMPHRIES had found a combination of surface and shaft ventilation the best solution of the problem, and considers that the abolition of the intercepting trap on house drains would be of the greatest and most necessary assistance to the ventilation of the sewers.

MR. C. CHAMBERS SMITH favoured an artificial system of ventilation, such as that of Messrs. Shone & Ault.

The discussion was of the most valuable character.

(See Abstracts, pages 130 to 138 of Appendix.)

On April 23rd, 1904, Mr. H. Gilbert Whyatt, ASSOC.M.INST.C.E., Borough Engineer and Surveyor of Grimsby, contributed a Paper on "The Ventilation of Sewers" at a meeting of the Association of Municipal and County Engineers.

This Paper is conspicuous as a very thorough attempt to arrive at satisfactory conclusions in regard to the ventilation of sewers under extremely unfavourable and difficult local conditions.

The Author, after stating that in his opinion the ventilation of sewers—*viz.*, a continuous current of air in one direction—is not desirable, except on those occasions where workmen have to enter the sewer for certain purposes, says that the solution of the problem appears to be :—

(*a*) The adoption of a large number of reasonably sized vent shafts at frequent intervals.

(*b*) That sewers must be regularly and frequently flushed.

(*c*) That the ventilation of the length of drain between the sewer and the intercepting trap should rest on the building owner.

(See Abstract, page 138 of Appendix.)

In November, 1904, Mr. Ernest Van Putten, Borough Surveyor of Lewisham, reported to his Council on Sewer Ventilation. The leading points in his Report are :—

(1) Where surface ventilators are closed and shafts erected the nuisance is removed from the road surface, but the sewers are badly ventilated unless some artificial means are adopted to create an up-draught.

(2) The air emitted from a high shaft is far more foul than that which is discharged from the surface gratings.

(3) Considers the use of interceptors on house drains are largely to blame for presence of foul air in sewers.

(4) Suggests as a "partial mitigation of the nuisance" that sewer ventilators should be put much closer together, and that the by-law as to intercepting traps should be repealed.

(See Abstract of Report, page 142 of Appendix.)

In February, 1906, Mr. Oliver E. Winter, Borough Engineer of Hampstead, presented to his Council replies from twenty-six Metropolitan Sanitary Authorities to his questions on Sewer Ventilation:—

(1) What system of sewer ventilation have you adopted?

Twenty-four towns reply: That surface gratings in centres of streets were originally adopted, but these surface gratings are gradually being closed, and upcast shafts against adjacent property erected to extract foul air.

Replies from two towns (Westminster and Southwark): Surface gratings only.

(2) Is it giving satisfaction, or have complaints been made?

Twenty-five towns reply admitting complaints of different degrees.

Reply from one town (Southwark): "Yes."

(6) Give your personal opinion on the subject, especially on the question of ventilation by open grids in the centres of streets:—

Fourteen towns condemn surface grids, either directly or indirectly.

Two (London County, and Westminster) give a qualified approval to open grids in the centres of streets.

Ten towns do not reply to this question.

Mr. Winter also presents recommendations from Dr. W. F. Andrewes, F.R.C.P., D.P.H., and Dr. W. H. Huntley, as to minimising the effect of sewer air escaping into the streets.

(See Abstract of Report, page 143 of Appendix.)

In November, 1906, Mr. Nelson F. Dennis, Borough Surveyor of West Hartlepool, presented a Report to his Council giving details of certain tests for air velocities through ventilating shafts, columns, surface ventilators, and manholes respectively, and from which he found that ventilating columns in the line of kerbs were the most efficient, and based a recommendation thereon as follows:—

To ventilate the "dead" ends of sewers by means, where practicable, of shafts 6 in. diameter without bends, affixed to the gables of houses and connected to the sewers by 9-in. drains, provided with proper rust boxes. In other places, where shafts against houses are impracticable, it is proposed to erect ventilating columns 8 in. diameter fixed on the kerb line, at an estimated cost as follows:—

For the erection of 139 shafts at gables.. ..	£695
,, ,, 70 columns on kerb line ..	980
	£1,675

(See Abstract of Report, page 146 of Appendix.)

Mr. Nelson Dennis has kindly informed the Author that his practice is to place ventilating upcast shafts by the gables of houses, at the termination of back street drains, without any bends except what are necessary to connect the shafts to the sewers. About ninety of these have been erected. Ventilating columns are erected on the line of kerbs in such front streets as have no back street at the rear, of which about sixty have been erected. Most of the ventilating columns have been of the following dimensions: 8 in. diameter bottom section, 6 in. diameter top section, each section 15 ft. long, making a total height of 30 ft. from footpath level, with ornamental base, and 9 in. connection to sewer. A few columns have been erected to larger dimensions—*viz.*, 10 in. bottom section and 8 in. top section. As a rule, all ends of sewers are connected to ventilators, either shafts at gables or columns at kerb line.

Dr. A. Campbell Munro, Medical Officer of Health for the County of Renfrew, reported to his Council in January, 1907, that "upcast shafts and closed manholes which in 1896 had replaced open gratings in Renfrewshire had given every satisfaction, and that the new system has obviated complaints of foul smells from sewer gratings and overcome the troubles which formerly arose from the mud from macadamised roads being swept into the sewers."

Dr. Munro concluded his report with a warning against a return being made to the old system.*

Special High Shaft Ventilators.—Mr. Ambrose W. Cross, ASSOC.M.INST.C.E., Surveyor to the Urban District Council, King's Norton, has used an arrangement, known as Bladon's patent, of special air inlet and outlet high shafts (see Fig. 5).

The inlet shafts consist of short columns, 10 ft. to 12 ft. in height, about 6 in. internal diameter, with hexagonal heads, fitted with non-return aluminium flaps on each of the six sides so as to ensure their acting as fresh-air inlets only, and not as outlets. The outlet shafts are of the same diameter as the inlet, but are from 30 ft. to 40 ft. in height, surmounted with ordinary wire netting.

All the surface ventilators are closed.

Tests made by anemometer showed that 2,098 lineal feet of air passed into the sewer through the 6-in. inlet shaft in five minutes during a high wind. This would appear to be a velocity of about 7 ft. per second through the air inlet, corresponding to a wind velocity of 4·76 miles per hour.

Another test, extending over twenty-four hours in breezy weather, showed that 21,000 cubic feet of fresh air was passed into the sewers through an inlet shaft 11 ft. in height, fitted with the hexagonal shaped inlets as described above. This is equivalent to an air velocity through the 6-in. inlet shaft of about 1·22 ft. per second, or a wind velocity of about three-quarters of a mile per hour.

It therefore appears that, as the experiments were carried out "during a high wind," and "in breezy weather," only a comparatively small proportion of the velocity of the wind was caught by the special inlet head and transmitted through the shaft into the sewer.

The cost of the patent large ventilator, made of strong galvanised iron, with tube to fit column, 5½ in. diameter, is £1 15s.

Spare aluminium valves, the only moving parts for repairs or renewals, cost about 1s. 10d. per dozen.

These ventilators, if alternate inlet and outlet, are placed about a quarter of a mile apart.

The "Omnifex" System of Sewer Ventilation.—This system consists of special ventilating columns, combining in one column a fresh-air inlet and a foul-air outlet, and has been

* "The Surveyor," vol. xxxi., p. 37, January 11th, 1907.

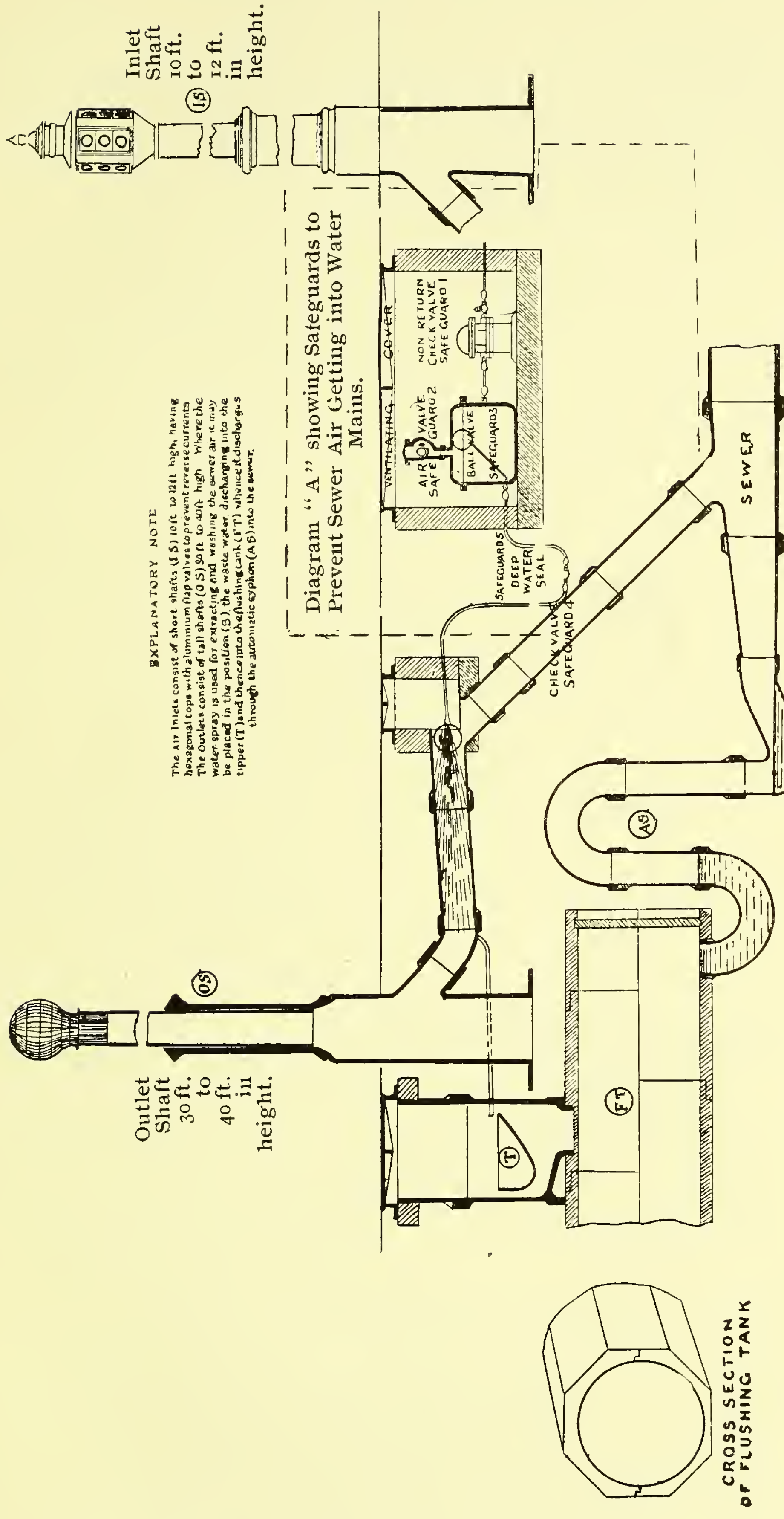


Diagram "B" showing King's Norton System of Sewer Ventilation in combination with Suggested Water Spray Extractor and Automatic Flushing Tank.

FIG. 5.

introduced by Mr. William E. Farrer, of Star Works, Cambridge-street, Birmingham.

Each column consists in the lower part of a tube cast within a tube, the outer portion being divided vertically by partitions running the entire length and terminating in a bonnet, which is

FIG. 6.

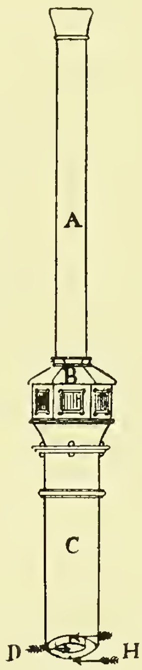


FIG. 7.

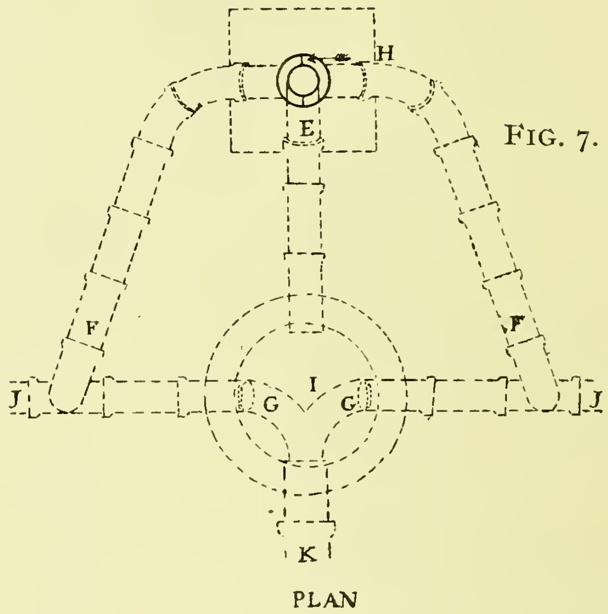
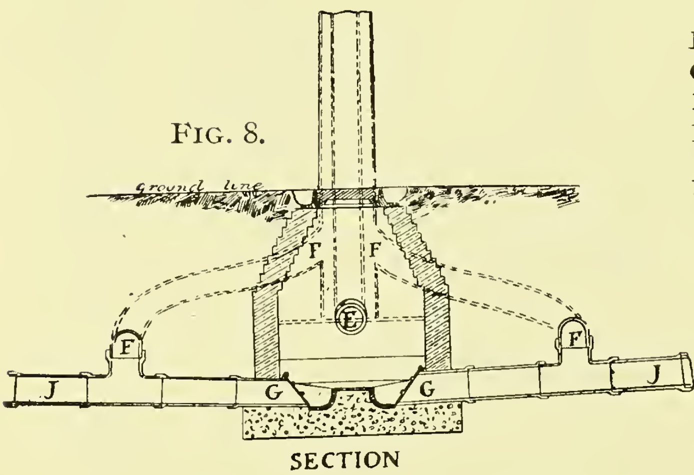


FIG. 8.



A —Inner Tube as extended above bonnet
B —Bonnet, with Aluminium Flap.
C —Outer Tube.
D —Inner Tube
E —Inner Tube passing through outer to connect manhole
F —Branch Connections from Outer Tube carrying fresh air into drain
G —Flap Valves fixed in line of drain
H —Webs cast in forming sub-divisions in Outer Tube
I —Manhole.
J —Drain connected to Vent Shaft
K —Main Drain from Manhole

THE "OMNIFEX" SYSTEM OF SEWER VENTILATION.

fitted with a series of aluminium flaps and gratings forming fresh-air inlets. The inner portion, which at its lowest point is extended through the outer, constitutes the connection to the manhole which it is proposed to ventilate, and thus forms the foul-air outlet. The inner portion has no connection with the outer, but passing right through it is continued to a greater height by means of cast-iron or steel extending tubes.

One of the methods in which the ventilator can be applied to the sewer is shown in the illustration Figs. 6, 7 and 8. Each half of the outer column has a branch leading right and left of the sewer, as shown; but three or four drains can be connected to one column by enlarging its area and subdividing the outer portion with a corresponding greater number of branches. While the pressure of the atmosphere from without causes the aluminium flaps in the bonnet to open, it also causes fresh air to pass down the outer portion of the column into the sewer, and drives the foul air and sewer gas along a section of the drain until it reaches the next shaft of the series, when it is drawn through the inner tube and passes away. Should a down-draught occur through the inner tube and a pressure be thereby exerted through the outer portion against the aluminium flaps, they are at once closed by this pressure, and the foul air cannot escape except by its proper channel.

In connection with this arrangement a special flap valve has been designed, which, being fixed at the open ends of the inlet drains connected to manholes thus ventilated, and swinging easily and lightly in sections (the flaps being formed in two or more pieces), effectually prevents the sewer gas passing beyond the outlet shaft connected to such manhole, but at the same time does not impede to the slightest extent the flow of the liquid, however small, passing along the drain, whilst the movement of the sections forming the flap is such that air currents from behind can easily pass into the manhole, and thus up the extractor, but cannot pass from the manhole into the drain.

This system of sewer ventilation has been in actual operation for upwards of three years, and is said to be giving unqualified satisfaction.

It is said to possess the merits of:—

(1) Extreme simplicity.

(2) The ready subdivision of a system of sewers into separate sections for the purposes of ventilation.

(3) The ventilation of one section is not affected by the ventilation of another section.

(4) The absolute impossibility of foul air and sewer gases escaping at the street level.

(5) The ready means of ascertaining and ensuring the efficient working of the system.

The cost is given by the maker at £20 for each column complete, including shaft 20 ft. in height overall from ground level 10 ft. to top of bonnet, diameter of inner tube 6 in.

The inner tube can be extended to any height by extending lengths, price 5s. per lineal foot.

Special flap valves, for use in connection with the above, with cast-iron socketed pipe at back of same, sectional flaps with brass pins and bushes :—

6 in., £2 10s. each. 9 in., £3 10s. each.

The "Omnifex" system has been adopted by the authorities at Trowbridge in connection with the ventilation of the town sewers.*

* "The Surveyor," vol. xxx., p. 151.

CHAPTER IV.

SEWER VENTILATION BY ARTIFICIALLY-PRODUCED AIR CURRENTS.

NUMEROUS appliances have been invented, tried and abandoned, having for their object the extraction of foul air from sewers.

It would be unprofitable to even refer to many of these inventions, most of which appear to be so perfectly sound in theory, but as soon as they have been put to a practical test have been found to result in nothing but disappointment.

Ventilating valves, such as Sugg's Continuous Up-draught Ventilator, Cregreen's Air Inlet Valve, and many others, have been tried in vain.

Many cowls, fixed on the tops of pipe ventilating outlets, including Banner's, Boyle's, Buchan's, Hellyer's, Kite's, Stevens' and others, both outlet and inlet, have been tried extensively, but the generally expressed experience of those who have tried them is that the outlets of ventilating pipes are better without them than with them, and that the usual result of a cowl of any kind is to materially and detrimentally affect the very purpose for which it has been put up.

The result of all these trials has been that scarcely any air valves or cowls are now in use anywhere.

The application of heat in order to produce an induced current of foul air from the interior of the sewer, and to cremate the foul gas before it passes into the outer atmosphere, has been tried with some measure of success.

Among the earliest apparatus on the above lines was the Ventilating Column invented about 1887 by Messrs. Holman & Keeling. It consisted of an iron column connected to the sewer by ordinary earthenware pipes, somewhat in appearance like a lamp column, with an ordinary street gas lantern at the top. Openings were made into the column a little below the level of the lantern. An atmospheric gas burner was placed in the base of the column, and above this burner was a system of inverted iron cones and fluted passages. The sewer air entered at the base of the column, and passed up through and around the burner and inverted cones and fluted passages, heated by the gas consumed at the burner to a temperature of 630 deg. Fahr.

It was claimed that all germs were destroyed by contact with the heated cones and passages before escaping into the atmosphere.

The burner consumed about 6 cubic feet of gas per hour, and the cost for gas was from £5 to £6 per annum.

It may be not unprofitable to take the recorded evidence of experts who have had experience of ventilating gas lamps.

Mr. W. N. Blair, when Borough Surveyor of Bootle, erected one of Holman's Sewer Ventilating Columns. He found it to be passing from 2,430 to 2,640 cubic feet of air per hour. The velocity in the shaft was 235 ft. to 260 ft. per minute, and the cost was £10 to £12 per annum for gas. With plain 6-in. pipe shafts he got quite as much result as from a Holman Column, without any cost for gas.

In a further set of trials in London, in 1893, Mr. Blair got practically as much air extracted without gas as with it.*

Mr. O. C. Robson, of Kilburn, found on experiment that he was getting a better velocity with an ordinary upcast shaft than with a Keeling Destructor. It was very expensive and very unsatisfactory.†

Mr. Lemon, of Southampton, had the same experience as Mr. Robson.

Mr. A. E. Collins (Reading) erected fourteen Keeling's Sewer Gas Destructors in 1890. In other parts of the borough 6-in. pipes were erected against houses, or 9-in. standards were fixed in the streets. The latter system proved itself to be quite as satisfactory as the Keeling Destructors, without the heavy expenditure necessitated by the latter apparatus for gas.‡

Mr. Thomas Walker, of Croydon, has stated that he put up one of Keeling's Destructors which was well tried, with results far better than any other. It was placed on high ground, on the apex of a 9-in. sewer, and on the 6-in. pipe connected with it an anemometer was placed for many weeks, registering the speed of air passing from the sewer to the destructor. The average was 1,507 cubic feet per hour, with 8 cubic feet of gas consumed in the burner, and the temperature of the air inside the column, 4 in. above the burner, was 190 deg. Fahr. (April, 1890). At the same time, anemometers placed in ventilation pipes in various parts of the borough gave an average of 1,852 cubic feet per hour.§

Mr. George B. Carlton (Beckenham) found he could get the

* "Proceedings of the Association of Municipal and County Engineers," vol. xxiv., p. 74, 1898.
† "Proceedings of the Association of Municipal and County Engineers," vol. xxiv., p. 275, 1898.
‡ "Proceedings of the Association of Municipal and County Engineers," vol. xx., p. 130, 1894.
§ "Proceedings of the Association of Municipal and County Engineers," vol. xvii., p. 9, 1890.

FIG. 9.
WEBB'S SEWER VENTILATING LAMP AT BLACKPOOL.

same result from an upward shaft as Keeling gets from his destructor without the additional expense of burning gas. "Sewers can be ventilated by pipes without introducing the burning of gas." *

Mr. H. H. Humphries (Erdington) says: "Good gas lamp ventilators are undoubtedly useful for fixing at isolated points where it is difficult or undesirable to erect a shaft."†

The Webb System of Sewer Ventilation or Sewer Ventilating Lamps.—One of the most satisfactory of the heat extractors and destructors is that invented and patented by Mr. J. E. Webb, C.E. (The Webb Lamp Company, Limited, 11 Poultry, London, E.C.).

"This apparatus (according to the inventor), although having the same appearance as the ordinary street lamp, but somewhat more substantial, is really a mechanical apparatus. The burning of coal gas, or other inflammable material, cannot be carried out except combined with oxygen, and at the same time provided with an outlet for the products of combustion of the spent gases to pass away. The construction of the Webb Lamp facilitates the burning of coal gas or oil fuels with the greatest possible consumption of oxygen per unit of the combustible material, whether coal gas or oil, generating the maximum amount of heat contained in the material consumed, and at the same time giving the full amount of light contained therein, while the products of combustion, or unconsumable gases, pass away freely without allowing the escape of heat until it has accomplished its intended work, and also creating a continual partial vacuum between the point of combustion of coal gas or oil in the apparatus itself, thereby making a powerful extractor. It is only necessary to connect the apparatus by a hermetically sealed tube to sewer, sewage tank, or underground convenience or building, and thereby draw away the air at any given point. The rays of light and heat are caught on reflectors, one at the top and one at the bottom of the apparatus. These are made concave at such an angle that every ray of light passing upward or downward from the burners will strike on the reflector, and thus pass through each other. The top reflectors being the most powerful, the sewer gases are forced up through this cone of heat and light. The top reflector is contracted to an outlet of about 3¼ in. in diameter. The sewer gas or air drawn into the apparatus has to pass through this superheated cone of air, which maintains an

* "Proceedings of the Association of Municipal and County Engineers," vol. xvii., p. 20, 1890.
† "Proceedings of the Association of Municipal and County Engineers," vol. xxix., p. 183, 1890.

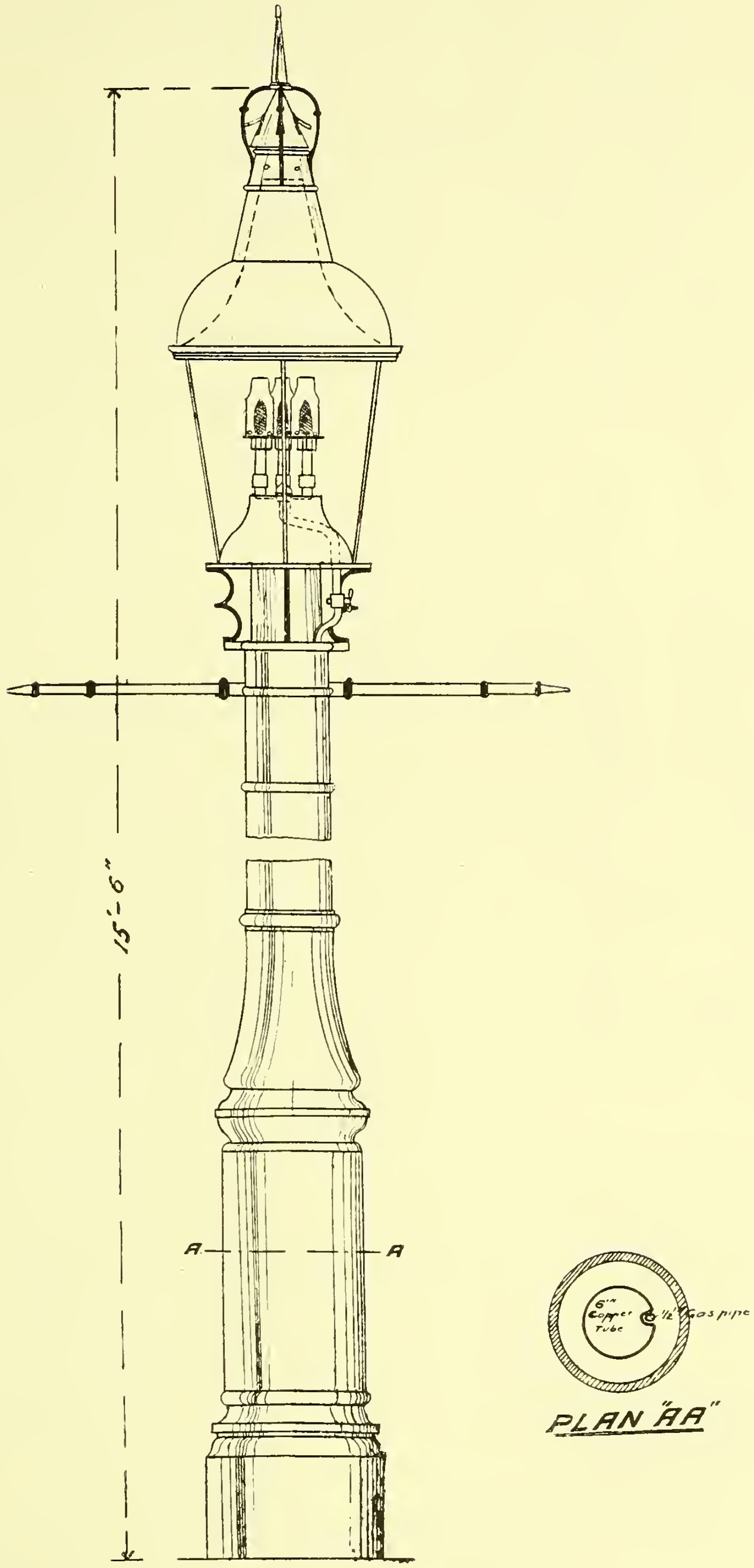


FIG. 10.
WEBB'S SEWER VENTILATING LAMP, BLACKPOOL.

equal temperature of approximately 550 deg. Fahr. for the last 12 in. before it reaches the outlet, thereby ensuring the splitting up and destruction of every molecule of combustible gas or organic matter.

"The top part of the lamp is made of two steel cones, hermetically sealed top and bottom, forming an air-jacket with about 4 in. between the two cones in the centre, thus preventing the escape of the heat from the inside by radiation.

"The whole of the apparatus is circular to counteract unequal expansion and contraction in inclement weather. The glass is specially treated to withstand the rapid changes of temperature when the gas is turned out.

"This apparatus possesses several new features:—

"(1) Convection of rays of light and heat by reflectors, and thereby producing 'convex rays.'

"(2) Destruction of organic matter by focussing heat rays on them.

"(3) Conservation of heat by air or pneumatic isolation.

"So pronounced is the reflection that a photograph taken in daylight shows the cone of reflected light from the point of combustion to the base of the top reflector.

"There is no possibility of organic matter or foul gases passing through the apparatus without being destroyed, from the fact that it does not rely on actual contact with heated surface, but is forced through superheated space."

Four of Webb's Ventilating and Destructor Lamps, as shown in Figs. 9, 10, 11 and 12, have been installed, under the Author's supervision, at Blackpool. They are as follows:—

No.	Lamp.	Diameter of Sewer in inches.	Length of Sewer in Lineal Yards.	Number of Manholes.	Number of House Connections.	Cubic Capacity of Sewer.	Gradient 1 in
						Cubic feet.	
1.	Highfield-road...	15	717	12	208	2,640	286·17
2.	Abbey-road ...	15	800	11	48	2,945	500
3.	Middle-lane ...	15	807	10	13	2,970	350
4.	Hawes Side-lane	{ 600 yds. 15 } { 325 yds. 18 }	925	9	47	{ 2,209 } { 1,723 }	500
						3,932	

FIG. 11.

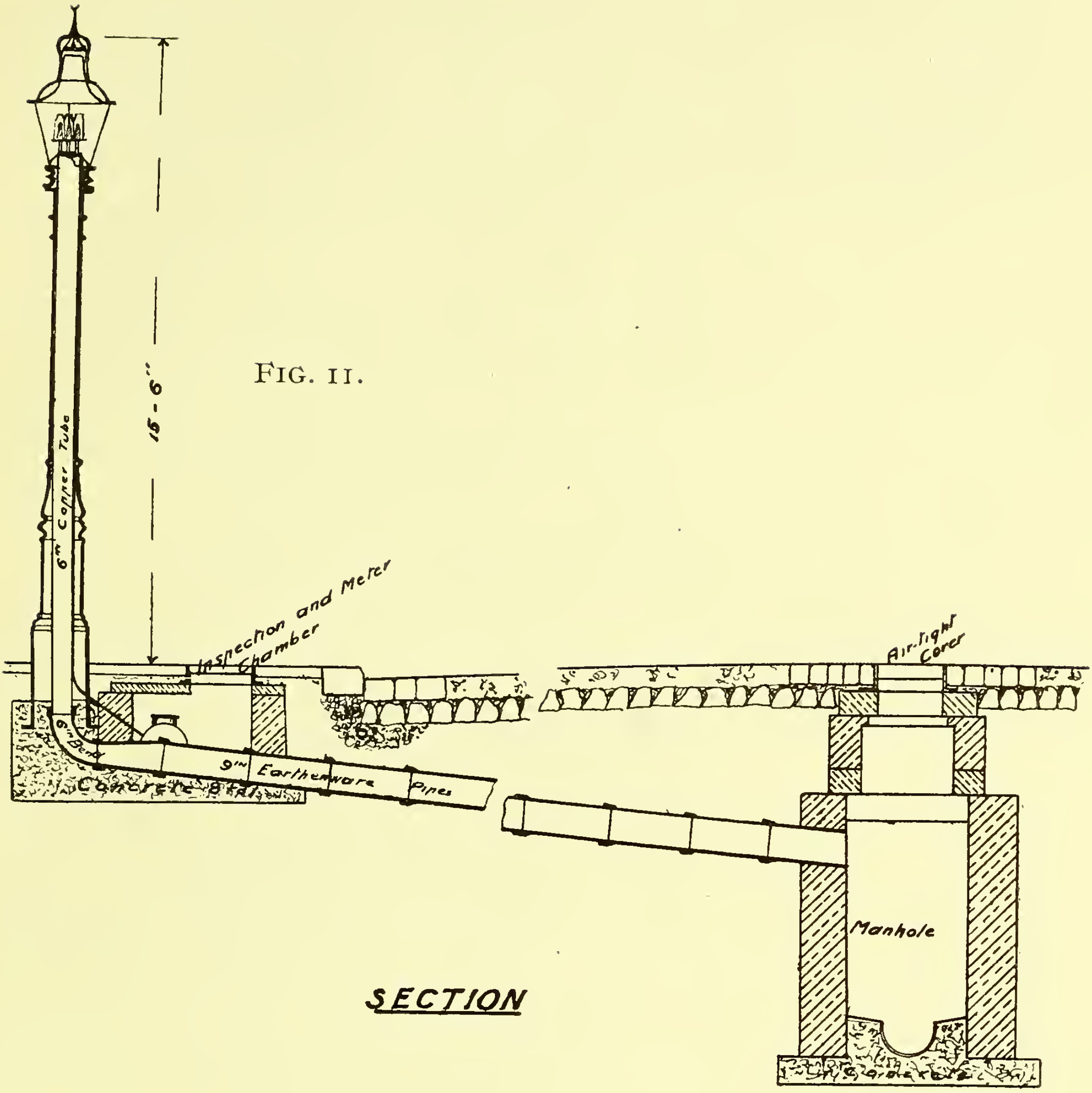
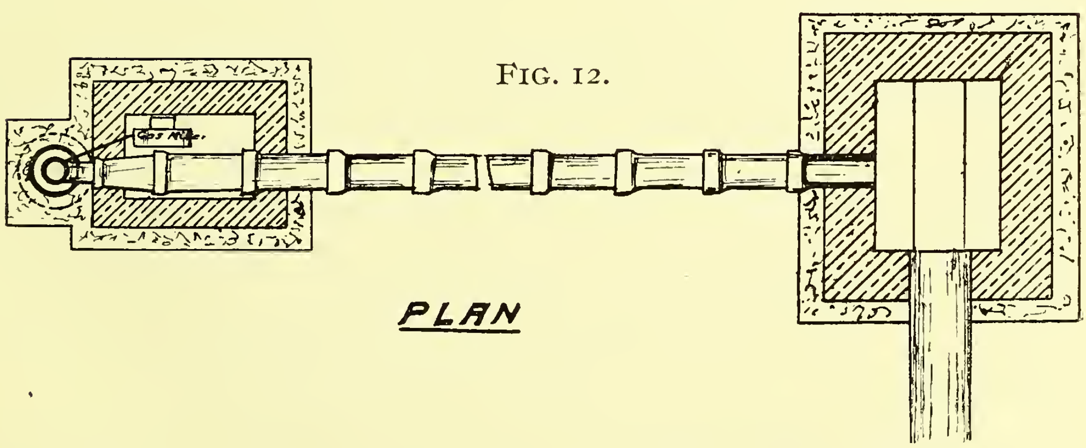


FIG. 12.



WEBB'S SEWER VENTILATING LAMP, BLACKPOOL.

The cost of installing the ventilators was as follows:—

	£	s.	d.
Four lamps complete, delivered at Blackpool	80	0	0
Laying gas on to same	4	1	11
Erecting and connecting to sewers	31	18	10
Total	£116	0	9

Average cost of one ventilating lamp complete, £29 nearly.

Annual Working Cost for Four Ventilating Lamps.

	£	s.	d.
Corporation gas: 397,383 cubic feet at 2s. 4d.	46	7	2
Mantles and chimneys	5	4	7
Attendance, repairs, painting, etc.	8	4	1
Depreciation, 10 per cent on £116	11	12	0
	71	7	10
Deduct credit for street lighting	5	0	0
Net cost per annum	£66	7	10

Average cost for one lamp, £16 11s. 11d.

Messrs. Shone & Ault's Hydro-mechanical System of Sewer Ventilation.—This system is based on the principles which have been in successful operation for many years in the ventilation of mines. The air is extracted from the sewers by means of a fan, driven electrically or otherwise, and the admission of fresh air into the sewers is rigidly controlled at all openings leading into the sewers. By this means only sufficient fresh air is drawn into the sewers to keep the air in the sewers wholesome and free from danger, and the amount of vacuum caused by the fan is so graduated as to avoid any possibility of destroying the water-seals in the house drain intercepting traps.

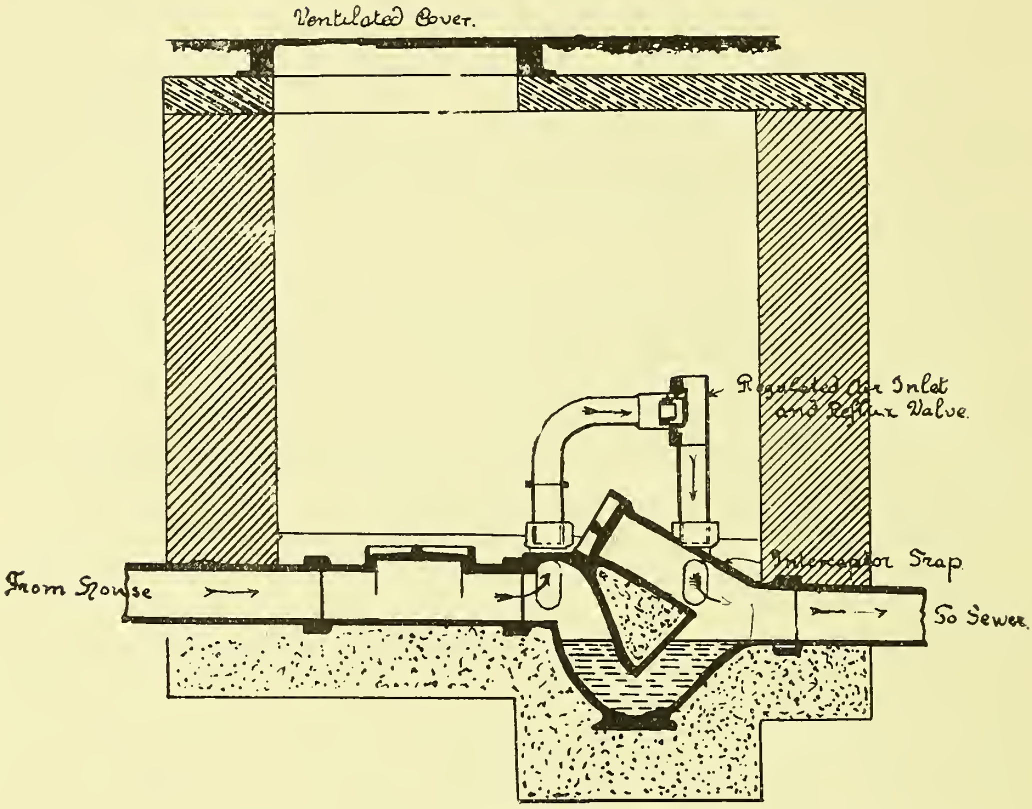
The following description of the details of the above system of sewer ventilation is abstracted from a Paper read by Mr. Shone before the Annual Meeting of the Association of Municipal and County Engineers held at Liverpool in June, 1907, and reported in the "Proceedings" of the Association (vol. xxxiii., page 354):—

"The system has been called the 'hydro-mechanical' system because, as its name implies, mechanical power is employed to drive a fan for the purpose of creating vacuum or air-exhausting power, as is done in connection with the ventilation of mines; and the natural plenum power that is created by water-closet discharges falling down soil pipes is also to be utilised on the hydro-mechanical system to augment, as much as possible, the volumes of air that will be drawn down the soil pipes into the drains, and through these into the sewers, by the exhaust action of the fan, wherever the ventilated interceptor traps will be in use.

"The adoption of the hydro-mechanical system of ventilation will practically involve the reversal of the existing methods, but that, notwithstanding this radical change, it can be readily adapted either to existing old, or to proposed new, drainage and sewerage works, whether such works are on the 'dual,' or 'combined,' or on the 'separate' system.

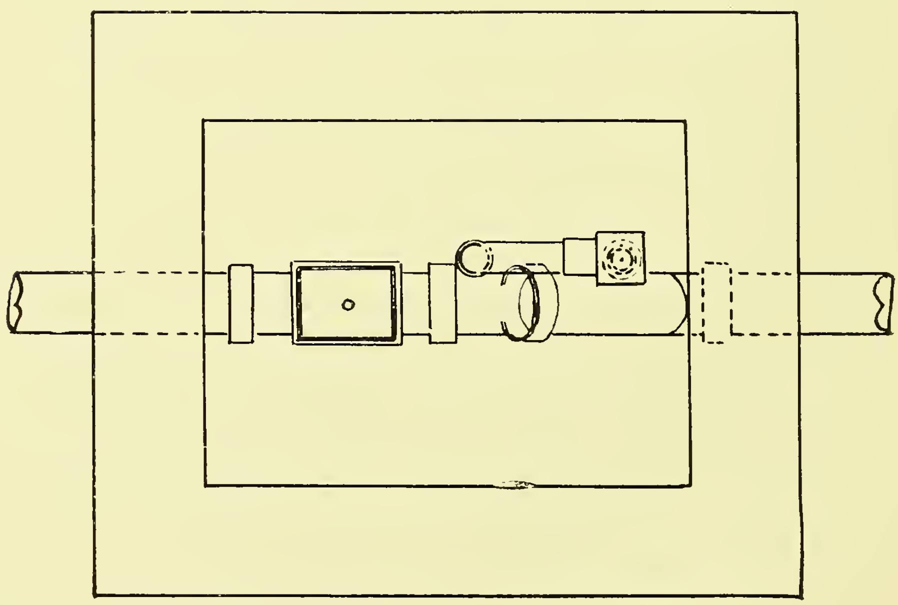
"A fan and motor (steam, gas, oil or electrical power) can be built and fixed in a chamber above or below ground, at some convenient place, with an air-purifying or filtering chamber attached (see Fig. 20). It would then be necessary to provide and fix as many of the special interceptor traps (see Figs. 15, 16, 17 and 18) as there would be house drains to be ventilated by them; also a like number of small special regulated air inlets would be required in connection with the ventilation of house drainage work. Again, in order to ventilate the pipe which carries the surface waters from the street gullies into the sewer, as many special regulated air inlets (see Fig. 19), having automatic aluminium reflux valves attached to each, should be provided and fixed as may be most convenient; the number of these latter to correspond to the number of gully drains to be ventilated. It is intended (see Figs. 15 and 16) to fix the special ventilated interceptors in ordinary house drain manhole chambers, having perforated entrance covers, to permit of free ventilation in the chambers; also the drains and intercepting traps to be laid on the inverts of the ordinary manhole chambers in question ought to be wholly covered, and made air and water tight. That part of the drain pipe which joins the interceptor on the house side of the latter should have a movable airtight cover fixed over it for inspection purposes, as shown by Fig. 17 (page 53).

"The improved interceptor shown by Figs. 15, 16, 17 and 18 not only permits of the sewage water-seals on both sides of it to be ventilated, but also permits the air on the house side of it to pass over it into the drain on the sewer side of it to ventilate it.



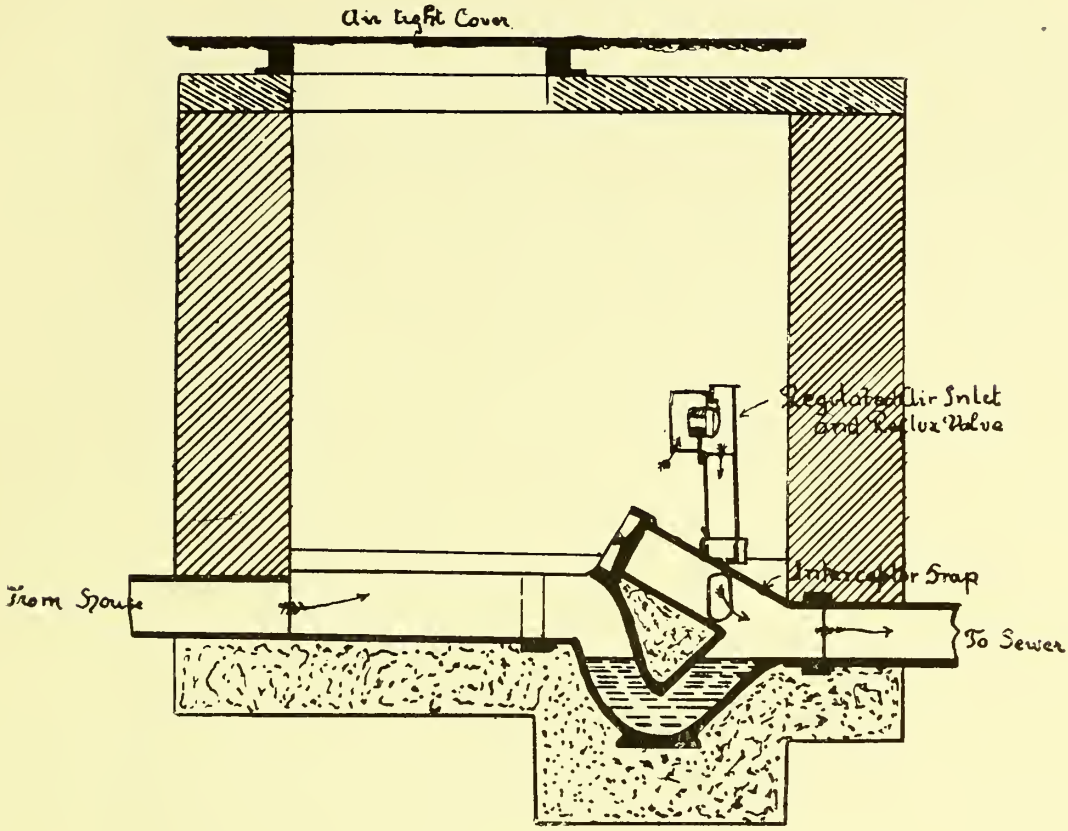
Section.

FIG. 15.



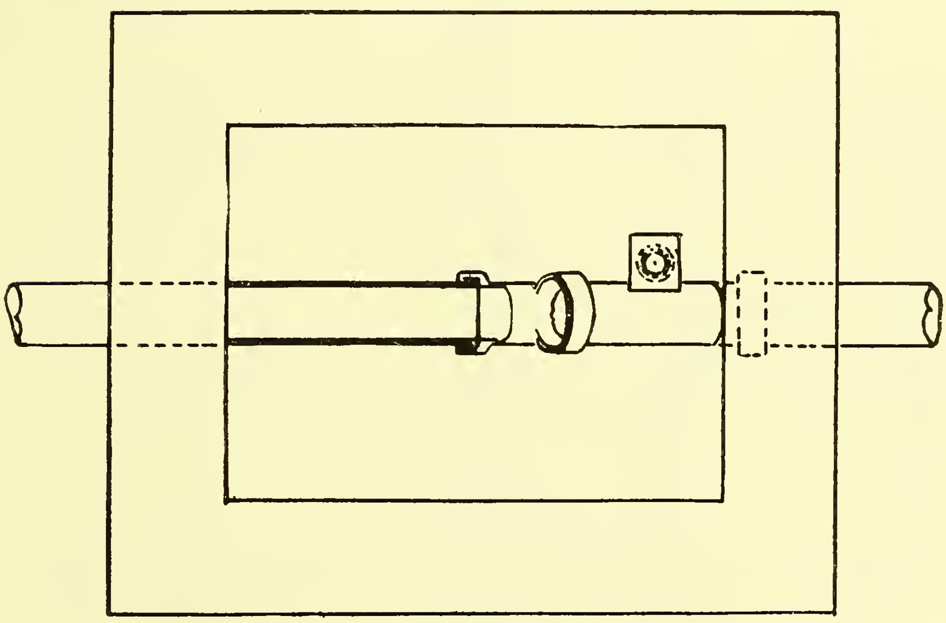
Plan.

FIG. 16.



Section.

FIG. 17.



Plan.

FIG. 18.

"In order to ventilate the drain on both sides of the interceptor two small and short pipe openings are inserted in the body of the interceptor itself, well above the level of the trap waters on either side of it; these pipe openings have socket terminals in which are fixed air pipes of the shape and form shown in Figs. 15 and 16. One of these air pipes—the one which stands perpendicularly in its socket on the sewer side of the interceptor—has a special cap piece at its upper end, and to this is fitted a very sensitive and mechanically precise aluminium reflux valve, which opens freely when the current of air flowing from the house drain is sufficiently strong to compel it to do so; but which, on the other hand, when plenum actions take place in the sewer instantly closes again. By the aid of this simple sensitive reflux valve the foul air of the sewer can be prevented from gaining access to the house drain, on the house side of the interceptor, as effectually, sanitarily speaking, as it can be by the interposition of the water-trap of an efficient interceptor.

"The hinged valves used are made (see Figs. 15 and 16) in the form of spherical segments, with their concave sides resting against the valve seating. The valves are carefully stamped out of thin sheet aluminium, and ground true to their seatings so as to be quite airtight, and they are accurately suspended from pointed screws and balanced so as to open and shut with the least movement of air; and as aluminium is very light and strong, and is not oxidised by air and not attacked by sulphuretted hydrogen, carbonic acid or hydro-carbon gas, its durability and uncorrodible character may be relied upon.

"Figs. 17 and 18 are facsimiles of Figs. 15 and 16, so far as the shape and make of the house drain manhole chamber is concerned, but in Figs. 17 and 18 the iron entrance cover is made air and water tight, and the drains within the manhole chamber which carry sewage from the house to the interceptor are open and semi-circular in shape. The body of the interceptor, too, in this chamber, although identically the same as the interceptor shown in Figs. 15 and 16, has only one air opening in it, and the hood piece at the top of the perpendicular air pipe—which is in communication with the interceptor, and in which the regulated air-inlet piece and the aluminium reflux valve are fixed—is so designed that the air of the manhole chamber can readily enter it to ventilate the drain on the sewer side of it."

The arrangement shown in Figs. 17 and 18 is intended to be applicable to ordinary manholes with exposed inverts and closed

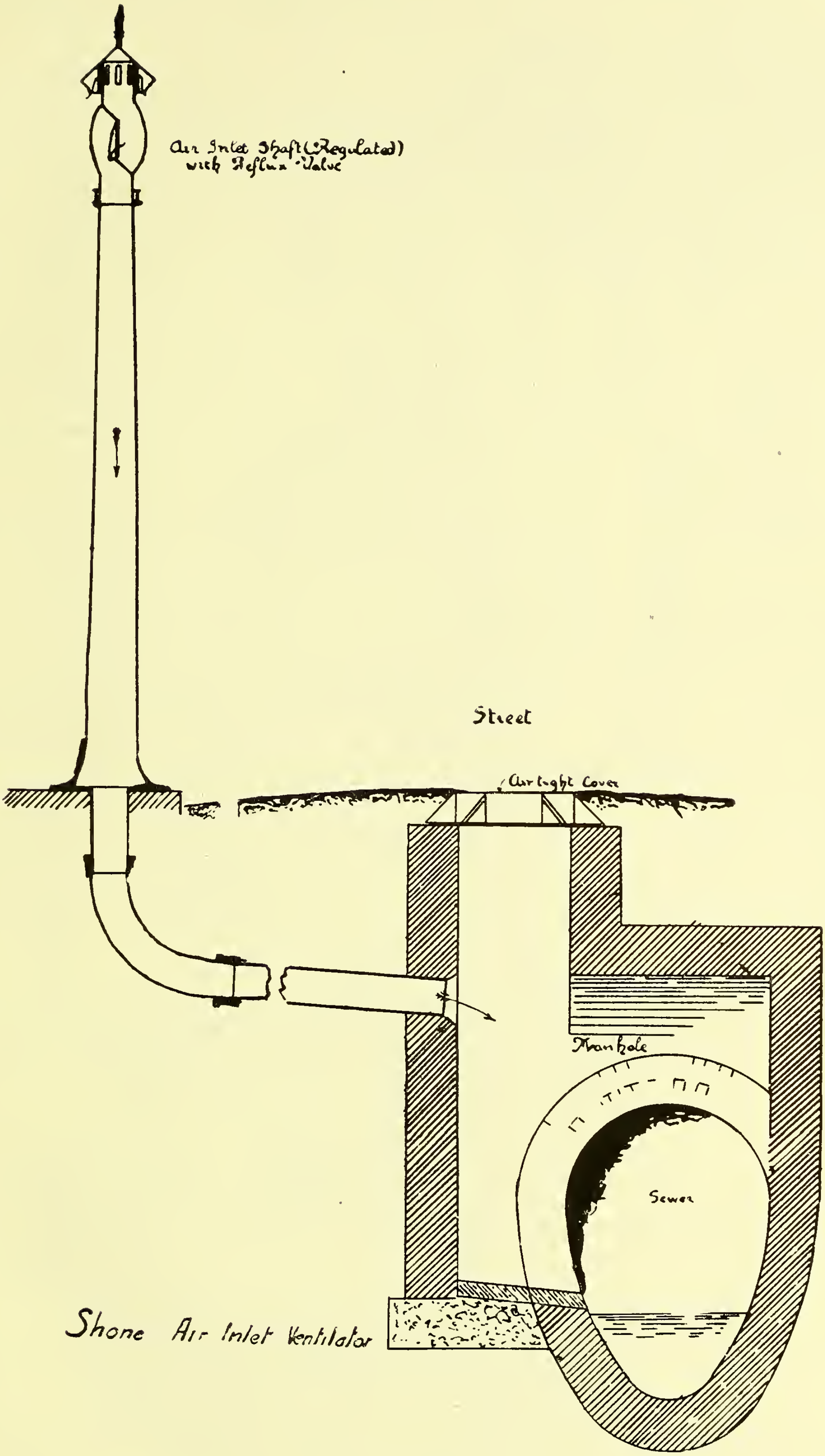

Air Inlet Shaft (Regulated)
with Reflux Valve
Street
Airtight Cover
Manhole
Sewer
Shone Air Inlet Ventilator

FIG. 19.

covers, but the arrangement much preferred by Mr. Shone is illustrated by Figs. 15 and 16.

By the adoption of the latter system the soil and other waste pipes connected with the interceptors and drains, and with the sewers as well, would then be ventilated, partly by the air which would be forced by water-closet and bath discharges down the soil and other waste pipes into the drains and sewers, and partly by the air that would flow by gravitation down the soil and other pipes into the sewer, whenever the air in the latter was of a lighter specific gravity than that of the outside atmosphere surrounding the roofs and the tops of the soil and other pipes. These latter would then act the part of downcast shafts, and the sewers themselves would become equivalents of upcast shafts on the principle upon which furnace ventilation is brought about in mines—*e.g.*, if the temperature of the air of the sewer became, as it would do at times, 10 deg. Fahr., more or less, higher than the air of the drain on the house side of the interceptor, then undoubtedly a current of air would be induced to flow from the drains on the house side to the drain on the sewer side of the interceptor. If this latter be 30 ft. long to the sewer, and we treat it as a chimney or upcast shaft of that length terminating in the atmosphere outside and not in the atmosphere inside of a sewer, then the velocity at which the air would flow to the sewer through the regulated air inlet opening of the interceptor would be, allowing 33 per cent for friction, about 4 ft. per second. If the regulated inlet be circular in shape, and 1 in. in diameter, the volume of the ventilating current would be equal to 1·32 cubic feet, or 8¼ gallons, per minute.

The power required to move the air by means of a fan can be found approximately, when the size of the delivery pipe is known, from the following formula, which is for fans of good design:—

$$\text{B.H.P.} = \frac{u^3 \times a \times \sqrt{1 + h}}{250{,}000}$$

Where u = Velocity of air through delivery pipe of fan in feet per second.

a = Area of delivery pipe, in square feet.

h = Total pressure against the fan (suction and delivery), in inches of water.

In regard to cost, two separate egg-shaped sewers—3 ft. by 2 ft., each to be 2 miles long, or 4 miles altogether, flowing two-

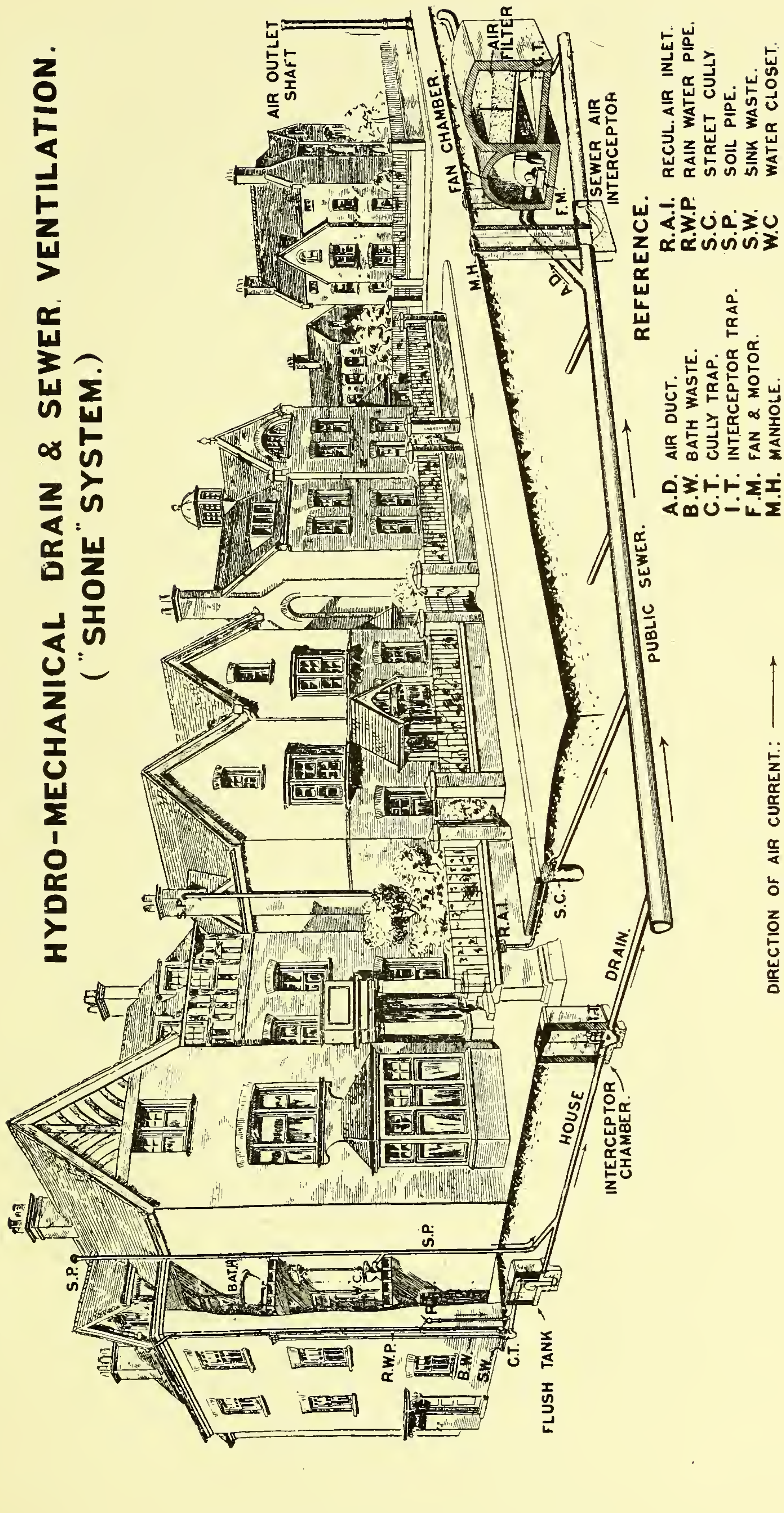

HYDRO-MECHANICAL DRAIN & SEWER VENTILATION.
("SHONE" SYSTEM.)
AIR OUTLET SHAFT
AIR FILTER
FAN CHAMBER.
SEWER AIR INTERCEPTOR
F.M.
M.H.
A.D.
PUBLIC SEWER.
DRAIN.
HOUSE
INTERCEPTOR CHAMBER.
R.A.I.
S.C.
S.P.
BATH
W.C.
R.W.P.
B.W.
S.W.
C.T.
FLUSH TANK
REFERENCE.
A.D. AIR DUCT.
B.W. BATH WASTE.
C.T. CULLY TRAP.
I.T. INTERCEPTOR TRAP.
F.M. FAN & MOTOR.
M.H. MANHOLE.
R.A.I. RECUL. AIR INLET.
R.W.P. RAIN WATER PIPE.
S.C. STREET CULLY
S.P. SOIL PIPE.
S.W. SINK WASTE.
W.C WATER CLOSET.
DIRECTION OF AIR CURRENT.:

FIG. 20.

thirds full of sewage, and having 1,408 house drains and 282 street gully drains connected to them, and for each connection to contribute half a cubic foot of fresh air into them, plus 50 per cent as an allowance for leakages—could be efficiently ventilated by a fan requiring one-fifth of a horse-power to drive it; and the cost of power in the case of a motor using about 8 British thermal units of electrical energy, at, say, 1d. per British thermal unit, would be 8d. per day only, or at the rate of 1d. per day for 1,000 of the population, equivalent to £1 10s. 5d. per 1,000 of the population per annum. The water-gauge vacuum necessary to create to effect the ventilation would be under 1 in. at its maximum—*i.e.*, at the fan; and the plenum necessary to force the air through the filter and up the outlet into the atmosphere would be equal to about ½ in., or 1½ in. of water altogether. But at no house drain interceptor, or street gully trap, would the vacuum caused by the working of the fan required to ventilate the two separate hypothetical egg-shaped sewers (each to be 2 miles in length, and both to converge at or near to the fan chamber) exceed half an inch of water, and consequently there need be no fear whatever that any of the traps named would be unsyphoned.

Mr. A. M. Fowler, M.INST.C.E., in a Paper read at the Manchester Congress of the Sanitary Institute in September, 1902, apparently quoting from figures which had been supplied to him, states that the cost of the electrical energy alone, at 3d. per Board of Trade unit, amounts to £5 17s. 10d. per 1,000 of the population per annum.

Mr. E. G. Mawbey, M.INST.C.E., Borough Engineer of Leicester, in a Paper read at a meeting of the Association of Municipal and County Engineers in July, 1904, states as the result of actual experience at Leicester that the electrical energy at 1d. per unit amounted to £8 3s. 11d. per 1,000 of the population per annum for a population of 356 experimented upon, but admittedly the air was changed in the sewers an excessive number of times during the experiment referred to, and Mr. Mawbey states that probably satisfactory results could be obtained at an expenditure of £2 7s. 6d. per 1,000 of the population per annum for electrical energy.

CHAPTER V.

DEODORISATION OF SEWER AIR OR SEWER GAS.

MANY devices have been tried, from about the year 1866 until the present time, to purify, or at least to render harmless, the foul odours emanating from sewer manhole openings. Most people have felt what was so happily, if somewhat sarcastically, expressed by the late Mr. Wm. George Laws, when City Engineer of Newcastle-on-Tyne, that "the system of surface ventilators over sewer manholes as a means for securing that every person passing by shall breathe the greatest possible amount of poisonous gas is almost perfect, but as an outcome of engineering effort it is depressing."

Charcoal, sulphurous acids, dry earth, and other absorbents have been placed in the manhole or other sewer openings.

We have seen that as far back as 1862 the late Sir Robert Rawlinson advocated the use of charcoal filters.

In 1875 Mr. H. P. Boulnois, when City Surveyor of Exeter, introduced a system of conveying the sewer air through the crown of the sewer at regular intervals into earth deodorisers fixed above the crown of the sewer. Mr. Boulnois, in a somewhat humorous footnote at page 342 of his "Municipal and Sanitary Engineers' Handbook," states that in consequence of the adverse criticism of an eminent sanitary authority he "allowed the matter to drop." Many will think he would have been well advised if he had developed the principle of his patent, which was undoubtedly a good one, *pace* the "eminent sanitary authority."

In 1879 Mr. Baldwin Latham invented and patented a charcoal ventilator or trap which was extensively introduced, but which has now been almost entirely discarded in consequence of the difficulty of renewing the charcoal after it had become saturated and useless as a deodorant.

Messrs. Adams brought out a chemical deodoriser, soon after Mr. Latham's, in which the outward current of sewer air was made to pass through asbestos yarn, which was kept saturated by capillary attraction by dipping into a liquid disinfectant. This system was well tried, but experience derived from its use was not encouraging.

In 1884 Mr. Knight, then Surveyor to the Mile End Vestry, introduced a deodorising sewer ventilator practically on similar lines to that of Messrs. Adams, but using cotton wicks instead of asbestos.

Reeves' Ventilators (Reeves Chemical Sanitation Company, Limited).—The Reeves system is intended to produce artificial oxidation of the sewer air, before it escapes in the outer atmosphere, by means of apparatus placed in specially prepared sewer manholes, the other manholes being closed with airtight covers.

Two chemical-ware vessels are placed in a recess formed in the manhole. The larger vessel contains a specially-prepared mixture of dry manganate of soda, called by the proprietors "Reevezone," and the small vessel contains strong, clear sulphuric acid. These chemicals are caused to mix continuously, meeting on the ware drip, the result of their mutual reaction being the formation of sulphuric acid gas, oxygen gas, permanganic acid and soda sulphate. These gases purify the foul air they come in contact with, whilst the oxidising solution falls into the sewer and has a beneficial effect on the sewage. The water supply for mixing the "Reevezone" is taken from the water main. Where it enters the manhole a drop stop valve is fixed to the pipe, which when the pressure from the main ceases closes, and so entirely prevents air being sucked into the main. There is also another valve and a syphon of water about 3 ft. deep, which completely locks the pipes against any back pressure. Beyond the syphon a branch pipe with valve and spray is fitted, the discharge of the spray being thrown on to the three pots on which the chemicals fall after the gases are given off. The result of the water striking against the pots is that a fine spray or mist of the chemicals is produced, which in falling into the sewer purifies the gases coming up the shaft.

The cost of introducing the fifty-three sets of apparatus at Edinburgh was:—

	£	*s.*	*d.*
Three experimental apparatus, at £15	45	0	0
Fifty apparatus as per contract, at £10	500	0	0
Altering fifty-three manholes to suit apparatus, at £7	371	0	0
Total	£916	0	0

Say, £17 5s. 8d. each.

Cost of providing the necessary chemicals is from £2 to £3 per annum.*

Mr. Greatorex, at Sutton, also had experience in Reeves' system.

Mr. Harris Reeves' Latest Improved Type of Sewer Ventilator.—It is claimed for this ventilator that it is much cheaper in use than the type described on page 60.

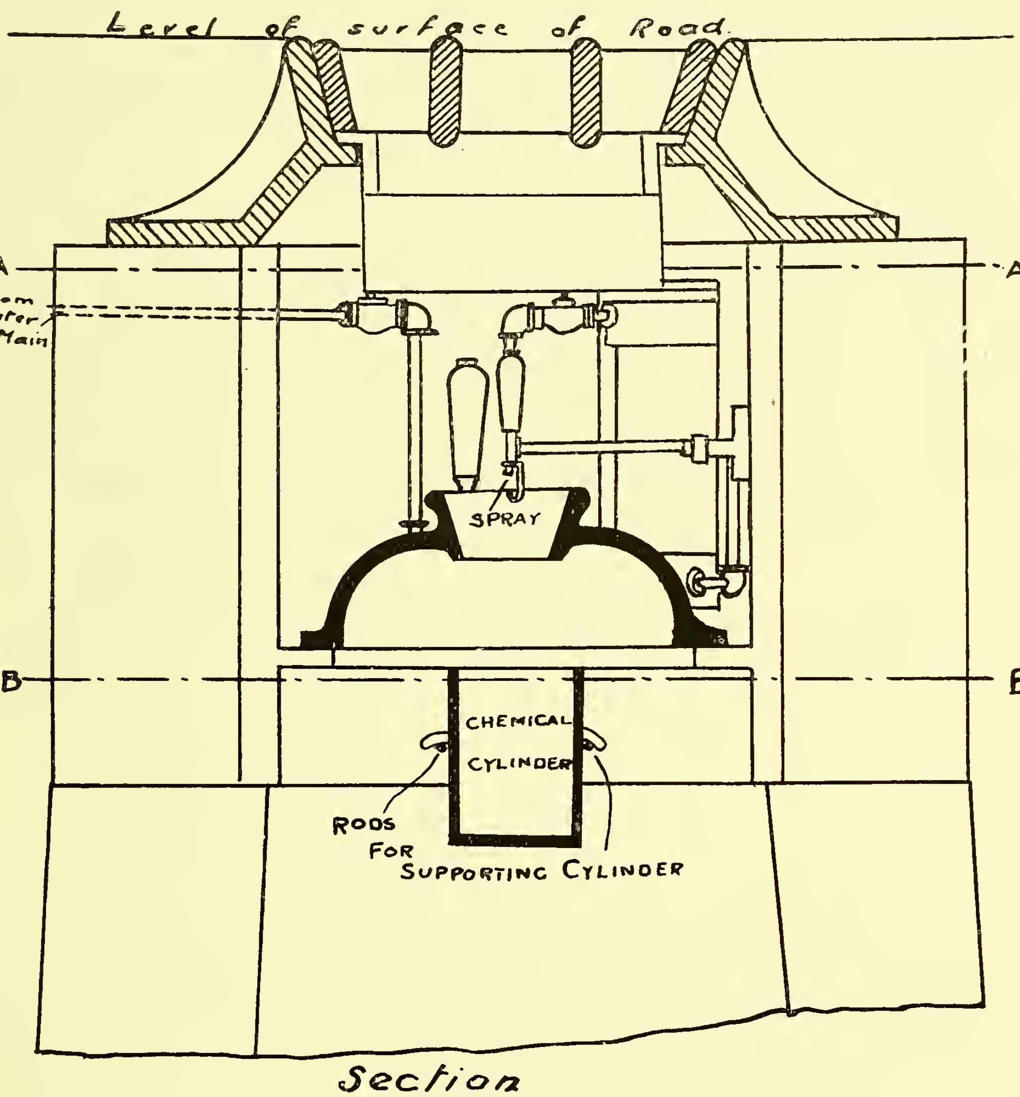


FIG. 21.

The principle upon which this improved ventilator works is the prevention of sewer gas being made by keeping up a continuous flow of saturated air through the sewer, and rendering unnecessary the work of deodorisation. It falls, therefore, more

* Paper by Mr. Alex. Stewart, ASSOC.M.INST.C.E., "Proceedings of the Association of Municipal and County Engineers," vol. xxiv., p. 269.

properly under Chapter III., but for convenience will be described in the present chapter.

"As much fresh air as possible is continually forced into the lower sewer at a pressure that will not affect the traps connected to the adjoining higher sewers, and is of sufficient weight to freely shift the heavier gases of such lower level sewer. The air from the surface is saturated with a chemical which prevents the action on the sewage that, in ordinary ventilation, produces sewer gas."

The Reeves 1908 Sewer Ventilating Apparatus is made in two patterns. Figs. 21 to 23 inclusive show a section and two plans of the apparatus as fixed in a specially-built sewer manhole, not required for the means of entering the sewer, or in a sewer manhole having a side entrance thereto. Fig. 24 shows a section of the apparatus as fixed in an ordinary sewer manhole. In the latter case each part can be easily removed in a few minutes, so as to allow entering the manhole when necessary.

The cost of working three of the above ventilators in the manholes of the deep-level sewer of the London County Council in Dawes-road, Fulham, for the year ending December 31st, 1906, is reported to be as follows :—

	£	s.	d.
388,000 gallons of water, at 6d. ..	9	14	0
Chemicals for saturation	0	18	0
Chemicals for cooling the water ..	0	12	0
Total for three ventilators	£11	4	0

$$\text{Cost of one} = \frac{£11\ 4s.\ 0d.}{3} = £3\ 14s.\ 8d.\ \text{per annum.}$$

Mr. Harris Reeves courteously informs the Author that the price of the apparatus Fig. 21 (on page 61) for sewers having side entrances is £9 each. For apparatus Fig. 24 (page 65), for ordinary manholes, the price is £10 each. Prices are f.o.r., and exclusive of fixing and laying on water supply.

For an unventilated sewer Mr. Harris Reeves considers that his apparatus should be placed at not exceeding 300 yards apart, and for sewers where ventilating shafts are already erected against houses they may be placed at not exceeding 440 yards apart.

Mr. Harris Reeves also states that in his newest apparatus the consumption of water is reduced to 230 gallons per day.

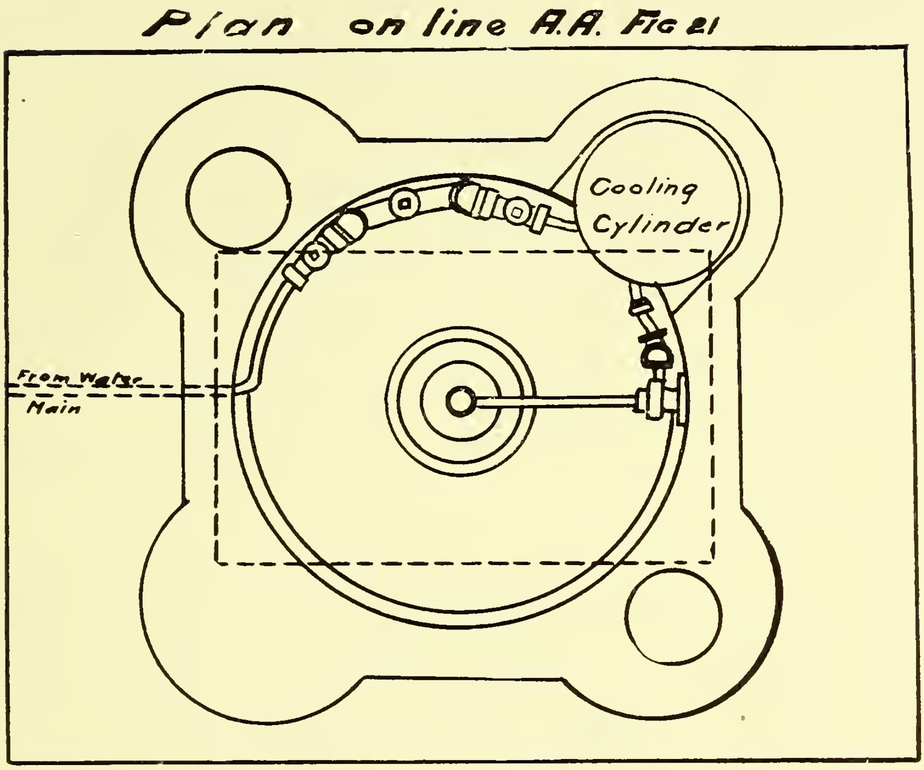

Plan on line A.A. Fig 21
Cooling Cylinder
From Water Main

FIG. 22.

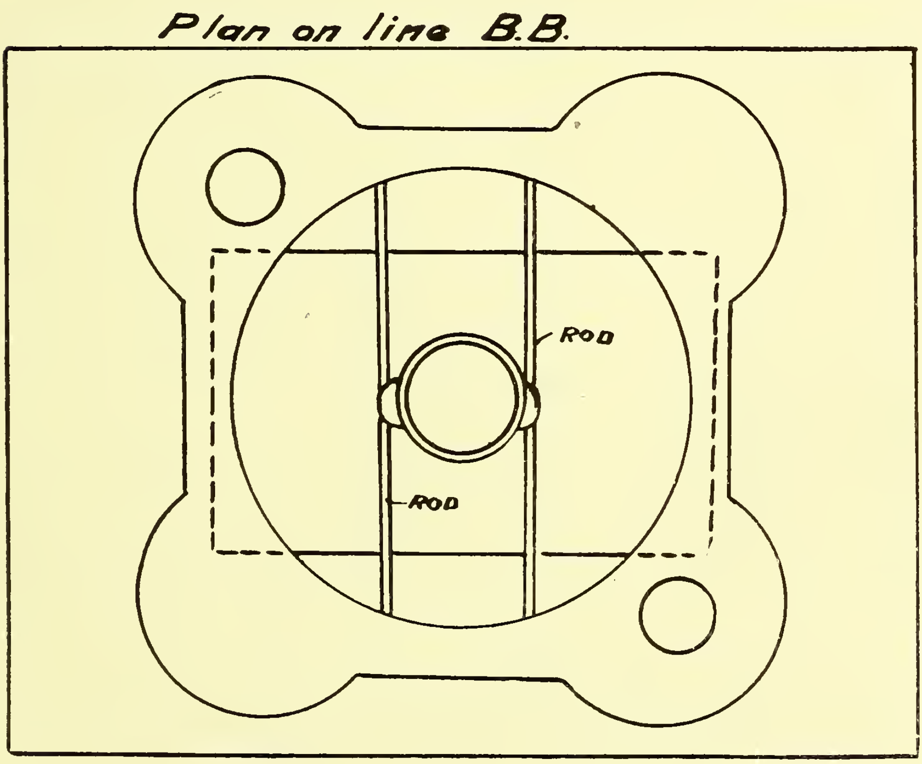

Plan on line B.B.
ROD
ROD

FIG. 23.

Caink's Sewer Ventilating Apparatus.— The object sought to be attained in the above invention was to prevent any appreciable rise in the air pressure of the sewer, and yet maintain a very slow movement of the sewer air in its exit from the ventilator. It was necessary, therefore, to distribute the outflow as evenly as possible over all the ventilators in the neighbourhood, and to exclude any active interference on the part of the wind. The air is therefore caused to pass through a layer of cotton-wool. It allows a gentle ingress and a gentle egress of the air as the conditions within the sewer required. The effect of the wind is practically excluded.

The cotton-wool also possesses the property of filtering the air in its passage through it.

During the summer months the cotton-wool remained in good condition, but in winter, when the external temperature was much below that of the sewer, the disc of cotton-wool became soddened and useless. To overcome this difficulty an arrangement was devised whereby the heat contained in the sewer air was made to raise the temperature of the cotton-wool above that of the air which warmed it. Referring to the illustration Fig. 25, A is a cylindrical casting having ribs projecting inwards for the purpose of increasing the surface of contact for absorption of heat. The lower end of this casting rests upon the ventilating shaft, which rises from the sewer; the top of the casting carries the surface grating. B is a separate casting, which is kept thermally insulated from A. The above part of this casting is also ribbed for the purpose of securing the maximum abstraction of heat; the upper part of it consists of a cylinder enclosing the layer of cotton-wool, which is supported by a grid under which is the arrangement of gills forming part of the casting. In the centre of the gills a cup is formed which, if desired, can be used to contain a disinfectant or germicide.

Upon the top of the inner cylinder rests a conical glass cover to protect the wool from water getting in from the surface.

When the air passes outwards from the sewer to the external atmosphere it first comes in contact with the inner casting, which extends a short distance down the shaft, and when the temperature of the atmosphere is below that of the sewer air the cold metal lowers the temperature of the latter, causing it to part with some of its moisture, which condenses upon the metal. The heat abstracted from the air is conducted upward by the metal, raising the temperature of the cylinder surrounding the cotton-wool, and consequently by radiation from the inner surface of the cylinder raising the temperature of the cotton-wool

Section through Manhole.

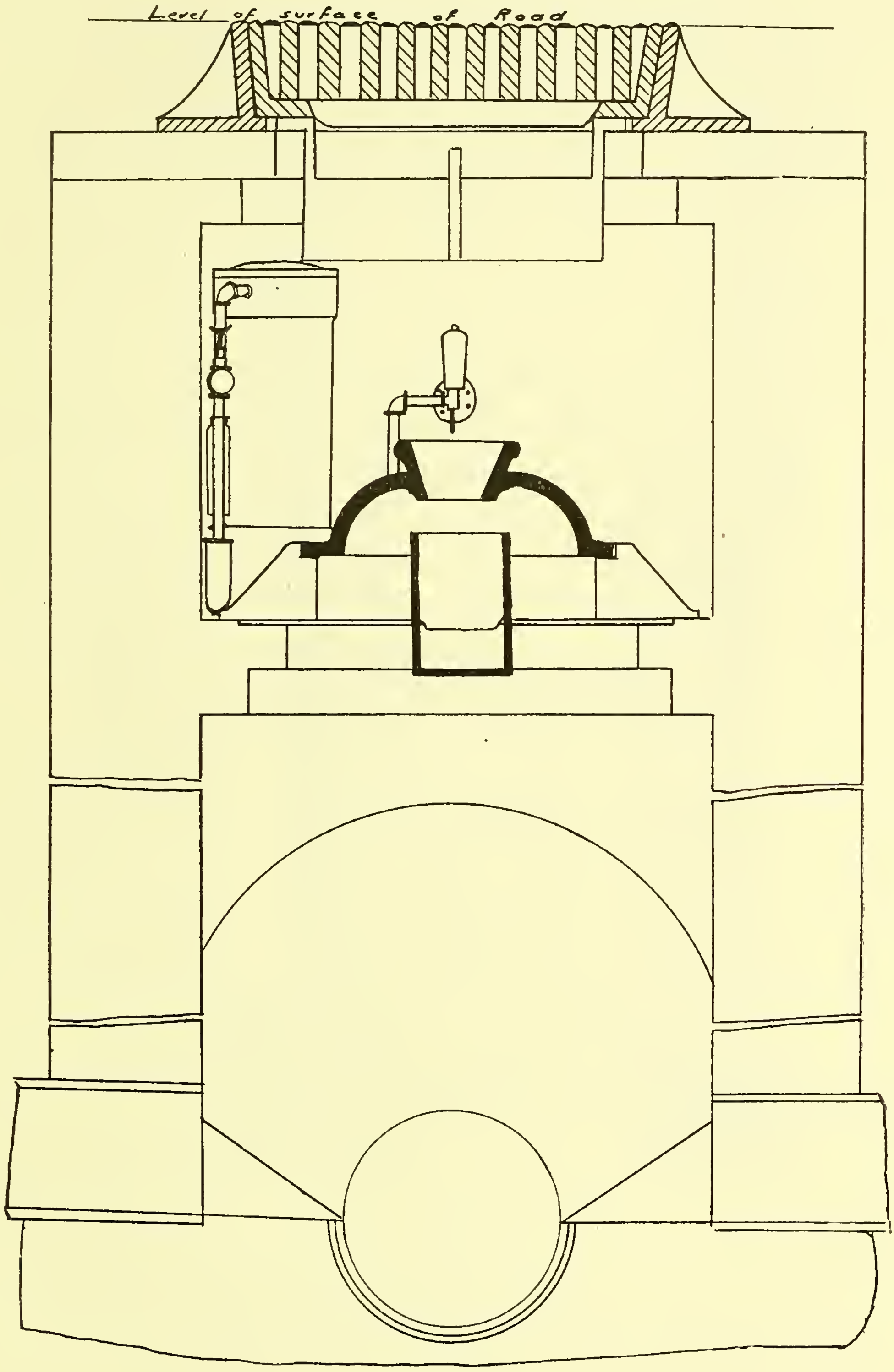


FIG. 24.

also, the outer surface of the cylinder being surrounded by non-conducting material.

The air, after playing round the lower part of the inner casting, passes into the annular space between it and the outer ribbed casting, which is in contact with the cold earth, and at the

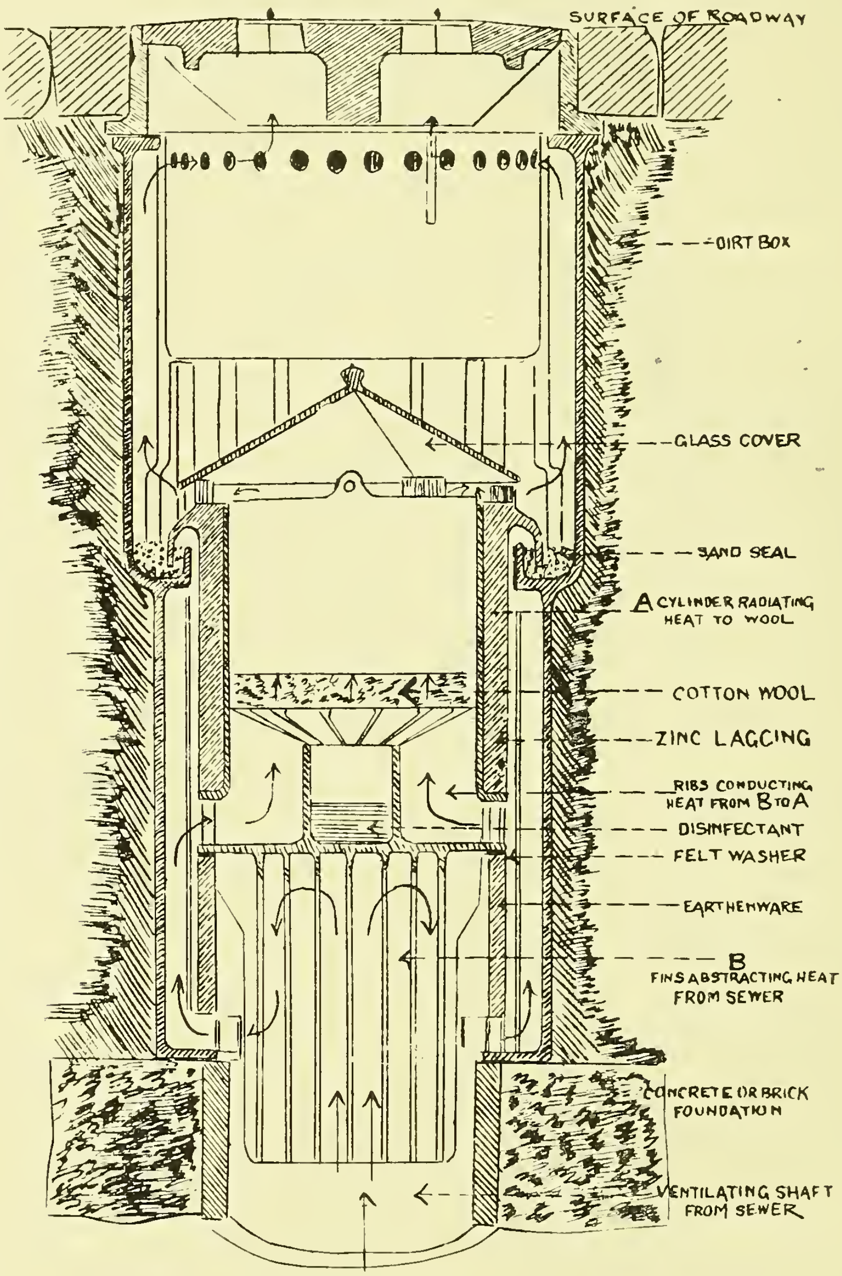


FIG. 25.

CAINK'S SEWER VENTILATION.

surface of the ground with the external atmosphere: this cold metal lowers still further the temperature of the sewer air, depriving it still more of its moisture, which trickles down into the sewer. The air now, although containing much less moisture than before, is still saturated, owing to its temperature being correspondingly lowered. It then leaves the outer casting and returns to the upper part of the inner one, passing through the openings between and coming into contact with the gills before mentioned, whereby its temperature is somewhat raised and consequently reduced dry; it then passes through the cotton-wool, which has been warmed by conduction and radiation above the dew-point of the sewer air passing through it, and escapes under the glass cover to the grating at the surface.

The cotton-wool filter should be changed every three months. A slight dampness does not interfere with the transmission of air; on the contrary, dampness would add to its efficiency as a filter of the organisms, the microscopic globules of water more effectually arresting and retaining any minute particles of solid matter, whether dead or living, than perfectly dry fibres.

The apparatus is said to be quite successful in attaining the object desired.*

Mr. Caink kindly informs the Author that the price of his sewer ventilator is:—

For 9 in. diameter ..	£8	f.o.r. Worcester.
For 12 in. diameter ..	£11	

The working expenses consist merely in changing the cotton about four times a year, at a cost each time of about 2d. For sewers up to 18 in. diameter Mr. Caink recommends that his ventilators should be placed about 200 yards apart; and for sewers 18 in. diameter they should be placed about 100 yards apart. For sewers up to 15 in. in diameter the smaller size (9 in. diameter) may be used.

The evidence of many of those who have had practical experience in the use of charcoal trays and other deodorants is almost uniformly unfavourable. Thus:—

MR. THOMAS WALKER, Croydon (1890).—Up to 1876 no town used charcoal in sewer ventilators so fully. Four men were exclusively engaged in changing it and reburning it. Since then the manholes and ventilators have been open to the street surface.†

MR. T. DE COURCY MEADE (1892).—They become useless in

* "Proceedings of the Association of Municipal and County Engineers," vol. xxix., p. 147.

† "Proceedings of the Association of Municipal and County Engineers," vol. xvii., p. 9.

two or three days. Had removed hundreds of these ventilators, as he found them worse than useless.*

MR. J. T. EAYRS (1892).—Agreed as to the inefficacy of these ventilators. Does not know of any town in England where believed in now.

MR. COWAN, Mr. ROBINSON and others agree.*

MR. R. READ (1899).—The application of costly apparatus containing charcoal and other chemicals for deodorising the gas is of very little use; they are generally merely stoppers of the ventilation—an effect which can be more easily and cheaply produced by plugging the holes in the manhole covers.†

* "Proceedings of the Association of Municipal and County Engineers," vol. xix., pp. 34, 35, 36.
† "Proceedings of the Association of Municipal and County Engineers," vol. xxv., p. 303.

CHAPTER VI.

COMPARATIVE COSTS OF THE VARIOUS SYSTEMS NOW IN USE.

THE AUTHOR has experienced some difficulty in obtaining reliable information as to the first cost of installing the systems of sewer ventilation now in actual use, as well as the cost of working and maintenance of the same. In every case he advises his professional brethren to regard the following particulars as approximate only, and as some guide for comparisons, but not to be taken as bases for estimates or other responsible purposes. For such requirements the Author need not emphasise the necessity of obtaining direct information from the makers or users of the particular apparatus under consideration.

In estimating for annual costs, the item "Depreciation" (in every case put at 10 per cent of the first cost) must be considered to mean an approximate annual allowance for providing interest and sinking fund for repayment of the capital outlay within a limited time, and does not include cost of repairs or maintenance. It is, of course, merely a rough approximation to what would be allowed for in practice, having regard to the comparative durabilities of the articles in question.

For purposes of comparison it will probably be most convenient to proceed on a basis of cost per mile of sewer ventilated, but here, again, caution must be observed in not assuming the figures given as absolute costs, although they are based on much experience, as it is obvious that a 9-in. pipe sewer will be much less costly to ventilate than a 9-ft. barrel sewer.

SHAFTS 6 IN. BY 4½ IN. AGAINST GABLES OF BUILDINGS.

	£	s.	d.
12 lineal yards of 9-*in.* glazed stoneware socket pipes, laid 3 ft. under cover, cement joints, connected to manhole and cleaning chamber at foot of shaft, at 4s. ..	2	8	0
Cleaning chamber at foot of shaft, 12 in. by 9 in., 9-in. brickwork set and rendered in cement mortar, with cast-iron airtight cover	1	0	0
Carried forward ..	£3	8	0

	£	s.	d.
Brought forward ..	£3	8	0
30 lineal feet of cast-iron shaft, 6 in. by 4½ in. inside, 15 lb. per lineal foot, rust joints, and fixed to wall, at 1s. 6d.	2	5	0
Galvanised wire net to protect top..	0	2	6
Total	£5	15	6

Placed at intervals of 176 lineal yards apart:—

	£	s.	d.
Cost per mile of sewer	57	15	0

Annual Cost per Mile.

	£	s.	d.
Depreciation, 10 per cent on £57 15s.	5	15	6
Repairs and maintenance, say, ...	5	4	6
Annual cost per mile of sewer	£11	0	0

SHAFTS 8 IN. BY 6 IN. AGAINST GABLES OF BUILDINGS.

	£	s.	d.
12 lineal yards of 12-in. glazed stoneware socket pipes, laid 3 ft. under cover, cement joints, connected to manhole and chamber at foot of shaft, at 5s. 2d.	3	2	0
Cleaning chamber at foot of shaft 15 in. by 12 in., 9-in. brickwork laid and rendered in cement mortar, with cast-iron airtight cover	1	3	0
30 lineal feet of cast-iron shaft, 8 in. by 6 in. inside, 30 lb. per lineal foot, rust jointed and fixed to wall, at 2s. 9d.	4	2	6
Galvanised wire net to protect top..	0	3	0
Total	£8	10	6

The above placed at average intervals of 176 lineal yards apart, or ten to one mile, will cost £85 5s. per mile of sewer.

Annual Cost per Mile of Sewer.

	£	s.	d.
Depreciation, 10 per cent on £85 5s.	8	10	6
Repairs and maintenance, say, ...	5	9	6
Annual cost per mile of sewer	£14	0	0

6 IN. DIAMETER VENTILATING COLUMNS, 30 FT. HIGH ABOVE GROUND LEVEL, 6½ IN. DIAMETER AT BOTTOM, 6 IN. DIAMETER AT TOP, FIXED ON LINE OF KERBS.

	£	s.	d.
9 lineal yards of 9 in. diameter glazed stoneware pipes as above, at 4s.	1	16	0
Cleaning chamber at base of column	1	0	0
6½ in. to 6 in. internal diameter taper wrought-iron or steel tubular ventilating column, 30 ft. high above ground level, with cast-iron ornamental base, section collar, and galvanised top protector, erected complete	8	0	0
Total	£10	16	0

Placed 176 lineal yards apart :—

	£	s.	d.
Cost per mile of sewer	108	0	0

Annual Cost per Mile of Sewer.

	£	s.	d.
Depreciation, 10 per cent on £108	10	16	0
Maintenance and repairs	5	4	0
Annual cost per mile of sewer	£16	0	0

8 IN. DIAMETER VENTILATING COLUMNS, 30 FT. HIGH ABOVE GROUND LEVEL, 9 IN. DIAMETER AT BOTTOM, 8 IN. DIAMETER AT TOP (BOTH INTERNAL), FIXED ON LINES OF KERBS.

	£	s.	d.
9 lineal yards of 12-in. glazed stoneware pipes as above, at 5s. 2d.	2	6	6
Cleaning chamber	1	3	0
9-in. to 8-in. wrought-iron or steel tubular ventilating column, 30 ft. high above ground level, with cast-iron ornamental base, section collar, and galvanised top protector, erected complete	14	0	0
Total	£17	9	6

If placed at an average distance of 176 lineal yards apart :—

	£	s.	d.
Cost per mile	174	15	0

Annual Cost per Mile of Sewer.

	£	s.	d.
Depreciation, 10 per cent on £174 15s... ..	17	9	6
Repairs and maintenance, say, ...	6	10	6
Total	£24	0	0

BLADON'S PATENT ALUMINIUM VALVE NON-RETURN INLET VENTILATOR.

This ventilator, made by Mr. T. E. Bladon, Northwood-street, Birmingham, has been used by Mr. Ambrose W. Cross, Surveyor to the King's Norton Urban District Council.

	£	s.	d.
Cost of ventilator, made of strong galvanised iron, with tube to fit a 5½ in. diameter inside, is about	1	15	0

If placed alternate inlet and outlet it is stated to be effective at about 440 lineal yards apart; the cost will therefore be about £1 15s. in addition to the cost of the 6-in. ventilating column (page 39); or spaced as above, equal to £12 11s. each, or at the rate of £50 4s. per mile.

Annual Cost per Mile of Sewer.

	£	s.	d.
Depreciation, 10 per cent on £50 4s.	5	0	0
Repairs and maintenance	5	19	7
Total	£10	19	7

THE "OMNIFEX" SYSTEM OF SEWER VENTILATION.

	£	s.	d.
Cost of each ventilating apparatus..	20	0	0
Carriage and fixing, say, ...	5	0	0
18 lineal yards of glazed stoneware 6-in. socket pipes for branch connections, at 3s. 6d.	3	3	0
Base for ventilator, say, ...	4	17	0
Total	£33	0	0

As the ventilators are placed about 300 lineal yards apart, or, say, six to a mile of sewer, the cost per mile of sewer ventilated will be about £198.

Annual Cost per Mile of Sewer Ventilated.

	£	s.	d.
Depreciation, 10 per cent on £198..	19	16	0
Repairs and maintenance, say, ...	5	16	0
Total	£25	12	0

THE WEBB SYSTEM OF SEWER VENTILATION.

Full details of cost have already (page 50) been given of the above system.

The average length of sewer ventilated is nearly half a mile.

The cost per mile is therefore £58 nearly.

The annual cost of working and maintaining the system is, in the same proportion, £33 per mile nearly.

MESSRS. SHONE & AULT'S HYDRO-MECHANICAL SYSTEM OF SEWER VENTILATION.

Messrs. Shone & Ault state: That to adequately ventilate a sewer 3 ft. by 2 ft., 4 miles in length, and having 1,408 house drains and 282 street gullies connected to it, with an allowance of half a cubic foot of fresh air for each connection, plus 50 per cent as an allowance for leakages, a fan requiring one-fifth of a horse-power to drive it is required. An electrical motor, using about 8 Board of Trade units of electrical energy per diem, at a rate of 1d. per Board of Trade unit, would amount 8d. per day, or at the rate of 1d. per day per 1,000 of population, or at the rate of about 2d. per day per mile of sewer ventilated.

In addition to providing the fan and motor, it is necessary to provide and fix at each house drain connection a special interceptor trap (Figs. 15 and 17, pages 52 and 53), with regulated air-inlet piece and automatic aluminium reflux valves, as well as one or more small special regulated air inlets (Fig. 20, page 57). Also, on each drain connection between the street gullies and the sewer (in combined systems of sewerage) a special regulated air inlet, having an automatic aluminium reflux valve attached to it, must be placed in order to ventilate the drain pipes from the gullies.

The first cost of the system will therefore be approximately as follows:—

	£	s.	d.
One one-fifth B.H.P. electrically driven fan, motor and all necessary connections ..	40	0	0
One underground fan chamber for the above, 6 ft. square by 7 ft. in height, with cover, drainage, ventilation, etc., complete ..	30	0	0
One air filter and chamber, 8 ft. square by $7\frac{1}{2}$ ft. in height	35	0	0
Carried forward ..	£105	0	0

	£	s.	d.
Brought forward ..	£105	0	0
One 12-in. air outlet shaft, 30 ft. in height, with 9 lineal yards of 12-in. glazed stoneware pipes, cleaning chamber, etc., complete	35	0	0
9 lineal yards of 12 in. diameter glazed stoneware pipe from sewer to fan, at 6s.	2	14	0
1,408 special interceptor traps (Figs. 15 and 17, pages 52 and 53), with regulated air-inlet pieces and automatic aluminium reflux valves, at 60s. each, less value of ordinary house drain ventilating shaft and pipe connection, say, 60s. each net ..	4,224	0	0
282 special regulated air inlets, with automatic aluminium reflux valves for street gully drains with pipe connections, say, 40s. each	564	0	0
Total for 4 miles of sewer ventilated	£4,930	14	0

Therefore, first cost for 1 mile of sewer ventilated, say, £1,232 13s. 6d.

Annual Working Cost per Mile of Sewer Ventilated.

	£	s.	d.
Depreciation, 10 per cent on £1,233	123	6	0
Repairs and maintenance	20	0	0
Electrical energy, 720 Board of Trade units, at 1d. per unit	3	0	0
Attendance	5	0	0
Total	£151	6	0

MR. CAINK'S SYSTEM OF SEWER VENTILATION.

	£	s.	d.
Average cost of ventilating apparatus at maker's works	9	10	0
Carriage and fixing	5	10	0
Total	£15	0	0

Average distance apart, 176 lineal yards; therefore cost per mile of sewer is £150.

Annual Cost per Mile of Sewer.

	£	s.	d.
Depreciation, 10 per cent on £150	15	0	0
Repairs and maintenance	3	0	0
Attendance	2	0	0
Total	£20	0	0

REEVES' ORIGINAL SEWER VENTILATORS.

The cost of this apparatus, as applied to the Water of Leith Intercepting Sewer, was as follows:—

	£	s.	d.
Cost of each ventilating apparatus	10	0	0
Altering manholes and fixing	7	0	0
Total	£17	0	0

Placed at 352 lineal yards apart, the cost per mile of sewer ventilated is therefore £85.

Annual Cost per Mile of Sewer Ventilated.

	£	s.	d.
Depreciation, 10 per cent on £85	8	10	0
Cost of chemicals, ten apparatus per mile, at £1 each	10	0	0
Cost of water, five apparatus per mile, about	8	0	0
Total	£26	10	0

MR. HARRIS REEVES' IMPROVED SEWER VENTILATOR.

	£	s.	d.
Cost of apparatus for ordinary manholes f.o.r., and exclusive of fixing and water service	10	0	0
Carriage and fixing, say, ...	2	14	10
Water service, say, ...	3	0	0
Total	£15	14	10

Placed at an average of about 352 lineal yards apart, the cost per mile of sewer ventilated is about £78 14s.

The annual cost is as follows:—

	£	s.	d.
Depreciation, 10 per cent on £78 14s.	7	17	5
* Water and chemicals, about	11	10	0
Repairs and maintenance	1	0	0
	£20	7	5

* The Author is courteously informed by Mr. Harris Reeves that in his latest apparatus the consumption of water is reduced by about 30 per cent, with a corresponding reduction in annual cost.

COMPARATIVE SUMMARY OF COSTS OF THE VARIOUS SYSTEMS OF SEWER VENTILATION.

System.	First Cost per Mile of Sewer Ventilated. £ s. d.	Annual Cost per Mile of Sewer Ventilated. £ s. d.
Open surface gratings, with 6-in. by 4½-in. shafts against gables of buildings	57 15 0	11 0 0
Open surface gratings, with 8-in. by 6-in. shafts against gables of buildings	85 5 0	14 0 0
6 in. diameter ventilating columns, 30 ft. in height, placed on line of kerbs	108 0 0	16 0 0
8 in. diameter ventilating columns, 30 ft. in height, placed on line of kerbs	174 15 0	24 0 0
Bladon's Patent (King's Norton) Ventilator ...	50 4 0	10 19 7
The "Omnifex" System of Sewer Ventilation	198 0 0	25 12 0
The Webb System of Sewer Ventilation ...	58 0 0	33 0 0
Shone & Ault's Hydro-mechanical System of Sewer Ventilation	1,232 13 6	151 6 0
The Caink System of Sewer Ventilation ...	150 0 0	20 0 0
The Reeves' Original System of Sewer Ventilation	85 0 0	26 10 0
Mr. Harris Reeves' Improved System of Sewer Ventilation	78 14 0	20 7 5

CHAPTER VII.

SUMMARY.

ONLY a few observations are necessary by way of general comparison of the different methods of sewer ventilation already described.

Strictly, no reliable comparison of any two or more methods of ventilating sewers can be made, either in regard to efficiency or cost, unless the data as to lengths, areas and gradients of sewers, and the nature of the sewage carried, as well as the atmospheric and surface conditions, are the same, and at present no reliable experiments or observations exist which would enable a correct general conclusion to be arrived at on this subject. Each system of sewers must therefore be considered and dealt with on its own basis, and having due regard to its own peculiarities.

The late Mr. Santo Crimp was the first to point out the great influence which the velocity and direction of the wind had on air currents in sewers.

Mr. Mawbey, Borough Surveyor of Leicester, has done invaluable pioneer work, in the true scientific spirit, in the direction of obtaining reliable data. His Report of 1899 stands out prominently as a mile-post on the road to ultimate success in the solution of this difficult problem. Mr. Mawbey has undoubtedly established the fact that sewers can be efficiently ventilated by means of shafts or columns without the assistance of surface ventilating grids, and for that work alone all sanitarians owe him a debt of gratitude which it will not be easy to repay.

The "Omnifex" and Bladon Systems are efforts in the right direction—namely, to supply such a strong current of fresh air into the sewers as will render comparatively harmless the noxious gases given off by the sewage.

The Sewer Ventilating Lamp System invented by Mr. Joseph E. Webb possesses the obvious advantage over most other methods of not only exhausting or drawing foul air from the sewers, but also of successfully cremating it, and thereby rendering harmless, before allowing it to escape into the outside atmosphere, to the danger, annoyance and general discomfort of the public.

Messrs. Shone & Ault's Hydro-mechanical System of Sewer

Ventilation is based on scientific principles, which have been, and are, in successful application in the ventilation of mines. It is perhaps not too much to say that by this system only has the solution of the double problem of sewer and house drain ventilation been solved. It will probably be objected that the first cost of this system renders it impracticable on financial grounds. The answer to this is that no just comparison can be made unless the absolute efficiencies of a so-called "cheap" system and a perfect one are taken into account.

It may also be pointed out that the first cost of this system appears, at the present stage, to be more apparent than real, and that when confidence in the system has been established it will be found that much of the apparently costly devices in the interceptor traps and chambers will be saved in less expensive house drain and other plumber's work in connection therewith.

Both Mr. Caink's System and that of Mr. Harris Reeves are well deserving of careful consideration, as they both depend on the adoption of scientific principles in details, and both have already been well tried and highly spoken of by those in responsible positions in regard to public sewers.

What, after all, are the primary objects to be attained, if possible, in ventilating a sewer?

First, and most important, to ensure that the *individual* dwelling is, so far as is possible, aërially cut off from the sewer which is common to *several* dwellings. That was the central idea of Sir Robert Rawlinson, Sir George Buchanan, and other pioneers in sanitary science. Hence the now much-abused intercepting trap. The Author has already shown that the Ventilation-of-the-Public-Sewer question has arisen almost entirely in consequence of the introduction of the intercepting trap, and some sanitary engineers now appear disposed to quarrel with the medical officer because the latter insists upon keeping his premises (the private house) separate from the common receptacle (the public sewer) by means of the intercepting trap. This desire of the medical officer is surely not unreasonable, and is really the primary instinct of self-preservation, and has been greatly strengthened by the recent researches of Major Horrocks.

Secondly, it should be, then, the object of the engineer to do for the *common* sewer what the medical officer has done for the *individual* house--namely, to make it discharge its functions (of carrying away its contents) without danger or offence to the general public. Surely this is not beyond the resources of modern engineering, without attacking the intercepting trap.

The Author is of opinion that until the present method of water-carried sewage is superseded by some greatly improved method, which at present is certainly not within sight, the intercepting trap is a necessity, and that the problem of successfully and economically ventilating the common sewers is now well within reach of accomplishment, without invading the privacy of the house drain.

Then, thirdly and lastly, there is the not unreasonable demand that the workmen whose duty it is to keep in working order a system of public sewers shall be protected in a reasonable way from danger in discharging their (at the best) disagreeable and laborious duties. This can only be satisfactorily accomplished by adequate arrangements for keeping the sewers as free as possible from dangerous germs and unhealthy conditions.

APPENDIX.

SUGGESTIONS AS TO SEWERAGE WORKS.

BY THE LATE SIR ROBERT RAWLINSON, K.C.B.,

Late Chief Engineering Inspector to the Local Government Board.

1878.—EXTRACT.

(1) *Sewer Ventilation.*—Towns situate on land rising considerably will be best sewered in zones—that is, by intercepting lines of sewers contouring the site—as such intercepting sewers will prevent gorging the low-level districts, and also prevent the rush of sewage down steep gradients at high velocities, which in times of heavy rain may burst the low-level sewers at the steep gradient junctions. By intercepting lines of sewers, sewage may also, in some cases, be retained at such an elevation as to enable it to be delivered in the country by gravity on to and over land for agricultural uses. Sewers with steep gradients, if the flow of sewage is unbroken, get up a velocity in the sewage which is liable to be very injurious in its wearing action on the sewers. Sewage should not be allowed (except when flushing is in operation) to acquire a greater velocity at any state or time of more than 6 ft. per second, as any higher velocity will take grit or other solids along the sewer invert with a cutting and disintegrating action rapidly destructive to the material of the sewer.

(2) Main sewers are underground conduits for sewage to flow down, and if they are not fully ventilated at regular intervals along the crown, by fixed openings communicating with the external air, they become flues up which sewage gases will rise and pass through the drains to the connected houses.

(3) Sewers formed along steep gradients therefore require to have more care bestowed on the means for ventilation than other sewers laid along flat districts, to prevent dangerous accumulations of sewage gases in the upper districts of towns. Sewers rising from lower and flatter districts should therefore have manhole, or "*side entrance*," tumbling-bay and double venti-

lating arrangements. This form of tumbling-bay should also be repeated on steep gradients at intervals of not less than 300 yards apart.

(4) Steep gradients in sewers must also be modified to prevent the sewage during heavy rains acquiring such a velocity as shall not only wear out the invert and blow the joints, but also burst the sewers. Earthenware pipe sewers when laid down steep gradients should also be bedded and jointed with concrete. The steps, or ramps, should be so formed as to prevent any accumulation of deposit.

(5) Ordinary main sewer ventilation should be provided for on all sewers at intervals not greater than 100 yards, or not fewer than eighteen fixed openings for ventilation should exist on each mile of main sewer. If, however, it is found that some of the ventilators are a nuisance, additional sewer ventilation should be provided at shorter intervals. Pipes taken up the gable ends of houses should not be substitutes for street and road surface ventilation, unless such pipes have a diameter not less than 6 in.

(6) The upper or "*dead ends*" of all sewers and drains should have means provided for full ventilation continued beyond the junction of the last house drain.

(7) Details for manholes and side chambers for sewer ventilation are given in drawings.

(8) Steam boiler or other furnaces and tall chimneys may be used for sewer ventilation where the owners of factories and of steam engines will permit of such use; but the ordinary means for sewer ventilation must not on this account be dispensed with, as the ventilating effect of a furnace or tall chimney will be limited to a comparatively short length of the sewer by the number of openings into the main sewers, such as house drains, street gullies, etc.*

(9) Separate costly tall shafts or furnaces for main sewer and house drain ventilation cannot be of use in proportion to their cost, as sewers cannot be ventilated as tunnels and coal mines are, in which close airways have to be provided and are also kept under control.

(10) Sewers liable to be affected by the rise of tides or land floods, as on the seashore or on a river, must be so arranged that any backing of the sewage shall not injuriously affect the sewers and drains within the town. The lower portion of any

* Furnace ventilation of sewers may be dangerous if a damaged gas main should leak into the sewer, in which case there might be an explosion.

system of sewers below the level of high water of the sea or land floods of an inland river must therefore be cut off from the upper portions, and must be so abundantly ventilated that any sewage gases may be forced out at points specially provided for the purpose, and not be driven inwards and up the steeper sewers of the town through the drains and into the houses.

(11) The ends of all sewers and drains at the lowest outlets must be so protected that the wind cannot blow in and force any sewage gases back to the streets and houses. Flap-valves, or other contrivances, may be provided to cover and protect outlet ends of sewers and drains, and so prevent the wind blowing in.

(12) Means for full and permanent ventilation of town sewers and house drains are required to prevent stagnation or concentration of sewage gases within sewers and drains, and with numerous openings from the sewers to the external air, as described, there will be unceasing motion and interchange between the outer air and the inner sewer air, which will bring about and maintain extreme dilution and dispersion of any sewage gas as soon as generated. It has been found by experiment that in unventilated sewers the gas concentrates and so becomes deadly,* whilst in fully-ventilated sewers the air is purer than that of some stables, or even than in a crowded public room. If sewer air at any sewer ventilator, or at any other point, should be offensive, additional means for ventilation on this sewer are required, and should, as soon as possible, be supplied. Trapping should not be resorted to in such a case. It may, however, be practicable to remove such sewer ventilator to some more convenient point.

(13) If cesspools are required for any purpose they should be made watertight, and be placed as far from wells and dwelling-houses as possible, and should be abundantly ventilated. An open cesspool will be a nuisance, but if fenced in may be comparatively harmless; a covered cesspool must be a source of danger even though ventilated.

(14) Dustbins should also be fully ventilated.

(15) Ventilation cannot be fully accomplished through single tubes or openings. There should never be less than two

* Men have lost their lives by entering unventilated sewers on some occasions in London, as also in other places. There are many towns in which the sewers are not ventilated because the inhabitants refuse to have any open sewer ventilator at the street surface; this is a sad mistake, as a town having unventilated sewers, and house drains connected with them also unventilated, must have disease in excess. These paragraphs as to using charcoal are retained, but it must be distinctly understood that a system of sewers properly devised and efficiently constructed, having full and free means for ventilation to the external air, will need no intervention of charcoal, so that a use of charcoal is not recommended.

passages, or any single tube or pipe must be divided by a diaphragm. Single pipes will ventilate sewers which have numerous openings, but for house drains there must be inlet as well as outlet pipes or openings to secure ventilation.

(16) Where charcoal is exceptionally used in sewer ventilation it must be understood to retard motion, and provision should be made to meet this. Charcoal trays or boxes for sewer ventilation should never have less than 1,000 square inches of surface exposed for the passage of sewage gas to each 50 square inches of free opening to the outer air. The meshes of a charcoal tray may be about one-eighth of an inch. The charcoal (wood) may be about the size of coffee beans, clean sifted, and placed in a layer of 2 or 3 inches. Charcoal in a dry state acts best, but its disinfecting property is only diminished by damp; it is not entirely destroyed. The length of the intervals between the renewals of the charcoal will depend upon the dryness of the situation where the material is placed, and the volume and strength of the gas to be acted upon. In some cases two or more charcoal trays may be used apart, one above the other, so that the gas to be acted upon may have to permeate and pass through the whole of the trays. The charcoal may require in some places to be renewed at intervals of six months. In ordinary sewer ventilation charcoal need not be used, as the more readily and freely the interchange of air can take place from the sewer or drain to the outer air and *vice versâ* the better will the ventilation be.

(17) For detached houses, villa residences, or larger establishments, drains should never end at the house to be drained, but should be continued beyond and above to some higher point or ventilating shaft, where means for full and permanent ventilation can be provided so as effectively to relieve the house from any chance of sewage gas contamination.

(18) Drains for soil and sink refuse should never traverse the basement of any house, but should be external; if, however, there are drains within a basement, and crossing it, such drains should be absolutely air and water tight within such basement, and should also have full means for permanent ventilation provided outside at both sides of the basement. Pipes of earthenware may be bedded in concrete. In some cases pipes of cast iron may be used within house basements, as they will be both best and cheapest.

(19) All drains should be laid at least twice their full

diameters below the surface of the subsoil of any basement, and have a fall of not less than 1 in 60 towards the sewer. The full half diameter of the sewer (at least) should be below the junction of the house drain.

(20) Wherever a trap is placed on a sewer or drain there should also be means for sewer and drain ventilation provided to relieve such trap, as traps are only safe and useful in conjunction with full and permanent means for sewer ventilation.

N.B.—It has been suggested that free and open sewer and drain ventilation will so taint the atmosphere within and over a town as to cause houses at a lower level to pollute those situate at higher levels. Any serious injury from this result need not be feared, as, with the abundant means for ventilation suggested, the air within the sewers (by dilution) will be comparatively pure, and further dilution and dispersion will dissipate every trace of taint and danger, the dilution, through dispersion, being as the cube of the space and the velocity of the air for the time being. The air in one mile of street sewer may be taken at 1,000 cubic yards, the air in the street above at 500,000 cubic yards; changed and renewed many times during the day, so that the air in the sewers will be several millions of times less in comparative volume than the air in the street, the dilution of any sewer gas will therefore be in some such proportion.

CONGRESS OF THE SANITARY INSTITUTE AT BRIGHTON, AUGUST, 1890.

"JOURNAL OF THE SANITARY INSTITUTE," VOL. XI., P. 183.

DISCUSSION ON SEWER VENTILATION.

[ABSTRACT.]

DR. A. CARPENTER (Croydon) said that with regard to the question of open sewers there was the minimum amount of danger with the maximum amount of fear. The fear was wholly with the public, but from an experience of thirty years he was satisfied that the mischief was of a very minor character, and it was far better that some effluvium should escape through an open sewer than that there should be gases confined in the sewers themselves. He contended that sewer gas was a misnomer, for in sewers properly constructed and washed out no such gas could ever exist.

MR. WOODRUFF (Brighton) had had considerable experience in sewer ventilation. In Brighton they were working on the principle of closing up surface ventilators, and substituting for them ventilators at the tops of houses.

MR. WILLIAM WHITE (London) said there was no generation of sewer gas in properly-ventilated sewers.

SIR THOMAS CRAWFORD (London) said that the great object of the ventilation of sewers was not to let out gases, but to let in fresh air. When the street ventilators became offensive that was an absolute proof that the sewer was not sufficiently perfect for its purpose. Their object, then, was not to close but to keep open the ventilators, in order, amongst other advantages, that they might detect any effluvium that might exist.

MR. H. H. COLLINS (London) drew attention to the danger of preventing the access of free air to ventilators. The system of carrying up pipes to ventilate sewers was a confession that the sewers were defective. Let the sewers remain open, and let them get a current of air to pass through them as frequently as possible.

COLONEL JONES (Carshalton): The notion that they could get rid of bad smells by carrying them into the air was radically wrong. Far better was it for smells to remain on the surface, for then steps could be taken to set defects right.

MAJOR CONDER (Southampton) said that odours in the street were very offensive to the inhabitants, who could hardly stop to inquire their possible advantages before doing everything in their power to get rid of them.

THE SEWERAGE OF THE TOWN OF MALDON.

Paper read by MR. RICHARD F. GRANTHAM, M.INST.C.E., before a Sessional Meeting of the Sanitary Institute at Maldon, Essex, December 9, 1891.

"JOURNAL OF THE SANITARY INSTITUTE," VOL. XII., P. 45.

[ABSTRACT.]

The author reviewed the existing state of the important question of sewer ventilation. He stated that at many towns, including Hornsey, Croydon, Twickenham, Liverpool, Birmingham and other places, upcast shafts have been erected to improve the ventilation of the sewers, although the surface ventilators have not in every case been closed, nor does the author recommend that they should be. At Maldon the ventilating covers are fitted with Latham's cover and bucket, without the spiral trays for charcoal. By the raising or lowering of the bottom of the inner cylinder of the bucket by means of a small handle the passage of air from the sewer can be stopped if it is found offensive. He condemned gas destructors, the use of chimney shafts, and similar devices, as being ineffective and costly.

The practice of establishing upcast shafts for the ventilation of main sewers is obviously increasing, and no doubt it will in time be generally adopted.

The beneficial effect observed from the increasing practice of erecting upcast shafts on the sides of houses and elsewhere to ventilate the main sewers, coupled with the absence of any danger or prejudice to the public health if they are carried sufficiently high, suggests the consideration whether the main sewers might not be advantageously ventilated through the house drains, omitting the syphon traps now usually fixed on those drains outside the houses.

DISCUSSION.

DR. LOUIS PARKES (Chelsea) said he thought disconnecting syphon traps a very proper and necessary precaution to take, inasmuch as sewer air might at any time contain the poison of infectious disease—notably typhoid fever—in this country, and it was advisable to exclude such air entirely from house drains and soil pipes, which were not always perfect, even when newly laid and fixed.

MR. E. BAILEY DENTON (London) said that if the abolition of the disconnecting chamber between the house and the public sewer was aimed at he begged to entirely disagree with Mr. Grantham. He looked upon the provision of disconnecting chambers as most essential.

MR. READ (Gloucester) said that the so-called interceptor was an obstruction both to the flow of the sewage and to the ventilation. From experiments that he had made he found that when the flow of sewage equalled or exceeded 3 ft. per second the direction of the air current in the sewer was nearly always the same as the flow—that is, down hill. To ensure that there should always be a down-draught at the street ventilators it would be necessary to keep them comparatively small, say, 30 to 36 square inches area and 60 to 100 yards apart, and to have an upcast shaft on every house, but in any case the excess of ventilating area should always be on the sides of the outlets to allow for friction and bends. That is to say, the sum of the sectional areas of the outlet shafts between any pair of street inlets, multiplied by the average velocity of their several discharges, must exceed the sectional area of the air space of the sewer, multiplied by the velocity of the air current in the sewer.

MR. THOMAS WALKER (Croydon) said that at Croydon they were flushing every house drain, and as a consequence the cessation of smells in the roads had been most remarkable. Criticising the Keeling Destructor, he said that one of the ordinary columns in use at Croydon up a tree or a house was found by exhaustive anemometer trials to be more effective.

MR. ROGERS FIELD (London) considered they must have disconnecting traps, but it was essential that these traps should be well and properly made and always perfectly accessible. Ventilating shafts for town sewers were very valuable if the street ventilators or most of them were left open, but to close all the street ventilators and substitute a few small shafts, as was sometimes done, was a great mistake.

CAMBRIDGE SEWERS.

Report by MR. JAMES MANSERGH.

"THE SURVEYOR," VOL. XIII., P. 508, MARCH 13, 1898.

MR. MANSERGH reports: "There is undoubtedly offence caused by the escape of sewer gases through the surface ventilators, and I accept this as a fact without further discussion . . . . It is not an unusual thing in the early days of a new sewer system to have unpleasant smells from the ventilators, and this is due to several causes. I think it is possible that the offence was aggravated in the early months of the system by the house drains and old sewers clearing themselves of deposit, but during the twenty-one months which have elapsed since the new sewers were finished this process has probably completed itself. . . . .

". . . . The fact that the sewage has to be pumped may, in certain circumstances, cause a slight addition to the smells. During heavy rain, if the sewage is not lifted out of the sewers with the same rapidity as it flows down them, it ponds up. This has two drawbacks from the ventilation standpoint. First, the air in the sewer is displaced by the ponded sewage, and consequently is forced out of the openings. Secondly, the sides of the manholes are wetted with sewage, and when the pumps clear the sewers there is evaporation from the sides and benchings, and it is also possible that paper and solids may be stranded above the line of general flow and left exposed to the sewer air."

After enumerating several local causes which partly accounted for the offence, Mr. Mansergh proceeds: "The question arises whether, if these were done away with altogether, the surface ventilators would become wholly inoffensive. I regret to say that I confidently say 'Yes.'

"My first recommendation is that where a surface ventilator is offensive a careful inspection should be made to ascertain if there is any special reason for the offence. If any is discovered it should be corrected if possible. If the investigation shows no special cause, then a column or shaft should be erected and the surface opening closed. The columns or shafts should not have their outlets near windows or chimney heads."

LONDON SEWERS.

Report by SIR A. R. BINNIE, *re* Ventilation.

"THE SURVEYOR," VOL. XIV., P. 134, JULY 22, 1898.

In accordance with the instructions of his Committee, the Engineer issued two circular letters to the engineers and surveyors of the various vestries and district boards in the County of London, inviting them to a conference on the subject of the ventilation of sewers, with a view to some uniform system being adopted, if possible, for dealing with complaints of offensive emanations from gratings connected with both local and main sewers. Forty invitations were accepted, and after two hours' discussion it was resolved :—

(1) That the closing of sewer ventilators in response to complaints increases the general evil, the diminution of which is to be attained by the multiplication of the ventilators at regular frequent intervals.

(2) That in connection with any interceptor hereafter fixed on a main house drain it is advisable to carry up a ventilating pipe from the sewer side of the interceptor, up the front, side or back of the house, to the satisfaction of the local sanitary authority, and that the outlet drain from the interceptor shall not be flap-trapped on sewer unless required by the local authority.

(3) That pipe ventilators, up buildings or otherwise, where possible should always be adopted in addition to surface ventilation.

The Engineer concludes : "It will be observed that the general result of the conference has confirmed the action of the Committee and the Council in recent years, and that the remedy for sewer emanations is to be looked for from the maintenance of more frequent ventilating openings, both at the street level and by means of pipes carried up houses and other buildings."

SEWER VENTILATION AT BRISTOL.

Reports by MESSRS. TAYLOR, SONS & SANTO CRIMP, MR. T. H. YABBICOM, and the MEDICAL OFFICER OF HEALTH, BRISTOL.

"THE SURVEYOR," VOL. XV., P. 13, JANUARY 6, 1899.

MESSRS. TAYLOR, SONS & SANTO CRIMP report : Comparing Bristol, where the sewers are unventilated, with Brighton, where the sewers are fully ventilated, both having a tidal outfall, they found that the average zymotic death rate over the years 1888-90 in Brighton was 2·16, in Bristol 2·12.

Further, separating from the general zymotic death rate the cases which are generally associated with sewer gas—namely, diphtheria, diarrhœa, and fever—for the same period, the deaths were: Brighton ·98, Bristol ·77. Hence they deduce that Bristol is not prejudicially affected by unventilated sewers.

Continuing, the above state: The necessity for ventilating sewers can only arise from two causes—danger to sewer men and danger of forcing the intercepting traps of private houses. In the first case, the side entrance doors should be opened some time before the men enter, and in the second case if the traps are forced the gas would escape up the soil pipe rather than force its way through the traps and sanitary appliances into the houses.

They cannot recommend the Council to ventilate the sewers at a probable cost of £40,000, as they "are certain that the ratepayers in the vicinity of each ventilator would rebel against its existence, and a pressure that would prove irresistible would be brought to bear upon the Council which would lead to the closing of the ventilators."

MR. YABBICOM reports that he has analysed replies from eighty-one towns and urban districts in England, with a total population of 6,775,910, or an average of 83,653 each.

Continuing: Where sewers are properly constructed—rapid falls—the sewage is not retained sufficiently long for decomposition to set in, and no sewer gas is evolved . . . . The question of sewer ventilation is a vexed one, subject to much difference of opinion . . . . The results obtained from sewer-ventilated towns are not sufficient to warrant interference with a system which works in a satisfactory manner, the proof of the satisfaction being in the few cases of complaint of sewer gas from the street gullies, which would be the first places to give indications if they became untrapped for want of water. Sewer ventilation, if properly carried out, means thousands of openings direct from the sewer on to the surface of the streets, with other vents carried up houses, trees, or specially-designed posts at the sides of the footpaths, discharging their gas at the level of the bedroom windows. The City Engineer "feels sure that for every complaint we now get of smells from a street gully we should have a hundred smells from the ventilators, and that the state of things would be worse for the public health."

THE MEDICAL OFFICER OF HEALTH, after quoting statistics from the Registrar-General's Returns comparing Bristol with the averages of the thirty-three great towns, including London, Brighton and Croydon (the three latter all having ventilated sewers), to the advantage of Bristol as regards fever, diphtheria and diarrhœa, concludes: "What are we to gain by reconstructing the sewers as a ventilated system? There is no reason to expect any improvement in the present satisfactory returns as to sickness and mortality. There is no reasonable hope of improvement, but rather the reverse, as to complaints. There may be an increased mortality from certain forms of disease—*e.g.*, diphtheria. An immense sum of public money will be spent for no conceivable good end. In certain old towns with unventilated sewers fever used to be in excess. Following the introduction of ventilated sewers came a reduction in enteric fever prevalence, which was attributed to change in the type of sewer. It is, in reality, the provision of better sewers, the prevention of water contamination by sewer leakage, and the greater care given to the control, isolation and nursing of cases, and the disinfection of infectious discharges, that has caused the marked diminution in enteric fever mortality. In fact, the change must be ascribed to improvement in public health organisation generally rather than to the superiority of one type of sewer over another. The kind of sewer, ventilated or unventilated, exerts no influence on the fever rate, and the cause of epidemic outbreaks of enteric fever must be looked for elsewhere than in occasional foul smells from grid or grating."

The Bristol Corporation, having duly considered the above reports, decided to take no action to ventilate the sewers, but that they would enforce their power to insist on the provision in every case of a proper intercepting trap and a soil pipe carried above the roof.

MAIDSTONE.

REPLIES FROM TWENTY-TWO TOWNS *Re* SEWER VENTILATION, *March*, 1899.

"THE SURVEYOR," VOL. XV., P. 418, MARCH, 1899.

QUESTIONS:

1. Have you adopted upright shafts for sewer ventilation?
2. If so, are they independent shafts or attached to buildings, and what is the average height?
3. Have you made any tests to ascertain the working of these shafts, and what is your opinion as to their efficiency?
4. Have you received any complaints of nuisance from the shafts?
5. Are the manhole covers in the streets open or closed, and do you receive complaints of nuisance from them?
6. Have you adopted any other means of sewer ventilation? If so, kindly describe, with your opinion on same.

(See Replies pp. 96 to 100.)

MAIDSTONE.

	ASHFORD, KENT. 12,000.	BIRMINGHAM. 510,000.	BOURNEMOUTH. 55,000.	BRIGHTON. 120,000.	BRISTOL. 318,000.
1	Yes.	Yes.	Yes.	Yes.	The sewers in this city are not ventilated in any way.
2	Affixed to buildings in every case (25 ft.).	Both ; heights vary.	Both ; 30 ft. to 40 ft.	Some independent, some built against buildings but not connected to buildings. Heights vary according to circumstances.	—
3	No ; I believe they are satisfactory in every way. When they are painted it is anything but pleasant near the top of shaft.	Not recently.	The sewers should be cut up into sections, and each section separately ventilated. Where sewers are not so constructed the shafts will frequently be a nuisance.	They are examined and tested with smoke to see that they are in working order four times a year. Good.	—
4	None whatever.	Sometimes.	—	No.	—
5	Open, but closed on complaint if permission is given for a shaft to be fixed against house or building.	Open.	Closed.	Closed near the ventilating shafts; others are open, but closed if considered a nuisance when a suitable site for ventilating pipe can be obtained.	—
6	None whatever.	No.	See 3 and 4.	No.	—

MAIDSTONE *(continued)*.

	BROMLEY, KENT. 27,000.	CANTERBURY. 25,000.	CHELMSFORD. 12,000.	DOVER. 36,000.	EALING. 34,000.
1	Yes.	Partly, and gradually extending same.	No.	Yes.	Yes.
2	Both; 24 ft.	Affixed to buildings; vary according to heights of buildings.	—	Some of each carried up above the buildings.	Fixed to houses and trees. No special tests have been made, but we are satisfied as to their usefulness.
3	Yes; tests gave in most cases satisfactory results.	No.	No.	Yes, and find them efficient.	—
4	In a few instances, when there was no connection with sewer.	On rare occasions, and these due to purely local causes.	—	No.	No.
5	Open at foot of steep gradients only; otherwise sealed.	Closed.	Closed.	Generally speaking these are closed, but a few have ventilating covers where they are found to act as fresh air inlets.	A large proportion are open.
6	Yes; Holman's gas destructor, use discontinued as being unsatisfactory.	No.	No; we are now rearranging the whole system of sewers.	No.	No.

MAIDSTONE (*continued*).

	EASTBOURNE. 45,000.	FOLKESTONE. 27,500.	GLOUCESTER. 42,000.	GUILDFORD. 17,000.
1	Yes.	Yes.	Yes; 6-in. and 4-in. iron shafts in conjunction with surface ventilators 60 yards apart. The shafts are all fixed to buildings, except a few against telegraph poles where there are no buildings.	Yes; both shafts and columns.
2	Some of both; independent shafts 30 ft. high. Others vary according to height of building.	Affixed to buildings; taken above eaves.	—	There are about twelve columns, remainder are shafts fixed to buildings; open gratings in manholes.
3	I am inclined to question their efficiency as ventilators; in my opinion they act as pressure reliefs.	—	Yes; for 20 years . . . the efficiency of shafts depends entirely upon their numbers and arrangement with regard to the street ventilators. The shafts, if they are to act as outlets, must be largely in excess of the street ventilators acting as inlets.	No, but my personal experience tends to show that they are to a great extent dependent on atmospheric conditions.
4	No.	No.	No.	I have, where the shafts have not been carried high enough.
5	Closed in the vicinity of shafts.	Closed.	As a rule they are open. I only close a manhole cover on getting a serious complaint, and obtaining one or more shafts in its place.	There are only twelve open manhole covers. Very few complaints received, as they are well away from habitations, and Hope & Evan's pynerzone disinfecting blocks are suspended in wire cages under the dirt box.
6	Yes; we have tried the Reeves system, but on account of expense are not at present proceeding further with it.	No.	I have one or two shafts in connection with factory chimneys, but their success is only local, as indeed all ventilation of sewers must be . . . the current of air being nearly always in the same direction as the sewage.	—

MAIDSTONE *(continued)*.

	HASTINGS. 76,000.	LEYTON. 100,000.	NORWICH. 112,000.	RUSHDEN. 12,000.
1	Yes.	We have a large number.	Yes.	Yes, shafts just being erected.
2	Have some of both; independent shafts 35 ft.	They are fixed to the buildings, a few feet higher than the houses.	Both; heights to suit surrounding houses.	Both; 25 ft. by houses, 40 ft. by factories.
3	They are satisfactory, if sufficiently numerons and placed in suitable situations.	No.	Yes; quite satisfied.	No.
4	No valid complaints.	No.	Practically none.	See No. 3.
5	Closed.	Manholes open. Yes, during summer months especially complaints are received.	Gradually being closed.	Open; complaints are frequently made.
6	No.	We have six Holman's sewer gas destructors; they work well, but require a lot of attention.	Yes; sewer gas furnace columns not so good as plain columns.	No; the town has only recently been completely re-sewered.

Maidstone *(continued)*.

	Sevenoaks. 9,000.	Sutton, Surrey. 16,500.	Tonbridge. 12,000.	Tunbridge Wells. 30,000.
1	Yes.	Partly so.	Yes.	In parts of the town.
2	Up buildings and trees from 18 ft. to 45 ft.; lamp columns, 13 ft. 6 in., 15 ft. and 22 ft.	Independent shafts with a few exceptions.	Fixed to buildings, &c., 25 ft. to 30 ft. high.	Independent shafts as lamp columns, 14 ft. high. Sites chosen so as to be distant from houses.
3	Yes; they are a great improvement on the street grids. At times they alternate as upcasts and downcasts, varying according to the atmosphere and the winds.	No.	No.	No tests.
4	Very little; not where they are of good height, and the positions need to be carefully chosen.	Yes.	No.	Yes; generally complaints from nearest houses.
5	Close the grids in most cases where ventilating shafts are put.	Mostly closed; occasionally.	Have now all been closed owing to complaints.	It is owing to complaints of open manholes that we have closed them and substituted shafts.
6	No.	Yes; the Reeves system. It is certainly effectual.	No.	One of Webb's patent extractors and destructors; it is good but costly.

THE VENTILATION OF SEWERS AND DRAINS.

Paper read by MR. R. READ, ASSOC.M.INST.C.E., Borough Surveyor of Gloucester, before the Association of Municipal and County Engineers in June, 1899.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXV., P. 301.

[ABSTRACT.]

Since 1858 it has been generally recognised, with the one exception of Bristol, that ventilation is an absolute necessity, because if provision be not made for the ventilation of sewers and drains they will ventilate themselves in a dangerous manner; and although it is stated that the Bristol sewers are not ventilated, this probably means that no provision has been officially made with that object in view; but, nevertheless, it is more than probable that the Bristol sewers ventilate themselves through the house drains by means of the rain-water pipes and ventilated soil pipes connected to the drains.

No amount of ventilation will convert a badly-constructed sewer, or one with insufficient fall, into a good one; and however well a sewer may be designed and constructed, it may be converted into a sewer of deposit by badly-constructed street gullies, or by defective or neglected buckets for catching road dirt under the ventilated manhole grid.

Factory chimneys create a very strong draught, and are useful in the case of a long line of sewer to which there are no connections, such as the Brighton outfall sewer, but otherwise they simply draw air in from the nearest opening; there is great risk of untrapping gullies in their immediate neighbourhood; and the required effect can be obtained by an ordinary shaft without the above risk.

After discussing the theory of the flow of sewage, the direction of the air currents, the relation of temperatures of the external air and that of the air in the sewers, the author continues: "If a sufficient number of shafts are erected against houses between each pair of road surface ventilators, all the road surface ventilators will then be converted into inlets and the shafts into outlets, and the ventilation will be constant in one direction, because there is always more motion in the outer air at the top of a ventilating shaft, say, 30 ft. above the ground, than there is at the ground level, sufficient to create an up-current in the shafts, each set of which is practically isolated, and supplied with air by the manhole on the upper side of it acting as an inlet. . . . The only way to get a sufficient number of shafts to produce this result is to use every house drain as a ventilator by abolishing the intercepting trap." The author gives diagrams showing the temperatures of the sewers in Gloucester in August, 1882, November and December, 1884, and June and July, 1885, taken each day at 9 a.m., 2 p.m. and 7 p.m. He also shows a plan of a main trunk sewer 18 in. diameter to illustrate his scheme of ventilation.

SEWER VENTILATION.

Paper read by MR. J. MORGAN before the Association of Municipal and County Engineers in June, 1899.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXV., P. 311.

[ABSTRACT.]

The author classifies the various gases generated in sewers by the putrefaction of sewage matter under two heads :—

(1) Heavy Gas.
(2) Light Gas.

The author describes his improved method of ventilation :—

A grooved flange is arranged at the bottom of the frame which supports the manhole grating. In this flange a hole is formed to receive a pipe, which is firmly and tightly fixed therein. This pipe, which may be 3 in. or 4 in. in diameter, extends into the manhole to a point which will be level with one-third of the diameter or depth of the sewer. The groove in the flange is filled with sand, on which the corresponding rim of the upper end of the dirt box rests, thus rendering it airtight. The air inlet arrangement is fitted at every alternate manhole, leaving the intermediates to act as surface outlets if not substituted by shaft outlets. One outlet must be placed on either side of an inlet, and the distance between them shall not exceed 100 yards and at as equal distances as possible.

The author recommends that the pipe from the manhole or other point of connection with the sewer should be, say, 6 in.

diameter, reducing to 4 in. in diameter at the base of the upright shaft. On the other hand, the upright shaft should be, say, 4 in. diameter at the bottom, increasing to 6 in. diameter *near* the top, but bellmouthed to 4 in. diameter *at* the top.

The advantages claimed are :—

(1) The inlet is automatic in its action.

(2) Each section of the sewer is aërated independently.

(3) No gas can escape through the inlet, as it will pass up or down the sewer above the level of the lower end of the inlet pipe.

(4) Outlet shafts may be dispensed with except for flat gradients.

(5) The form of outlet shaft is more effective.

DISCUSSION.

[ABSTRACT.]

MR. YABBICOM (Bristol).—(Area of district, 11,000 acres; population, 320,000.) Sewers not ventilated. For six months, January to June, 1899, no complaints at all of the smell of sewer gas from any house in Bristol; and for same period, only fifty-one complaints as to smells from sewer gullies. For same period again, death rate was 17·3, zymotic diseases less than 2.

MR. MAWBEY (Leicester).—The only thing is to carry out practical tests, as all general theories are unreliable. Been carrying out tests at Leicester for six years past. Has now recommended his Committee to do away altogether with open grids in the streets and also all intercepting traps except where the drains pass under the houses. Local Government Board have sanctioned the construction of 8 miles at Leicester without any open grids at all.

MR. MACBRAIR (Lincoln).—About twenty years ago Committee decided not to insist upon the disconnecting trap. Now 95 per cent of house drains directly connected with the sewers, and so every house drain acts as a ventilator to the main sewer. About 200 ventilating shafts up sides of houses, and all surface grids closed.

MR. J. A. ANGELL (Beckenham).—Experimented on a sub-district containing 300 houses, and 1,500 population, with surface grids. Frequent complaints as to noxious smells (average over forty per annum). Five years ago closed all surface grids, and erected sewer ventilating columns 13 ft. to 25 ft. in height on the footways at intervals of 150 ft. Each of the ventilating columns takes the place of a lamp column, lanterns being attached to a bracket fixed on the columns. Result altogether favourable, as during last five years no complaints have been made, and zymotic death rate not increased, being only ·3 per 1,000 per annum.

MR. MANSERGH made extensive anemometer tests of Beckenham sewers, but the results were so conflicting and capricious as regards surface and shaft ventilators that no definite theory could be deduced from the results. In any case, the result of the substitution of columns for surface grids has, so far as Beckenham is concerned, proved entirely satisfactory.

MR. COTTERELL (Barton Regis, Bristol).—Deprecates the undue importance attached to sewer ventilation. "Apparently the erection of simple vents to prevent any undue pressure of sewer gas (should such be found) ought to be quite sufficient; or if, instead of the present open ventilators, openings were formed in the top of sewers communicating only with the subsoil, an inexpensive vent would be provided without having to pollute the air we breathe." Considers that "all this seems to point to the need of reducing rather than increasing the ventilation of sewers."

MR. A. M. FOWLER hoped it would not go forth as the opinion of the Association that there should be no disconnection between the house drains and the public sewers. Such an opinion would show ignorance of sanitation. In various schemes of sewage disposal he had provided for shaft ventilation.

MR. J. T. EAYRS.—Objects entirely to intercepting traps and surface ventilators, and blames Local Government Board for much bad sanitation in connection with both. Is glad to learn that Local Government Board have now given way on ventilating grids.

MR. CUTLER was in favour of the intercepting trap and street grid, as he thought the use of these should be left to the engineer who has to deal with the matter. In combined drainage is of opinion that ventilating shafts will be unable to carry off air driven out of sewers by storm water, and fears that many seals in the drains of houses would in consequence be forced.

MR. W. NISBET BLAIR (St. Pancras).—The great difficulty of London authorities is getting permission to erect ventilating shafts. Small ventilating pipes are of no use in dealing with large brick sewers. Differed from Mr. Morgan as to no induction being necessary, and considered that Mr. Morgan's proposed tapered pipes are impracticable. Complained as to action of London County Council in new drainage by-laws, in that they have ignored the recommendations of the metropolitan surveyors.

MR. READ replied.

LEICESTER SEWERS.

Report by MR. E. G. MAWBEY, Borough Surveyor, *re* Ventilation.

"THE SURVEYOR," VOL. XVI., PP. 104, 131, JULY 28 AND AUGUST 4, 1899.

[ABSTRACT.]

MR. MAWBEY had ten years' experience with the sewers at Leicester, commencing in October, 1889. He reported to the Highway and Sewerage Committee on the ventilation of the sewers in 1894, 1895 and 1899.

Soon after May, 1881, 13¾ miles of the existing sewers were opened up, cleaned out, and provided with 512 new manhole and lamphole surface ventilators at an average distance of 47 lineal yards apart.

Complaints as to nuisances from these ventilators became so frequent and effective that a very large number of them were closed, and replaced by connections to factory chimneys and by 4-in. by 3-in. cast-iron ventilating pipes fixed on buildings where permission could be obtained.

Having found the above small-sized ventilating pipes unsatisfactory, Mr. Mawbey had, in 1893, increased their size to 6 in. by 7 in.

In his report of 1894 Mr. Mawbey recommended the closing of surface ventilators and the adoption of shaft ventilators of descriptions, sizes and distances apart according to the various sizes of the sewers to be ventilated.

In his supplementary report of 1895 Mr. Mawbey related: (1) The results of tests he had made which proved the efficiency of shaft ventilation of sewers without open grids; (2) replies to inquiries made in 1894 from forty-eight other towns as to surface *versus* shaft ventilation; and (3) information from, and opinions of, experts in support of shaft ventilation.

Recommendations made in the report of 1895:—

(*a*) That in sewers in all new and unadopted streets *closed* manhole and lamphole covers be used, and, as new buildings are erected, tall shaft ventilators be provided by the Corporation.

(*b*) That in new buildings the Corporation allow any owner to connect his house drains at the building lines to the stoneware pipe laid by the Corporation connecting the public sewer with the ventilating shaft erected on the front of his property.

(*c*) That *closed* manhole and lamphole covers be used on any new sewers constructed by the Corporation, and that adequate tall shaft ventilators be provided.

(*d*) That any existing surface sewer ventilator causing a nuisance be closed, and adequate tall shaft ventilation be provided in lieu thereof.

(*e*) That all tall shaft ventilators be to the approval of the Borough Surveyor.

The Committee, instead of adopting the above recommendations, resolved:—

(*f*) That in every newly or recently constructed sewer, either on a new building estate or in any street where the fall and general condition of the sewer permit it, open grids and manholes be provided.

(*g*) That, as supplementary to this, the Borough Surveyor be authorised and directed to continue to provide other modes of ventilation in any case where, from the circumstances of offensive emanations from manholes, such manholes have been closed.

(*h*) That, in all cases where owners will render assistance, ventilation be secured by chimney shafts, or pipes by the sides of houses, factories, churches, schools and other public buildings.

Also in October, 1895, the Committee resolved:—

(*i*) That the Borough Surveyor be authorised to enter into negotiations with builders and others depositing plans for the erection of buildings for permission to erect ventilating shafts of the requisite sizes on such buildings, the Corporation offering, as an inducement, to make the sewer connection and lay the shaft branch up to the building line, and to permit the owner of the building on which the shaft is to be put to have the use of it for drainage purposes.

In 1894 there were on the foul-water sewers 978 open covers and 2,083 closed, and in 1899 there were 1,639 open covers and 2,332 closed.

Mr. Mawbey continues: "The system of surface grid ventilation has been well tried in Leicester, and has been found a fruitful source of nuisance and strenuous complaints from the public."

Referring more particularly to the present (1899) report, Mr. Mawbey gives some interesting and important conclusions at which he has arrived as the result of a large number of anemometer observations, thus:—

"Although the temperature of the external air was much higher than that of the air in the sewers, there were found to be excellent up-currents through the tall ventilating shafts, the tops of which were higher than the ridges of the roofs.

"In the absence of open grids, the private ventilating pipes or drains not disconnected from the sewers, and some untrapped rain-water pipes, acted as air inlets in the old streets. There are, generally, about twelve 4-in. private ventilating pipes to every 100 yards of sewer.

"Disconnecting traps are only enforced where drains pass under houses or other buildings. In all other cases disconnecting traps are allowed to be dispensed with, or used at the option of the owner, and this arrangement is a great aid to the ventilation of the sewers, for reasons which are stated.

"That in all cases where a disconnecting trap is provided a 4-in. ventilating pipe should be carried up the building from the drain on the sewer side of the trap, terminating well above the eaves of the roof, so as to act as air inlets in conjunction with tall outlet shafts.

"One thousand six hundred and seventeen tests were made, each of fifteen minutes' duration, in connection with four sizes of shaft ventilators erected on houses and other buildings, and carried up above the roofs so as to be exposed to the direct action of the wind, the results of which are summarised in Table No. 1. Both down and up currents frequently alternated during the fifteen-minute tests. The 6-in. and 9-in. diameter standard shafts were erected in more isolated positions, and were not surrounded by so many private ventilating pipes as the rectangular shaped shafts, and therefore do not show such good results."

LEICESTER.—Table No. 1.

—	1,042 Tests. Thirty 6-in. by 4-in. Shafts.	24 Tests. Two 12-in. by $5\frac{1}{2}$-in. Shafts.	368 Tests. Nine 6-in. diameter Shafts.	183 Tests. Nine 9-in. diameter Shafts.
	Feet per minute.	Feet per minute.	Feet per minute.	Feet per minute.
Upward current: average of all tests	162	139	97	87
Downward current: average of all tests	35	31	33	32
Minimum average upward current in any one shaft	78	—	35	45
Next lowest average upward current in any one shaft ...	92	—	40	—
Maximum average upward current in any one shaft	242	—	159	156
Minimum average downward current in any one shaft ...	30	—	31	31
Maximum downward current ...	79	—	36	35
Number of occasions on which up-currents were found... ...	1,002	23	344	180
Number of occasions on which down-currents were found ...	619	16	273	160

Shafts placed from 50 to 200 yards apart.

KENSINGTON VESTRY.

REPLIES TO QUESTIONS PREPARED BY DR. T. ORME DUDFIELD, Medical Officer of Health to the Kensington Vestry, March, 1900.

"THE SURVEYOR," VOL. XVII., P. 266, MARCH 9, 1900.

Thirty-one towns returned replies to fourteen questions sent out by Dr. Dudfield, and the information contained therein is of a very interesting and instructive character.

QUESTIONS:

1. Is there a dual system of drainage?
2. Are the sewers ventilated by the local authority?
3. If so, whether by (*a*) gratings in the road surface, and at what intervals of space; (*b*) shafts carried up private houses; (*c*) shafts formed in lamp columns; (*d*) or by any other, and what, means?
4. Are the ventilators open and unobstructed?
5. Is any appliance fixed in the ventilator for the combustion, disinfection or deodorisation of sewer vapours; and if so, of what description?
6. Is any appliance or chemical agent employed in the sewers themselves for preventing effluvia from the sewage matter; and if so, what?
7. How long have the appliances or agents (if any) referred to in answers to questions 5 and 6 been in use?
8. Are such appliances in general use, or are they fixed in selected positions only?
9. (*a*) The cost of the appliances; (*b*) the approximate annual cost of chemicals and labour for replacement and attention?
10. Is the system regarded as satisfactory by the authority?
11. Are the complaints of offensive smells from ventilating openings received with any frequency?
12. Are the street gullies trapped by syphons or any other means; and if so, by what means?
13. Are house drains ventilated?
14. Are house drains intercepted from the sewer by syphon traps; if so, whether (*a*) under regulations of by-laws of the authority, or (*b*) at the discretion of the house owners?

KENSINGTON VESTRY.

	BIRKENHEAD.	BIRMINGHAM.	BLACKBURN.
1	No.	Only in certain districts.	No.
2	Yes.	Yes.	Yes.
3 (*a*)	Yes.	By means of open manhole and lamphole covers generally, but in special cases by shafts up private houses, and also formed as columns.	Yes.
(*b*)	Yes.		A few.
(*c*)	—		—
(*d*)	—		—
4	Yes.	Yes.	Yes.
5	—	No.	No.
6	—	Yes.	No.
7	—	—	—
8	—	—	—
9	—	—	—
10	—	The system is looked upon as the best practicable known system.	—
11	—	In summer frequently, but generally traced to gullies being untrapped or unsealed.	—
12	Trapped.	—	—
13	Yes.	—	—
14	Yes; under by-laws.	—	—

KENSINGTON VESTRY (*continued*).

	BOLTON.	BRADFORD.	BRIGHTON.
1	No.	No.	No.
2	Yes.	Yes.	Yes.
3 (*a*)	Yes; at change of direction or gradient.	Gratings at intervals of 100 yards.	Gratings at varying intervals.
(*b*)	—	—	Iron or brick shafts up high buildings whereever permission can be obtained.
(*c*)	Yes.	—	—
(*d*)	Mill chimneys.	Occasionally, by connecting to factory boilers, Stott's system.	—
4	Yes.	Yes.	Yes.
5	No.	No.	No.
6	No.	No; in Bradford a considerable quantity of dyers' chemicals is discharged into the sewers, and this probably to a great extent accounts for the absence of offensive smells from the sewers. In addition, the gradients of the sewers are very good. They are therefore, with one or two exceptions, perfectly self-cleansing.	No.
7	—	—	—
8	—	—	—
9	—	—	—
10	Yes.	Yes.	Yes.
11	Occasionally.	No.	No.
12	By syphons.	By syphons.	Trapped in themselves.
13	Yes.	Yes.	Yes.
14	Yes; under by-laws.	Yes; under by-laws.	Yes; under by-laws.

KENSINGTON VESTRY (*continued*).

	BRISTOL.	BURNLEY.	CARDIFF.
1	—	Yes.	No.
2	The sewers are not ventilated by artificial means, and, in the opinion of the City Engineer, local circumstances have much to do with preventing the necessity for such ventilation. No difficulty has been experienced about men entering the sewers when necessary, but two manholes are always opened some time previous to entry. Gullies are syphon-trapped. House drains are ventilated at two points, and are syphon-trapped under drainage regulations.	Yes; and partly by house drains.	Yes.
3 (*a*)		Gratings at intervals of from 30 to 60 yards.	All these methods are adopted as may suit the locality; road gratings are placed about 80 yards apart.
(*b*)		Shafts have been fixed in several cases.	
(*c*)		—	
(*d*)		All soil pipes and cellar drains are ventilated.	By arrangement with owners ventilating connections have been made to tall chimney stacks.
4		Yes.	Yes.
5		No.	No.
6		No.	Porcelain porous cells filled with permanganate of potash with good results.
7		—	Two or three years.
8		—	In selected positions.
9		—	(*a*) 18s. per cell.
10		—	Fairly so.
11		Complaints of smells at certain points, and in several cases shafts have been fixed to walls of houses.	Complaints are occasionally received.
12		Yes; by syphons.	Yes; by syphons.
13		Only cellar drains, in addition to the rain pipes at the rear of houses.	Yes.
14		Yes; under by-laws.	Yes; under regulations.

KENSINGTON VESTRY (*continued*).

	DERBY.	EDINBURGH.	FULHAM.
1	No.	Population 296,000. Length and dimensions of sewers 300 miles, varying from 9 in. to 9 ft. 3 in. by 7 ft. 2 in. The sewers are ventilated by gratings in the road surface at intervals of from 50 to 100 yards. The manholes, forty-four in number, on one of the principal outlets have been fitted with Reeves' appliances at a cost of £10 each. The annual cost for maintenance of these appliances amounts to from £2 to £3 for chemicals, £5 for water, and £3 for attention. Gullies are syphon-trapped. House drains are ventilated and trapped from the sewer by means of syphon traps, under the Edinburgh Municipal and Police Acts.	Three of Reeves' apparatus have been fixed in foul sewers, at a cost of £10 or £12 each, exclusive of fixing. These apparatus cost about 13s. 6d. per month for maintenance. Since they have been fixed no complaints have been received as to smells from the sewers with which they are connected.
2	Yes.		
3 (*a*)	Gratings about 100 yards apart.		
(*b*)	A few shafts have been carried up private houses when gullies have been trapped owing to complaints.		
(*c*)	A few.		
(*d*)	Most of the gullies, being untrapped, act as ventilators.		
4	Yes.		
5	No, except in the case of Holman's patent sewer gas destructors.		
6	No.		
7	Holman's patents, fixed about four years ago.		
8	Holman's patents, fixed in selected positions.		
9	Holman's patent gas lamps cost £20 each; annual cost of gas to each of the two, £9 to £10.		
10	Yes, generally.		
11	Not very often, except at particular times.		
12	Street gullies not trapped as a rule; some trapped when serious complaints are made.		
13	Yes.		
14	Yes; under by-laws.		

KENSINGTON VESTRY (*continued*).

	GATESHEAD-ON-TYNE.	GLASGOW.	HUDDERSFIELD.
1	No.	No.	No.
2	Yes.	Yes.	Yes.
3 (*a*)	Gratings just where convenient.	Gratings at intervals of 30 to 100 yards, according to size of sewer.	Gratings about 200 ft. apart.
(*b*)	—	—	—
(*c*)	—	Shafts in lamp columns in a few experimental cases.	—
(*d*)	Two shafts up telegraph post.	—	—
4	Yes.	Yes.	Yes.
5	Some baskets were fixed, but two have not been renewed.	In several of the lamp ventilating columns the sewer vapour comes in direct contact with the burning gas.	No.
6	No.	No.	No.
7	—	For a considerable number of years.	—
8	Very few.	Arrangements are in progress for their adoption on an extended scale.	—
9	(b) *nil.*	Lamps with connecting columns cost £18 each.	—
10	—	So far as yet tried.	Yes.
11	Sometimes an iron plate is put in for a time.	No.	No.
12	Yes; by syphons.	A few gullies are trapped.	Untrapped.
13	Yes.	Yes.	Yes.
14	Yes; under by-laws.	Yes; under by-laws.	Yes; under regulations.

KENSINGTON VESTRY (*continued*).

	KINGSTON-UPON-HULL.	LEEDS.	LIVERPOOL.
1	No.	No.	Area drained into Mersey is on combined system; area drained to sewage farms (population 70,000) is dual system.
2	Yes.	Yes.	Yes.
3 (*a*)	Gratings every 100 yards.	Gratings every 50 yards.	Manhole covers and gratings 80 yards apart.
(*b*)	Shafts carried up houses in twenty or thirty cases.	Shafts up private houses occasionally.	Shafts up private buildings.
(*c*)	—	—	A few columns.
(*d*)	Connections to chimneys.	—	6-in. columns in footways where safe outlets can be obtained.
4	Yes.	Yes.	Yes.
5	No.	No.	Ten disinfecting trays are fixed, containing wick saturated with carbolic acids, at manholes where smells were detected.
6	A little carbolic disinfectant is used with flushing vans.	No.	No.
7	—	—	From two to three years.
8	—	—	They are not in general use.
9	—	—	Ten shillings each. The originals are still in use and are attended to twice a month.
10	—	Generally so.	Yes.
11	Very rarely, and there is always some special local reason.	Complaints are sometimes made.	No.
12	Yes; by syphons formed in gullies.	No.	Brick gullies with flag midfeathers generally, but other types of gullies are also in use.
13	Those constructed under the present by-laws are ventilated.	No.	Yes.
14	Those constructed under the present by-laws are trapped.	—	Yes; under by-laws.

KENSINGTON VESTRY (*continued*).

	MANCHESTER.	MIDDLESBROUGH.	NEWCASTLE-ON-TYNE.
1	No.	No.	No.
2	Yes; but the system varies in different parts of the city.	Yes.	Yes.
3 (*a*)	Gratings at intervals of about 100 yards.	Yes.	Gratings 55 yards apart.
(*b*)	Yes.	Yes.	Two or three shafts up private houses.
(*c*)	—	—	—
(*d*)	A few connections with tall chimneys of manufactories.	—	—
4	Yes.	Yes.	Grid cover with dirt tray below; open area 100 square inches.
5	No.	Special boxes for disinfection.	No.
6	No.	In flushing the sewers a certain amount of coal-tar extract is put in the tanks.	No.
7	—	For the last fifteen years.	—
8	—	—	—
9	—	—	—
10	—	—	—
11	Complaints have been received but not with any great frequency.	No.	Occasional complaints only, and always traced to private drains.
12	Yes.	Yes; by syphons.	Yes.
13	Yes.	Yes.	Usually.
14	Yes; under by-laws.	Yes; under by-laws.	Occasionally.

KENSINGTON VESTRY (*continued*).

	NORWICH.	PLYMOUTH.	PORTSMOUTH.
1	Yes; in many parts of the city.	No.	For a portion of the borough.
2	Yes.	Yes.	Yes.
3 (*a*)	Gratings formerly, but these are being discontinued.	Manholes at varying distances.	Gratings at every manhole, about 100 yards apart.
(*b*)	Shafts are fixed up private houses where consent can be obtained.	Three shafts up private houses.	Shafts up private houses where permission can be obtained.
(*c*)	—	One ventilating lamp column.	About ten shafts in street lamp columns.
(*d*)	Columns from 30 ft. to 40 ft. high, at suitable points in the streets.	Two stacks, one 70 ft. and one 30 ft. high.	—
4	New columns have louvre crinolines to increase draught when wind is blowing. These do not obstruct flow at other times.	Yes, in most cases.	Yes.
5	No gas furnaces; ventilating gas lamps, &c., have been tried, but such fittings are thought to be of no service.	Arnold's patent disinfectors in a few special cases.	No.
6	No.	No.	No.
7	—	Four years.	—
8	—	In selected positions only.	—
9	—	(*a*) £5 10s. each. (*b*) £1 per annum for each disinfector.	—
10	—	Yes.	Not entirely satisfactory.
11	No complaints where columns or vent pipes up houses have been fixed, except in rare cases.	Not where Arnold's apparatus is fixed.	As to gratings, in streets only.
12	Yes.	Yes.	Patent Fenwick iron gullies trapped with iron tongues.
13	Yes.	Yes.	Yes.
14	Yes; under by-laws, but this is thought by the Engineer to be a mistake.	Yes; under by-laws.	Yes; under by-laws.

KENSINGTON VESTRY (*continued*).

	PRESTON.	ROCHDALE.	SALFORD.	SOUTHAMPTON.
1	No.	No.	No.	Street gullies discharge into storm-water drains.
2	Yes.	Yes.	Yes.	New sewer works under construction with self-cleansing gradients, and will therefore require little ventilation; upcast shafts are erected at highest points. (rows 2 to 5)
3 (*a*)	Gratings 50 yards apart.	Manholes about 100 yards apart, with lamp-eyes between.	Manhole lid-grids to street sewers, about 200 ft. apart.	
(*b*)	Yes.	Shafts up private houses at upper ends of sewers.	Shafts up private houses from the summit of each passage sewer.	
(*c*)	—	—	—	
(*d*)	—	—	Open ends into sewage works.	
4	Yes.	Yes.	Yes.	
5	—	No.	No.	
6	—	No.	No.	—
7	—	—	—	—
8	—	—	—	—
9	—	—	—	—
10	—	—	Not quite, as there is some nuisance from the manhole grids.	—
11	No.	No.	Yes.	—
12	Yes.	Yes.	Yes; by syphons.	—
13	Yes.	Yes, generally.	Yes.	Yes.
14	Yes; under by-laws.	Yes; under by-laws.	Not usually; but in future under by-laws.	Yes; under by-laws.

KENSINGTON VESTRY (*continued*).

	SOUTH SHIELDS.	SUNDERLAND.	YORK.
1	No.	No.	No.
2	Yes.	Yes.	All new sewers are ventilated, and vents are being put to old ones.
3 (*a*)	Shafts and open covers on manholes (the majority of the manholes are close covered).	Gratings in road surface.	Gratings on all new sewers, about 50 yards apart.
(*b*)	—	—	Shafts up private houses at summits of sewers.
(*c*)	—	One ventilating lamp column only.	—
(*d*)	—		Vertical vent columns, 25 ft. to 30 ft. high.
4	—	With exception of dirt pans.	Yes.
5	No.	Combustion by constant coal-gas burner (Keeling's patent).	No.
6	No.	No.	No.
7	—	About ten years.	—
8	—	Selected positions.	—
9	—	—	—
10	—	—	—
11	There are no open manholes except in out-of-the-way places.	Not unusual.	Occasionally; where a surface vent has proved persistently offensive it has been closed and an upright shaft provided as near as possible.
12	Yes; by syphons and dip-stones.	Yes.	Yes; by syphons.
13	Yes.	Yes.	Yes.
14	Yes; under by-laws. In the older parts of the borough drains are being trapped on re-construction.	Yes; under by-laws.	Yes; under by-laws.

KENSINGTON VESTRY.

Analysis of Replies from Thirty-one Towns.

1. Three "Yes"; twenty-one "No"; three "Part."
2. All "Yes."

3 (*a*). Twenty-six "Yes"; one "No."

(*b*). Nineteen "Yes."

(*c*). Nine "Yes."

(*d*). Eleven "By other means."

4. Twenty-five "Yes."
5. Eight "Yes"; eighteen "No."
6. Three "Yes"; twenty-one "No."
7. "Various times."
8. "In selected positions only."
9. "Various costs."
10. Eight "Yes"; three "No"; two "Qualified."
11. Twelve "Yes"; nine "No"; two "Occasionally."
12. Twenty-one "Yes"; four "No."
13. Twenty-three "Yes"; one "No."
14. Twenty-four "Yes"; one "Occasionally."

GRIMSBY SEWERS.

Report by MR. H. GILBERT WHYATT, Borough Surveyor, *re* Ventilation.

"THE SURVEYOR," VOL. XIX., PP. 28, 140, 168, JANUARY, 1901.

[SUMMARY OF THE REPORT.]

1. The condition of the air in sewers depends in great measure upon their construction, condition and cleanliness.

2. Tide-locked sewers had aërial contents forced up into the streets and curtilages of the houses twice each day.

3. Since pumps were introduced; only in times of flooding, when pumps are overcome, is air forced out of sewers.

4. Opinion of Mr. J. Parry-Laws, F.I.C., as given in his report to the London County Council, 1893, quoted, in which Mr. Laws found "that the micro-organisms in the air of sewers are related to the micro-organisms in the external air, and not to those in the sewage itself," and that "however full the sewage is of disease germs, the latter do not pass into the air of sewers in the absence of violent splashing, nor yet when considerable air currents prevail in the sewer." Mr. Laws also found by experiment "that no micro-organisms were disseminated in the sewer air from the walls of a pipe sewer which had been empty for twelve days, and where immense numbers of microbes must have been clinging to their sides."

5. In a later report Mr. Laws says that although there is no direct evidence that the organisms found in sewer air constitute any source of danger, yet it is impossible to ignore the evidence, though it be only circumstantial, that sewer air in some instances has had some casual relation to zymotic disease.

6. Does not recommend that the intercepting trap should be abandoned in view of probable defects in house drains.

7. In Grimsby there are 446 manholes with ventilating covers. Majority of these have been complained about, and orders given to close the covers.

8. The policy of closing grids without providing other means of egress for the foul air only results in greater foulness of the sewer air, and forcing traps in the near neighbourhood.

9. Describes the Reeves method of filtration.

10. Theory of sewer ventilation: Low-level air inlets, high-level air outlets. Sanctioned by Local Government Board, but often proves fallacious, as air currents are frequently reversed.

11. "The ventilation of sewers is not desirable, except on those occasions where workmen have to descend for certain purposes."

12. "A current of air along a sewer is not a necessity. What is required is a free vent for sewer air."

13. Tall chimney shafts and house chimneys not found successful. (King's Norton case, in which the Rural District Council connected a ventilating shaft into a chimney, the owner died, and jury found for the executors of deceased £3,500 against the Council.)

14. Webb's Sewer Gas Destructors described. Consume 8 cubic feet of gas per hour at 2s. 6d. per 1,000 cubic feet, equal to £9 per annum. This capitalised at thirty years amounts to £270, plus cost of lamp, say, £15, equal to capital cost of £285 for dealing with sewer gas at any particular point.

15. Lamp columns as ventilators. At Southport over 200 lamp-posts are used as sewer vents, and are so generally unnoticeable that no complaint of nuisance arising from them is ever made.

16. Property owners at Grimsby do not object to give facilities for vent shafts.

17. Ventilation of house drain between sewer and intercepting trap. Two thousand of these vents in use at Torquay. Thinks that with the present legal powers of the Corporation this could be insisted upon at owners' expense.

18. Rust pockets should be provided at all vent shafts.

19. Flushing arrangements at Grimsby.

20. Recommendations by Borough Surveyor:—

- (*a*) As to closing manhole grids complained of in the past and erecting vent shafts instead.
- (*b*) Vent shafts to be placed at syphons and flaps in sewers.
- (*c*) Vent shafts to be placed at dead ends of sewers.
- (*d*) Where manhole grids are complained of, in future to be closed only on condition that property owners give facilities for erecting vent shafts.

(*e*) Vent shafts to be placed on sewer side of each intercepting trap at expense of owner.

(*f*) Ventilation of Pyewipe outfall.

(*g*) To alter flushing arrangements so as not to flush when sewers are tide-locked.

(*h*) To construct hand-discharging cisterns or tanks so as to fill with sea water at high tide, and to be let off by hand three-and-a-half to four hours after high-water.

Sub-Committee adopted recommendations (*a*) to (*e*) with certain modifications; (*e*) to be compulsory only as regards future buildings.

MANCHESTER SEWERS.

Report by MR. T. DE COURCY MEADE, City Surveyor, *re* Ventilation.

"THE SURVEYOR," VOL. XXI., P. 259, FEBRUARY 28, 1902.

Information obtained by City Surveyor from sixty towns in the United Kingdom, and eight towns in Canada or the United States.

The Surveyor recommended :—

1. That a systematic course of ventilation should be put in hand over the whole of the 1,700 miles of sewers belonging to the city.
2. That upcast shafts be erected in suitable positions, with surface ventilators as inlets for fresh air.
3. That the ventilating shafts be periodically examined and painted, and the rust pockets at the base of the shafts regularly emptied.
4. That the plant used for treating manufacturers' refuse should be open to official inspection.
5. That when such refuse contained chemicals which would become of an explosive or dangerous character on admission to the sewers, such refuse be rigidly excluded from the sewers.

A Sub-Committee was appointed to go into the whole matter.

RETURNS FROM FORTY-NINE TOWNS AS TO CLOSING SURFACE VENTILATORS AND ERECTING TALL SHAFTS.

RECEIVED AND TABULATED BY MR. H. GILBERT WHYATT, Borough Surveyor, Grimsby.

"THE SURVEYOR," VOL. XXII., P. 117, JULY 25, 1902.

[ABSTRACT.]

Query 1.—Have you abandoned surface ventilation of sewers?

Query 2.—If so, was alternate method of ventilation provided by loan obtained under sanction of the Local Government Board or out of rates?

Query 3.—If the former, did the Local Government Board consent to the surface ventilators being closed, or have you closed them without consent?

REPLIES.

Seven towns (names not given).—No reply.

Seven towns (names not given).—Have never abandoned surface ventilation.

One town (name not given).—Surveyor desires his reply to be kept quiet.

Four towns (Table A).—Surface ventilation was never adopted.

Twenty-eight towns (Table B).—Surface ventilation has been entirely, or was being gradually, abandoned out of the rates, and therefore without consulting the Local Government Board.

Nine towns (Table C).—Surface ventilation has been, or is being gradually, abandoned, the cost being defrayed out of loans sanctioned by the Local Government Board.

TABLE A.

Containing list of four towns where surface ventilation was never adopted.

NAMES.	ACRES.	POPULATIONS.
Aberystwyth	847	8,014
Canterbury	3,955	25,000
Devizes	907	6,529
Wigan	2,181	62,000

TABLE B.—GRIMSBY.

Containing list of twenty-eight towns and urban districts where surface ventilation has been entirely, or was being gradually, abandoned out of the rates without consulting the Local Government Board.

NAMES.	ACRES.	POPULATIONS.	REMARKS.
Basingstoke	4,194	10,000	Yes, to a great extent.
Blackpool	4,244	47,346	Partially; all new manholes have closed covers.
Bootle	1,590	58,556	In part.
Bournemouth	5,850	60,000	Yes; many years ago.
Chesterfield	1,338	—	Yes; in one portion of the town.
Deal	1,111	11,000	Yes.
Eastbourne	5,410	43,000	In some parts of the town.
Folkestone	2,481	30,694	No surface ventilation.
Harwich	1,870	10,140	In the narrow streets.
Hastings	4,857	68,000	Yes.
Henley-on-Thames...	348	6,500	Yes, in all cases.
Leicester	8,586	220,000	Yes, on all new sewers; and on all old sewers wherever a complaint is received and sanction to erect a shaft obtained.
Lewes (Sussex) ...	1,024	11,245	Yes.
Lincoln	3,891	48,500	Offending covers closed on complaint wherever sanction to erect a shaft is obtained.
Maidenhead	2,123	13,000	Yes, in all streets.
Norwich	7,582	111,728	Yes.
Penzance	472	15,000	Manholes provided with flap inlets, to allow entrance of air only.
Ramsgate	2,343	27,586	Practically; only a few open covers left.
Reading	5,878	73,895	Not entirely.
Swindon	4,246	45,000	Yes.
Tenby...	735	4,500	Not entirely.
Torquay	3,879	33,000	Yes.
Widnes	3,039	29,000	Yes.
Slough (Bucks.) ...	—	12,000	Yes.
Surbiton	2,858	15,020	Yes; some years ago.
Sutton (Surrey) ...	1,835	17,100	Yes, with the exception of manholes where deodorising plant is fixed.
Tipton	2,700	32,000	Not entirely.
Uxbridge Rural ...	18,500	18,300	Yes; all surface grids are now closed.

TABLE C.—GRIMSBY *(continued)*.

List of nine towns where surface ventilation has been entirely, or is being gradually, abandoned, the cost being defrayed out of loans sanctioned by the Local Government Board.

NAMES.	WHETHER ABANDONED.	WHETHER UNDER LOAN.	WHETHER WITH CONSENT OF LOCAL GOVERNMENT BOARD.
Brighton (2,620 acres, 123,478 pop.)	Partly.	By loan under sanction of Local Government Board.	Ventilating shafts would be useless unless the surface ventilators in the neighbourhood were removed. We did not ask the consent of Local Government Board.
Canterbury	Never been adopted.	—	System of ventilating by tall upright shafts was approved of by the Local Government Board some forty years ago.
Leicester	Yes, on all new sewers.	—	The Local Government Board have sanctioned a scheme for new tributary sewers, in which all the ventilation is effected by tall shafts.
Norwich	Yes. It constitutes a nuisance dangerous to health in most cases.	—	On old sewers this work has been charged to revenue; on new sewers we provide nothing but standard vent shafts, costs of which have been included in estimates and approved.
Scarborough (2,292 acres, 38,109 pop.)	Yes.	By loan.	No record; they were probably not asked.
Southend-on-Sea (5,172 acres, 30,000 pop.)	Yes.	By loan.	By consent of the Local Government Board.
Tenby	Not entirely.	By loan.	Some have been closed without consent.
Tonbridge (1,200 acres, 13,000 pop.)	Yes, entirely.	—	Yes; half of old sewers relaid, and 5 miles of new provided with vent shafts, all out of loan sanctioned by Local Government Board.
Weston-super-Mare (20,000 pop.)	Not entirely.	By loan for erecting ventilating pipes up sides of buildings.	—

The general opinion to be gathered from the above replies from thirty-six towns is :—

1. That the emanation of sewer gas at street level is objectionable.
2. That in four cases surface ventilation was never adopted.
3. That in twenty-eight towns and urban districts they (the surface ventilators) are closed, or are being closed, out of revenue account.
4. That in certain other towns surface ventilators are closed, or are being closed, and ventilating shafts erected instead, out of capital account, and with the sanction and definite approval of the Local Government Board.

SEWER VENTILATION.

Paper read by MR. COUNCILLOR W. F. DEARDEN, M.R.C.S., L.R.C.P., D.P.H. (Manchester), at the Congress of the Sanitary Institute at Manchester in September, 1902.

"JOURNAL OF THE SANITARY INSTITUTE," VOL. XXIII., P. 746.

[ABSTRACT.]

The Manchester City Surveyor, Mr. T. de Courcy Meade, had recently obtained information on the methods adopted for the ventilation of sewers from sixty of the principal towns of the United Kingdom, and eight important cities of Canada and the United States.

In response to advertisement, information on the subject had also been received from firms and individuals having special knowledge of the subject.

All methods of sewer ventilation classified under three headings—*viz.*, Natural Ventilation, Artificial Ventilation, and Deodorisation.

Under "Natural Ventilation" are three sets of advocates :—

1. The production of as free a circulation of air along the sewer as can possibly be obtained.
2. No admission of fresh air, but only a few carefully guarded outlets for the relief of pressure.
3. Ventilation at all is not only useless but absolutely wrong in principle.

Without free ventilation sewer gas is likely to take the place of sewer air, and the excess of pressure due to the production of sewer gas is usually found to vent itself through the street gullies. Other points against closed or semi-enclosed sewers are the greater liability to explosion, with a likely increase in attendant damage, and the rendering of the air irrespirable for workmen repairing or cleansing.

The Transatlantic cities of Buffalo, Chicago, Minneapolis, Philadelphia, Washington, Boston and Toronto all use street surface grids placed at proper intervals apart, which appear to give satisfaction.

As regards the sixty towns in this country, twenty-eight use surface grids, but twenty of these have found it advisable to erect a few shafts under special circumstances. The evidence collected from the above towns is that perforated manhole covers should not be placed at greater intervals from one another than 100 yards, with lampholes with similar coverings in between the manholes, the effective ventilating area of the manhole grids being between 40 to 50 square inches, and that of the lamp-eye about 20 square inches.

The objections to surface grid ventilation are :—

1. The undoubted nuisance from evil smells emitted from some of the openings, particularly in narrow streets, during hot weather where the gradient is low, and the sewage practically stagnant, through the sewers being old and silted, or from discharges from chemical works.
2. Street dirt and sweepings finding their way through the openings into the sewers.

The objection founded on a common belief that some zymotic diseases can be communicated to persons kept in close proximity to a street grid.

The character of the sewer air emitted from surface grids as a disease-spreading agency is *the* factor to be determined first of all, and this can only be decided by bacteriological experiments, and the author's Committee propose to have fresh experiments made with this end in view.

Twenty-three towns out of the sixty effect their ventilation by a combination of surface grids and high shafts. Mr. Mawbey's experiments at Leicester show conclusively that high shafts, though they may act mainly as extractors, yet the surface grids are not effectually influenced thereby, but in many cases the latter continue to pass out foul air, and to act as outlets with more than twice their effect as inlets.

In four towns in the list the drains are disconnected and the sewers ventilated solely by high shafts, varying in diameter from 4 in. to 12 in. according to the size of the sewer, and placed at an average distance apart of about 150 yards. These shafts are either against buildings (in which case an acknowledgment is paid) or take the form of columns in the streets, and if the columns or shafts are vertical or nearly so, of fair diameter, and at frequent intervals, the evidence shows that they are satisfactory for the purpose aimed at. The objections to shafts are :—

1. Long tubes offer much friction to air.
2. Bends seriously reduce the effect of the tubes.
3. If the pipes forming the shaft are leaky there is great danger from sewer gas getting access to house windows.

VENTILATION OF SEWERS.

Paper read by MR. ALFRED M. FOWLER, M.INST.C.E., F.S.I., at the Manchester Meeting of the Sanitary Institute in September, 1902.

"JOURNAL OF THE SANITARY INSTITUTE," VOL. XXIII., P. 754.

[ABSTRACT.]

This subject must be based upon sound principles of design and construction, inasmuch as the best results in the ventilation of sewers cannot be obtained in the absence of proper design and true level of the works themselves.

There is no part in the details of the construction of main sewers which has made less progress to arrive at satisfactory results than the question of ventilation.

The aim to obtain sewers which will not admit of deposits is the initial stage in securing an early and safe means to prevent foul air being discharged into the atmosphere.

It is both desirable and necessary to provide a means of ventilating the sewers so that the sewer air can be diluted with as much fresh air as possible, and passed off as far away from the inhabitants as practicable.

It is the wind that forms the great power in ventilating sewers.

It is therefore with this initial condition (correct design and sound execution), forming the groundwork for the construction of sewers, that I wish to bring forcibly before the notice of the meeting that such "prevention is better than cure," whilst I am free to admit that the ventilation of sewers is absolutely necessary, although the emanations from a channel open throughout its entire length like the becks at Leeds, or any river so channelled, are comparatively harmless. It is on this basis, I submit, that as much fresh air as possible should be admitted to dilute the vitiated air in covered sewers as far as practicable.

Mr. Shone has recently invented a system of ventilation, based on a carefully-prepared formula, and, I may say, on scientific and quite original principles. A mechanical fan . . . . draws into the sewer at least one-tenth of a cubic foot of fresh air per minute per inhabitant, and every street gully and domestic soil pipe is to be provided with an inlet apparatus. The fan, by every revolution, propels forward the necessary number of cubic feet of air, and by a sufficient number of fans revolving at the necessary velocity in different zones, or sections of sewers, the amount of air required is said to be supplied independent of all atmospheric conditions. One fan is said to be sufficient to supply a population of 15,000, and can be worked by electricity at 3d. per Board of Trade unit, which would amount to £88 7s. 6d. per annum, or £5 17s. 10d. per 1,000 of the population, or 1·41d. per head per annum.

SEWER VENTILATION.

ABSTRACTS FROM SIX PAPERS read and discussed at a District Meeting of the Incorporated Association of Municipal and County Engineers at Birmingham on January 31, 1903.

Paper by MR. T. CAINK, City Engineer, Worcester.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXIX., P. 141.

[ABSTRACT.]

The author discusses two points:—

(1) Whether it is necessary to ventilate sewers at all, and

(2) Whether, having regard to all the circumstances, the object sought to be attained in the ventilation of sewers is best secured by the ingress and egress of as *great* or as *little* a volume of air as possible, consistently in both cases with avoiding any appreciable pressure being put upon the water seals of the private drains.

In the author's opinion provision for the ventilation of sewers is necessary.

The author found that the closing of surface grids and the erection of tall shafts against private property was unsatisfactory, as the latter was not only costly and without legal authority, but that they failed to put an end to the complaints.

The author also found, from experiments, that by far the most important cause of offensive emanations from manhole grids was the wind, and that the more rapid the current issuing from the ventilator the more foul the smell.

After trying sewer gas destructors, each consuming £8 to £10 worth of gas per annum, and obtaining unsatisfactory results, the author arrived at the conclusion "that the solution of this problem lies, so far as the prevention of nuisance is concerned, in checking the rapid discharge of sewer air from the ventilators, or, in other words, in *transmitting as little air as possible from the sewers*, consistently with affording such relief as will prevent the pressure therein rising appreciably above that of the atmosphere.

To accomplish this object the author designed the following apparatus, by which the sewer air is regulated and filtered through a layer of cotton wool.

In regard to private drains, the author would prefer to dispense with the surface opening entirely, and to construct tall shafts for both inlet and outlet.

Paper by MR. R. READ, City Surveyor, Gloucester.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXIX., P. 155.

[ABSTRACT.]

Deposits occur in sewers from the following causes:—

1. Flat gradients.
2. Insufficient flushing either at the water-closets or in the sewers themselves.

3. Inefficient or neglected street gullies and manhole buckets.

4. Temporary insufficient number of live drain connections in new undeveloped districts.

All the causes of deposit mentioned above are more or less preventable, and if there is no deposit in a well designed and constructed sewer, why is ventilation necessary?

The methods of ventilation now in use may be classified as follows:—

1. Openings in the manhole and lamphole covers at the street surface, at various intervals of from 40 to 100 yards apart.

This system discharges sewer air or gas immediately under the noses of the people, and is uncertain in its action.

2. Vertical shafts attached to buildings, trees, telegraph poles, or self-supporting, 4 in., 6 in. and 9 in. diameter.

This is an improvement on the first, as it discharges the sewer air from 20 ft. to 60 ft. above the street level at an elevation exposed to the wind.

3. Various combinations of surface gratings and ventilating shafts, generally in wrong proportions and positions owing to legal difficulties.

This system has seldom had a thorough trial in the proper proportions and arrangement which are necessary to harmonise with the action of the sewers and thus convert it from a haphazard into a scientific and reliable system.

4. Connections to factory chimneys.

5. Various patent systems of induced current ventilation by means of gas jets, water jets, or compressed air.

6. Systems of deodorising the gases given off at the manholes by the introduction of chemicals.

Nos. 4, 5 and 6 systems are altogether too costly for general application, although they are occasionally useful for isolated cases of offensive manholes, to avoid the expense of a reconstruction of sewers.

The watery vapour rising from the sewage (of well-constructed sewers) should not be putrid, but generally is so for the following reasons:—

1. The alternate wetting and drying of the sides of the sewer, owing to the rise and fall of the sewage.

2. The discharges from the house drains are more or less decomposed owing to the interposition of the intercepting trap, which acts as a cesspool.

3. For want of proper ventilation.

The author concludes with an interesting description of the action of sewer air in a sewer, and with remarks strongly condemnatory of the intercepting trap as usually laid under the Model By-Laws.

Paper by Mr. W. J. STEELE, Deputy City Engineer of Bristol.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXIX., P. 164.

[ABSTRACT.]

The sewers of Bristol are not ventilated. All the manholes and lampholes have closed covers, and no means are intentionally made to provide a communication between the sewers and the atmosphere.

There are eight outfalls into the River Avon fitted with tidal flaps, the head against the bottom of which at high water of ordinary spring tides varies from 7 ft. to 20 ft.

All street gullies are trapped.

Since 1882, drains connected to the sewers have been provided with an intercepting trap, with openings to the air on the building side of the trap, and also at the highest point of the drain.

Every building used for human habitation is provided with at least one water-closet, and all roof water, bath and sink waste pipes, discharge over trapped gullies.

Prior to 1882, intercepting traps were not compulsorily fixed.

Possibly there are several instances where a roof water pipe forms a means of communication between the sewers and the atmosphere, owing to there being no water seal between such pipe and the sewer, but the number cannot be stated with any degree of accuracy. If any notification of bad smells in or about buildings is received, the sanitary inspectors of the Health Department cause the drainage system to be modified on the lines indicated above. During the year ended December 31st, 1901, over 4,800 systems were amended.

During the year ended December 31st, 1902, only ninety-one complaints were received of bad smells in the streets, and these were in every case found to be from gullies which, from defective traps, had the water seal broken. Vital statistics are quoted to show that Bristol compares favourably with most other towns similarly situated.

The responsible authorities in Bristol have quite an open mind on the question of sewer ventilation in general, but they hold the view that it has never been demonstrated that the practice at present applied in Bristol is prejudicial to the health of its inhabitants. . . . .

Finally, the following points occur to the author as requiring solution, based upon full experimental data—*viz.* :—

Is it necessary to continuously admit atmospheric air to a properly constructed sewerage system ; and, if so, how ?

Is it necessary to continuously provide a vent for the air displaced from a properly constructed sewerage system by various causes ; and, if so, how ?

Paper by MR. A. W. CROSS, ASSOC.M.INST.C.E., Surveyor to the Urban District Council, King's Norton.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXIX., PP. 171–174, JANUARY 31, 1903.

[ABSTRACT.]

Mr. Cross has installed a system of short columns 10 ft. to 12 ft. in height, with hexagonal inlet ventilating heads controlled by non-return aluminium flaps, and tall vent shafts 30 ft. to 40 ft. in height.

Tests made by anemometer showed that 2,098 lineal feet of air passed into the sewer through a 6-in. shaft in five minutes during a high wind.

Another test, extending over twenty-four hours in breezy weather, showed that 21,000 cubic feet of fresh air was passed into the sewers through one of these inlets fixed on a short shaft 11 ft. high.

Mr. Cross has devised an arrangement whereby an induced current of air is caused by a water spray from the water supply mains. This apparatus is *not* in use in consequence of the water authority at King's Norton refusing to give a supply of water for fear of contaminating the public water supply. The cost of each installation is from £3 to £4. The Local Government Board endorsed the action of the water authority.

Paper by MR. HERBERT H. HUMPHRIES, Engineer and Surveyor to the Urban District Council of Erdington.

[ABSTRACT.]

Views expressed in the paper are based upon experience gained in a modern residential suburban district, having most of its sewers constructed with small stoneware pipes.

The author has found that a judicious combination of surface and shaft ventilation has been the best solution of the difficulties encountered, the shafts, as far as possible, being placed at junctions of sewers and the *lower* ends of gradients and other suitable points, and surface ventilators placed at higher points, in order to act as inlets, with the shafts acting as outlets. The abolition of the intercepting trap on house drains would be of the greatest and most necessary assistance to the ventilation of sewers, and would keep the sewage quite fresh instead of being fouled by continual half-decomposed discharges from private drains. Its abolition would, however, only be warranted upon thoroughly well-constructed and otherwise amply well-ventilated sewers.

Paper by MR. C. CHAMBERS SMITH, Surveyor to the Urban District Council, Sutton, Surrey.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXIX., P. 184.

[ABSTRACT.]

The weak point of all methods of ventilating drains and sewers by utilising atmospheric influences only is that in no such method can the volume of air or point of exit be controlled.

Apart from any question of treating the issuing sewer gases, the control of the volume and direction, as well as the choice of a place of exit, are important matters as regards ventilation of itself, and any method which gives such control and choice is based upon correct principles.

Mr. Chambers Smith therefore favours such a system as that introduced by Messrs. Shone & Ault, which is "a means of extracting air from drains and sewers by a fan, driven electrically or otherwise, and the controlling of all air admitted to the drains and sewers by openings regulated in diameter in accordance with the volume desired to be admitted at any one point, and the vacuum available at that point."

DISCUSSION ON THE PAPERS ON "SEWER VENTILATION," JANUARY, 1903.

[SUMMARY.]

MR. J. PRICE.—Cost of any new system of sewerage may be increased 50 per cent by provisions for ventilation. Has seen Cross' apparatus at work in his own district, and was surprised to see so large a volume of air passing through the pipe caused by the induced current resulting from the water spray.

MR. J. PARKER.—All agree that the old system by open gratings at the street level is a failure. Unaided or natural means are inadequate for the ventilation of sewers. Mr. Cross' method unsatisfactory; without the water spray it is costly and complicated, with the water spray it is impracticable. Air inlets or outlets which depend upon the correct action of either mica or aluminium valves are absolutely unreliable.

MR. E. B. SAVAGE.—Sewer emanations (leaving out those cases due to special causes) are of two entirely distinct origins—*viz.*, (1) those due to putrefactive changes in the sewers; and (2) those due to the foul-smelling liquids and excreta passed into the sewers. As regards the system of ventilation adopted in Birmingham, after having tried various costly systems we still find that *the vent placed in judiciously selected positions, used in conjunction with a reduced number of open gratings, give the best results.* Eighty now in use, and are being extended.

MR. W. WEAVER.—There is a vital difference between sewer gas and sewage smell. There is nothing injurious to health in sewer smell. Considers the syphon trap a great mistake. "Close up as many of your surface gratings as possible, and put up your extracting shafts in whatever positions may be suitable, with a wire guard or dome on the top."

DR. W. F. DEARDEN (Manchester).—What have we to ventilate our sewers for? Manchester is starting experimental work from that point of view. We do not know yet what the effect of sewer air is, and it is of primary importance that we should know. Messrs. Parry-Laws and Andrewes drew the conclusion that the air of sewers instead of being worse was better than the air in the streets above them. Dr. Arthur, of King's College, and Dr. Nash, Medical Officer of Health of Southend, have taken up the question, and certainly appear to have proved that dangerous germs can be obtained from sewer air. Manchester Corporation have decided before undertaking expensive engineering works for sewer ventilation to seek aid from the bacteriologist, the chemist, and the electrician, and have instructed Professor Delepine to take up the question of sewer air and the relation it bears to the health of the people. They have also decided to try Shone & Ault's system, and to give a fair trial to other systems. Does not agree that the proper way to ventilate sewers is by utilising the ventilating shafts on the house drainage systems. Manchester will stick to dual system, as they find that the traps and pipes are, when opened up, always found in good condition.

PROFESSOR BOSTOCK HILL.—When a sewer smells it is evidence of putrefaction. Gas is formed, and the bubbles of this gas burst and take up into the atmosphere micro-organisms in the sewage, and danger results. Sewer gas may be very dangerous if it is confined in a limited space. If the sewer gas gains access to a house, disease may ensue; but where it comes out into an open street there is certainly much less danger.

DR. BRUCE LOWE.—Has proved that offensive sewers were scarcely ever associated with zymotic disease. Not hopeful as to heat or other mechanical means of ventilation, neither is he sure that anything is going to be done in the way of disinfecting sewer air. The use of disinfectants cannot produce anything proportionate to the trouble and expense entailed. Is inclined to think at the present time it is not a very scientific state of affairs; that the putting up of ventilating shafts (up the sides of houses only in exceptional circumstances), together with the closing of as many as possible of the surface grids, is the best way out of the difficulty.

MR. E. J. SILCOCK.—Would abolish the intercepting trap. An arrangement of inlets and outlets, with flaps attached, is open to grave objections. Not aware of any mechanical flap which would maintain itself in proper repair for any time. As far as one can see, the best way of dealing with the question is to do away with the intercepting trap, to close all the surface grids, and to have as many high shafts as possible with perfectly plain open ends, to keep the shafts away from the buildings, to have few complications and connections with the sewers, to avoid as much as possible all bends, and make the route to the air as direct as possible.

MR. T. DE COURCY MEADE.—Does not agree with the proposal to abolish the intercepting trap. It is a very dangerous principle to advocate, and he protests against it. It is unscientific, and it is not the remedy for unventilated sewers.

MR. W. HARPUR (Cardiff).—Describes in general terms Cardiff sewerage system, about 30 per cent of the built-upon portion lying below the level of equinoctial tides, and for four hours out of every twelve the sewers are tide-locked. All the sewers are large; there are no small pipe sewers. The gradients are bad, running from 1 in 2,000 to 1 in 200. The sewers are made large, because with such low gradients good self-cleansing sewers cannot be expected, so they are made large enough to be traversed by sewer men for the purpose of cleansing. Open street ventilators. About seventy automatic flushing tanks, each with a capacity of 2,000 gallons. A large-sized Austin's porous cell, charged with permanganate of potash, is placed in each tank.

MR. H. N. DAWSON (Reading).—Tried gas destructors, but they are very expensive, and not completely successful. Thinks the doing away with the grids and putting up shafts is a sufficient remedy, provided the shafts go well above the house chimney tops.

MR. R. M. GLOYNE (Eastbourne).—Some years ago he fixed at Eastbourne six of the apparatus described by Mr. Caink, of which no complaints were afterwards made. An objection to this arrangement is that it cannot be fixed in shallow sewers. As long as the Model By-Laws are in force, the abolition of the intercepting trap as proposed by Mr. Read is practically impossible.

THE VENTILATION OF SEWERS.

Paper read by MR. H. GILBERT WHYATT, ASSOC.M.INST.C.E., Borough Engineer of Grimsby, before the Association of Municipal and County Engineers, April 23, 1904.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," VOL. XXX., P. 248.

[SUMMARY OF PAPER.]

"Where there are frequent alterations of level in the flow of sewage, and strong currents of air, it is possible for disease germs deposited upon the sides of the sewers to pass into the sewer air through evaporation."

"In view . . . . of the probability of defects existing in the house drains, the author does not recommend that the intercepting trap should be abandoned."

If a "vent pipe from this drain could be generally insisted upon it would be a great benefit to the sewers of towns, and in view of the present powers possessed by corporations, the author thinks it can be everywhere insisted upon in the future . . . . These lengths between the sewer and the trap are single private drains, and the duty of ventilation rests upon the owner."

"In the author's opinion the ventilation of sewers (and by that is meant a continuous current in one direction) is not desirable, except on those occasions where workmen have to descend for certain purposes . . . . nor is a continuous current of air in any one direction along a sewer a necessity. What is required is a system of vent openings on the sewers, so arranged as to act either as inlets or outlets, and when acting as outlets discharging the sewer gases away from human beings, house windows, etc."

"The policy of closing the manhole covers without providing other means of egress for the foul air only results in greater offensiveness in the adjacent manholes, with the risk of forcing the foul air through the traps in the near neighbourhood, and producing a similar nuisance in a more confined situation."

(*a*) The use of tall chimney shafts.

(*b*) The use of house chimneys (King's Norton case).

(*c*) Sewer gas destructors (Webb's and others).

(*d*) Lamp columns as ventilators (Southport and others).

(*e*) Mechanical ventilation (Shone's system and others).

1. That ventilation of sewers at the level of the street is both objectionable and dangerous.

2. That the ventilation of sewers by means of alternate surface openings and tall shafts is . . . . unsatisfactory in practice . . . . as the surface openings often act as outlets.

3. That the filtration of sewer air whilst passing upwards through surface openings has been proved a failure.

4. That the destruction of sewer gas by cremation, the prevention of the formation of sewer gas chemicals, and the mechanical removal by fans, are too expensive for ordinary use in towns.

5. That the use of factory chimneys, or of a few tall shafts of large sectional area, is not satisfactory, as their influence is often local.

6. That the solution of the problem appears to be the adoption of a large number of reasonably sized vent shafts at frequent intervals (this being practically the adoption of surface ventilation at the level of a horizontal plane a few feet higher than house roofs), the vent shafts in all cases being provided with rust pockets.

7. That sewers must be regularly and frequently flushed, so that putrefactive matters may be removed before the production of foul gases commences.

8. That the ventilation of the length of drain between the sewer and the intercepting trap should be arranged for and carried out by the person building at the time of the erection of the property.

EXPERIMENTS ON SHONE'S SYSTEM OF SEWER VENTILATION AT LEICESTER.

Paper by MR. E. GEORGE MAWBEY, Borough Engineer of Leicester.

"PROCEEDINGS OF THE ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS," JULY, 1904, VOL. XXX., P. 454.

[ABSTRACT.]

District Experimented Upon :—

Area, 2½ acres.

A modern built-up part of the borough.

Eighty six-roomed houses of the artisan class.

Population, 356.

Average population per house, 4·45.

Rentals, £17 10s. to £19 10s. per annum.

Total length of foul-water sewers, 297 yards, laid at an average depth of 10 ft.

Separate system for storm and rain water from roofs and streets.

Hassall's single-lined stoneware pipes, laid in 1896-7, with gradients for 12 in. from 1 in 120 to 1 in 36, and for 9 in. 1 in 50.

Cubical contents of pipe sewers . . 661 feet.
Cubical contents of private drains . . 304 feet.

Total . . 965 cubic feet = 6,021 gallons.

No intercepting traps, but twenty-seven ventilating pipes provided for eighty houses, each 4 in. diameter.

Sewers flushed from manholes every three weeks.

A 15-in. Sirocco fan, 700 revolutions per minute by electric current at 200 volts, is placed in a chamber under footway 6 ft. 6 in. by 3 ft. wide, and fan is connected to flushing manhole by 18-in. stoneware pipes. Foul air is forced up a 9-in. circular steel ventilating shaft 40 ft. high.

The sectional area of the twenty-seven inlets was increased from 10·278 square inches to 75·258 square inches, or to 89 per cent of the 9-in. diameter extraction shaft.

From experiment, 752 cubic feet of air per minute were discharged by the 9-in. shaft at an average velocity of 1,284 ft. per minute, and 324·53 cubic feet of air per minute were admitted through the twenty-seven inlets (or nearly half the total volume discharged) at an average velocity of 226·2 ft. per minute, or an average of 5·23 cubic feet per house per minute.

By further experiments the above 5·23 was reduced to 1·73 cubic feet per house per minute, thus changing the air in the private drains about once every three minutes.

The electric current required for the above was 1·92 units per twenty-four hours for eighty houses, or 356 population, which at 1d. per unit equals £8 3s. 11d. per 1,000 population per annum, or about 2d. per head per annum.

With half a cubic foot per house per minute, the air would be changed about once every ten minutes, at a cost of about ·57d. per head per annum.

Previous to the above ventilation the sewer air contained an average of 20·62 parts of carbonic anhydride per 10,000 parts of air, the worst being 24·98 and the best 15·95. After ventilation the sewer air contained 7·04 CO_2, the worst 7·54, and the best 6·32 CO_2, per 10,000 parts of air.

After two years' trial Mr. Mawbey is able to say that by this system the drains and sewers have been satisfactorily ventilated at a cost which cannot fairly be considered prohibitory.

LEWISHAM SEWERS.

Report by MR. ERNEST VAN PUTTEN, Borough Surveyor, *re* Ventilation.

"THE SURVEYOR," VOL. XXVI., P. 573, NOVEMBER 11, 1904.

[ABSTRACT.]

The points in this report are:—

1. Where surface ventilators are closed and shafts erected the nuisance is removed from the road surface, but the sewers are badly ventilated unless some artificial means are adopted to create an up-draught.
2. The air emitted from a high shaft is far more foul than that which is emanated from the surface gratings.
3. The latter is caused by the more sluggish current always found in a deep sewer.
4. You practically deepen your sewer by the height of your column—*e.g.*, a sewer 10 ft. in depth with a 30-ft. shaft is equivalent to a sewer 40 ft. in depth.
5. Engineers are agreed that a deep sewer is more difficult to ventilate than a shallow one.
6. In Lewisham an old sewer about 10 ft. deep, in very bad condition, both structurally and as regards alignment, was reconstructed in 1893 at an average depth of 23 ft., well laid and on a uniform gradient. Complaints were seldom made as to the old sewer, but numerous complaints are being made as to "smells" from the new one.
7. Several mechanical devices for securing an up-draught in column ventilators, but none are considered satisfactory.
8. Considers the use of interceptors on house drains is largely to blame for presence of foul air in sewers.
9. Suggests "as a partial mitigation of the nuisance that sewer ventilators should be put much nearer together; that efforts should be made by combined action among the Metropolitan Borough Councils to obtain the repeal of the London County Council's by-law with reference to interceptors."

10. The author's ideal sewer "is a trough of the necessary depth to drain adjoining premises, finished off level with the road surface, with a continuous open grating."

11. If such a thing were constructed, the author firmly believes he would never have a single complaint.

HAMPSTEAD SEWERS.

Report by MR. OLIVER E. WINTER, Borough Surveyor, *re* Ventilation.

"THE SURVEYOR," VOL. XXIX., P. 282, MARCH 2, 1906, AND P. 300, MARCH 9, 1906.

[ABSTRACT.]

Present Condition : Defects.

1. Inadequately ventilated condition of the sewers in the lower portions of the borough.

2. Higher temperatures of the air in the lower level sewers as compared with the better ventilated sewers in the higher levels.

3. High temperatures in lower sewers undesirable, as about 55 degrees decomposition goes on with ever-increasing rapidity up to about 130 degrees.

4. Improved ventilation in lower level sewers will reduce the temperature of the air within them, and will create a tendency to a down-draught of air.

5. Sewers in Hampstead have generally excellent gradients, and a consequent rapid flow of sewage, tending to create a current of air in the same direction.

6. The air in the lower level sewers being warmer than that of the higher level is able to take up more moisture. This makes it lighter, and consequently more liable to rise up the sewer.

7. Other influences, such as the direction of the winds and the outside temperatures, affect the course of the air currents.

8. Offensive smells have arisen in consequence of settlements of the sewers, causing deposits to accumulate. When the sewers where such settlements have taken place have been reconstructed complaints have ceased.

9. Many of the Hampstead sewers are too large. A brick sewer 3 ft. 6 in. by 2 ft. 3 in. would have been better if laid as a 12-in. or 15-in. diameter glazed stoneware pipe sewer, when it would have been self-cleansing.

10. The brick sewers contain a large quantity of warm, moist air, which rising from the surface ventilators in cold weather becomes visible in the form of vapour. This vapour is harmless and free from smell, but is viewed with apprehension by nervous people as a form of sewer gas.

11. The late Mr. Mansergh chiefly recommended to increase the number of surface ventilators to one at least in every 60 yards of sewers, with ventilating gratings of at least 60 square inches. This only partially carried out. To fully do so would entail the construction of 631 additional ventilating shafts and 614 larger gratings to replace the small ones now in use, at an estimated expenditure of upwards of £10,000.

Recommendations.

1. To improve the ventilation of the sewers in the lower parts of Hampstead.

2. To encourage a down-draught in the sewers.

3. To make the existing surface ventilators act as inlets as far as possible.

4. To erect Webb's Sewer Gas and Destructor Lamp in place of the ordinary street gas lamp at or near all junctions with the main sewers of the London County Council, at an estimated cost of £25 each, exclusive of cost of connection to sewer.

5. To fix the apparatus made by the Reeves Chemical Sanitation Company at points near the top ends of the sewers in the borough, at an estimated cost of £12 each, including cost of fixing.

Summary and Estimate.

	£
21 Webb's extractor lamps	525
17 Reeves' apparatus	204
Total	£729

SEWER VENTILATION.

Reports by DR. F. W. ANDREWES, F.R.C.P., D.P.H., and DR. W. H. HUNTLEY.

[ABSTRACT.]

"The problem of sewer ventilation lies in the freest possible admixture of the sewer air with the fresh air outside the sewers, whereby its prompt dilution can be secured, together with the oxidation of such harmful substances as it may contain."

In order to minimise the offence of the escape of sewer air into the streets, they recommend :—

1. Cleansing and disinfecting the sides of the sewers.
2. The use of the Reeves Chemical Sanitation Company's apparatus experimentally.
3. To avoid all splashing of sewers by side sewers delivering at a considerable height above the inverts of the main sewers.

Mr. Winter attaches replies to six questions from the surveyors to *twenty-eight* metropolitan authorities with respect to the ventilation of sewers as follows :—

Query 1.—What system of sewer ventilation have you adopted?

Twenty-four reply (in effect) that surface gratings in centre of street were originally adopted, but these surface gratings are gradually being closed, and upcast shafts against adjacent property erected to extract foul air; two (Southwark and Westminster) reply "Surface grating only."

Query 2.—Is it giving satisfaction, or have complaints been made?

One reply only (Southwark), an unqualified "Yes"; twenty-five reply admitting complaints of different degrees.

Query 3.—If special shafts have been fixed, have you experienced any difficulty in arranging for the positions of such?

In reply, all admit difficulties in obtaining permission.

Query 4.—Relates to the sizes and distances apart of ventilators.

Query 5.—Relates to the proportion of brick and pipe sewers, and as to self-cleansing gradients.

Query 6.—Give your personal opinion on the subject, especially on the question of ventilation by open grids in the centre of the streets.

Fourteen reply condemning surface grids, either directly or indirectly; twelve do not reply at all; two (London County Council and Westminster) give a qualified approval to open grids in the centres of streets.

WEST HARTLEPOOL SEWERS.

Report by MR. NELSON F. DENNIS, Borough Surveyor, *re* Ventilation.

"THE SURVEYOR," VOL. XXX., P. 566, NOVEMBER 16, 1906.

[ABSTRACT.]

At present the ventilation of sewers is effected by means of open manhole and ventilator covers at the surface of roadways, together with a certain number of upcast shafts—chiefly 4 in. in diameter—erected at the gables of houses. On well-grounded complaints being made of offensive smells arising from the surface gratings these have been closed from time to time. During the past two years *forty* ventilating columns have been erected on the line of kerb for the purpose of ventilating certain of the main sewers. These columns are 30 ft. in height, the lower 15 ft. being 8 in. in diameter and the upper 15 ft. being 6 in. in diameter. The connection to the sewer is made by means of a 9-in. pipe.

SUMMARY OF ANEMOMETER TESTS.

Percentages of Tests.

Discharge of Sewer Air in Cubic Feet per Minute.	Ventilating Columns in Line of Kerb.	Ventilating Shafts at Gable Ends of Houses.	Ventilators at Surface of Roadways.	Manholes.
100 and over	21	0	14	3
Between				
100–80	15	0	5	8
80–60	18	0	15	14
60–40	23	0	19	15
40–30	15	3	6	15
30–20	4	6	3	11
20–10	3	21	1	6
10–1	0	31	0	0
Upcasts and downcasts alternately	0	0	6	17
Not recording	1	39	31	10
Number of tests	115	68	100	256

Tests were made in the ventilating columns to ascertain if they could be relied upon as extract ventilators when the external temperature was as nearly as possible the same as the temperature of the sewer, and when the wind was nearly calm, not exceeding $\frac{3}{4}$ knot to $1\frac{1}{2}$ knots per hour. Under the above conditions the average discharge was 26 cubic feet of sewer air per minute per column.

The average discharges in cubic feet per test per minute were :—

Ventilating columns on line of kerb	70·03
Ventilators at surface of roadways	45·79
Manhole covers	33·23
Ventilating shafts at gables of houses	7·16

Omitting certain of the above which were not recording at all, and only including those actually recording, the comparison is as follows :—

Ventilating columns on line of kerb	70·70
Ventilators at surface of roadways	66·34
Manhole covers	37·47
Ventilating shafts at gables of houses	11·87

The ventilating shafts are 4-in. pipes from the sewers to the top of the shaft, and have several bends in them, and many of them had an accumulation of rust at the bottom of the shafts. It also appears from the tests made that the extracting power of the columns, as distinguished from the shafts, is very nearly in proportion to the force of the wind, the temperature remaining the same.

It is proposed to ventilate the "dead" ends of sewers by means (where practicable) of shafts 6 in. diameter without bends, affixed to the gables of houses, and connected to the sewers by 9-in. drains, provided with proper rust boxes. In other places where shafts against gables are impracticable it is proposed to erect ventilating columns 8 in. diameter, fixed on the kerb line.

Estimated cost:—

	£
For the erection of 139 shafts at gables	695
For the erection of 70 columns on kerb line ..	980
Total	£1,675

Say, £1,700.

SEWER VENTILATION AND THE INTERCEPTING TRAP.

Papers read by Mr. Francis J. H. Coutts, M.D., B.SC., D.P.H., F.C.S., Medical Officer of Health, Blackpool, and Mr. John S. Brodie, M.INST.C.E., F.R.SAN.INST., Borough Surveyor, Blackpool, at a Sessional Meeting of the Royal Sanitary Institute at Blackpool, March 13, 1908.

[ABSTRACTS.]

Paper by Mr. F. J. H. Coutts, M.D., B.SC., D.P.H., F.C.S.

Our attitude towards the question of sewer ventilation is, of course, very greatly influenced by the views which we hold as to the dangers threatened by "sewer air" or "sewer gas."

Very considerable doubt has been thrown upon the power for evil of sewer air, although most people have appeared to agree about the potential harmfulness of "sewer gases," the latter term being used to denote gases given off by stagnant and decomposing sewage. The experiments which seem to have influenced most strongly recent views were those of Mr. J. Parry-Laws and Dr. Andrewes on the micro-organisms of sewage and sewer air, which appeared to indicate that sewer air had no power of taking up bacteria from the sewage with which it was in contact, and that, bacteriologically, the air of sewers was no worse than that of the street above, and that, in fact, the number of micro-organisms found might actually be less, whilst the types of germs were precisely those present in the external air, and not those of sewage. They never found the *B. coli communis* in sewer air, although it is present in such enormous numbers in sewage, and they thought the possibility of the existence of the typhoid bacillus in the air of sewers as infinitely remote.

The full deductions from these results were too startlingly different from the teachings of practical experience to allow them to be accepted unconditionally. Nevertheless, these experiments have undoubtedly led to a considerable amount of uncertainty, and many people have gone so far as to controvert entirely some of the older views as to the connection of diphtheria, typhoid fever, scarlet fever, septic sore throats, etc., with the inhalation of sewer gas.

Their reasonings have, however, failed to convince many of us as to the innocuousness of sewer air. Personally, the author has been strongly impressed by the firm opinions held by many shrewd and careful observers who have had long experience in general medical practice, and who have unhesitatingly expressed their belief that certain forms of disease are induced, directly or indirectly, by exposure to sewer gases. Several have recorded their opinion that typhoid fever is undoubtedly caused sometimes by inhalation of sewer air. In these very scientific days we are apt to look down with undue contempt on the views held by our forefathers, forgetful of the fact that some of them enjoyed wide experience, and had been trained in the habit of close observation, which was all the more necessary before the advent of those aids to diagnosis which are now at the disposal of every doctor.

The conclusions of Laws and Andrewes have not gone entirely uncontradicted. Even before their researches, Professor Frankland, in 1871, showed that although liquids flowing smoothly along gave off no solid particles to the air, yet the bursting of bubbles of gas in a liquid had a marked effect in allowing the dissemination of solid particles. Several later observers, although confirming generally the experiments of Laws and Andrewes, as far as regards the types of bacteria found in the air of sewers, at any rate where the sewage was fresh and not putrescent, do not altogether agree with the conclusions deduced from those experiments.

The most remarkable set of recent experiments on the subject which have come to my knowledge are those of Major W. H. Horrocks, R.A.M.C., recorded in a paper read before the Royal Society, and printed in *Public Health* for May, 1907, under the title "Experiments Made to Determine the Conditions under which 'Specific' Bacteria Derived from Sewage may be Present in the Air of Ventilating Pipes, Drains, Inspection Chambers and Sewers." It is in this paper that the new facts arise which the author thinks should be carefully studied in any fresh consideration of the sewer ventilation question.

The results obtained by Major Horrocks will no doubt be tested by other experimenters, but no one who closely studies the records of his experiments will fail to agree that they deserve serious consideration. Personally, the author is satisfied that further experience will only serve to confirm these conclusions.

The simplest plan of dealing with sewer ventilation is, if one may venture on an Irish bull, to have no ventilation at all. This is the solution of the problem in certain towns such as Bristol and Cheltenham. But in such a case it is obvious that a sudden inrush of sewage, or a sudden expansion of sewer air through the introduction of hot liquids into the sewer or other cause, will lead to the breaking of the seals of the intercepting traps in the vicinity and the access of sewer air into the house drains. The gases will come out at the low vent, and if the drains are at all defective, there is a great tendency for the gases to penetrate into the house itself. We know that the difference of temperature between the interior of the house and outside is sufficient to draw any foul gases in the adjoining subsoil into the building.

Of actual methods of attempting to ventilate sewers, the easiest and cheapest is to provide surface-level openings in connection, either directly or indirectly, with the manholes. Probably more sewers have been laid on this plan than on any other. But common sense and actual experience tell us that these surface openings are frequently offensive and cause a nuisance. Horrocks' experiments give us good reason for believing that, in addition, they are a danger to health, and that disease germs may be inhaled by persons passing over such openings. The author is under the impression that various safeguards which have been proposed in connection with this method—such as filtering the escaping air by means of charcoal or some chemical—are rarely used now. The charcoal method is certainly ineffective as soon as the charcoal becomes wet; also, all these methods must create great obstacles to the free passage of air, besides being costly and troublesome to maintain in anything like proper working order.

The next method of sewer ventilation which the author will refer to is dependent upon the abolition of the intercepting trap. This is a method which has found much favour of late, especially among engineers, whereas most medical officers of health have been opposed to it. At first sight it appears an excellent solution of the difficulty, as, by having tall ventilating shafts on each house drainage system, you have the sewers connected to an immense number of ventilating shafts, each of small area, but combined giving a splendidly ample area of openings for the extraction of foul, and the admission of fresh, air. The local authorities have nothing to pay in the shape of wayleaves, no trouble to find suitable positions, no expense of upkeep, and no complaints of smells from surface-level ventilators. Some of the soil-pipe ventilators no doubt act as inlets and others as outlets, and most of them act sometimes in one direction and sometimes in the other. The total result is very satisfactory, however, from the point of view which looks only at the constitution of the sewer air. Probably under such a system the air in the sewers would never smell very foul. But if Horrocks' experiments prove anything, they prove the value of the intercepting trap in preventing the air of sewers from contaminating the house drains, and in cutting off the drains of one house from its neighbour so that the presence of typhoid excreta in the drains of one house will not mean the possible, and even the probable, passage of the typhoid bacillus into the drain air of the adjoining and other property. In such a case a comparatively minute leak in the drainage system close to the house might be a very great danger. It is precisely the joints close to the house which, even if sound at first, are apt to become defective owing to a slight settlement of the foundations. There is very good reason for the almost universal desire among tenants to know that their drains are effectually cut off from all direct aërial connection with those of their neighbours and from the sewer. The author is therefore of opinion that this method, although very tempting on account of its simplicity and cheapness, is dangerous, and cannot be recommended.

In some places where they have not gone so far as to abolish intercepting traps, ventilating pipes of light iron, such as is often employed for soil pipes, and of 4 in. or 6 in. diameter, are employed, connected directly to the sewers, but running up house walls. These, of course, if carried well above the roof, are safe so long as all the joints are airtight, both those above as well as those underground. But any settling of the house walls leads to a defective joint at the most important place—namely, the connection of the iron pipe to the earthenware drain. Any leak in this situation allows sewer gas to enter the house. The fear of this creates great difficulty nowadays in getting permission to fix these pipes to a houseside; the author would have much objection to living in a house to which such a sewer ventilator was attached. There is less objection to affixing such pipes to the walls of buildings such as stables or warehouses. The author has seen them attached to telephone or telegraph posts, but should imagine the effect of strong winds would rapidly cause a defective joint at the foot of the pipe.

Attempts have been made in some places to secure effective ventilation by connecting large diameter pipes to mill chimneys or furnaces to obtain a strong extracting effect. Unfortunately it is found that the suction may be so strong as to unseal the intercepting traps in the immediate neighbourhood of the ventilator, whilst the effect is felt only very slightly at a little distance. Shone's system of mechanical ventilation carries the principle of mechanical extraction very much further, and is undoubtedly very ingenious, with its scientifically arranged size of air inlet proportioned to the distance from the source of extractive power. It seems, however, that the cost both of installation and of working must necessarily be very high, whilst any accidental or unauthorised inlets would be liable to upset the working of the whole system.

Certain forms of ventilating lamps in the shape of small iron independent columns give a certain extracting effect, and are at the same time supposed to burn up and destroy organic matter and effectually kill any germs present. No doubt this does occur to some extent, but we have as yet no satisfactory evidence that this disinfection of sewer air is so complete as to render these lamps quite safe to be employed in such close proximity to the windows of dwelling-houses as would sometimes be necessary. Besides, with a sufficient number of these lamps to give efficient ventilation the cost of the gas consumed would amount in the course of the year to a very considerable item.

In the author's opinion the only method of sewer ventilation which can be safely recommended at present is by means of independent ventilating columns of iron or steel, tall enough to carry all dangerous gases well above all dwelling-houses, placed as near the sewers as possible, and with the smallest possible number of bends. Where lighter, but still gastight, shafts can be erected against buildings not used for constant occupation by human beings these might also be used. It is no use labelling one as inlet and another as outlet, because each column will act sometimes in one direction and sometimes in the other. Natural agencies would keep up air currents, such as the wind blowing over the top of the shafts and the effect of the sun's heat, which often acts very strongly in the case of an iron shaft. Such a system gives us at any rate an outlet for sewer gases, and prevents the forcing of house traps. The author does not believe that it would give a pure air in our sewers under all conditions, such as a state of little wind and a close approximation of temperature outside and inside the sewers, but under ordinary circumstances it will keep the air sufficiently safe to allow of the workmen entering the sewers when necessary. This is all we can expect or require, and would be very much better than the state of things now existing in many places, in which a policy has imperceptibly grown up of closing all the surface ventilators as complaints occur, until at last the sewers are left entirely unventilated, giving rise to occasional forcing of traps and the consequent dangers.

If the author may refer for a moment to a subject not exactly within the scope of his paper, he would say that Horrocks' experiments have confirmed a conclusion which has been forcing itself on his mind for several years past, and that is, that the low ventilator, as usually fixed, is a danger, and will have to be abandoned. Sometimes these are fixed in the front garden walls of houses. The flushing of a water-closet in a house where there is a case of typhoid may easily convey the germ to a casual passer-by. Similarly with sewer gas escaping through the forcing of a trap. Another form of danger arises from the increasing frequency of fixing an intercepting chamber instead of merely a trap. Builders, unless they are strictly looked after, often neglect to cement the inside of these chambers. The result is practically to have a leaky drain, as the ordinary brick walls of these manholes are pervious to drain or sewer gas. Similarly the manhole cover is often left unsealed by Russian tallow. What is the use of being so careful to have airtight cement joints to the drain, buried many feet underground, and yet to leave the manhole defective? Another item in this connection requires careful attention—*viz.*, the stopper of the rodding arm of the disconnecting trap in the chamber. All who have had much experience will agree that it is the exception rather than the rule for a builder's workman to fasten in the stopper with Russian tallow. Consequently, when examining such a manhole one finds the stopper loose and practically useless, or out altogether, thus giving free access to sewer air; or it may be that a mysterious block causes an investigation, and the stopper is found to be the delinquent, having been carried through the trap and blocking the drain on the sewer side of the trap. Some form of stopper, arranged to be securely fastened, should be compulsory, and the author hopes that some inventive genius will soon produce an intercepting trap with a patent stopper, easily fixed, perfectly airtight, and immovable under ordinary circumstances, yet easily removed from the manhole top in case of a block, and not substantially more expensive than the ordinary type.

Paper by MR. JOHN S. BRODIE, M.INST.C.E., F.R.SAN.INST.

Do sewers require ventilating at all? Probably that popular and infallible authority the "man in the street," in his inmost thoughts, believes they do not; that sewer smells are largely, if not entirely, imaginative; that it is only a "fad" of medical and other sanitary enthusiasts; and that both himself and his immediate predecessors, who were probably gathered to their fathers at a green old age, never suffered any inconvenience from sewer air or sewer gas.

But even usually well-informed people are to be found who are convinced that unpleasantly smelling air or gas issuing from a sewer grating is really not dangerous or injurious to health. This party has, until recently, had much scientific support from the investigations of such scientists as Mr. Parry-Laws, Dr. Andrewes, and others in this country, and from those of Professors Kirchner and Soyka, to name only two, on the Continent. Those men have given us their assurance that "there is no proof of there being any connection between sewer gas and the spread of epidemic diseases."

Yet another group of people are to be found who do not deny that gases of a dangerous nature are actually to be found in sewers, but who sincerely believe in the "bottling-up" theory, presumably on the old principle of "out of sight (or smell) out of mind (or danger)." These latter advocate the closing up of all openings into or out of the sewers except the connections thereto made by the drains to houses and other premises, and then only by means of airtight water-sealed traps.

Now, what are the simple facts on this subject?

1st.—Every year cases are reported in the public prints of workmen whose duty it is to see to the efficient working of sewers being poisoned, sometimes fatally, by the escaping gas from the sewers; and for one case reported it is well known that at least twenty are never publicly made known when the results are not fatal. Surely, the proof of the quality of the sewer air is in the breathing!

2nd.—Why are those who are responsible for the health of the districts committed to their care—namely, the medical officers of health—so anxious that the house (the unit of each district) shall be as effectually cut off from the sewer, by means of the intercepting trap, or some equally efficacious arrangement, as the ordinary householder is to keep out burglars? Because they are well aware of the dangers to health which would follow from a free communication between the sewers and the house drains.

3rd.—We now have, as the result of recent bacteriological investigations by Dr. S. Rideal,* Major Horrocks,† M.D., F.R.S., and others, very good proof that sewer air is "a nuisance and injurious to health."

If, then, we are all of one mind that sewers should be ventilated, the only question (a fairly large one) that remains is, by what method or methods can this object be best accomplished? Very many attempts have been made in the past, by more or less ingenious contrivances, to ventilate sewers. Most of the "methods" or "systems" tried have been found wanting, and are now consigned to oblivion in the dust-heap of useless inventions. The present author will make no effort whatever to attempt a resurrection of the dry bones of those failures, even by describing them.

Generally, it may be said that all efforts to ventilate sewers can be classified into three divisions—*viz.*:—

1. Natural Ventilation.
2. Artificial Ventilation.
3. Deodorisation.

The author will content himself with a description of one or more of the most important types only of each of the above methods.

Natural Ventilation.

The natural ventilation of sewers may be said to include the almost total absence of any intentional ventilation of any kind, as at Bristol, to a well thought-out system of high shaft inlet and outlet ventilators, such as has been so thoroughly worked out, and is now being adopted, at Leicester.

The first beginnings of sewer ventilation were doubtless the

* "Journal of the Royal Sanitary Institute," vol. xxv., p. 596.

† "Journal of the Royal Sanitary Institute," vol. xxviii., p. 176.

untrapped house drains and gully connections of the middle of the last century (1852).

Then followed the regularly made shaft connecting the surface of the street with the underlying sewer, generally called a "ventilating shaft"; but when of sufficient size to admit the passage down it of a workman known as a "manhole," with open gratings, so as to allow sewer air to escape, or fresh air to enter, it mattered little which.

Then a distinct epoch was marked in the history of sanitary engineering by two important events (1870-71). One was the invention of the water-seal or intercepting trap, by Mr. W. P. Buchan, of Glasgow; the other was the succession of the late Sir Robert Rawlinson, C.E., K.C.B., as Chief Engineering Adviser to the Local Government Board. The present author never thinks of that distinguished man without a feeling of disappointment that greater honour has not been paid to his memory than has yet been done. For it may be truly said that the practical sanitary progress made during the last forty years is due to the pioneer work of Sir Robert Rawlinson, who so well and truly laid the foundations, both broad and deep, upon which all the good sanitary work to be found to-day has been built, not only in this country but abroad.

Well, then, under Rawlinson's sympathetic guidance, Buchan's, or what is now known as the intercepting trap, was fixed on nearly all house drains, so that no aërial connection between the separate house drains and common sewer should be possible. He also recommended "that wherever a trap is placed on a sewer or drain there should also be means for sewer and drain ventilation provided to relieve such trap." Unfortunately, the Local Government Board in their By-Laws did not insist on a ventilator being fixed on the sewer side of the trap, with the result that while house drains were provided with high shaft ventilation, sewers were not, but relied entirely on the surface gratings. It is easy to see, therefore, that with the general introduction of the intercepting trap, and the consequent shutting off of sewer ventilation by means of the house drains, the conditions of the sewers as regards the emanation of foul smells from them gradually became worse, until about 1880 onwards the question became pressing. In many towns the sewer gratings were gradually closed as they were complained of; in other towns the surface gratings were allowed to remain open, but high shafts against buildings were connected to the sewers;

in still other cases a combination of both the above modifications were tried, until, by the able experiments and tests made by Mr. Mawbey at Leicester, it is now generally admitted that good sewer ventilation is possible by high ventilating shafts alone, without surface gratings at all.

From inquiries recently made the author finds that in regard to natural sewer ventilation in English towns the present practice is approximately as follows:—

81 per cent have adopted upright shafts in addition to surface gratings,

14 per cent are now substituting high ventilating shafts for surface ventilators, which are being closed, and

5 per cent have surface ventilators only.

From the above statistics we may conclude that sewer ventilation at the surface of the carriageways is now rapidly going out of use, as it deserves to do.

The upright ventilating shafts, whether placed against buildings, or special columns placed on the footpaths, should be of sufficient height to be from 6 ft. to 10 ft. above the ridges of adjacent buildings, of a proportionate sectional area to the sectional area and capacity of the sewer to be ventilated, and should be from 150 to 200 lineal yards apart.

Artificial Sewer Ventilation.

Two systems of artificially produced air currents in sewers now hold the field, and both have good promise of ultimate success.

One is the Webb system, a method of extracting foul air from sewers and at the same time cremating it by heat, invented and patented by Mr. Joseph E. Webb.

In appearance the Webb Sewer Ventilator closely resembles an ordinary incandescent street lighting gas lamp, with a cluster of three incandescent gas burners. By a system of heat reflectors the sewer air or gas is drawn from the sewer through an air-tight copper tube fitted inside the lamp column into the narrow neck of the lamp, about 3¼ in. in diameter, through which the sewer air is made to pass through a temperature of about 550 deg. Fahr., generated by the three incandescent coal-gas burners in the lamp.

By the Webb method is claimed:—

(*a*) The convection of rays of light and heat by reflectors, thereby producing convex rays.

(*b*) The complete destruction of organic matter in the sewer air, by focussing heat-rays on them.

(*c*) The conservation of heat by air or pneumatic isolation.

(*d*) That there is no possibility of organic matter or foul gases passing through the apparatus without being destroyed, from the fact that it does not rely on actual contact with heated surface, but is forced through superheated space.

The other artificial sewer ventilator which the author will refer to is that recently introduced by the well-known sanitary engineers, Messrs. Shone & Ault.

This system is known as the hydro-mechanical system, and is the only method by which the double objects of ventilating both the house drains and the common sewers are accomplished by one operation.

The system is based on the principles of coal-mine ventilation. The foul air is exhausted from the sewers by means of a fan, driven electrically or otherwise, and the admission of fresh air is rigidly controlled at all openings leading into the sewers. By means of these controllers or regulators, which are adjustable and fixed in the intercepting trap chambers of the house drains, and at other openings where necessary, only sufficient fresh air is drawn into the sewers to keep the sewers in a wholesome condition and free from danger, and the amount of vacuum caused by the fan is so graduated as to avoid any possibility of destroying the water-seals in the house-drain intercepting traps.

The foul air, when extracted by the fan from the sewers and house drains, is forced through a deodorising medium, and is then discharged into the open air by means of a high upright pipe or column of adequate sectional area. The system has been tried on a limited scale at Leicester, and has been found to give satisfactory results at a fairly moderate cost.

It must, of course, be borne in mind that by the hydro-mechanical system, not only is the sewer ventilated but the house drains also, and allowing for the saving to be effected by doing away with the present inlet and outlet ventilators under the present house-drain ventilating system, the cost of Messrs. Shone & Ault's system will probably compare favourably with that of the present system of house-drain ventilation plus that of any other efficient sewer ventilating system.

In the author's opinion this system is well worth being tried in new districts, when the first cost would not be great, whereas its adoption on existing sewerage systems, while not prohibitive, would necessarily be greater.

Deodorisation of Sewer Gases.

Many devices have been tried to render harmless the foul odours emanating from sewer ventilating openings.

As far back as 1862 Sir Robert Rawlinson advocated the use of charcoal filters, and this idea was taken up and thoroughly tried by Mr. Baldwin Latham in 1879 and onwards, but these and many others have now been discarded as being worse than useless.

The apparatus most in use at present as a sewer-air deodoriser is that of the Reeves Chemical Sanitation Company.

This apparatus consists essentially of two chemical-ware vessels, placed in a recess formed in a sewer manhole shaft. One of these vessels contains a patented chemical mixture called "Reevezone," and the other contains strong sulphuric acid. These chemicals are caused to mix continuously, the result of their mutual reaction being the formation of sulphurous acid gas, oxygen gas, permanganic acid, and soda sulphate. These gases purify the foul air with which they come in contact, whilst the oxidising solution falls into the sewer and is said to have a beneficial effect on the sewage.

The Reeves apparatus has been extensively tried at Edinburgh, Southport and other places, and is now understood to be under trial, in a modified form, on some of the large main sewers of the London County Council.

The author ventures to submit, from the facts and figures already given, that the satisfactory ventilation of the common sewers is now practicable, at a cost which is not unreasonable compared with the objects to be accomplished; and also, that no public sanitary authority is now justified in neglecting their responsibilities in this connection under the Public Health Act, which plainly states (sec. 19) that "Every local authority shall cause the sewers belonging to them to be constructed, covered, *ventilated*, and kept so as not to be a nuisance and injurious to health."

The Intercepting Trap.

It will probably have been already gathered, from what has gone before, that the author is not among those borough surveyors who have recently taken to agitating for the abolition of the intercepting trap. Not its abolition, but its proper construction, as regards size, shape, materials and proper fixing, is required as regards that useful sanitary appliance.

At bottom, the objections to the trap appear to be as follows :—

1. That it is a hindrance to the proper ventilation of the common sewer.

Surely, the exit of foul air from the common sewer, *viâ the private house drains*, to the open air only needs to be clearly stated to carry its own condemnation, for reasons which must be obvious to everyone.

2. That it is of itself a small cesspool, liable to produce insanitary conditions.

Now, this objection simply begs the whole question, as if the trap is laid with reasonable care and intelligence, under normal usage, no such insanitary conditions can arise.

3. That it is constantly stopping up and causing trouble, expense and danger to the household.

The author, from the experience of a lifetime, can honestly bear testimony to the fact that in every stoppage in an intercepting trap coming under his observation one of three reasons has been found out as the cause of stoppage :—

(*a*) An imperfect trap, having practically no gradient, or drop, in itself.

(*b*) A good trap, improperly laid, with the joints badly made.

(*c*) A trap of proper construction and well laid, but such utensils as worn-out blacking brushes and similar articles found in it, which should have been put in the house-refuse bin and not sent down the house drain.

4. That the intercepting trap causes a considerable diminution of the limited fall available in many cases for the house drain.

The proper amount of fall, or "drop," for any house-drain interceptor is certainly not more than *two inches*, and if the gradient of the house drain is cut so fine as not to allow that—well, then, it ought *not* to be.

The author is of opinion that, until the present method of water-carried sewage is superseded by some greatly improved method, which at present is certainly not within sight, the intercepting trap is a sanitary necessity, and cannot with safety be dispensed with.

DISCUSSION.

DR. G. J. FOWLER, Superintendent of the Manchester Sewage Works, upon being called upon by the Chairman, said he had had occasion not infrequently to go down sewers, and recently he had taken a certain part in experiments on the ventilation of sewers which had been carried out in Manchester. He was only sorry Mr. T. de Courcy Meade, the City Surveyor, was not able to be present, as he could speak on the subject with more authority than he could do. However, it was evident that the discussion on the subject was not at an end. It had occurred to him that they might consider how far the proposed remedies for dealing with sewer gas would be effectual. One of the chief causes of the accumulation of foul gas in sewers was the deposits which formed in them, and in that connection the effect of trade effluents had to be borne in mind. In Manchester, owing to two or three fatalities which had occurred, they had obtained very drastic powers for dealing with this class of refuse, and the result was that all effluents which might give rise to danger were not allowed to be turned into the sewers. Therefore they might say that accumulations were frequent causes of the ebullition of gas, and it had been shown that harmful bacteria would flourish as well. A rise in temperature, too, would affect the decomposition of sewage matter. This had been brought home to him on the occasion of a recent visit to India, and that was why in Bombay very great precautions were taken before workmen were allowed to enter the sewers. It was possible that Major Horrocks' results were more marked for the reason that the experiments were carried out in Gibraltar, where the temperature was very high and the air currents perhaps more rapid. The velocity of the air current was another source of danger. Those being the causes, what were the remedies? They had, of course, the various artificial methods spoken of. These had been tried in Manchester, and as regarded two of them, the results, he might say, had been published in a report to the City Council; but after all, they had found the natural method the best. He had made numerous inquiries in towns on the Continent, and the almost uniform reply was that if the sewers were kept clean and free from deposit ordinary ventilation by shafts would be sufficient. Of course, in many towns on the Continent the sewers were very new. In Frankfort that was particularly noticeable, and in that town everything was carefully designed so that one sewer flushed out another, and so prevented deposits. In Berlin the sewers were constructed of the finest terra-cotta bricks. Therefore it seemed to him that with the present state of things they ought to have as good sewers as it was possible to have, with thoroughly good self-cleansing gradients and ventilating shafts at suitable points.

MR. C. BROWNRIDGE, Borough Engineer of Birkenhead, congratulated Dr. Coutts and Mr. Brodie on the fair way in which they had stated their case. Their remarks were interesting and valuable, and should produce a good discussion. He was in a town where the intercepting trap was general, and where they were swinging over from the surface grating to the high shaft. But he thought they would have to look to the bacteriologist to guide them very much in the matter. Speaking of sewer gas and drain air, the material which went into the sewer had to pass through the drain, consequently the sewer gas or drain air, unless it were generated by some septic action, was actually the same, for the material which gave rise to the smell passed through both pipes. So they had to look upon this gas or air as being rather identical. The engineer had to see how he could meet the objections of the public, for the latter did not want to be confronted with the smell as they walked along the street. It was, however, not always the smell they experienced that was the danger, and he thought bacteriologists might give a little assurance on that point. The smell that came from a sewer grating was not one that would cause a serious illness, but that was no reason why it should be there. They had to take into account the sentimental feeling, and when a smell existed there they ought to get it well away from people's noses. But if they did that the question was where were they going to take it, for if a pipe was conveying gases which were a danger to health, then it was equally dangerous, or nearly so, to discharge them above a bed-room window as it was to discharge on the road level. One could not dissociate the subject of sewer ventilation from the design and condition of the sewers and drains. If they did not have good sewers they knew that they were likely to have smells. If they had good sewers they had very few smells, but how few did take precautions to see that they had good sewers and drains. An imperfect pipe joint was likewise a source of danger by reason of the pollution of surrounding soil which resulted. Since November last he had tested under a 20-ft. head for one hour the pipes of thirteen makers, and he had found that only five makers' pipes would stand that test. Consequently he could not help but say that in many towns there were being put in the ground pipes which were in themselves setting up a condition of affairs which could not possibly conduce to the health of the community. In his opinion the intercepting trap was all right in its place if it were properly laid and designed. But the 2-gallon flush from water-closets, which was the limit imposed in many towns, was not sufficient to remove everything from the drain. Consequently, in considering the intercepting trap they ought not to neglect the question of the flush, and they ought to insist on one of not less than 3 gallons. One of the requirements of the Model By-Laws was that the air inlet should be down somewhere near the floor and the outlet higher up on the side of the house; but engineers had proved that currents in a sewer were altogether dependent on the outside wind, and that the outlets and inlets were often thereby reversed in action. If in providing intercepting traps they were to in all cases put down two pipes of equal height it would remove every objection and be more satisfactory to the average engineer. He had been surprised to find at Bristol that with no ventilation they had the best results. That was rather startling, but speaking simply from practice he would say that there was a good deal in that system of ventilation—and that was very largely proved by Major Horrocks' investigations. They had, therefore, as a result of their experience, decided that they would have no surface manholes, but upcast shafts at limited distances, these being mainly for the adjustment of the air pressure in the sewers and not for ventilation. If those precautions were taken, he thought it would be generally found that with such a system they would have the least trouble. How they were going on, however, if the defective so-called stoneware pipes were allowed to be used, and to contaminate the soil in the neighbourhood of their houses, he was not going to express an opinion.

DR. E. SERGEANT, County Medical Officer of Health, Lancashire, said he practically agreed entirely with Dr. Coutts and Mr. Brodie. Mr. Brownridge, however, had stated that smell need not be dangerous to health, and he differed with him on that point. It was a view that many people held, and he thought they were very wrong indeed, because he looked upon a smell as an indication of a danger to be avoided. He thought medical officers and engineers had been very much led astray by the researches of bacteriologists. These gentlemen no doubt had done very useful work, and they relied upon them very largely;

at the same time he should not claim infallibility for all bacteriologists. They had, for example, allowed them to assume that if one wanted good air one should go into a sewer. He maintained that was wrong. It did not accord with his own experience, his view being that although sewer gas might not produce a specific disease it rendered the individual more susceptible to attacks in certain ways. He strongly adhered to the intercepting trap, which he thought should be looked upon as the first line of defence.

MR. COARD S. PAIN, ASSOC.INST.C.E., F.S.I., said that from the municipal point of view shafts up houses were simply ideal. There could be no question about it. But there were such things as the rights of private property, and Mr. Brodie had stated that he would not agree to live in a house up which such a shaft had been carried, because it was extremely difficult, without periodical tests of a most careful character, to ensure that the pipe was always airtight. Then apart from the rights of property, was not a 6-in. pipe on the side of a building an architectural eyesore? It was no doubt a very good idea to destroy sewer gas by cremation, but it seemed to him that in the application of the Shone & Ault system the real difficulty was that in sucking out the air from the main sewer they were getting it from all the tributary sewers at the same time. He feared that it would be extremely difficult to ensure such a result in practice. Although there was no doubt that intercepting traps did stop up, that was almost always preventable.

MR. A. J. PRICE, Engineer and Surveyor to the Lytham Urban District Council, did not think that an extraordinary amount of ventilation was necessary, and he believed he had stated on previous occasions that ventilation was not so much to be desired as vents. From what Dr. Coutts had said, and the experience of Major Horrocks, together with what had fallen from Mr. Brownridge, there seemed to be a feeling that they could have too much ventilation. He thought they would all agree that surface ventilation was not only obsolete, but offensive and dangerous. At Lytham they were really going in for tall shafts. He was doing it himself as far as he could, but he did not think there was any need for putting them as close together as was the general practice—he suggested 300 yards, or perhaps 200 yards, apart, but not closer. As regarded the size, he had found a 6-in. pipe sufficient for all purposes of ventilation. He had always had an objection to putting shafts against houses, and he had never any sympathy with engineers who said that sewers should be ventilated in that way; it was very dangerous. As far as possible he always put them in the main streets. With regard to mechanical means of ventilation, he agreed with Dr. Coutts rather than with Mr. Brodie on that point. He agreed that there were cases where it would be desirable to use it, but he could not see how Mr. Shone's system would work as well in fine and warm weather as it might do in wet and cold. If the system was not automatic it was going to add greatly to the expense, and he could not see how it was going to work efficiently during a heavy rainfall, for at such a time neither the sewers nor the house drains required any ventilation at all. There was no smell in the sewers at that time, but in the hot weather it was a very different matter. With regard to the Webb lamp, he had had no experience with that, but he had had experience with ventilating gas lamps, and they cost about £10 per year for gas. That was too expensive for Lytham, and they were not adopted. They had been told that the Webb lamp had an outlet of $3\frac{1}{4}$ in.; how was that going to ventilate a mile of sewers? He could quite agree that there were certain directions in which the system could be useful, but he was doubtful whether they could adopt it generally, and whether they could get equally good results with it as they did with ordinary ventilation. He had an objection to putting ventilating shafts on private property, and thought they ought to keep to the public way. He was in agreement with Dr. Coutts and Mr. Brodie with regard to the intercepting trap, and he disagreed with some London engineers who contended that it could be done away with. Gullies in front of houses were very apt to become unsealed, and in those cases it would be distinctly objectionable if the intercepting trap were absent. Another point was that the Local Government Board would not sanction any by-laws unless provision was made in them for the fixing of intercepting traps. Therefore, if they did not see that these were put in they ran a risk if there was any infectious disease in a house. Under those circumstances, if two or three medical men agreed that the outbreak was due to the absence of the trap they would be likely to be mulcted in heavy damages. Personally he was a strong believer in both the air inlet and the outlet shaft, but he was opposed to the mica flap, for in 50 per cent of those he had examined the flap had been broken.

DR. COUTTS, in reply, expressed disappointment that he had not heard the views of anyone opposed to the intercepting trap. Almost the only criticism of Major Horrocks' experiments came from Dr. Fowler. He agreed that the results obtained in a warm climate like that of Gibraltar would not be obtained in England, where it was colder. In reference to the question of the smell, he agreed with Dr. Sergeant that that should be regarded as a danger signal. On the point as to sewer air being the same as that in a drain, the effect of disease on the air in the drains had to be considered, and was the reason why they desired to separate the air. As to the question of pipes above the housetops, he thought there was less danger in the opening above the housetop than on the ground level, for the gas quickly became diluted and the germs blown away from the inhabitants of the houses. As to Bristol, he was not so sure about the absence of any bad results, diphtheria, for one thing, being very prevalent there. He was rather inclined to agree with Mr. Price that it was not necessary to have shafts at too frequent intervals.

MR. BRODIE regretted along with Dr. Coutts that there were not present any advocates of the abolition of the intercepting trap. He thought they would all agree that the old surface ventilator was dead and gone, and that good ventilation could only be achieved by means of shafts fixed along the kerbs or at the ends of houses, closing altogether gratings on the surface of streets. His friend Mr. Mawbey, the Borough Engineer of Leicester, had established that, and they were all obliged to him for what he had done in showing that he could ventilate his sewers by means of shafts only. Bacteriologists had been alluded to with a lack of that respect to which they were entitled, but a crumb of comfort for them was that borough engineers were waiting for a lead from them in regard to the point as to what were the constituents of sewer gas, and what was the proper way to deal with it. He had read with considerable interest the researches of Major Horrocks, and he had only the feeling that he should like to have these corroborated, because the conditions in Gibraltar did not strike him as being the same as those in this country. For his own part he had very little doubt but that they were correct. People said there was very little harm in a smell, but he for one said they must get rid of those smells from sewers. This question of sewer ventilation should be looked at in this way: it should not be left to chance, but should be considered in connection with every system of sewers. It should be dealt with it at the beginning, and then it would be a much more simple problem to solve than when the mischief had been done.

The proceedings then terminated with the customary votes of thanks.

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