REPORT

TO THE

HONORABLE THE COMMISSIONERS OF SEWERS

OF THE

CITY OF LONDON,

UPON THE RESULTS OF THE EXPERIMENT OF APPLYING CHARCOAL TO THE SEWER VENTILATORS.

BY

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AND

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21ST JANUARY, 1862.

LONDON:

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1862.

At a Meeting of the Commissioners of Sewers of the City of London, held at the Guildhall of the said City, on Tuesday, January 21st, 1862:—

A joint Report by the Engineer and Medical Officer of Health, on the subject of the application of Charcoal in the Ventilation of Sewers was laid before the Court.

ORDERED—

That the same be printed, and a copy be sent to every Member of this Court.

JOSEPH DAW,
Principal Clerk.

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To the Honorable the Commissioners of Sewers of the City of London.

Sewers' Office, Guildhall,
21*st January*, 1862.

Gentlemen,

1. We beg to report that, in pursuance of the resolution of the Commission, we have conducted an experiment with the view of testing the effects of the application of charcoal to the ventilating openings of the Sewers.

2. It will be remembered that this experiment was suggested by the facts detailed in the Report of the Medical Officer on the Ventilation of Sewers, and on Sewer Gases, in 1858, wherein he described the powerful oxydising effect of charcoal as determined by the investigations of Lowitz, Saussure, Thenard, and others, at the beginning of the present century, as well as by the recent inquiries and practical results obtained by Dr. Stenhouse. All of these tend to prove that charcoal has the power of absorbing and oxydising the miasms of organic decomposition, when, with atmospheric air, they are passed over it. In commenting on these facts, it was remarked that in common wood charcoal there was evidently a powerful means of destroying the foul gases of sewers; and that the practical application of it was fortunately a question of but little embarrassment; for to use the words of the Report, "let the sewers be ventilated as they may, either by open gratings in the streets, or by the rain water pipes in the houses, or by the pillars of the gas lamps, or by tubes carried up at the landlord's expense from the drains of every house, or by especial shafts in the public streets—in fact, let the gases go out of the sewers how they will, and where they will, you have but to place a small box containing a few pennyworths of charcoal, in the course of the draft, and the purification of the air will be complete. As far as we know, the strength

and the endurance of this power is almost unlimited, so that when once the air filter has been set up, it will last continuously for years. Its action also upon the draft cannot be particularly injurious; and I have no doubt that the temperature of the sewers, and the agencies which are now at work in circulating the air, and ventilating them, will be sufficient to keep up a current of foul air through the filters; and if these were multiplied to a large extent, the friction of the gases upon the charcoal would be reduced to an insignificant amount."

3. Acting on this recommendation, the Engineer was instructed to report on the practical capabilities of the suggestion; and he advised in his Report of 22nd November, 1858, that the proper mode of ascertaining the cost and effect would be to select "a limited district; adapt the existing ventilators in the first place; add to their number, and perfect the system to such an extent as may be practicable; and watch, and record the results before adopting it for the whole City."

4. The consequence was, that it was decided that an experiment should be made. A district was therefore selected, and plans were prepared for the application of the process on a considerable scale towards the end of the year 1859.

5. The district experimented upon is in the Eastern portion of the City of London. It includes a space bounded by Bishopsgate Street on the west, from Cornhill to Widegate Street; by Middlesex Street and Somerset Street, on the east, to the City boundary; and by the Minories and then by Leadenhall Street to Cornhill on the south; the whole of the main thoroughfares above-named being included in the area. It comprises a space of about fifty-nine acres, with about 1,700 houses, and about 14,000 inhabitants.

6. This district was selected for various reasons: 1st, because the sewers have but a slight fall, and the currents in them are sluggish; 2nd, the area is densely populated, and has more than an average proportion of resident poor in it; 3rd, the thoroughfares are mostly narrow, and are, therefore, disagreeably affected by the sewer gases which issue from the ventilators; 4th, the district affords comparatively good means of isolation from other sewers.

7. The total length of sewers in the district is 25,587 feet; of which 2,081 feet are pipes, and the remainder are constructed of brick, varying from 3 feet high by 2 feet wide, to 5 feet high by 3 feet wide, internal dimensions.

8. Upon this length of sewer there are 104

air shafts, 265 gullies, 15 flushing shafts, 4 tanks, and 26 side entrances.

9. The number and condition of the house drains entering the sewers are, upon the average, the same as those of other sewers within the City.

10. The whole of these sewers were isolated as far as possible, so as to prevent air currents passing through them either from, or to the adjacent sewers; and, as we have said, the general arrangement of the sewers of the district admitted of such isolation being effected with considerable completeness, so that the sewers were dependent upon their own conditions for ventilation.

11. There were two varieties of mechanical arrangements adopted for applying the charcoal; one was that patented by Messrs. Bean and Burgess, which consisted of one large sieve with compartments, the other was an adaptation of our own; and, consisted of a series of trays for holding the charcoal, and were so constructed as to be capable of being readily removed from the frames into which they fitted. The principle of the arrangement will be best understood by reference to the drawings submitted; but owing to differences in the construction of the existing air shafts and the contiguous gullies, as well as

the impediments offered by gas and water pipes, the mode of fixing the ventilators was at places considerably varied.

12. Wood charcoal was employed, broken into pieces of the size of a filbert. It was packed closely, but without compression, upon the various trays ; and each tray held about $1\frac{1}{2}$lbs. of charcoal, making altogether $6\frac{1}{2}$lbs., distributed over the six trays of each air filter.

13. The experiment was commenced on the 14th of July, 1860, and is still in operation. It has, therefore, been continued for a period of rather more than eighteen months. A single air filter (the first affixed within the City) was, however, put into action in Philpot Lane, early in the summer of 1859. This was done to remedy the cause of complaint from the inhabitants of the lane, who, it has been stated, suffered very severely from the effluvium from the ventilating gratings. That apparatus is still in action, and has continued effective for more than two years.*

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* Mr. Capes, a medical man then resident in Philpot Lane, complained much of the nuisance arising from the ventilation in that street, and stated that nine or ten deaths had occurred about the same time in houses situated there. His complaints were referred to the Engineer and Medical Officer, who recommended the effect of the charcoal to be tried.

14. During the summer and autumn of 1860 the temperature of the air was low, and the rainfall was great. These had an influence in checking putrefaction and in scouring the sewers; we were, therefore, unable during that year, to form an opinion of the efficacy of the filters; but in 1861, when the conditions of the atmosphere were more favourable for observation, we were able to gather sufficient facts for the present Report.

15. The points to which we have directed our attention are the following:—

1st. The deodorizing power of the charcoal.

2nd. The length of time that the same charge of charcoal will continue to deodorize the sewer gases.

3rd. The effect the air filters have on the ventilation and temperature of the sewers.

4th. The exact cost of the experiment, so as to obtain data from which to estimate the probable expense of the process if it were applied to the whole city, or even to the metropolis.

16. *First.* The deodorizing power of the charcoal has been satisfactorily proved to be complete. Not only have there been no complaints from the public of stenches from the ventilating gratings, but we have ascertained by actual observation that

the odour of the sewer gases is not perceptible when they have traversed the charcoal. This, indeed, might have been predicated, from the extensive laboratory experiments, and the other practical inquiries to which we have alluded.

17. Charcoal from the ventilators has been submitted to chemical examination after having been in action for from nine to twenty months, and when heated with water, it yields abundance of alkaline nitrate, showing that some of the organic miasmata have undergone complete oxydation. But besides these compounds, others are present, namely—peculiar alkaline salts, which indicate the fixation not only of ammonia, but also of other volatile nitrogenous bodies which are peculiar to organic decomposition. The nature of these compounds has yet to be determined, for all that can be said of them is that they have a remarkably bad odour, compounded of urine, sewage, bad meat, ammonia, and stale tobacco, attempts have been made to isolate them, but without success. This, however, is not surprising when we consider that chemists have hitherto failed to separate and identify the miasms of organic corruption.

18. Guntz, for example, tried to collect the volatile matters of putrid flesh, but he only obtained a stinking alkaline liquor that he could not analyse.

Moscati condensed the organic vapour from the miasms of the pestilential rice fields of Tuscany, but the solution which he procured defied investigation, notwithstanding that it was so highly charged with organic matter as to putrefy quickly. Rigaud did the same with the atmosphere of the marshes of Languedoc, and Boussingault with the air of some of the worst districts of Paris. We have ourselves sought for the putrid miasms which infect the overcrowded dwellings of the poor; and although the liquid obtained in each case is so charged with alkaline organic compounds as to blacken sulphuric acid, and reduce the salts of gold and silver, yet the nature of the miasms is still unknown. Graham thinks they are not actual vapours, but organic molecules, like the pollen of flowers, floating in the air. This was also the opinion of the late Dr. Wilson, of Edinburgh; and both of these chemists have adduced very cogent reasons for believing that the infection or disease producing molecule is not volatile in a strict chemical sense, but is merely diffused by suspension in the atmosphere. This may perhaps be true of the actual morbific agent, but there are also organic vapours of an alkaline nature present in these miasms, which are the invariable products of putrefaction. As far back as the year 1849, the researches of Dr. Stenhouse into the products of the decomposition of nitrogenous organic matters by heat, by acids, by

alkalies, and by spontaneous decay, demonstrated that "whenever ammonia is generated in large quantities from complex substances (either animal or vegetable), it is always accompanied by the formation of a larger or smaller amount of volatile organic bases." Many of these bases he collected and obtained in the form of an oily liquid, but it was so difficult to separate them that he was unable to determine their exact composition. More recently Dr. Crace Calvert has examined the volatile alkalies from putrefying flesh, and has found that they are very remarkable substances, containing carbon, nitrogen, hydrogen, phosphorus, and sulphur. Dr. Odling has also collected the alkaline emanations from sewage, and has ascertained that they are more complex than is usually supposed, for in addition to nitrogen and hydrogen, the constituents of ammonia, they contain carbon. Let them, however, be what they may, either physically suspended organic molecules, or complex volatile alkalies; and be the morbific agent either the one or the other, there is in charcoal a perfect means of arresting and oxydising all the noxious compounds contained in these gases. This is demonstrated not merely by their absence in the sewer air which has passed the charcoal, but also by the presence of the alkalies and the changed molecules in the charcoal itself.

19. *Second.* As to the duration of the powers of deodorization, we have hardly sufficient proof.

20. The charcoal appears to lose much of its power when saturated with water; and as the position in which the trays containing it are placed, is such, that leakage of water into them in times of rain is, to some extent, all but impossible; and as moreover the atmosphere of the sewers is always very moist, the charcoal becomes so wet as to require removal, long before it has failed as a deodorizer. Upon an average the sieves have been re-charged about once in three months. Those which have been in very wet situations have been re-filled much more frequently, and those in dry situations less.

21. If the situation of the ventilators could be so arranged as to keep the charcoal dry, we are of opinion that it would not require renewal more frequently than once in a year, perhaps not so often, but under existing circumstances many of them require to be changed not less often than once a month. Secure situations might, however, be obtained by enclosing the charcoal in the lower compartments of the lamp posts, and by other means which have been suggested in our previous reports, or by placing the ventilators against the sides of the houses, as in Philpot Lane. And here we may

remark that no apprehension need be felt of the escape of effluvium, for the experience of the last two years has proved beyond all doubt that this is impossible. We make prominent allusion to this fact, because there was great opposition on the part of the occupiers of houses when it was desired that the charcoal sieves should be placed against the outer walls of their premises; and we were therefore compelled, in arranging the experiment, to fix the filters in a much more expensive and inconvenient situation than we wished to do.

22. *Third.* The effect of the application of charcoal upon the general ventilation of the sewers, is a point of the highest importance, and is, unfortunately, one upon which, after the most careful consideration of the facts elicited by the experiment, we are unable to pronounce a very positive opinion.

23. The necessity for sewer ventilation has already been the subject of separate reports by each of us, and therefore it would be superfluous to dwell now at any length upon the subject. It is merely needful here to hold in remembrance that, whilst diminishing the escape of effluvium into the streets, it is essential that the dilution of the gases generated in the sewers should not be so lessened by the diminished supply of air, as to

render the atmosphere of the sewers dangerous to the men who work in them; and it is also equally essential that the effluvium should not find its way more freely or in a more concentrated state into the interior of houses, by the house drains and their inlets, than it already does. These two considerations deserve attention, and may be best examined separately.

24. As regards the sewers. We must first state that observations made within them by means of delicate anemometers and other means, have not exhibited any perceptible currents of air through the ventilators fitted up with the charcoal sieves; and also that observations of temperature made contemporaneously in sewers with and without the charcoal boxes, have tended to show that those with the charcoal sieves were less influenced by the external atmosphere than those without them, for they were cooler in the summer months and warmer in the winter; from which it might be inferred that the currents of air were somewhat interfered with, and that the ventilation of the sewers was not so perfect as in other cases: but it must at the same time be stated, that the differences in respect of temperature were extremely slight.

25. On the other hand, there appears to have

been no appreciable effect on the condition of the air within the sewers, as far as the experience and observations of the workmen have gone, for no complaints of a worse atmosphere have been made by them.

26. Chemical and physical considerations indeed would lead us to the conclusion that, although the coarsely granulated charcoal may offer some slight resistance to the passage of an actual current of air, it cannot affect the diffusive power of gases, which is so largely concerned in maintaining the chemical equilibrium of the atmosphere: in fact, experiment has shown that media, much denser than charcoal, will permit of the free interchange of air, and of the quick dilution of noxious effluvia. Again, the chemical condition of the internal atmosphere of the sewers, as far as analyses have gone, show a proportion of 79.96 per cent. of nitrogen, 19.51 per cent. of oxygen, and 0.53 per cent. of carbonic acid, with traces of ammonia, marsh gas, and sulphuretted hydrogen: there is, therefore, abundance of oxygen to maintain the functions of life.

27. We believe, therefore, we are justified in the conclusion, that the danger to the workmen in the sewers has not been materially increased by the application of charcoal to the ventilators. How far they would obstruct the passage of a large

quantity of coal gas escaping into the sewers, is yet a matter for observation. This gas is at all times dangerous, and is most frequently the cause of sewer accidents by explosion; fortunately, however, the presence of it is betrayed by its odour long before it reaches a dangerous proportion, and with due precaution, the risk of its exploding may be avoided.

28. And here, while discussing the accidents which are incidental to the presence of foul gases in the sewers, it may not be out of place to speak a little more fully concerning the safety of those who are exposed to them.

29. The deadly and morbific effect of concentrated sewers' gases is, unfortunately, a matter of common experience. Again and again it has happened, that these gases have killed with the energy of the most deadly poisons. In France, the fatal effects of sewer and cesspool miasms have been frequently observed; and the writings of Portal, Gériel, Labouire, Parmentier, Alibert, Dupuytren, Cade de Vaux, Hallé, Geraud, Parent-Duchâtelet, Chevalier, D'Arcet, Orfila, Devergie, and others, abound with instances of the fatal *mephitismés*, caused by the gases from the *fosses d'aisances*. In this country such accidents are of much rarer occurrence; for,

over a period of sixty years, there have been but five such accidents in the sewers of this metropolis: these, however, were the cause of eighteen deaths. One of these accidents occurred about a year ago in the sewer of Fleet Lane, and it was the first upon record within the sewers of this city. We have but little knowledge of the immediate cause of that accident, for the four men who were killed were the only persons in the sewer, and they seem to have died instantly; but the inquiries which were instituted at the time, suggested the necessity for some protection against a similar disaster.

30. The experience of our present investigations, as well as the results of laboratory experiments, point to the advantage which may be derived from the use of an apparatus in the form of a respirator, containing charcoal. Dr. Stenhouse has already contrived such an apparatus; and we believe that it might be resorted to by the men in times of danger, as when there is an odour of foul gas, and would afford them an opportunity of quitting the dangerous locality, and reaching a place of safety. It is very probable that under the worst circumstances, when the air is charged with a large proportion of sulphuretted hydrogen, there is still enough oxygen to maintain the functions of respiration: the danger indeed is not from the absence of

atmospheric oxygen, but from the presence of sulphuretted hydrogen; and this the charcoal of the respirator would destroy. It is desirable therefore that each of the sewer men be provided with a respirator of this construction, and be advised to use it when the air of the sewer is expected to be unusually offensive, and when they are disturbing large deposits of mud. There will be, doubtless, difficulty in compelling men to use these precautions; but if they are provided for their use, the Commission will have the satisfaction, should an accident again occur, of knowing they have done the utmost in their power to prevent it.

31. The second part of this branch of the inquiry—is as to the effect the introduction of the system has had upon the sanitary condition of the houses, as regards the escape of sewer gases into them from the drains. Upon this head our information is of a negative character. All that can be said is that we have had no evidence of increase of effluvium in the interior of dwellings; nor do the mortality or sickness returns indicate an unusual amount of disease of a pythogenic character. Unfortunately, as has been pointed out by your Engineer in his Report on the Ventilation of Sewers, there are evidences that from most of the house drains, even in the houses of the better

classes, where the inlets are supposed to be properly protected, effluvium periodically escapes into the dwellings, and is the cause of mischief; but that such escape has been in excess in the district alluded to, we can discover no proof.

32. As to the effects of the diluted gases when they find their way into dwellings, little need now be said, for the Medical Officer has already discussed the subject in his Report of 1858 on Sewage and Sewer Gases. Abundant evidence is there produced of the disease-producing agency of the diluted effluvium; and the sad experience of the last few months is sufficient to show how those gases may exert their action in places where they are hardly suspected to exist. It can no longer be doubted, after the experiments of Dr. Barker, and the clinical observations of Dr. Murchison, that these gases are concerned in producing a form of continued fever, which is very aptly termed from the cause, *pythogenic*. This fever is often seen in the filthy haunts of poverty where corruption is abundant; and its ravages are in proportion to the defective state of the drains and sewers. Twelve years ago, when Mr. Simon reported to you on the matter, he remarked that the constant prevalence of fever in certain courts and alleys of this city told, without reference to the Surveyor's Plan of the Sewers, that

they were then destitute of the means of perfect drainage; and the occurrence of typhoid or gastric fever, even in the houses of the rich, is a matter for grave suspicion as to the state of the cesspools or the house drains and their appliances.

33. These considerations force upon our minds the conclusion, that wherever there is an escape of gases from the private drains or the public sewers, it is of the utmost importance that those gases should be destroyed as far as practicable; and we are of opinion that by the application of these charcoal filters a remedy may in numerous cases be found.

34. *Fourth.* With respect to the cost of the process:—The expenditure incurred in fitting up the 104 ventilating shafts was £918. 18s. 5d., which is at the rate of about £8. 16s. 8d. per ventilator. An experiment is necessarily more costly than an established system, and a much less sum than this may be taken as a fair average of the probable expense of extending the process even to the whole of the City, where, as may be gathered from what we have before said, the difficulties in the adaptation of the existing ventilators are considerable, and the cost therefore large. The charges named will not therefore serve for esti-

mating the cost of adapting the shafts in districts which are less dense, and in streets which are less encumbered. Still less will it furnish an indication of the cost of the system when applied to new sewers, which may hereafter be constructed with the especial view to adopting it. In the latter case the cost, under well considered arrangements, would be very moderate.

35 The total expense of reparation and renewal of damaged trays, frames, and coverings, averaged 16s. 6d. per ventilator per annum. The cost of supervision, supplying, and changing the charcoal, was 8s. 9d. per ventilator, making together £1. 5s. 3d. per ventilator per annum. The very large cost for reparation was mainly attributable to the repeated breakages of one class of apparatus used, which is not found to be capable of standing the severe traffic of the City thoroughfares. This item might therefore at a future day be considerably lessened; but if the process should be still applied in the manner herein detailed, much annual expense will always have to be incurred. We are confident, however, that with the experience already obtained, a more economical and effective mode of applying the process at the sides of the public way, or otherwise as suggested, might be adopted; and in that case the expense of repara-

tion might probably be reduced by two-thirds, and that of maintenance would be very considerably reduced likewise.

36. Our general conclusions from these experiments, and from the consideration of collateral evidence are—that dry charcoal in the presence of atmospheric air is a powerful means of destroying the mephitic gases and vapours of sewers and house drains. That the charcoal filters may be used with efficacy in the course of the air channels from the drains and closets of houses, as well as in the ventilation of the public sewers; that in applying the charcoal, those contrivances should be used, which offer the least resistance to the free passage of the air; that the situation of the filters is best, when the charcoal is protected from wet and from dirt, and is easily accessible; that from the ascertained efficacy of charcoal in destroying the dangerous emanations from sewers, the system may be generally applied with great advantage; and that from the experience derived from this extensive practical inquiry, we are satisfied that the expense of the system might be considerably reduced below that indicated by the cost of the experiment.

37. Finally we have to state that we have departed from our usual custom in reporting sepa-

rately upon the matters referred to us, for the reason that, although the investigations have been necessarily carried out separately in the different branches with which we respectively are most competent to deal, yet joint action and consideration of the whole has been a frequent necessity during the last two years, and the result of our investigations are capable of being presented in a clearer and more comprehensive manner for general reading, than if given in two separate and distinct reports.

We have the honour to remain,

GENTLEMEN,

Your most obedient Servants,

WILLIAM HAYWOOD,
Engineer and Surveyor.

HENRY LETHEBY,
Medical Officer of Health.