REPORT

TO THE

HON. THE COMMISSIONERS OF SEWERS

OF THE

CITY OF LONDON,

UPON THE

VENTILATION OF SEWERS.

BY

WILLIAM HAYWOOD, M. INST. C.E., F.R.I.B.A.,

ENGINEER AND SURVEYOR TO THE COMMISSION.

March 16*th*, 1858.

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1858.

At a Meeting of the Commissioners of Sewers of the City of London, held at the Guildhall of the said City, March 16th, 1858:—

The Engineer and Surveyor laid before the Court a Report as under.

ORDERED—

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

JOSEPH DAW,
Principal Clerk.

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Sewers' Office, Guildhall,
16*th March*, 1858.

At a Meeting of the Commission held 2nd May, 1857, it was resolved,—"That it be referred to the Engineer and the Medical Officer of Health to consider the question of Sewer Ventilation generally: and to report."

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

Gentlemen,

In accordance with the terms of the foregoing resolution, I have prepared, and have now the honor of submitting to you the subjoined Report.

It was the intention of your Medical Officer and myself to have laid before you our respective Reports at the same time, but Dr. Letheby having informed me that he was working out an extensive series of chemical investigations, into the composition of sewage waters, and the gases usually found in sewers, which would probably still occupy some time, I have thought it right to lay this before you without further delay.

I have the less hesitation in doing so, inasmuch as the considerations which fall to my division of the subject matter of reference, may be said to be distinct from the chemical portion; it is the question of the possibility of ventilating sewers by the usual agencies employed for cognate purposes, and the practicability of applying those chemical modes of treatment which have been proposed up to the present time, with which I have to deal, and not with the effects of chemical agents as proved by laboratory experiments.

I therefore lay the Report before you, which, I believe, contains reference to all the means hitherto suggested or experimented upon, for the purpose of relieving a district from the effluvium of its drainage channels. If the solution of this great difficulty, arising from large aggregates of human beings residing in comparatively small areas, can be re-

medied more effectually or cheaply by chemical agents, which your Medical Officer, after his investigations can suggest, than by any of the processes to which I shall refer, it will be my duty to deal with the practical application of his views in a Supplementary Report.

ON THE VENTILATION OF SEWERS.

Before considering the practicability of ventilating sewers by any of the means which have been suggested, or by any other mode than that adopted at the present time, it will be well to lay before you some preliminary information with regard to the necessity which exists for ventilation, and what has been already done with the view of effecting it, without the creation of a nuisance or causing injury to the health of the community.

ORIGIN OF THE EXISTING MODE OF VENTILATION.

In former times, sewers were built for the sole purpose of carrying off the pluvial waters, and those which by chance or otherwise were thrown upon the public ways. The discharge of fæcal matters into them was forbidden under penalties, and the chance of its introduction diminished both by the slight depth of the sewers relatively to the base-

ment of premises, as well as by the regulations of the various Commissions of Sewers, all of which jealously guarded against it. Every house had at that time a permeable cesspool, into which the dejecta of the inhabitants were thrown, and the waters carried off by the sewers were nominally innocuous, and, probably were nearly so, as their greatest pollution resulted from the washing of the surfaces of the streets (then not frequently cleansed) in times of rain, and what was occasionally thrown down the gullies by the inhabitants.

At that period the gullies were large open shafts, or shoots, connected with the sewers without traps of any description; they were covered with gratings of large size, the bars of which were farther apart than those at present in use; there were no ventilating shafts rising to the centres of the carriage-ways, nor were there any side entrances by which access to the sewers could be had: whatever ventilation took place therefore, was effected by the gullies; and, if a sewer required to be cleansed or examined, the mode adopted was to open holes in the centre of the carriage-way, down to what are technically called man-holes, or working shafts, and perform the operation from those apertures, the shafts being left open a sufficient length of time to ensure ventilation before the men descended, if there was fear of an accumulation of gas, or

mephitic vapour, which sometimes was the case near the heads of the sewers, but at few other points of them.

In the course of time the severity of the prohibition of aught but the pluvial waters lessened; the increase in the consumption of water for domestic purposes, rendered its discharge into the cesspools highly inconvenient; a relaxation therefore in favor of waste water, as from sinks, and other channels, appears to have been made, and it was allowed to flow by drains into the sewers. It may be safely assumed that thenceforth, most of the waste fluids of every description which could be discharged by that means, were so, and the usage of the sewers for their modern purposes may be said to have partially commenced.*

* "In London, the open and daily removal we have described, was early superseded by cesspools, and in the better houses a drain was carried from the kitchen and offices into the cesspool; but it must not, in justice to the owners and occupiers of houses, be forgotten, that at this period all passage of night-soil and filth from the cesspool to the sewer was an indictable offence, and perhaps necessarily so, for there not being then water enough to carry the soil along the drain, the latter would have been liable to be choked, and would have caused the cesspool to overflow; nor would any moderate inclination have kept the sewer clear, if the soil had been allowed to pass into it. Under the then existing circumstances, it was the duty of the Commissioners of Sewers, or of the other authorities, to enforce

The next stage may be said to date from the introduction of water-closets: these were invented about forty-five years ago, and became general, in houses of the better class, about thirty or thirty-five years since, and the entire discharge of the dejecta from the houses in which the apparatuses were fixed, in many cases took place; nevertheless, even their introduction did not directly in all cases, lead to this, inasmuch as the interdiction of the Commissioners of Sewers prevented it; and the custom obtained to a large extent, of building cesspools, having overflow drains just beneath their doming, by which means the solid matters deposited, and the supernatent liquid only ran off: but gradually the existing mode of construction crept in, and the entire refuse of the better class of new houses, flowed by the drains into the public sewers.

In the year 1849, what may be said almost to be

these regulations, and to oblige cesspools to be made and periodically emptied by nightmen, so that the drains and sewers might not be choked. A great revolution has since been effected, in achieving which, the principal means were Bramah's water-closets, patented about forty years since, but not brought into general use for a period of from twenty to twenty-five years afterwards; the more abundant supply of water at a reduced price, for which we are chiefly indebted to the improvements in the steam-engine, and the displacement of wooden pipes by iron of twenty times the size."—*Report by Messrs. Walker, Brunel, and Cubitt upon the Sewers of the City of London.* 1847.

an organic change in the system took place; in 1848 the City Commission of Sewers obtained its Act for sanitary purposes, which became operative upon the 1st January of the following year, for the first time indeed then, was this discharge into the sewers legalised: previously a penalty might have been enforced for such an usage of them, but henceforth within the City of London those incurred a penalty who failed, upon notice, to construct the drainage of premises in such a manner, as not to discharge all waste waters and fæcal matters directly into the public sewers, of which the full utility, was therefore, for the first time recognised by statute: this Act was speedily followed by others for the remaining area of the metropolis, and for the entire country, the Clauses of the City of London Sewers' Act being the basis upon which they were framed.

Complaints of the effluvium from the gullies, appear to have been made before the year 1830, and to have grown louder and stronger after that date; my predecessor in office, in a Report dated 27th October, 1840, in allusion to this, says: "Owing to the vast increase of the metropolis, and to the impracticability of preventing the drainage of all the filthiest refuse of houses into their adjacent sewers, together with their more pungently offensive products of gas-works, chemical laboratories, and

such like establishments, all of which have to be received by the sewers of the City from those of the Holborn and Finsbury Division, in addition to its own refuse, the ill odor which escapes from the gullies, although it might not be noxious or pestilential, became daily more repulsively offensive, and your attention having been drawn to the evil, it was felt that some remedy or palliative ought to be devised ; " a statement which shows that the introduction of offensive matters to sewers was then deprecated, and interdicted, but its prevention found impracticable; to obviate this inconvenience, a gulley-trap was devised by him, the first of which was fixed in the Pavement Finsbury, in 1834, and which was, I believe, the first of any description used in the sewers of the metropolis.

About the same period, great complaints were made in the Holborn and Finsbury Division of Sewers, and petitions to that Board were made upon the subject praying for remedy ; flap-valves were accordingly applied there shortly after they had been introduced into the City of London.

In 1840, nine hundred of the gullies in the City had been trapped. It became apparent even before that number was fixed, that the sewers were becoming dangerous for workmen to enter, and that the gases generated found vent by the house drains.

and through the closets (then generally untrapped) into dwellings. To obviate this, ventilating shafts connecting directly with small iron gratings in the centre of the carriage-ways were then formed: this mode of ventilating was also first adopted in the City, and the system of trapping the gullies (with numerous modifications in manner) and ventilating the sewers in the centre of the carriage-ways, spread throughout the length of the metropolis, and is still the only mode adopted here. It was likewise so throughout England, excepting in experimental instances, until recently, when ventilation has in some towns been effected by connecting the rain-water pipes of houses with the sewers.

At the end of the year 1848, all the gullies within the City of London had traps affixed to them; those originally used had been found to be of a construction not well adapted for their purpose, but others of an improved design were rapidly replacing them; and the whole of the sewers were ventilated by the shafts before described. The City was at that time the sole district of the metropolis where trapping the gullies, and ventilating in the centre of the carriage-way had been carried out as a complete system, and I believe still continues to be the exception.

OF THE NECESSITY FOR THE VENTILATION OF SEWERS.

Although the experience within this metropolis alone has sufficiently demonstrated the necessity for the ample ventilation of sewers, and although, indeed it might be considered a necessity which needed no special demonstration, but would have suggested itself to any one having the simplest elementary knowledge of hygiene, yet it is certain that it has been treated frequently as a matter of but little importance; even recently, the sewers of a district not far from London, have been formed without the slightest provision being made for it, and the Board of Health in 1852, issued suggestions for effecting it in a manner opposed to common practice, apparently in expectation of results, the attainment of which by the suggested means was utterly impossible.*

It is not surprising, therefore, that the subject has been but little comprehended by the public generally: among them the demand for an improved

* "Make proper provision for the ventilation of all sewers and drains, in such manner that there may be a free current of air through them, in the direction of the sewage flow."—*Elementary Maxims for Town Drainage, issued by the Board of Health.* 1852.

system, if judgment may be formed from the correspondence which has come officially before me, and what from time to time has appeared in the journals of the day, has arisen from one cause only, viz., the escape of effluvium from the street gullies and ventilating shafts; if a more extended view of the question has been taken by some, it has certainly not been apparent, and it seems probable that, had the repeated demands for closing the ventilating gratings been complied with, the increased noxiousness of the escape of gases by the house drains, which would have resulted, might have been regarded simply as a domestic evil, for which the cure was to be sought privately, and individually by those who felt the annoyance, and a broad comprehensive remedy have been for a still longer period unlooked for.

I append a list of accidents which have occurred through deficiency in the ventilation of sewers, and which will be, perhaps, more instructive than any amount of reasoning upon the subject. *See Appendix A.*

That accidents are certain to occur, unless means be adopted to prevent the accumulation of gases in sewers, will be admitted after the perusal of the instances given in the Appendix, which have been collected from such information only as I have

readily at hand, but which might be amplified considerably by further inquiry; reference to the experience of nearly every large town in England, would indeed unfortunately enable the list to be augmented fearfully.

But such accidents are not peculiar to this country, for instances equally serious are known to occur in other large cities. In Paris, in the year 1782, one of the most grave of the kind took place, eight men, who entered the sewer beneath the Rue Amelot, being suddenly destroyed by the mephitic gases; and although much care has apparently been taken to prevent the recurrence of such catastrophies, still, from that to the present time, their hygienic records abound with cases of death, resulting from men entering sewers in which the circulation of air had not been sufficient to ventilate them.

Great as the boon would be if a system can be carried out which shall prevent the recurrence of such calamities, there is even a more important object to be gained: the relief of the streets and dwellings from noxious emanations. The investigations of sanitary science appear to have demonstrated, that these influence materially the vitality of the inhabitants of cities, who are almost promised an increase in the average duration of life if they can be effectually prevented. Within the last few years

much progress has been made in London towards checking them, and their foulness has been perceptibly lessened; but nevertheless at periods, their emission takes place, not only from the openings to the sewers in the streets, but from almost every inlet. I do not attempt to discuss how far this, among the numerous causes physical, and moral, now said to be preventable, may determine the death rate of large towns; for private judgment in these matters has long been handed over entirely to the medical profession, who are alone it is said, capable of determining upon them. It is unnecessary therefore for me to recite the instances which have been given, of illness and death resulting from exposure to these emanations, in a less concentrated state, than when in the sewers; I assume here, that the injury resulting to the whole population from them (for all are exposed more or less if one is) is admitted, that their emission at all times is to be prevented at any cost, and unless it can be accomplished by chemical agencies, that it must be by an efficient system of ventilation.*

* Hitherto there has been apparently, much unity of opinion among medical men who have written or spoken publicly upon the hurtfulness of emanations from sewers; there has been almost equal unanimity upon the subject of the injuriousness of the existing condition of the river; but in the quarterly Report for September, 1857, of Mr. Robert Barnes, M.D., F.S.S., to the Shoreditch vestry, a very opposite view, supported by an

The necessity for ventilation is caused by the accumulation, or generation of certain gases in the sewers, which are inimical to health and life; these are various, their refined chemical distinctions will

eminent chemist, is taken. Upon the latter subject he says, "It is a momentous question, involving perhaps some millions in taxation—to be either wasted or saved—whether the influence of the summer heat upon the waters of the Thames, be such as to empoison the atmosphere of London, and so to increase the mortality of the inhabitants. Never before have we enjoyed equal facilities for observing the influence of sewage and of high temperature on the Thames as a cause of disease. The temperature of the Thames has rarely been so high. The quantity of sewage was never so great. The population has vastly increased, and the excreta of many thousands which were formerly received into cesspools, have been within the last eighteen months added to the sewage flowing into the river. The eminent engineers appointed by Sir Benjamin Hall to report upon the Main Drainage of the Metropolis, lay it down as an axiom, as the unquestioned justification for gigantic works, and commensurate expenditure, having for their object the 'dispollution of the Thames.'

"*That the influence of the sewage upon the river is pernicious.*"

"In what way the influence of the sewage is pernicious to the river, it would be foreign to my duty to inquire. I presume it to be meant 'That the influence of the sewage poured into the river is pernicious to the health of the inhabitants of London.' I will not assert that this influence, if any, is not pernicious to health, but I do most emphatically deny that any definite proof that it is pernicious has been produced. The question and the consequences are too weighty to be decided by declamation or by prejudice. It must be decided by facts. Where are those

be dealt with by your medical officer, Dr. Letheby; but for my purpose it will be sufficient to particularise three of the most common, and the most dangerous, and the leading characters of which

facts? If the theory be true, we ought to trace the deadly influence of the river. 1st. And in the severest degree amongst those who live on its waters. 2nd. In those who dwell near its shores. 3rd. We ought to find comparative immunity from fever and diarrhœa amongst those who live at a distance from the river. These are points that admit of being determined by observation; by the comparison of the returns of the Registrar-General, and of the weekly register of new cases of sickness compiled by the association of Medical Officers of Health. Chemistry and microscopy may indeed prove the existence of a small proportion of living and dead organic matter in Thames water: this kind of proof is all that has been advanced in the elaborate mass of documents that form the appendix to the Report of the Referees on the Main Drainage of the Metropolis; but to prove the actual presence of this organic matter is a different thing from proving that it acts perniciously upon the health of the population. The effect of the Thames upon the public health is not be determined by chemical, or engineering science. Nor ought it to be taken for granted. It is a question for medical observation and statistical analysis. The evidence of these has not been called.

"From the special opportunities of observing the forms and progress of disease prevalent on the Thames, from careful inquiry into the origin of those diseases, from a comparison of the sickness of the Thames with the sickness of Shoreditch, and from the periodical examination of the water of the Thames under the varying influences of tides, wind, rainfall, and temperature, in which I have been aided by Dr. Odling, the medical officer of health for Lambeth, the conclusion has been forced

almost every one is now conversant with. These are the ordinary Coal Gas, which from one of its elements is generally known as Carburetted Hydrogen; the others are Sulphuretted Hydrogen Gas, and Carbonic Acid Gas.

Carburetted Hydrogen, is a highly inflammable gas, which collects in the sewers and their appliances, generally owing to leakage from the gas pipes, although it is probable at times, from decomposition of the sewage matters; the danger to be apprehended from this gas is explosion upon contact with fire. Its specific gravity is less than that of the atmosphere; it consequently floats in the upper portions of the sewers, and collects in any chambers above

upon my mind that great exaggeration, if not a total misapprehension, prevails upon the subject of the pernicious influence of the Thames upon the public health.

"I call attention to one fact: since the replacement of the old 'Dreadnought' by the present ship, now nine months ago, not a case of fever has originated on board this floating hospital."

Will these views be supported? There are many among the most eminent of the profession, whose opinions do not appear yet to have been given upon this important subject. What if it should be stated at a future day, that great exaggeration, if not total misapprehension exists upon the subject of the pernicious influence of the chance emanations from gullies. Has it yet been proved that they are to be feared when diluted to such an extent that they are no longer offensive to the sense of smell?—W. H.

the average level, and lingers there until freed by ventilation. Accidents from this gas, it has been seen, have frequently occurred, and still take place from time to time. *See Appendix A.*

Sulphuretted Hydrogen, is the gaseous product of putrid decomposition; it is found in nearly all sewers, more or less concentrated, and more or less in combination with other gases; it hovers over accumulations of decaying matter, and gradually concentrates in the absence of air currents to dilute or remove it. When of a certain degree of strength, its inhalation causes illness, and not unfrequently sudden death. It is this gas which mainly constitutes the stink of sewers; it is its sickening odour which escapes from untrapped gullies, from the ventilating gratings in the streets, and from the ill-secured inlets to drains in the interiors of houses. Although slightly inflammable (I have witnessed its ignition more than once in the sewers), serious accidents rarely have occurred owing to its taking light therein.

Carbonic Acid Gas, is the choke damp of the mines: like Sulphuretted Hydrogen, it is also specifically heavier than the atmosphere; it is quite uninflammable, but nothing in the whole range of gases is more deadly, and its inhalation in a concentrated state, and even when largely diluted,

will cause a man to drop as if shot dead. It is not largely found in the sewers at the present day.

It is to prevent the accumulation of these gases to the destruction of health or life of the sewermen, to prevent their emission into the highways to the annoyance of the public, and their escape into houses through drains, to the injury of the inmates, that remedy by ventilation is needed.

Before entering upon the consideration of the best means to be adopted for this purpose, the question of the possibility of remedying the evil by other means, than improved ventilation, should be inquired into.

It has been suggested that sufficient remedy may be found by the adoption of the following measures:—

1st. By such an arrangement of the sewers and house drains, and such an adaptation of water supply, that the whole of the matters cast into them shall be carried off to the outlet without impediment, and with such uniformity and velocity of flow, that decomposition shall not have previously

ensued, and that an atmospheric current shall be maintained with that of the water towards the outlet.

2nd. By increased cleanliness in the existing sewers.

3rd. By the deodorisation of all fæcal matters before passing into the sewers.

4th. By disinfecting the sewage waters, by chemical agents applied in the sewers.

5th. By the extinction or neutralisation of stench, by the application of gases, made in the sewers.

6th. By a copious dilution with water of all the matters cast into the sewers.

With regard to the *first* suggestion. If the end could be attained by such means, it could only be so in a district having an entirely new system of sewers and house-drains, coupled with an ample and well-regulated water supply; reliance however has been placed on such an arrangement at Croydon, and has failed; and the impossibility of effecting it by such means has been found in other places. In truth such a system may be theoretically conjectured; but no practical engineer could, I think, even have hoped for its accomplishment; for to proceed upon the assumption that any system of sewers and drains, complicated as the best

system must be, comprehending miles of small subterranean channels, having thousands of inlets open to the usage of all clases of society, should maintain the flow of its sullage so uniformly, uninterruptedly, and quickly, as to draw with it the atmosphere of the sewer and prevent the chance of effluvium is so absurd, that had it not been publicly and gravely laid down, in books having the attention of the public, it probably might not have been worth while to allude to it here.*

I have had, at different times, observations made upon the air-currents in sewers, varying from 8 feet to 140 feet in sectional area, and at points where the velocities varied from 0·75 to 5·47 miles per hour, nearly the whole having a velocity of more than 3·5 miles per hour; and these observations plainly show that ventilation of sewers cannot

* No provision was made at Croydon for the ventilation of sewers at the higher levels, but implicit belief appears to have been placed in the maxim of the Board of Health before quoted. I am informed by Dr. Carpenter, a medical man of extensive practice in that town, who has studied closely the whole of the detail of the sewerage, that for some time a furnace was kept burning at the mouth of the outfall sewer with the view of aiding the exhaustion, and consuming the gases; and that during the action of the furnace, the draught was frequently up the sewer, and not down it; yet it was believed that all inlets and upper levels had been securely trapped, and the system almost hermetically closed, excepting at the outlet.—W. H.

be effected solely by the agency of the water running through them; for although in some cases a decided current of air was shown in the same direction as that of the water, in no case did it approach it in velocity; and it uniformly decreased in velocity as the air was distant from the surface of the water, and generally speaking, at a short distance above, it was entirely lost.

The direction of the air-current, was however by no means uniformly with the water; sometimes it drove in the contrary direction to it, at other places it was perfectly quiescent; in many instances, even when the flow of water was considerable in quantity, and had a high velocity, the air immediately in contact with it travelled along it, for some distance, then returned against it at a higher level in the sewer, and re-descended after it had reached a certain point; nor was there any local cause detected to which this rotatory action could be ascribed.

These observations were made in sewers ventilated upon the present system, at points in them as far removed from the direct influence of the ventilators as possible; but that their action was at times felt, there can be no doubt; and to it must be ascribed, in a degree, the contradictions manifested in some of the results which ensued; but in sewers without the ventilators the air-currents are also variable, for local

influences are almost equally at work, disturbing the regularity of action, and careful allowance should be made for them in any generalisation upon the subject; but it was clearly shown by the average of many observations, that even with large velocities, the ordinary flow of water in sewers could not be depended upon as a sufficient power, to extract the air of a system of sewers by the outlets, which has been a maxim promulgated by those who imagined the ordinary means of ventilation might be neglected or superseded.

But both velocity and quantity are, in fact, essentials to the formation of an air-current in any degree; and if the uninterrupted flow of sullage, which is the first essential, could be maintained, no velocity can be expected in an ordinary system of sewers, which would influence more than a thin stratum of the atmosphere directly in contact with the water, and in the main lines only. The bulk of air in the sewers and drains would remain inappreciably affected; nor would it reverse the order of gravity, by descending from the highest points of a town and discharging itself at the lowest, but would follow the natural law, of seeking the highest point of discharge due to its rarefaction.

It is not easy to discover whence arose the idea of influencing the air to such an extent by the flow

of water, unless the effect of the water-blast as applied to mines, suggested an analogy; but the difference between the circumstance of water falling freely from a height, with all the velocity due to gravity unimpeded, and that of a current of a sewer is so very great, that it scarcely seems possible that it could have originated such an erroneous expectation; and the fact must have entirely been lost sight of, that the natural current of the air in a sewer, beyond the influence of the water, is directly in the opposite direction to its flow.

With regard to the *second* suggestion: The conditions sought are nearly the same as by the previous one, and their consideration might, perhaps, be conveniently taken together; the aim of both being a high condition of cleanliness, consequent upon the rapidly passing off of all organic refuse. Now it cannot be doubted, that the freer sewers are from deposit, the less the stench will be from them, and it is of the utmost importance that the greatest care should be taken, to maintain them so; but even with an entirely new system it has been shown that detentions will take place, and in sewers like those of the metropolis, a large portion of which are at least a half a century old, and of which the structural arrangements are far from being those which our present knowledge approves, accumulations are certain to occur.

But were the sewers maintained in such a desirable condition that refuse should pass out of them almost as quickly as it was produced, stench would nevertheless arise; it would be impossible that ducts, saturated, and coated, as they must be, with the heterogeneous filth which for years had passed through them, would not stink of themselves, or that the sewage-waters would not even, upon their passage, give off offensive emanations, even when the maximum daily discharge and velocity were attained, and still more so when the minimum.*

All that can be reasonably expected from the remedies suggested, is that the offensiveness of the

* Dr. Reid in his "Illustrations of the Theory and Practice of Ventilation" has the following remarks upon the ventilation of sewers: "In the construction of sewers accordingly, it is important to provide means of ventilation, not only with the view of oxidating many of the noxious products developed there, the free action of the air tending ultimately, by its chemical influence, to purify and sustain in a less fetid condition the sides of the sewer, but also to dilute to a great extent the products that are evolved, and render them comparatively inoffensive.

"The more perfect the sewerage and drainage, the less the contamination from the air they evolve. The air from a sewer, however, must always be so far contaminated as to be offensive, even when the supply of water is considerable. Hence, then, it should not be left to escape promiscuously at gully holes in the streets, but, whenever it is practicable, be discharged into the atmosphere, like other offensive products, by a shaft placed at the highest accessible point."

emanations will be mitigated; but there is but little hope that, with the highest practicable condition of cleanliness, their contents will not give off their gases, which will rise variably as at present, from the ventilators, or gullies, and will only differ in intensity, as atmospheric conditions militate against, or favor their issue.

As to the *third* proposition: The mode that has been suggested for effecting it, is to throw down each closet after it has been used, a certain quantity of cheap deodorising agent, and that the closets, when fitted up with the means of applying water, should also have cisterns containing deodorising fluids, so arranged as to discharge portion of their contents into the basin, at the same time with the water.*

Most persons are conversant with the difficulty

* The first proposition of this character, that I am aware of, being made public in this country, was in a pamphlet, called "Sanitary Reform and Agricultural Improvement," written in 1848, by C. F. Ellerman, Esq.; it has been frequently suggested since then.

The disinfecting fluids which have been most prominently before the public in England during the last few years are those of Ledoyen, which is a solution of nitrate of lead; Sir William Burnett's, which is a solution of chloride of zinc; and Mr. Ellerman's fluids, which were either a solution of chloride of iron, or a solution of pyrolignite of iron.

of keeping a water-closet apparatus in perfect order, and can appreciate the trouble which would ensue if that apparatus were more complicated than at present; yet to carry out the suggestion, that increased trouble would be an unfailing result, and one of the main difficulties would be, that a special cistern in each house must be always filled, or the system would be a failure; now nothing could ensure this at all times in the very best class of houses, whilst in the inferior class it would scarcely ever be properly attended to, and its provisions could never be uniformly enforced: this alone places the practicability of such a system entirely out of the question.

To this may be added, that it appears to presuppose that fæcal matters from dwellings are the sole cause of the effluvium from sewers; whereas the 15,249,777 cubic feet of sewer-water daily discharged in dry weather from the area of the metropolis, comprises a vast amount of refuse of every description, besides that from the bodies of human beings; and, to prevent effluvium, the whole of this should be chemically treated, which it would be impossible to ensure being done effectually.*

* "We estimate from our investigation that the total volume of sewage discharged in twenty-four hours in dry weather on the north side is 11,513,227 cubic feet, and that the total volume on the south side is 3,736,550 cubic feet, making a total from

The expenditure also for carrying out the system, would, if practicable in other respects, be very great, and would always be regarded as a permanent tax by the inhabitants. The chemical agent might at once destroy all hope of the utilisation of the sewage waters, and it may be questionable (if the agent applied was similar to that in use on the Continent at the present day) whether

the present metropolitan area of 15,249,777 cubic feet, which is equivalent to 95,311,106 gallons."—*See* "*Report on Metropolitan Drainage*," *by Messrs. Galton, Simpson, and Blackwell, Engineers*, 31*st July*, 1857. Page 14.

In May 1853, Messrs. Bazalgette and Haywood assumed the discharge from the North side of the

Thames at	9,100,000	cubic feet.
Ditto South side	3,000,000	,,
Total.....	12,100,000	,,

See Report upon "*Scheme of Great London Drainage Company*," *by Joseph William Bazalgette and William Haywood, May 7th*, 1853.

At the period of that Report, the gaugings that had been taken of the sewers were of a most imperfect character, and altogether the information at hand, of the most meagre description. An estimate of the discharge was therefore made with much difficulty, but making allowance for the increased water supply since that date, and the additional area included by Messrs. Galton, Simpson, and Blackwell in their gaugings, the 12,100,000 cubic feet was most probably closely upon the true discharge at that time.—W. H.

the acid smell substituted, would be considered much improvement upon the existing stench in respect of nuisance, or whether after the sewage-waters had been so treated, they would not still evolve gases prejudicial to health.*

It is the custom at present in many houses in Paris and different parts of the Continent of Europe, to wash down the closet pans or pipes with a deodorising fluid. Now in the majority of those houses, the admission of aught but urine and purely fæcal matters, is carefully guarded against, and in none is but a very limited quantity of water admitted. The material to be acted upon by the chemical agent, is, therefore, in a very concentrated form; but I have never noticed a really satisfactory result from its use. The difference between the absence of water in the once case, and the copious supply

* Ledoyen's disinfecting fluid, extensively employed in France for the deodorisation of all feculent matters, does not appear to destroy their value as manure.—*See Report by Drs. Southwood Smith, D. R. Granger, and Joseph Toynbees, Esq., upon Ledoyen's Disinfecting Fluid, March* 1847. Page 14.

Mr. Ellerman's disinfecting fluid, according to the Report of Drs. Andrew Ure and Maurice Scanlan, "Does not destroy the efficacy of the phosphates in night soil for agricultural purposes." Mr. Glass, chemist to Sir William Burnett, subsequently denies this, quoting Leibig, who states that, "Oxides of iron and its salts are highly poisonous to vegetation."—*Parliamentary Paper. Session* 1848. No. 435.

of it as in England, renders the systems entirely different, and the difficulty of application in the latter instance infinitely greater.*

In every respect therefore, the successful adoption of such or similar means, in connection with the existing water-closet system in use in England generally, would be found to be utterly impracticable.

As to the *fourth* proposition: The question of the possibility of effecting the deodorisation of the sullage of towns by the application of chemical agents made in the sewers, has recently been brought with prominence before the public by Dr. Angus Smith, in a lecture upon disinfectants. This is in principle the same, or nearly so, as the one just adverted to, the difference only being that the application is to be made in the sewers themselves, instead of in the closets of houses. The process as proposed, may be best described by an excerpt from the lecture itself. The Doctor says :—

"The great object desired is to purify towns. We propose to disinfect the whole sewage of a town

* Dr. Letheby informs me that this is a solution of chloride of zinc.

in the town itself, and to pass the disinfectant into the sewage at various points, so that all the main arteries may be rendered pure. Air rushing from them into private sewers, will convey the impurities of the private sewers only, which each may disinfect for himself. *If disinfection of private sewers should be common, the public use might then be given up.* By this means we purify whole cities. The sewage-water will come from the town in a disinfected state, and it may be carried to any point without any fear of creating a nuisance. If carried through an agricultural district, it may be used as liquid manure, either by drains or by the jet, without any fear of an action for damages. Without disinfection, the sewage will certainly not be an agreeable neighbour; with disinfection, the channel will be a more wholesome institution than our present canals. A channel like this need not be covered. To make a covered channel is naturally a most serious undertaking, and even to use the liquid manure from a covered channel will be dangerous. Sewers will then for the first time be unqualified blessings. At present they are dangerous at the best, and we dread every connection with them."

"The state in which the disinfectant will be applied in the sewers, must differ to some extent according to the condition of the water or sewage, the principle of its composition not changing."

The agent suggested to be used, is termed "McDougal's Disinfecting Powder," and is apparently the result of the chemical labours of Dr. Smith and Mr. McDougal. Its value as a neutraliser of the emanations from sewage-waters, I give no opinion upon; but it may, perhaps, be reported upon by Dr. Letheby, within whose province such opinion lies. I confine myself entirely to the question of the practicability of its application to sewers and of all similar applications, for the remarks will apply equally to them all.

It is proposed to throw quantities of this powder into the main sewers at various points along their lengths. Now, the main sewers in London run with velocities varying from one to three miles per hour, and even more; and some of the most important of them discharge, at periods of the day, (in dry weather) from 1,000 to 2,000 cubic feet per minute, the same sewers discharging not one-fourth the quantity at one period of the day that they do at another: owing to this alone, the adjustment of the proper quantum of disinfecting agent would be very difficult, and, in times of rain, an utter impossibility. It is not indeed easy to conceive how a regulated application can be thus kept up at any time, to be effectual, unless the quantity employed be always largely in excess; and, however cheap the material may be, quantity must be a matter of importance.

But if it could be successfully applied to the main sewers, but little would be gained by it. This may be illustrated by reference to your own jurisdiction: there are, strictly speaking, within the City but two main sewers—the Fleet and London Bridge (for the classification of main sewers in Schedule D of the Metropolitan Local Government Act is purely arbitrary, and made apparently, upon no principle whatever). Now, supposing the sullage running through these to be perfectly disinfected upon its course by the chemical agent, it would be of but little value to the whole City area, for they are, in their aggregate length, not more than one-eleventh part of the whole City Sewers, and not one-fiftieth part of the whole drainage channels: thus it will be seen how limited would be the benefit.

Even if neutralising vapours are given off (as seems to be expected from the context of the excerpt), they could not effect more than a very small additional length of those intricate ramifications of drainage, which branch out from either side of the main channels, nor would it affect many of the house-drains; it would in fact, only disinfect certain valley lines running through large broad streets, where but slight nuisance is felt—and no more; and would leave untouched all those points where the principal nuisance accrues.

To effect its object thoroughly, a graduated supply of the agent should be introduced each minute by night and by day at the heads or summits of the thousands of sewers in this metropolis. No hopes can be entertained that any such system can ever be carried out successfully, and its difficulties have evidently never been understood by the projectors; yet if disinfection of all fæcal matters is to be properly made, it must be by beginning not only at the head of every sewer, but at the heads of the drains, and by dealing with the matters almost as soon as rejected; in fact, to deal with them in the mode laid down in the previous suggestion; this is, indeed, evidently contemplated, for the lecturer says—"So that all the main arteries may be rendered pure, air rushing from them into private sewers only, which each may disinfect for himself. If disinfection of private sewers should become common, the public use might be given up." Thus, he clearly indicates the former mode, of which the objections and the all but invincible difficulties have been already seen, and of which if they were not so, the propriety may still remain to be questioned.*

* Since the above was written, I find, by a pamphlet sent me by Mr. McDougal, that he proposes to employ a fluid for this purpose; but the difficulties attending its successful application are equally great, and all the remarks made in reference to the usage of the powder apply with equal force.

The *fifth* proposition consists in the application of gases, known to have chemical affinity, for the products of decomposition, so as to neutralise or destroy them.

Two schemes only of this nature have come before me, both suggesting the use of chlorine gas.

One, which was submitted by Mr. Sowerby in 1849, proposed to erect works, which were to connect with pipes to be laid through the sewers, by which chlorine gas could be discharged when required into them; this design also proposed shafts to be specially erected for the emission of gas, and to use the gas columns for the same purpose.

The other, submitted by Mr. Richardson, was to place in the sewers, at intervals along their length, vessels containing a powder which slowly evolved chlorine. This scheme was reported upon by me in October 1850, and the difficulty of such a mode of deodorising their atmosphere was therein explained; all those difficulties are in the way of gaseous applications.

My conclusions, with respect to all such modes of neutralising the emanations from the sewers. are that the mechanical difficulties alone oppose invin-

cibly their adoption; but that if these could be overcome, that they would require such nice adjustments, in respect of quantity, to suit the varying atmospheric and other conditions, as it would be practically impossible ever to make with the balance just sufficient to destroy the stench, and no more, so that one or the other would always predominate; and that, in addition to other minor objections, they would be attended with great perpetual outlay without commensurate benefit, and would, therefore, be but failures at a large cost.

As to the *sixth* suggestion: It is only to be observed that cold water checks decomposition, and that no doubt an almost, if not a complete, deodorisation may be effected, if the dilution of the offensive matter be carried to a sufficient extent, although what the quantity is that will be required I am unable to say, but more water delivered at the main sewers only will not effect this—the main sewers are those where water is least required, as there is enough already there to effect most purposes; any additional supply must be uniformly distributed, so that each house and each drain shall have its fair lavement—it then will find its way into the main lines, and thus run through, and improve the whole of them.

It remains, therefore, to consider the probability there is of such a supply being afforded to the metropolis. Now, we have already arrived at a consumption of water equal to thirty-six gallons per head per diem, nearly the whole of which runs through the sewers, and this quantity has not had the desired effect of destroying offensive emanations; and assuming that we reach a consumption of forty-five gallons per head per diem, which it is estimated by some we shall do, it is still open to question whether that quantity will accomplish it or not; but we are more likely to have an economisation of water than an increase.*

The engineers, who recently reported upon Metropolitan Sewage Interception, consider that seven cubic feet per head per diem will be the quantity of sewage produced in dry weather in future years; and as the largest quantity of sewage water is from the water pumped up from various sources, it may be inferred that they consider about forty-three gallons per head per diem will be given; it is not easy to say what the consumption will reach, if it be administered upon the constant

* The quantity of sewage water running off from the metropolitan sewers has by the most recent gaugings been found to be about 5·8 cubic feet per head per diem.

supply system in its integrity; for the waste where it has hitherto been tried, is serious. In the town of Boston in America, in 1853, it reached fifty-five gallons per head per diem, and has since I am informed reached seventy gallons; but the sources of supply for London will not bear a parallel consumption, which indeed rather deserves the term of profligate waste; and it is quite probable that by the agency of water-meters, now coming rapidly into use, or by means which will be adopted to check waste, the consumption will not exceed, in future years, thirty gallons per head per diem; in fact will not exceed the present rate of supply: a quantity which is ample for all ordinary purposes of a population, but, apparently not sufficient to deodorise its dejecta and organic refuse.

If therefore such a copious water-supply can be ensured; as will, coupled with increased care, both in the construction and maintenance of sewers, and drains, effect complete deodorisation, the provision of improved ventilation would be no longer an obligation; but if not, the remedy must be sought by other than the present means.

This brief examination will show, that neither of the modes suggested can be relied upon for the mitigation of effluvium to such a degree as to

render a complete system of ventilation of sewers unnecessary; of the first two it may be said, that their success involves preliminary conditions, which, in the metropolis, are practically unattainable, and although right in their general conclusion, that the offensive emanations will be lessened by the sewers being kept clean, they are wrong in supposing that those emanations will be sufficiently neutralised by the means intimated; of the third, fourth, and fifth, that they border closely upon the chimerical; and although doubtless projected after laboratory experiments, which gave results satisfactory in themselves; yet were designed without knowledge of the difficulty, or impossibility of their practical application, to the purpose for which they were specially intended; and of the sixth, that although water in sufficient quantity and well regulated in its supply would, undoubtedly, effectually deodorise the contents of sewers, so as to render the existing system of ventilation harmless, and any other unnecessary, yet there is but faint probability of a sufficient quantity to carry out that end being obtained, unless it be specially provided, delivered, and paid for, for the express object of copious dilution and deodorisation of the organic refuse of the metropolis.

None of the suggestions it may also be observed,

take cognisance of the coal gas found so much in sewers, yet this has been a prolific source of injury to human life; in a small town, and one subject to different arrangements in respect of gas companies, perhaps by careful management, all difficulty upon this hand might be entirely obviated, but in the metropolis it now cannot be; the existence of this coal gas must therefore not be ignored in designing any scheme of ventilation.

It appears then, that the only practicable means at present at hand of reducing the offensiveness of these emanations to a minimum, are keeping the sewers in the highest condition of cleanliness their character will admit of, by a proper construction of the drainage channels, by a sufficiency of water, and by the application of labor when requisite. There is, however, no novelty in these suggestions, for those practically acquainted with sewers have long known and acted upon them. Parent du Chatelet pointed them out in relation to the sewers of Paris thirty years ago, and in his analyses of the various stenches of sewers ("odeurs particuliéres des égouts") speaks of the one which is least offensive as specially belonging to those "qui sont bien entretenus, dans lesquels l'air peut circuler, et dont le courant est assez abondant;" and Tardieu, in his Dictionnaire d'hygiéne Publique, says, "la désinfection des egouts consiste á propement parler, dans un

bon emploi de la ventilation et de l'irrigation;" and again, "Mais la meilleur, et le plus efficace de tous les moyens pour remédier á l'infection des égouts, est d'y faire passer habituellement et á des epoques rapprochées, une masse considérable d'eau propre; par ce moyen, on enléve les matiéres susceptibles de se putrefièr, ou, si on ne les enléve pas, l'eau dissout et emporte avec elle les produits de la putrefaction á mesure qúils se forment."

These views have been endorsed by Boards of Health, and promulgated by their officers throughout the country, stereotyped and approved of by medical men, and adopted by engineers, and have been pointed to as a remedy by many who have been consulted respecting the better ventilation of sewers, and who have apparently found it easier to indicate these measures of alleviation as a complete solution of the difficulty, than to seek another in the careful consideration of the complex subject referred to them; there is therefore, an almost perfect unanimity upon the point: within the City of London, the first measures have been carried out as far as has been practicable, and the second as far as the water supply will admit of, and I assume this has been equally the case in the other portions of the metropolis; and although the evil has without doubt been very much abated, yet it still remains to be completely removed; whether this is possible

by the application of an ordinary system, and an ordinary expenditure, is yet to be seen; but unless a supply of water, not hitherto reached, can be given for the purpose, it can only be found in a more perfect system of ventilation than the existing one, the consideration of which will now be entered upon.

But before considering the various modes which may have been proposed, or have been adopted, the character of the channels to be ventilated, and the exact nature and extent of the ventilation required, should be clearly understood; the gases which are to be removed, and the danger resulting from their retention in the sewers, have already been explained.

OF THE CHARACTER OF CHANNELS TO BE VENTILATED.

It has been the popular custom, to compare a system of sewers to a mine, and to form conclusions as to ventilation, upon this assumed resemblance; in truth the only similarity which exists between them, is that both are extensive subterranean channels of communication; in most other respects, which affect the question of ventilation they are fundamentally different. It is necessary to comprehend this clearly, so that the difficulty of

effectually applying the same means to the one which are found most efficient in the other, may be fully understood; it will therefore be well to explain the difference which exists, taking for comparison a colliery in preference to others; coal mines being those where ventilation has been carried to the greatest excellence, and its neglect has always been fraught with the greatest danger.

A coal mine may for the present purpose, be described generally as a series of passages or gangways, cut for a special object through a particular stratum of the earth, the aggregate length of these gangways varies from a few hundred yards, to fifty, sixty, or seventy miles, according to the extent to which it has been worked, the whole of the gangways, whatever be the mode of working the mine adopted, (and they differ materially in that respect), being nearly of the same area upon transverse section, having but slight variations in level, and having well regulated communication with each other at different points, for the sake of ventilation and transit.

To each coal mine there is ordinarily but one entrance shaft; some it is true where the mine is large have more, but in that case the area of the mine is divided into sections, so arranged that the different portions may be actually considered as

separate and distinct mines, and arrangements for entrance, for the lifting of coal, and ventilation, are made accordingly.

Their ventilation, whether it be by natural or mechanical processes, is effected in all cases by a down-cast and up-cast shaft only: the former being the inlet for fresh air from above, the latter that by which the air, having performed its office in the mine and become vitiated, rises to the surface and is discharged.

The economical usage of given quantities of air in a mine is remarkable: according to the necessities of the workings (which are always varying), it is made to travel through air-courses of but a limited length, or make a circuit of many miles; it is turned and diverted into numerous channels at will, its main current is split and divided into many smaller, and again re-united into its original volume; but, however it may be utilized, the quantity at command is accurately ascertained, and however far it may travel, that quantity does not materially vary: upon its journey, whether that be long or short, it loses nothing by emission, and only gains by abstraction, those gases which issue from the workings of the mine, so that all that enters by the down-cast, is emitted by the up-cast shaft, and but little more; nor can the intake or the efflux be

made by any other orifices; and as the quantity of air can be regulated within certain limits, so the velocity of the current can be lessened or increased, according to special requirements of time and situation. It is this power of regulation and control which enables the ventilation of coal mines, to be perfected to the extraordinary degree it is.

The sewers and drains of a district (for they must all be taken as part of the system of drainage, and it is useless to consider the ventilation of one without the other) are essentially different: they consist of a series of channels, varying from tubes 3 inches in diameter, to sewers having from 1 to 140 or 150 square feet of sectional area; these are joined and connected with each other at every variety of level, and in large variety of manner, and at every few feet of their entire length, is a gully, water-closet, sink, rain-water pipe, or other inlet, through all of which water, and, therefore, at times, air, can and does enter or escape.

Figures will show this more plainly than mere description; and the City of London is, at present perhaps, in some respects, a better illustration than most other places, owing to the variations in level of the district, the large extent of sewers in relation to its area, the density of its habitations, and the comparatively complete condition of their drainage.

There are within the City of London about—

45½	miles of sewers large enough for men to enter; and
2½	„ of pipe sewers.
Total .. 48	„ of public sewers.

To these sewers there are about—

2810	gullies of every description.
1065	air-shafts, with ventilators.
Total..3875	openings to the sewers from the public ways.

There is, therefore,—

1 air-shaft to every 237·97 feet of sewer.
1 gully to every 90·19 „ „

Or, as gullies are generally in pairs,

1 pair of gullies to every 180·38 feet of sewer.

A careful examination and admeasurement of the drainage of 1000 houses, taken indiscriminately in all parts of the City, gave the following results. *See Appendix B.*

The total length of horizontal drain was 54,718 feet, or, upon the average, 54·71 per house.

The total number of inlets of all descriptions was, 2696, or 2·69 per house.

Or, 1 inlet or opening to every 20·29 feet of drain.

Taking 16,300 as the number of houses within the City, and applying these averages to them, it follows that the length of the house drains must be about 891,903 feet, or 168 miles.

Again, taking the data furnished by the examination of the 1000 houses, there must be 43,944 different inlets to the house drains.

A summary of the drainage channels within the City of London may be, therefore, estimated to stand thus:—

	48	miles of sewer.
	168	„ of house drain.
Total..	216	„ of drainage channel.

The No. of air-shafts	1,065
„ of gullies	2,810
„ of inlets to private drains ..	43,944
Total number of inlets to the drainage channels	47,819

Which gives one opening or inlet to every 23·84 feet of drainage channel.

Although it is not probable that in any equal area, of any part of the metropolis so great a length of drainage channel will be found, yet owing to the width of the streets, and the distance of the houses from their centre line, the length of drain relatively to that of the sewer, would be found to be greater in many parts; and the number of inlets from the houses may also be considerably greater in proportion to the number of houses.

This comparison between the structural arrangements (so to speak) of a mine, and a system of sewers, will show their essential differences, which, as they affect the question of their ventilation is this —that in a mine, there is by proper arrangement, practically but one main channel or air course to be dealt with, of nearly uniform section, of convenient levels, and having but one inlet and one outlet of well-defined and fixed areas in relation to the work to be done; that in a system of sewers there is but a small portion of the length which can be called main lines, but from which branch in all directions, like the fibres of the root of a tree, collateral sewers, and house drains, irregular in shape, dimension, and level, having upon every few feet of their length, outlets of various sizes, which are constantly subject to be altered in number, situation, and area.*

* There are also many minor differences, such as the uni-

The consequences are that in a mine a given result can be obtained by the exertion of a known ventilating power, the amount and velocity of the current can be regulated at will, and the atmosphere be dragged through the air-courses completely under control, (I omit here the consideration of this power in relation to the fearful emergencies which suddenly occur in mines, and allude to the usual daily ventilation only), whereas in the sewers, their direction, the number of inlets, and the other conditions previously enumerated, must render the action of any system uncertain, and the regulation of the intakes being practically beyond more than a limited control, the power required cannot be calculated, and never can be applied with a closeness compatible with economy, but to approach efficiency, must always be largely in excess of that which would be actually required, if the sewers could be all but hermetically closed.

It may as well be anticipated at once, that upon this point much difference of opinion may be found.

formity in hygrometrical condition of the air of mines; the gradually increasing temperature from the point of intake to the up-cast, all of which simplify the operation of their ventilation as compared with that of sewers.

Where the air is split for the purpose of ventilating the workings of the mine, the various currents are all re-united before entering the up-cast shaft.

There are those having such confidence in the authority vested in Boards by Acts of Parliament, and the efficiency of official inspection, that they may believe in the possibility of keeping trapped, to the required extent, all the inlets to sewers, and maintaining them sufficiently air-tight for the purpose. Now, it may perhaps, be averred, that nowhere has domiciliary visitation by Inspectors been longer in operation, or more uniform and complete, than in the City of London; but, after a consideration of the result of their labors on this particular head, I have no such hope; and, although persistence in the requirement of closely trapping for some years would effect much, yet I do not anticipate that the three-quarters of a million of inlets to the Metropolitan Sewers, can be by any amount of official inspection, kept in such a perfect condition, that imperfect traps in houses, inoperative gully-valves, the opening of side entrances, the reparations of drains, &c.,&c., will not cause a vast amount of leakage, which will present one of the principal, if not the main, difficulty to be overcome.

It may also be as well to state here, that few of the ventilating gratings in the streets can be entirely closed; these mostly are at parts where chambers are formed in the sewer for various purposes, and where the coal gas principally lodges; a current through these must, therefore, be established, or

explosions will infallibly ensue, and the sewers be unsafe to enter from that cause. In a new system of sewers, and in a district less dense, and having more space for gas-pipes, this may in a degree, be avoided, but in a large portion of the metropolis it cannot be.

AS TO THE EXTENT AND NATURE OF THE VENTILATION REQUIRED.

It has been seen that ventilation is required to guard against explosions of inflammable gases, and the emission of other gases which are deleterious by gullies, house-drains, and other inlets. Of the former evil the public generally take no heed and know little; for it is remarkable that accounts of these explosions rarely have appeared in the journals of the day, and some time has now elapsed since carburetted hydrogen from a sewer found its way into private premises, nor is it a circumstance very likely to occur, constructed as sewers now are. Of the latter, the public generally take cognisance only of the effluvium issuing from the openings to the sewers in the streets; and as it has before been observed, if a system of ventilation could be devised, by which that stench could be abated, it is probable that there would be no further demand for improved ventilation.

Although the house-drains might by fixing of valves at the mouths of such of them as enter the large sewers, be in a degree separated from the system, so as to reduce the ventilating power required for the sewers only, yet their complete isolation would be impossible, for numbers of drains enter pipe sewers, which experience proves require ventilating as well as larger ones, and where valves could not be placed; and hanging valves, and indeed valves of all descriptions, are at times inoperative, and therefore, no system of ventilation can be carried out, which shall not include in some degree, that of the house-drains also.

But if the isolation of the drains, regarded only as air-courses, were practicable, it would be an error in system to attempt it, it would be leaving the work of ventilation but half done; for if there be truth in what the medical profession have told us for so many years, it is of far greater importance to have the interior of dwellings free from noxious smells, than to free the public ways from them; nor does it indeed need much discrimination to see, that far more harm may be done in the aggregate by house-drains constantly discharging their mephitic vapors within dwellings, and poisoning the atmosphere breathed for many consecutive hours, or days by whole families, than by the

chance inhalation of the same from a gully opening upon a public way, through which currents of air, are always passing more or less rapidly, and of which the enormous bulk of the normal atmosphere, as compared with that which issues from the gratings, is so large as to place it almost beyond the limit of comparison.

Efficient ventilation should have a far wider range of object than the mere suppression of the issue of stench from the street-gullies; it should answer two large purposes: firstly, prevent the sewers becoming so highly charged with explosive, or deleterous gases, as to render it dangerous for the sewermen and others to enter them; secondly, prevent the gases from finding vent, either by the street-gullies, or by the house-drains, to the injury of the public health and comfort; in brief, a system of ventilation of sewers, may be said to fall short of its purpose, if the issue of stench takes place from any drains, or sewers, at any period whatever, whether within the streets or dwellings, excepting by those points of efflux which the system must provide; but that a downward current from every inlet, communicating with a drain, or sewer, should be maintained. It may be found that, practically, this is unattainable beyond a very limited extent, but nevertheless the correctness of the principle

must be admitted; and in proportion as the theoretic standard can be reached, so will the system be efficient and complete.

And another point of equal importance in perfecting a system is, that it should also either discharge the air collected from the sewers, and drains, at such a level above the ordinary stratum of atmosphere respired by the inhabitants of a city, that it should in no degree vitiate it, or its noxious qualities should be neutralised or destroyed by the action of the furnace, or by such other means as science can devise.

OF THE DIFFERENT CLASSES OF VENTILATION.

All ventilation may be divided into two classes—the *natural* and *mechanical.* The former includes those methods which depend upon the movement caused in columns of air of different temperatures, and, therefore, of different densities; the latter, the mechanical means for gaining a current, whether generated by forcing air into the vessel to be ventilated, or exhausting it by suction, of pumps, bellows, fans, or other machines.

The principle upon which natural ventilation takes place may be briefly explained to be this: if

two tubes, of equal height are connected at the bottom, and filled with air, the one being filled with air lighter than the other, the heavier column will descend, and force out the lighter; or, in other words, the one will rise by reason of its lesser specific gravity, and the heavier will descend and assume its place. All natural ventilation, whatever may be the difference in detail of arrangements, is in principle the same.

The rate of discharge is determined by the relative heat, and height, of the two opposing columns; and it follows therefore, that the higher the columns are which thus weigh against each other, the greater (*cæteris paribus*) will be the ventilating power and velocity of efflux.

Mechanical ventilation is of two sorts, one commonly called the plenum, the other the vacuum; the former consists in pumping fresh air into the chamber to be ventilated,—the pressure forcing out the foul air at the point of efflux; the latter in sucking out, or exhausting it, when the air rushes in by the intake, to supply the vacuum created.

These simple principles should be clearly understood.

Upon the efficiency and economy of the respective

systems, in their application to mines and other purposes, competent authorities differ. Hood appears to think the mechanical the most effectual; Dr. Reid that the natural is the best and most convenient generally for a large proportion of ventilating purposes; whilst Dr. Ure has said that one species of mechanical ventilation (the fan) possesses many advantages over the natural, and in cost is more economical, in the proportion of 1 to 38, as compared with a furnace. Peclet is strongly in favor of mechanical ventilation upon economical grounds, and gives some striking illustrations of the correctness of what he advances. Mr. C. W. Williams also, in his work upon the combustion of coal, considers draught may be more effectually and advantageously obtained by mechanical agency than by the simple furnace; whilst Mr. Prideaux makes the startling statement that 1 lb. of coal expended in mechanical agency, will produce a stronger current than 500 lbs. of coal in heating a column of air to act by its diminished specific gravity through a chimney 35 feet high. Mr. Nicholas Wood, an engineer, whose experience in the ventilation of some of our most important northern collieries, entitles his opinion to great weight, prefers the natural, in every respect, for mines; and the majority of mining engineers appear to agree with him, although there are others who maintain the mechanical ventilation to be the most effectual, and cheapest.

It is, however, needless here to go into this question further ; should, at a future day artificial means be resorted to for ventilating sewers, the relative values of the various modes could then become the subject of closer consideration.

OF THE DIFFERENT MODES OF VENTILATION SUGGESTED.

The modes of ventilating sewers which have either been suggested or tried, are here separated for convenience into the two classes before alluded to.

Natural Ventilation, includes that by shafts carried up from the crown of the sewers terminating in openings at the carriage-way level, as at present in use.

By the rain-water pipes of houses connected with the sewers.

By pipes, or tubes, or flues, erected for the special purpose; and carried up the fronts of houses to the tops of the stacks of chimneys.

By large shafts or chimneys erected in suitable places, and carried up to a superior altitude to the surrounding buildings.

By the lamp columns, aided by jets of gas burning night, and day.

By furnaces and shafts, specially erected at suitable spots.

By the shafts and furnaces of steam-engines and factories.

Mechanical Ventilation includes that by fans or bellows to force air into the sewers, proper shafts being constructed for its efflux.

By pumps or fans for extracting the air.

Ventilation by the Steam Jet, which may be said to hold an intermediate position between the natural and mechanical.

That a good system of ventilation has not been found and applied long since, is evidently not owing to the want of suggestions, all of which, however, resolve themselves into the application of one or two well known principles or modes of effecting it. It is perhaps not very singular, that almost every one who has proffered evidence or made a suggestion, has treated the matter as one of much ease and simplicity; but at the same time has evidently had but a slight knowledge of the difficulties to be overcome, arising from the actual nature of the channels to be ventilated. I can only at this moment call to mind one or two exceptions, among

whom was the illustrious chemist Mr. Michael Faraday, who in the year 1834, before a Parliamentary Committee, alone, of all the witnesses, gave opinion, that the subject was beset with great difficulties: an opinion which, in the year 1848, he still apparently retained.

In examining the value of the different modes of ventilation hitherto proposed, it will be assumed that the sewers are in all cases kept in a proper condition, *i. e.*, in the highest state of cleanliness that circumstances will admit of, and therefore, that the effluvium from decomposition has been reduced to a minimum.

VENTILATION BY SHAFTS OPENING ON THE CARRIAGE-WAYS.

The origin of this mode has been hereinbefore given, it consists in building shafts at intervals along the sewers, which commence at the crown and terminate at the street level in the centres of the carriage-ways: the manner in which they connect at their lower ends with the sewers is various, but the general principle is shown by the two sketches subjoined (*see Appendix*); sometimes they are built at the heads of the sewers in the manner shown by Figures 1, 2, and 3, but more generally as shown by Figures 4, 5, and 6, as by the latter mode

they not only relieve the sewers, but prevent those gases which are specifically lighter from lodging in the working shaft; it is in those, when without ventilating shafts leading out of them, or with the shafts stopped up, that most of the explosions have taken place from the ignition of carburetted hydrogen gas, and they may be when thus unventilated, likened to the goaves of mines.

Of this system, the utmost that can be said in its favor is, that it enables gullies to be trapped with safety, and sufficiently ventilates to prevent numerous sewer accidents from occurring, and that in a degree (although far from effectually or uniformly), it also prevents the gases which are generated in the sewers themselves, from issuing through the drains, closets, and sinks of houses with such intensity as they otherwise would do; that the discharge of the gases takes place at points farthest removed from the traffic, where it is most readily exposed to the atmospheric currents, and is therefore less injurious or offensive to the public, and to these may be added that it is entirely self-acting, and inexpensive.

The principal, indeed the only objection generally made against it is, that it leaves the discharge of the deleterious emanations at such a level, and position, as frequently to be offensive to the smell,

and seriously to contaminate the air for the purposes of respiration, before its diffusion into the surrounding atmosphere renders it harmless.

As regards this objection it may be observed that the benefit of the system is directly as the street is wide or narrow; in those like Holborn or Cheapside, nuisance from the ventilators is rarely experienced, and the removal of the points of discharge from the side of the foot-ways to the centre of the carriage-way, is a positive advantage, whilst in narrow streets the benefit is very slight, although it is equally correct in principle, to place them every where as far from the houses as possible.

Whether these emanations are now ever sufficiently copious, or offensive in the streets, to prove as deleterious as is generally imagined, must be decided by others; that they are perceptible there is no doubt, and as it has been shown, they may be expected to be so.

These openings simply act as up-cast and down-cast shafts, the cold air enters at some, driving out before it the hotter air within by others, and in its turn being displaced by cold, when it has become rarefied and vitiated, and thus a circulation is maintained; but, although relief of the sewers is known practically to take place by these currents, it is very

difficult to ascertain which are the up-cast, and which the down-cast columns; for so numerous and varying, and so constantly in operation are the influences which disturb their regular action, that, in their turn, no doubt all serve in both capacities, and the discharge of hot water through a drain, or the opening of a bell-trap to a sink in an adjacent house, or of a side entrance for the entry of workmen, or other apparently trifling causes, are sufficient to establish temporarily the direction of the feeble currents through them; but in the absence of such locally determining causes, probably the ventilators near the summit levels, serve most frequetly as the discharge orifices.

In some instances their action may be more distinct and traceable, as in those districts where the sewers are gorged by the tides, or where the tides being excluded the sewage waters accumulate until the outlets are free; in which case, perhaps all the ventilators act alternately as intakes, or points of efflux, as the tides may be ebbing, or flowing. But even then, excepting in very flat districts, much of the air expelled by the tidal waters is rather discharged by the ventilators attached to sewers coming in from higher levels, than those in the sewers actually gorged. The extent of the emanations from this cause has, however, been much exaggerated, opinions being apparently

formed respecting it, more from reasoning upon erroneous grounds, than from the result of actual observations.

The action is more clearly established upon those main lines connecting directly with the river, of which the outlets not closed by valves, are, towards low water exposed; when they become lines of intake, and determine an upward current through the ventilators, as well occasionally of those in collateral sewers, the energy of the ventilation depending upon the direction, and force of the wind, and the extent of its influence depending upon the straightness, and size of the sewers, and other conditions.

There are periods when nuisance from the ventilators is more sensibly experienced than at other times, and this appears to be a compound result of temperature and barometrical pressure, for the times upon which the emanations are most copiously evolved and most offensive are when the temperature is high, the barometer low, or rapidly falling, and there is a comparatively stagnant atmosphere; upon these occasions (very few in number during the year), the emanations are unbearable, no trapping appears to be effectual, but gullies, ventilating shafts, sinks, and closets, equally evolve their sickening odours,—their emission undoubtedly

being more facilitated than during ordinary conditions of the atmosphere, and the atmospheric current sweeping them less quickly away.

Beyond relieving therefore the drainage channels, from the accumulation of pent up and concentrated gases, this ventilation does but little: it taints the atmosphere at the street level, and scarcely improves the condition of house drains; for the largest number of the inlets to drains are above the level of the street ventilators, the temperature within the drain always as high as that of the sewer, and that of the houses frequently higher, and, as in obedience to the natural law, gases specifically the lightest rise to the highest points, so it cannot but follow frequently, that when such inlets are opened, a rush of air from the sewer towards them takes place, and a down current to the sewer follows from the nearest opening, and that such inward current is constantly in operation where the trap is imperfect, or there is none at all; thus the street and sewer is relieved at the expense of the dwelling.*

* Dr. Arnott says in his "Report upon the Croydon Epidemic," "An important difference between the old sewers with gully holes—allowing the entrance of atmospheric air to dilute the drain effluvium, and the pipe sewers—without ventilation, is, that in the latter the effluvium being unmixed or concentrated is much more noxious."

It has been stated very distinctly by witnesses before a Government Board, that in a district where this mode of ventilation has been in operation, currents of air almost uniformly set in from the sewers up through the house drains; this must have been in a quarter much neglected, and where the inlets were not trapped in any way, or the observations must have been carelessly made; for, in districts where the sanitary conditions of the premises have been fairly supervised, the currents are not so marked; in the majority, none is perceptible to the nicest observations, unless the direction is determined that way by some temporary cause, or local circulation in the sewer: doubtless the tendency of the current is more or less in that direction, but knowledge of this is arrived at, rather by consideration of the laws which govern the flow of gases, and by other indications, than by observations made in the sewers themselves.

Upon the same natural grounds, the greatest discharge from the ventilating gratings should take place in the upper portion of a system of sewers, where the variations of level in a district are considerable; this appears to be corroborated, to a certain extent, by analysis of the complaints of effluvium from the sewer-openings within the City made during the last few years, of which the largest portion were made by inhabitants more that 25 feet

above the high-water mark; allowance must be, however, made in receiving this as evidence; the dwellers in many of the upper levels of the City, from whence complaints originate, being generally of a superior class, of greater susceptibility of nuisance, and higher intelligence, and who are far more likely to make complaints upon such grounds, than the poorer denizens of other districts: indeed, the effluvium from sewers is generally worse in the poorer than in the wealthier districts; probably owing to the quantity of water, proportionably to the feculent matters which runs through them being smaller, but complaints, comparatively rarely, come to the Commission on account of them from the poorer districts.

With the view of ascertaining the precise direction of these variable currents in the sewers, I have made experiments in them; the results in the main lines have already been given. In the branch sewers, which constitute the bulk of the sewers of a district, so conflicting are the results, owing to the various influences in action which are always operating differently; indeed, of so very delicate a character are the observations, and so readily influenced by the slightest disturbing causes (they are influenced by the movements, and, I have no doubt, by the caloric evolved by the workmen accompanying any one making them), that I am

unable to lay before you any results in the form I could desire; but, as far as I can judge, all the indications strictly accord with the phenomena which might be expected from a knowledge of those natural causes, which alone can be operating.

Frequently when effluvium from the ventilators is most perceptible, the slightest current in any direction from them cannot be detected; and the stench must, in such cases, be attributable to a peculiar condition of atmosphere, of which the depression of the mercury column is one, but only one, of the indications.

Such are the conditions of, and evils attaching to, the existing system, for which no trifling modifications can be a remedy. Its fundamental want is that of suitable up-cast shafts at higher levels than any of the surrounding inlets, with such strong currents established towards them, as shall ensure at all times the conditions before enumerated, as essential to a perfect system of ventilation. It is questionable whether at any time, and least of all in summer, the natural differences of temperature between the external atmosphere and the sewer, will ensure such currents, even if these shafts were built; but the consideration of this will be taken up in another section of the Report.

VENTILATION BY THE RAIN-WATER PIPES OF HOUSES CONNECTED WITH THE SEWERS.

This mode has been frequently recommended, and, next to the existing system, has been more extensively tried than any other.

The principle upon which ventilation takes place by the Rain-Water Pipes, is the same as that in the existing mode. The detail is somewhat different, as the pipes, for the most part, enter at the sides and not the crowns of the sewers; they will, however, relieve the sewers, and owing to their superior height, and the hot-air column being greater, there is more certainty of their acting uniformly as up-cast shafts, and a slight downward current from the street openings would, it is possible, be generally maintained, if the whole of the rain-water pipes of a district were connected as a system.

Towards the end of the year 1848, and early in the year 1849, I first made some experiments by leading ventilating pipes from the crown of the sewers to the tops of adjacent houses. These pipes were of cast-iron, five inches external diameter, and they were carried up a short distance above the parapets. This was done in a poor and densely populated neighbourhood, from sewers beneath

courts which were very narrow. By that means was avoided what otherwise would have been needful, placing the ordinary ventilating gratings at the street level, almost at the very doors of the inhabitants.

Having satisfied myself that an upward current was uniformly established through them, I erected a few others in different parts of the City with similar result.

Since that period notices having been served upon many owners of property in the City, whose sinks discharged into rain-water pipes, to stop the issuing of the waste waters upon the public ways: a few have been connected directly with the sewers without traps intervening, and consequently ventilation by them has been also established.

At the time I made the preliminary experiments, I feared some of the results in my Report upon the works for the year 1849, after stating that length of time was needed before the value of the system could be fairly demonstrated, I remarked, "And although I think I may venture an opinion, that the plan would prove successful as far as the ventilation of the sewers is concerned, if a sufficient number of pipes were connected, yet other objections may arise as to which my experience is yet insufficient to determine."

Inquiry subsequently proved that those fears were not groundless, and that there are periods when the effluvium from these pipes is not only perceptible, but in some cases a nuisance to the inhabitants living in the upper floors of the houses against which they are placed; but complaints of them were much more frequent, and much louder when they were first erected than they are at present,—they indeed appear to have almost subsided.

It has been found, also, with regard to pipes so erected and used, that although great care was taken in putting together the various lengths, yet that leakage took place at some of the joints, and caused annoyance to persons living in rooms upon the different floors of houses beneath the top stories.

In September 1849, Mr. H. Austin, then consulting engineer to the Metropolitan Commission of Sewers, took up the question, and in reporting upon the trapping of gullies, after quoting the experiments made in the City, states, as one of his conclusions in relation to ventilation by rain-water pipes, "That the experience already obtained as to the draught of air through tubes carried to the tops of houses, gives indication that, under proper management, a good system of self-acting ventilation may by these means be established;" and he concludes with the recommendation, that a more ex-

tensive and efficient trial should be made of it. It was, however, never extensively tried in the metropolitan districts, the City excepted.*

In Manchester, I am informed by Mr. Francis, the Borough Surveyor, that the ventilation has been carried out by this mode for many years successfully, no complaints having been made of the issue of effluvium from the pipes; but it must be remarked that it is not the rule at Manchester to connect the water-closets with the sewers, as in London; in some instances they are so, but they must be considered as exceptional; and when to this is added that exceedingly large quantities of nearly pure water are sent through the sewers from the dif-

* Although in an efficient system of drainage the generation of noxious gases from foul deposit will be avoided, it will still be desirable to adopt measures for the effectual trapping of the house drains, to prevent the annoyance of any smell from the refuse entering the houses.

If every opening into the drains were trapped, however, the pent up atmosphere would soon become most offensive; and as the greater warmth in the house creates the tendency to a draught from the drains, the foul air would be drawn in, unless some free communication be made for its discharge. We would recommend, therefore, that the rain-water pipes, which would form a series of ventilating shafts to the sewers and drains, without expense, should, in all cases, where no inconvenience would arise from it, be left with a free discharge into the drains. —*Report upon House Drainage presented to the Metropolitan Commission of Sewers in* 1849.

ferent manufactories, it will be seen that a very copious dilution of all decomposing matter takes place; the emanations must, therefore, be at all times less offensive in their character than in such a Metropolis as London. This the Borough Surveyor himself considers to be the case.

It is probable that this also may be the condition of the sullage of many towns recently sewered, of which the ventilation has been effected by this mode; indeed, it is known recently that in many of them the entire excreta of the population was not yet carried off by the sewers; the emanations from them therefore, are not likely to be of the aggravated character of those in the metropolis; but whether it be so or not, it is quite possible that this mode of ventilation might with care be applied in many country towns without perceptible nuisance accruing; whilst owing to the density, size, the structural and other conditions of the metropolis, it might be quite unfitted for adoption here.

It has been stated that in Edinburgh this system has for a long time been in operation to a considerable extent; this however is an error, it has been applied in a limited degree; but no complaints, it is said, are made of any nuisance resulting from it.

At Carlisle, a few pipes have been used for the

purpose, and the same has been done at Alnwick; Preston has also been similarly treated, as well as some other towns sewered entirely with pipes; it has been stated to be successful there; and is now being tried with caution in other places.

Such is the extent of evidence in favor of using the rain-water pipes of houses for ventilation; but results are different in other places. Thus, the village of Tottenham has been sewered under the direction of Mr. Pilbrow, with acknowledged skill; it has in fact, been considered one of the most successful instances of pipe-sewerage; stoppages have scarcely occurred; all refuse flows quickly from the point of dejection to the outfall of the system, with a considerable velocity; and, consequently those conditions have been closely obtained which the engineer desired, and the chemist would say, were favourable to the prevention of decomposition. And yet, I am informed by him, that their ventilation has been a matter of much difficulty, and that where he has used the rain-water pipes for the purpose, effluvium from them has produced a nuisance to those against whose houses they were placed; and not only has this been the case at Tottenham, but at several towns, to which he has been the engineer.

Nor is other evidence wanting to show that

nuisance has been caused by such an adaptation of the pipes, whether erected for carrying down the pluvial waters which fall upon the roofs, or specially erected for the purpose. Thus, opinions widely differ upon results; or, what is more probable, the information has been gathered with great variation in respect of care and attention; for it is impossible that the conditions determining the currents of air and the emission of effluvium can vary so extraordinarily in different towns, or that in one town, newly-sewered under most favorable circumstances, the pipes should prove a nuisance, whilst in others, as nearly as possible similar in conditions, they should not do so.

With these conflicting accounts, the difficulty of deciding is increased, and the result of my own experience determines my opinion, and not the rival statements that have reached me: I have no doubt the sewers may be kept in a safe condition, and that the emanations from all openings in the streets be so reduced as to be scarcely perceptible, excepting upon unusual occasions, by using the rain-water pipes of a district generally as ventilators; but this does not satisfy the idea of efficient ventilation, as it is upon those exceptional occasions that outcry against the existing mode is principally raised; moreover, if the system could be made permanently a preventive against the emission of effluvium at the

street level, it would simply be transferring the nuisance to a higher level; it would also, doubtless, improve the ventilation of the house-drains, but would not entirely effect it, and, therefore, failing in the prevention of the issue of effluvium at the most offensive periods, and in stopping upward currents from drains, and emitting the vapours in their original impurity, but at a different level only, it can be regarded but as a palliative of the present evil, and not as a radical cure.

VENTILATION BY PIPES OR TUBES ERECTED FOR THE SPECIAL PURPOSE, AND CARRIED UP THE FRONTS OF HOUSES TO THE TOPS OF THE STACKS OF CHIMNEYS.

This system differs but little from the previous one. In that case the pipes would be erected at the expense of the inhabitants individually; in this at the direct expense of the Commission. In the former, the point of efflux would be the head of the rain-water pipe beneath the parapet; in the latter it would be at the tops of the chimney shafts.

When I found that the effluvium from the pipes raised but slightly above the parapets, entered the dormers and descended into the windows of the

upper floors, I tried the experiment of carrying them to the tops of the chimney shafts. As respects the ventilation of the sewers, the effect was of course nearly the same; and it was found that in some cases nuisance was not experienced, whilst in others it was still created, although in a minor degree. Instances have even been known where, owing to currents created by differences of temperature in adjoining flues, the effluvium had descended them into apartments.

Conclusions with respect to the value of this system must, therefore, be nearly the same as upon that of the ventilation by rain-water pipes; the points of efflux being higher, the ventilating power would be slightly increased, and the probability of nuisance in every respect also lessened; but under many conditions of the atmosphere the stench might be expected to descend, to enter dormer windows, and even be carried down the flues into apartments; and a system is not complete or efficient, the adoption of which, other objections being waived, would simply transfer the nuisance from one inhabited stratum of air to the other.

In Paris at the present time, where official power is great, where local or individual objections are little heeded, and appear indeed, to have but little opportunity of making themselves heard, and are

rarely permitted to stand in the way of any general system which it has been decided to carry out, the Engineers of the Municipal Service inform me that they have received such opposition to their carrying ventilating pipes up the front of houses, that the system is not being prosecuted, although it is not said to have been abandoned.

Were this system adopted in London these objections probably would be found to be of frequent occurrence. A further objection is that these tubes must be very considerable in number; that their erection against buildings would be unsightly and inconvenient, and would be considered a great nuisance by those against whose premises they were placed; that they would be in situations where they might be readily tampered with; that they would require periodical inspection and painting; that this could only be done in most instances by going on to the roofs of premises to the annoyance of the inmates, and to the certainty of demand being made for injury done to roofs, and constant complaints of leakage from the joints, and of other annoyances.

VENTILATION BY LARGE SHAFTS OR CHIMNEYS ERECTED IN SUITABLE PLACES AND CARRIED TO A SUPERIOR ALTITUDE TO THE SURROUNDING BUILDINGS.

The principle that would operate in this system is the same as in the previous one, the points to determine before its efficiency could be pronounced upon, are whether a constant current of sufficient velocity can be produced through the drainage channels towards them; and if this was satisfactorily proved, whether the effluvium when emitted would descend to the prejudice of the neighbourhood.

If the difference of temperature between the normal atmosphere, and that of the sewers would originate a sufficient strength of current from a certain range of drainage channels, shafts of adequate capacity might be erected in suitable spots, varying from 100 to 200 feet in height, by which the whole might be discharged.

The Tables of Temperature, given in the Appendix (*see Appendix C*), include observations made in sixty-five sewers in different parts of the City during all seasons of the year; there are sewers where the temperature in portions of their length was found to be considerably higher, as well as others where it is slightly lower than any shown by

them ; but such extremes are accounted for by local circumstances, and, as they are quite exceptional cases, have been eliminated from the Tables, which may be taken to represent a fair average of the temperatures of the sewers in the metropolis, and of most large towns in England where they are ventilated and kept clean.

Now, the velocity of the ascending column in a shaft is (*cæteris paribus*) directly as the relative difference between it and the opposing column of air ; and as this velocity is in fact, the measure of the ventilating power, it follows that the greater the difference there is between the external and internal temperatures, the more chance there would be of the shafts fulfilling, satisfactorily, the object of their erection.

It is generally conceded that during the warmer periods of the year, the emanations from the sewers are most injurious ; it is firstly therefore, of importance to ascertain, whether in the summer months these shafts might be expected to ventilate sufficiently, and carry off all effluvium to the higher stratum of atmosphere.

Inspection of the Tables will show that between 9 A.M. and 6 P.M. of some days of the summer months, when the external temperature (at the

periods of reading) ranged from 55° to 72°, the mean being 65° (I reject fractional differences), that the mean temperature of the sewer was 62° or 3° below that of the open air; during such periods of the day, therefore, these shafts would be almost inoperative; it is to this excess of the external over the internal temperature that one of the causes of the issue of effluvium in the summer months is found.

The mean monthly temperature of June, July, and August, registered by Mr. Glaisher, at the Royal Observatory, Greenwich, for a period of fourteen years was about 61°; the mean temperature of the sewers during those months may be taken to be about the same; thus, during three of the most important months of the year, when the nuisance from the sewers is the greatest, these shafts would be useless.

Between this average of the reading through the three hot months, and their minimum temperatures, there is a considerable difference, whilst the temperature of the sewers throughout the twenty-four hours varies but slightly; the average difference at night, between the minimum open-air temperature and that of the sewers may, perhaps, be from 12° to 15°; but, it is in relation to the average of a season that the question must be fairly

considered, and not to any particular period of the day, for it would be only partially useful to have a system operative when the world was asleep, and inoperative during the busy periods of its existence.

In winter, ventilation by them would be more uniformly effectual. During those months, Mr. Glaisher shows, in his report upon the meteorology of London, that the mean temperature is about 39°, whilst my observations show that of the sewers to be about 44°; thus even during this period of the year the mean difference of temperature is too slight to afford much hope of efficient action resulting, excepting in the immediate vicinity of the shafts.

The mean yearly temperature of the air at Greenwich, according to Mr. Glaisher, may be taken at 49·4°, that of the sewers may be taken at 55·35°; a difference of 6° may, therefore, be said to exist thoughout the whole year. This is the average ventilating power at command; and taking into account loss of heat, leakage, friction, and the other retardative influences, it may be at once pronounced too slight to create a velocity of efflux sufficient for large practical gain.

Thus the popular impression, that a few high

chimneys erected in a large district would effectually relieve the sewers, proves upon examination to be erroneous, for shafts of considerable sectional area, having altitudes from 100 to 150 feet, would exercise but slight exhaustive powers at any time upon the channels immediately adjacent, whilst the range of their action, (although data are wanting to determine it accurately), could be but very limited, and their influence would be greatest during the season when least required, and at the minimum, if not entirely inoperative, when it was most needed.

It might perhaps be effectual at some periods of the year if a very large number of these shafts, all of considerable height, were erected; and, although without experiment it cannot be said what that number must be, they would certainly be numerous enough to liken London, in that respect, to many of our northern manufacturing towns, and to increase the expense of the system materially; for they would not only be expensive to build, but would require space to erect them upon; and within the metropolis, especially within the City, spots of public ground at suitable places could not be found, and sites would have to be purchased at a costly outlay.

As respects the effect upon the adjacent atmos-

phere, if carried to the altitude of 150 or 200 feet, it is most probable that no nuisance would be experienced from them, during any condition of the air, but upon this I do not venture to pronounce a very decided opinion, for it is well known that chimneys carrying off the smoke, and vapours from different manufactories, even when built to equal and greater altitudes, cause nuisance at times in their vicinity, and spread their effiuvia over considerable areas ; but the ordinary smell from a clean and fairly ventilated sewer, is not of that excessively pungent nature, which characterise the discharge from many factory chimneys, and it may I think, be confidently assumed, that dilution would take place to a sufficient extent to neutralise, and disinfect them at all times.

VENTILATION BY THE LAMP COLUMNS, AIDED BY JETS OF GAS BURNING NIGHT AND DAY.

This system would establish the gas columns as permanent up-cast shafts. It differs from the four preceding systems essentially, as it proposes to aid the natural ventilation by artificial heat ; this is, in fact a step on the road to furnace ventilation.

It would require the lamp columns to be entirely altered, or rather lamp columns would have to be

designed, and made in reference to this additional purpose, and upon a plan entirely different to that in use.

That the sewers might be ventilated by the gas columns so aided, there can be no doubt, but I do not think that, by such a multitude of ventilators at low levels, currents sufficiently strong would be established to create a down-draught through the drains.

Those who have made this suggestion can have thought but little about the cost, which would be found, however, to be a serious matter; the number of gas-burners which would be required it is not easy to say, but probably not far from the present number which illumine the streets at nights would be needed; now the cost of lighting these from sunrise to sunset throughout the year within the City of London is £11,754 per annum, and that sum would be doubled for keeping them burning night and day, even if only half the number would suffice, the enormous annual expense for the whole metropolis may be conjectured.

But if expense were no object, and if the object would be answered by the adoption of the system, it would be impossible to employ heat in a more expensive form, and equally impossible to apply it

as a ventilating power more unscientifically, for nearly the whole of it would be lost in the surrounding atmosphere, without aiding the sewers but in a slight degree.

The vitiated air from the sewers would it is possible, be in a degree deprived of its offensiveness by the action of the flame; but I do not think materially so; consequently its issue would take place at a level equally injurious to the public health.

There are other points to which objections might be made, but I think I need add nothing to them to show that the idea is purely chimerical, and, probably, scarcely worth having troubled you with: to use the words of Monsieur Versluys, Inspecteur de la voirie Communale de Bruxelles, in allusion to it—"il suffit d'enoncer un tel procédé pour en faire justice."

VENTILATION BY FURNACES AND CHIMNEY SHAFTS SPECIALLY ERECTED AT SUITABLE POINTS.

I now enter upon the consideration of the possibility of applying to sewers the mode of ventilation by which that of most mines is effected; and it

is here very essential that the difference of the arrangements of the channels and air courses of the two subterranean systems, as I have before explained them, should be distinctly held in recollection, as it is only by clearly understanding this dissimilitude, that the difficulty of applying furnace ventilation to sewers can be apprehended.

This mode of ventilation is proposed, upon the assumption that the differences of temperature of the normal atmosphere, and that of the sewers are not enough to establish a sufficiently strong exhausting power; and that to insure it at all times, artificial heat must be applied: this is to be obtained by erecting furnaces, which are to be kept burning night and day at the bases of large chimneys, causing a powerful air current at all times towards them.

About the year 1833-4, there appears to have been much agitation, stimulated by a recent epidemic upon the subject, of effluvium from sewers: trapping the gullies and ventilating by the present system was, as it has been already shown, at that time introduced; and at the same period, the propriety of ventilating sewers by furnaces was much advocated. In 1834 a select committee of the House of Commons sat upon the Metropolis Sewers, before which opinions were given by several wit-

nesses strongly in favor of this mode of ventilation ; but, with the exception of Mr. Faraday, none of them appeared to estimate sufficiently the difficulties to be overcome. He says in his evidence :—*

"I think the principle is good, but whether under the new circumstances one could decide beforehand whether it could be successfully applied, I cannot say. I have my doubts whether it would ultimately be successful at an expense which could be borne ; but the data required to be considered are so numerous that it is impossible to get at the result without an experiment. I should say the object is so great, and the plan so correct in principle, that if it could be tried on a small scale in the sewers, it ought to be tried."

The Committee, after weighing the evidence given, reported as follows, upon the subject of furnace ventilation:—

"A variety of suggestions have been made to your Committee, with regard to other defects in the present system, as bearing upon the health of the

* Mr. Faraday's evidence is so clear and forcible, and so fully does he appear to enter into the difficulties of the question in relation to furnace ventilation, that its entire perusal will be useful ; I have, therefore, placed it in the Appendix (*See D*).

metropolis; and it has been proposed by medical men of considable eminence, to purify the air in the main sewers, by building furnaces at intervals along their course, and by closing some of the gully-holes, and providing others with traps. Upon these projects your Committee cannot venture to pronounce an opinion, as none of them have yet been confirmed by successful experiments; nor can they be submitted to the test without a considerable expense. The House will perceive by the evidence of Mr. Faraday, the opinion which that gentleman entertains of their practicability, which is not at present sufficiently strong to warrant any very sanguine expectations as to the results. The minor improvement of traps for diminishing the emission of foul air from the gully-holes, has already attracted the attention of the Commissioners in several of the trusts, and appears to have been applied with success."

Since that date experience in all matters relating to sewers has increased, and the difficulties besetting their ventilating are better understood. In 1846, upon application being again made to him by the then existing Commissioners of Sewers for the Surrey and Kent districts of the Metropolis, Mr. Faraday gave what appears to be nearly the same opinion as in 1834; for, after informing the Commission that the state of his health prevented his

considering the subject closely, he says—"I have often thought that the many furnace and engine flues that rise up so abundantly in many parts of London, might be made to compensate in part for the nuisance which their smoke occasions, by being turned to account in ventilating the sewers, and burning the putrid vapors generated in them."

This opinion was partially concurred in by other witnesses, but experiments were not undertaken with the view of obtaining data which are still absolutely requisite before any extensive system of furnace ventilation could be designed.

In 1847, the Metropolitan Sanitary Commission took up the subject. They thought ventilating by furnaces was practicable, but nevertheless objected to it, because, in their opinion with the then existing condition of the sewers, the chimneys would only diffuse the gaseous products over a wider district; and the General Board of Health in 1850, say—"The expedient of erecting chimney shafts with furnaces to draw out the foul gases, has been tried for example at Paris and Antwerp. Sewers have been partially ventilated by these means; but some of these gases being heavier than atmospheric air, have again descended, and spread offensive odours over wide districts."

The exact nature of the experiments said to have been made at Paris and Antwerp, I have not been able to ascertain, and no details have been given in the Report of the Board of Health, by which conclusion can be formed as to the probability there was of success, or the cause of failure; but I know from personal observations made at both of those cities, as well as by concurrent testimony, that the house-drains entering sewers are very few in number; and the inlets being thus much under control, one of the chief difficulties in the way of applying furnace ventilation is lessened materially, as well as the expense; and if well-made experiments have failed there, but little hope remains of the system being successful in the metropolis.

I believe, however, that by error, the experiments in ventilating short lengths of sewers opened for special purposes, to permit of men entering, and cleansing them, after their action had been long entirely stopped by accumulations, have been mistaken for experiments in ventilating sewers in a clean ordinary condition, with the view to the establishment of a permanent system; for I never could discover, either from records, or by personal inquiry made in Paris, that the latter class had been undertaken; and certainly engineers who have been long in charge of the sewers of Paris, are not cognisant of them.

In September 1848, an attempt was made to draw off by fires the dangerous gases which had accumulated in a sewer in Friar Street, Southwark. Mr. Austin, who superintended this experiment, expressed a conviction that, if adopted as a system, the results would be far from satisfactory. He says: "Whatever power of draught may be applied, I am induced to believe the air would, for the most part, follow only with the greater rapidity from the nearest openings and readiest channels of supply, without producing any sensible effect on the atmosphere at any distance from the spot, or out of the direct course." Mr. Austin evidently, therefore, recognised one great difficulty besetting ventilation by furnaces.

Mr. Bazalgette informs me also, that two years since he made some experiments in ventilating by furnaces, and the results led him to believe that the system could not generally be applied to the sewers of London.

Experiments have been tried to some extent at Carlisle; that city has been drained by a system of pipe sewers, the ventilation of which appears to be principally effected by a few shafts carried up about 19 feet in height, and by connecting the rain-water pipes, or, as they are termed in the north of England "the down spouts," with them

in the ordinary manner. In addition to this, the sewers have been connected with four chimneys, two of which are 60 feet, one 150 feet, and one 300 feet in height, which appear to have been used rather as auxiliary to the general ventilation than for the purpose of obtaining data for the future extension of this mode; these shafts however, present the opportunity of trying the practicability of the system. Up to the present time the borough engineer has not had time to make observations of much extent, but the result of those he has made only go to prove the great difficulty that will be met with, and the great ventilating force that will be needed to ensure the required conditions of a perfect system.

Indeed, as far as can be gathered from the few accounts of the trials of ventilation by furnaces, it must be pronounced a failure; but in no case do the experiments, of which I have cognisance, appear to have been carried on for a sufficient length of time, nor are the results detailed with that minuteness and delicacy essential to give them substantial value.

Conclusions as to its practicability must therefore be drawn from general experience in sewerage details and cognate investigations, and not from the imperfect information I possess of the results of the experiments.

It has been seen that along the whole line of sewers are multitudes of inlets of different sizes, and at different levels, and it is these that constitute the main obstacle; were the sewers without connection with the house drains, there would be less difficulty to be overcome, for by trapping all gullies, and closing partially the ventilating shafts, and stopping off the air by various means in the sewers, they might be so assimilated, (although in a degree only), to the channels of a mine, that no doubt need be entertained that, if mere draught will effect it, a perfect ventilation might be accomplished at a reasonable expense. But the case is entirely different: a line of sewer may be compared to a tube perforated along its entire length; a furnace may be established at one end, or any suitable spot, and from the inlets nearest to it strong currents would be established, far stronger than would be essential for the purpose at those spots, but which it would not be possible to regulate materially; the draught through the nearest orifices would therefore be intense, and the furnace would be fed, and the up-cast shaft filled with air from them, whilst, as the distance from the furnace became greater, the current would become more and more feeble, until its influence ceased entirely to be felt.

The error that has been fallen into by those who have likened a system of sewers to a coal mine, is

therefore apparent; for they have proceeded upon the assumption that it was only necessary to start with a given velocity at any point upon the length, and that a sufficient current would be ensured throughout: whereas the true difficulty is in preventing undue velocity of intake at points where it is not wanted, to the destruction of the velocity at the points required.

But another difficulty, and one of magnitude, would be called into existence by this very mode of ventilation. The sewers of a district, whether they be formed large enough for men to enter like most of those in the metropolis, or upon the tubular system, as in some of our provincial towns, are regulated in their minimum size by certain practical necessities; and it will be found that the aggregate sectional area of the collaterals is far larger than that of the main line with which they connect; unless, therefore, every sewer had a shaft at its head, the united volumes of air will always at some point have to travel through a single channel; their effectual ventilation therefore would involve a gradual increasing velocity, from the terminating points of the system to the up-cast. Now, the initial velocity of the air at the sewer-heads or summits that would be required, it may safely be assumed, would not be less than the mean velocity of the air-currents of mines; and the draught, as it

approached the point of rarefaction, by the accumulation of air from many channels must, therefore, be very considerable, so great indeed, that I believe no human constitution could long withstand the effects of the draught, added to the other prejudicial agencies; and, moreover, no light could be kept burning by which men could work in those sewers which they might have to enter.

The fewer the shafts, and the greater the power raised at them, the greater would be these difficulties experienced; and, irrespective of other considerations, and as a question of economy only, a large number of shafts, would most probably even with the additional cost of building and constant attention, subsequently be cheaper than a small number with a higher ventilating power maintained at them; whilst, for the other reason, the greater number would become a positive necessity.

Of the practicability of maintaining a down-draught from all inlets, there can be no question, if a sufficient number of shafts, suitable in capacity and situation, and adequate furnace-power be provided, and expenditure be a matter quite of secondary consideration; but I am unable to give any estimate of the cost of this system, nor can any one, without having the result of experiment made with the greatest care, and carried on for a consi-

siderable period. I can but state my conviction that the only certain and uniformly efficient system of ventilation is to be found by this means, and that it can only be maintained at a very large permanent cost.

In this section of the subject the question again arises, as to whether the fears of the Board of Health of the descent or spread of the offensive odours will be realised, and whether it will be needful or possible to destroy them by the action of fire or by chemical means.

Upon the effects from the effluvium discharged at a higher level, opinion has already been expressed in a previous page; and it is only needful to observe here as to "their diffusion over a wider district," that the odours already arise under our noses, and must be ultimately spread over a district quite as wide as if they issued from the tallest chimney, but with infinitely greater chance of doing injury before their complete diffusion; but with sewers kept clean, with chimneys of considerable altitude, no fear need be entertained of injurious effects arising from the discharge from them.

VENTILATION BY THE SHAFTS AND FURNACES OF STEAM ENGINES AND FACTORIES.

This has been a frequent suggestion, and like that of ventilating by the Rain-water Pipes, seems to have found much favor, under the impression that it can be accomplished with but little cost to the public; and it would doubtless be a most satisfactory thing if the onus of ventilating the sewers of the metropolis could be thrown upon private furnaces, without causing expense or injustice by such an imposition; this will, after investigation, be no longer anticipated.

Its principle of operation would be the same identically as that by special furnaces, but whilst the mechanical difficulties attending it will be the same, the impediments to it will be augmented by serious obstacles in the way of establishing the system, and working it subsequently.

A fundamental necessity for a complete system of furnace ventilation, whatever may be the character of the furnaces employed, is such an arrangement of them, either in point of situation and number, or of power, as shall ensure the required draught at all times: it therefore must be in operation without ceasing; the capability, therefore, should exist of

increasing or diminishing the power, according to the exigencies of the varying temperatures, and other circumstances.

Three conditions are also essential to the working of a ventilating system, dependent upon private furnaces. Firstly,—that power should be given to the Commission to use them for the purpose compulsorily, or that they should be able to obtain the consent of their owners to their doing so. Secondly, —that there should be a sufficiency of shafts at suitable places and of suitable height. Thirdly,— that they should be during the periods of the extinction of the fires, capable of effecting the ventilation, or be placed during those periods under the direction of the Commission, at whose expense the fires should be kept burning.

As to the first condition. It does not appear probable that compulsory powers to apply furnaces to this purpose can be obtained, nor that any public Local Board, constituted as they mostly are in this country, would venture to apply for such power: the idea broached by Mr. Faraday of such exacted usage, being a just compensation due from the furnaces for the nuisance occasioned by their smoke was questionable in principle even at the time it was made; for the country doubtless, already reaps ample compensation from its manufactories; but

whatever justice there might have been in the suggestion once, it does not exist now, the smoke being in all cases consumed (or should be); thus the idea of the shafts of furnaces being made compulsorily available for the ventilation of sewers may be at once dismissed, and if so used, they could only be by the acquiescence of the owners, a thing not likely to be obtained readily, or if so, under various conditions, one of which would undoubtedly be the power of withdrawal of the permission at very brief notice, so that the ventilation of a district made dependent upon a private furnace, might at any time be suspended by the caprice of its owner.

But the difficulty of obtaining permission at all would, I fear, prove insuperable. In 1851, the usage of a large shaft at Liverpool was projected by Mr. Newlands, engineer to that borough, but permission was never obtained;* and at Edinburgh after the permission for the usage of one had been given, it was withdrawn before the connection with the sewer was made. Thus, at two principal towns, where all the usual legitimate influences were employed to obtain even an experimental usage of a private furnace, they failed in doing so.

* Whilst this was in press, Mr. Newlands informed me that permission had been obtained, but the furnace in question had not been used, and that another had been used experimentally.

Before the experiment was made with the portable or temporary furnaces in Friar Street, Southwark, (page 96), application was obtained to connect the sewer with the furnace of a manufactory in that street, and the connection was actually made; but a trifling explosion took place at the outset of the experiment, and permission for its continuance was at once withdrawn.

After inquiry at some of the largest towns in the kingdom I can only find the instances of Carlisle and Liverpool, in which private chimneys have been permitted to be used for the purpose; and as the subject has now been frequently brought before the public, and no accounts have been published of the practical application of the suggestion, it may be fairly assumed either that unsuccessful attempts have been made to obtain the requisite permission, or that the results when obtained have not been satisfactory enough to pursue the system with energy.

From this, as well as other considerations, the probability of getting more than isolated cases of permission, so to apply private furnaces seems slight, and all idea of depending upon them as a system must be abandoned.

If this difficulty could be satisfactorily adjusted,

there are others in the way; the shafts within London are generally of very limited height, and unless the air could be freed of its impurity before being discharged by them, the vapours would be disseminated, and in many cases might cause annoyance to the surrounding neighbourhood as at present.

But assuming that a sufficient number existed to ventilate the sewers by their heat during the time they were in action, and the shafts were all of sufficient height to discharge without any injury to the district, they should also be equal to doing so on Sundays, holidays, and during nights.

Now if the furnaces were capable of ventilating for six days in the week, they might not do so effectually at other periods, and arrangements would have to be made by which the furnaces should be kept in fire continually; for it would be absurd to ventilate the sewer for six days in the week and not upon the seventh.

If the shafts, aided by the residual heat of the furnaces, were sufficient for this purpose, it follows that when the furnaces were in fire, that there would be a large surplus of ventilating power: to this the objection would exist that workmen could not enter the sewers; but if private furnaces were to be depended upon, the first essential would be, that by

some means the power should always be maintained at its proper force, and it is not easy to suggest a satisfactory or probable arrangement by which the fires could be insured in private establishments at times when not required by their owners.

Those who have made the suggestion have apparently not thought upon another, but most important point connected with it,—the capacity of the shafts for the purpose. If the supply of air to the furnaces themselves could be made from the sewer, the question of the capacity of the shafts need not be entered upon, but the difficulty in making such arrangements would be greater than is generally supposed, and if inlets only were to be opened into the chimneys, then it is a question whether any of the shafts are built larger than is needful for their special purpose, in which case a reduction in the draught would result, prejudicial to the actions of the furnace, and not likely to be permitted by its owner.

Thus, upon consideration, many difficulties are in the way. If permission were given, or power obtained to connect the sewers either with the furnaces or shafts: it is probable that in some districts enough of them exists to enable an effective system to be carried out, but in the largest portion of London either their number would be too few, or they

would not be so locally disposed as to enable it to be done; but whether or not completed as a system, if all large chimneys were so connected under proper regulation they would be a most useful auxiliary to the present or any system of ventilation of sewers in operation, but there is no probability of such an usage of private property being made compulsory, and but little that the owners would consent to it: and no private arrangements could be expected to be made which shall enable the ventilation to work uniformly and permanently as a complete system.

MECHANICAL VENTILATION.

The application of mechanical means to ventilating sewers has apparently been but little thought of.

Plenum Ventilation, which can only be effected by mechanical agents, is totally inadmissible to sewers: channels so ventilated, being in fact under pressure; consequently in sewers the effect would be to discharge the effluvium by every one of the inlets more copiously than at the present time.

Vacuum Ventilation, whatever may be the mechanical agent employed is in effect the same as in ventilation by furnace, the one exhausting by simple suction (like the sucker of a pump). and causing a

draught of air towards a given point; the other causing the draught by diminishing the specific gravity of the air near the up-cast shaft by rarefaction; thus a ventilating current may be produced by either means, and it simply resolves itself into a question of which is the best and cheapest; the principal mechanical ventilators that have been employed in mines are Brunton's Fan and Struve's Pump, but there have been several others; the different views which exist upon the comparative values of furnace and mechanical ventilation have been before alluded to, and it is unnecessary to do so further here: it would be a matter to be considered at a future day, and it in no way affects the main question of the possibility of effectually ventilating sewers.

VENTILATION BY THE STEAM JET.

The Steam Jet was first proposed as a ventilating power for mines by Mr. Goldsworthy Gurney in 1835. It was first adopted at the Seaton Delaval Colliery in 1849, and has since been tried experimentally at other collieries. It consists simply in letting off steam at high pressure, through orifices properly adjusted in size and situation, into the channel or up-cast shaft of the channel to be venti-

lated. The steam is, in fact, blown off into it much in the same manner as the driver of a locomotive frequently lets off his spare steam through the engine chimney, the result being a powerful draught. In its application to mines or sewers, this draught probably would be a compound result of rarefaction, vacuum, and propulsive force, Mr. Gurney being of opinion that its power is almost entirely due to the latter.

Mr. Gurney, in 1849, wrote to the Metropolitan Commissioners of Sewers, stating his belief that by the jet, the effluvia arising from every sewer in London might be by such means drawn out to given points, decomposed, and rendered perfectly inoffensive.

An experiment was accordingly made upon a sewer in Friar Street, Southwark. This sewer was 1,500 feet long, had a sectional area of 13 square feet, and was in a fearful condition of insalubrity, owing both to improper construction and great neglect. On the 22nd October, 1849, Mr. Gurney reported it as successfully ventilated, and that a current was established throughout it sufficiently strong to extinguish a light.

This experiment however proved very little, for that a sewer or air-course could be ventilated by

the jet, had been known long previously. What was required to be ascertained, was the amount of air that could be exhausted by a given consumption of fuel, and the actual length of sewer having upon its line the average number of drains, gullies, and other openings, which that expenditure could ventilate; but this the experiment as far as can be judged from the official reports, entirely failed to demonstrate; and the results although satisfactory as regards ventilating the sewer for the special purpose for which it was intended, were barren in respect of information as to its applicability as a system.

In 1855, Mr. Gurney was permitted to make another experiment in ventilating the sewers in the vicinity of the Houses of Parliament. The Clock Tower was fitted up as an up-cast shaft for that purpose. This is reported by him to have been highly satisfactory, a considerable length of sewer being acted upon, and strong intakes being detected down the gullies; but, as in the other Report, no details sufficiently to estimate the power required for ventilating the sewers of a whole district appear to have been obtained; or, at all events none are given.

One thing was, however, plainly shown, that, along the line of sewer, a large amount of air leaked in; and it afforded, therefore, a good illustration of

the greatest difficulty in the way of any system of ventilation, by which the air is to be dragged some distance before it is discharged.

The difficulties which will beset the application of the steam jet are precisely those of furnace, or any artifical ventilation, and no more. As a sufficiency of furnace-power might exhaust the sewers completely, so, no doubt, might a sufficiency of steam jets; the only question, therefore, to resolve would be, which is the cheapest. Upon this, as upon many other professional topics, engineers who have witnessed its effects in mines differ; but a majority are decidedly of opinion, that the simple furnace is superior. If the furnace ventilation should ever be applied as a system to sewers, the steam jet should also have a fair trial given to it; but it is needless here to say more, than that with a sufficiency of jets, and a sufficient expenditure, there is no doubt that ventilation could be effected by its agency.

It is stated in the Report of the Superintending Engineer Mr. Grant, that the experiment in Friar Street, proved the practicability of depriving those gases of their noxious smell and character as rapidly as they were drawn out, by passing the jet through a coke fire.

Mr. Gurney records this as having been likewise

accomplished at the experiment near the Houses of Parliament, and states that simply passing sewer-air through the fire, would not decompose the effluvia, as was generally supposed. If this be a special merit attaching to the combination of the furnace and steam jet, it would of course give it a claim over simple furnace ventilation; but there does not appear to me to be conclusive evidence upon this point, and, in its absence, my impression is, that simple ventilation by furnace would be found the best and cheapest.

CONCLUSION.

I have now laid before the Commission a brief statement of the various modes which have been suggested, for destroying the emanations from the sewers, and an account of those modes of ventilating which have been advocated or tried. Upon each section of the Report much more might be added in the way of description and argument, and still more in technical detail and proof; if, however sufficient explanation is given for the full comprehension of the subject, the purpose of the Report has been answered, and the more scientific and professional mode of reasoning, is perhaps, better avoided here.

A review of the various points touched upon, and

the conclusions separately arrived at with regard to to them, it must be confessed, is not very encouraging; indeed, the Report seems to be but a recital of difficulties, which combat every suggested improvement, all seemingly insignificant, if not actually contemptible at first sight; but upon investigation found to be, from their peculiarity, formidable, if not practically invincible, and from which the only deduction must be, that there is but little hope of obtaining a thoroughly good uniform system of sewer ventilation at all, and, certainly not without great difficulty, and a large cost.

It has been assumed by me throughout, that it is absolutely essential to a town existence, that all sewer emanations should be either destroyed or withdrawn from the stratum of air usually respired by the inhabitants. The conditions of this complete system of ventilation are given at page 56. My considerations and conclusions are all based upon this dogma, and the unceasing uniform extraction of air from a vast system of subterranean channels, which alone will satisfy the strict necessities of that dogma, can only be accomplished by furnace ventilation, specially formed, adapted, and controlled by those charged with the care of the sewers.

Of the expense and extent of this system if applied, no one can give more than a mere approxi-

mation, for the information as to the ventilation of mines will assist but little; and as to the effects of the leakage (which will be one of the main difficulties), nothing but experiment of some magnitude can determine.

If any system less perfect than this can be admitted, if it may be made a matter of degree, then it only remains to decide to what extent, from the standard of perfect ventilation, retrogression may be allowed.

If the exigencies of public health will permit, if we may be content with transferring the stink from the street to the house tops, the furnace ventilation may be abandoned; for the uniform connection of the rain-water pipes of a district, and the erection of others where necessary, owing to structural arrangements in the sewers, and a few other auxiliary measures, will sufficiently ventilate them, and most of the street air-gratings may be closed, or partially so, and during ordinary atmospheric conditions, the streets may be left almost without nuisance from this source: it is for others to decide whether this so called necessity, may be thus compromised, and which of this choice of evils is the least.

But if there is no doubt as to the injury resulting from the present system, if the proof is so ample of

the danger of respiring air into which those emanations have been diffused; even to the extent that trace of them cannot be discovered by the sense of smell; if the demand for complete removal is imperative, and if it can be proved that draught will do this, then by furnace ventilation alone can it be obtained.

Experiments to determine the expense and the best mode of arranging for the 150 square miles of London through which the sewers (channels of good, but not unmixed with evil) now run, must then be undertaken, and data for estimate of cost and laying out the system be obtained before the work may be commenced.

Probably an outlay of between one and two thousand pounds, and a year's time, would be required to gather results of practical value; rougher and more general results may be arrived at, by simpler or cheaper experiments, but perfect data are wanted; and, unless the experiment be undertaken with the full intention of obtaining them, even should the cost be more than the sum named, the enterprise might as well be abandoned.

The question then arises—at whose responsibility, and at whose charge, should these data be ascertained. It may be considered by some that it

should be by the Metropolitan Board of Works; inasmuch as the subject is one of metropolitan and not purely local interest; and it is perfectly true that any experience gained, will be for the advantage of the whole of London, and, indeed, for the whole of the country; the main sewers lying in the valley lines which are under the control of the Metropolitan Board are not however those, upon which the experiment can be tried; it will require an area having a proportion of small and large sewers and house-drains, with an average variation of level; this can only be found by taking some entire area closely sewered and built over, and isolating it for the purpose in view, but there would be no difficulty in placing such an area temporarily at the disposal of the Metropolitan Board, if they were willing to take the work in hand.

Should this Commission decide to undertake the experiments, or try the system, to take the lead as they have done upon many other occasions, a district may be found within their jurisdiction very suitable for the purpose, and they may have the satisfaction of having taken the first steps towards an improved system of ventilation, as they did formerly in establishing the existing one.

If a perfectly efficient system of ventilation is to be abandoned, and we are to content ourselves with

measures less expensive and less certain, then various means may be adopted for the purpose, of which the principal are, trapping the whole of the outlets, so as to exclude violent currents by the action of the winds, carrying up ventilating pipes from the heads of all sewers to the tops of adjacent chimney shafts, connecting the existing rain-water pipes of houses with the sewers throughout the whole City, and compelling shafts from the drains or closets of each house also to be carried to the tops of the houses.

Still further improvement might be effected, if permission could be obtained to run up shafts inside the towers of many of the city churches. It is possible there might (as in all the other modes) be some difficulty in this, but still in many cases it might be done without injury to any one; and if only a few of the private furnace shafts in the City were connected with the sewers, they would be a valuable assistance to the existing or any other mode of ventilation.

Before closing, I would add one or two remarks incidental to the subject reported upon.

It has not unfrequently been considered, that the construction of the system of interception would materially improve the existing ventilation of the

sewers generally, and relieve the districts from effluvium.

This view appears to be adopted by the engineers, who recently reported upon Metropolitan Drainage Interception, who say, page 41 of their Report, "We believe the proposed Main Drainage Works, by insuring a continuous flow in the sewers, will relieve many districts from the effects of the alternate compression and dilation of the air in the sewers; but we attach great importance to the ventilation of all the sewers."

This, I believe, to be an error. The largest mass of the sewers are but little affected by the tides, and their ventilation would be in no way improved by the intercepting system; those large sewers alone which are tide-locked, by having uniformly a free outfall afforded them, may be in a degree improved; but it is questionable if they will be so to an appreciable extent; for were the views of the reporters correct, the quantity of vapor displaced each day could only be equal to the quantity of sewage water which accumulates between each period of the closing of the outlet valves; and if the expulsion of smell is largely due to that cause, it would appear to follow, that, during all the intervening periods when the valves were opened, a precisely opposite condition would ensue, and the issue of effluvium.

would, for the time being, be entirely prevented; but such is not the case, the issue of effluvium, although it may possibly be increased in a trifling degree, by the cause alluded to, is at all times the result of the general law which governs the diffusion of gases, which is most actively in operation when the gullies are the most offensive, and not of any cause so purely mechanical as the displacement, bulk for bulk, of different fluids; and I venture the opinion, that it is this law of diffusion which will render the complete prevention of smell from street gullies a matter of almost impossibility, whatever may be the ventilating system adopted, unless chemistry come to its aid.

I have now discharged the reference which your Honorable Court were pleased to make to me. I have brought before you the mechanical difficulties, (of the chemical possibilities I say nothing), in the way of curing the evil by chemical agents, and dealt with the question of the prevention of effluvium by draught, as if the ordinary ventilating processes might effect it, if there were no mechanical difficulties in the way of their application.

But upon the threshold of the whole consideration lies that of the conditions under which effluvium arises from the sewers, and is one of the earliest in importance to have investigated and determined:

it is a matter for the professional chemist, whose opinion will alone, upon such a point, be accepted as of value. I strongly incline to the opinion that the feeble circulation caused by the existing air shafts, but little if at all, increases the actual quantity of offensive gas which is given off, but that as I have before remarked, it is evolved according to some known chemical law, a law so powerful that even were the whole of the street-openings acting as down-cast shafts, nothing but an unattainable velocity would prevent its issue in some degree, so long as those openings existed, and if this be so, the sanitary benefit likely to arise from any of the systems of ventilation alluded to, can be but slight, unless coupled with the application of chemical agents, more sure in their action, less objectionable in their collateral effects, and from their nature more capable of being practically adopted, than those which have hitherto been suggested.

I have the honor to remain,
GENTLEMEN,
Your most obedient Servant,

WILLIAM HAYWOOD,
Engineer and Surveyor.

APPENDIX.

APPENDIX A.

LIST OF ACCIDENTS WHICH HAVE OCCURRED IN SEWERS.

November 15*th*, 1785. In a branch sewer running from the Irongate Sewer towards the Vine Inn, Bishopsgate-street (there being a dead wall at that spot), in which there was an accumulation of soil and rubbish, the inflammable air took fire and burnt one of the New River Company's workmen.

In *July* 1823, an explosion of gas took place in a sewer in Mount-street, Grosvenor-square, near South Audley-street, and a workman was so injured as to be confined in St. George's Hospital for six weeks.

August 20*th*, 1824, in Tower-street, a new sewer having been built there, and made temporarily air-tight, two workmen entered for the purpose of removing some centering, when the gas, which had collected, exploded, and they were severely burnt.

July 15*th*, 1826. A bricklayer and labourer were injured by an explosion of gas in a sewer in Praed-street, Paddington.

At the same period the sewer in King-street, Westminster, was found to be in a dangerous state by the gas issuing from the gullies, and it was necessary to make openings in the crown of the sewer in places about 100 feet apart, for the prevention of accidents, before workmen could enter.

November 27*th*, 1826, an explosion took place in Wood-street and Little College-street, Westminster, the gas escaping from

the mains into the sewers, found its way from thence up the private drains of the houses, an explosion took place in the rear of the house of Mr. David Young, of College-street, and communicated with the whole body of gas in the sewer, the dirt and rubbish being forced out of the gullies in the street by the force.

November 28*th*, 1831, an explosion took place in Great Queen-street, Drury-lane, when a workman was severely burnt.

November 30*th*, 1831, an explosion of gas took place in the sewer, Crawford-street, Marylebone, by which the Surveyor to the Westminster Commission of Sewers was severely injured.

In 1833, an explosion took place in the man-hole of a new sewer just then built at Peckham.

September 16*th*, 1833, an explosion of gas took place in Dean-street, St. Ann's, at the corner of Old Compton-street, injuring a person but slightly.

October 16*th*, 1833, an explosion of gas took place in the house, No. 6, King-street, St. James's-square, occupied by Mr. William Halson; the gas appears to have made its way from the sewer up the drain into the house, and the servant entering the kitchen with a light, it ignited; the room was filled with flame, the woman was lifted to the ceiling by the force of the explosion, which also blew off the skylight over the staircase.

December 1833, several explosions of a slight character took place in the sewers in Rathbone-place, Oxford-street, which were at that time open.

In 1855, an ignition of gas took place in the Lime-street sewer, and two men were slightly burnt.

In 1836, an ignition took place in the same sewer, and a man was injured.

April 2nd, 1836, two men were injured by an explosion of gas in the sewer in St. Mary Axe.

In 1844, an ignition of sulphuretted hydrogen gas took place in the old sewer in Leadenhall-street.

In 1845, an explosion of coal gas took place in the sewer in Bride-lane, and a man was burnt.

In 1845, an explosion of coal gas took place in the sewer in Golden-lane, and a man was burnt.

In 1846, an explosion of coal gas took place in Fleet-street sewer, and three men were injured.

In 1847, an explosion of coal gas took place in Holborn sewer, and two men were injured.

In 1849, an explosion of coal gas took place in Gracechurch-street sewer, and one man was injured.

In *October* 1849, five men were killed by entering an unventilated sewer in Kenilworth-street, Pimlico; the chemists and analists examined by the inquest attributed their suffocation to sulphuretted hydrogen.

In 1850, an explosion took place in the sewer in Back Gravel-lane, Pimlico, and one man was injured.

In 1850, an ignition of sulphuretted hydrogen took place in Paternoster-row sewer.

In 1850, an explosion of coal gas took place in the sewer in Petticoat-lane.

In 1851, an explosion of coal gas took place in Duke-street, Aldgate sewer, and one man was burnt.

In 1851, an explosion of coal gas took place in Fore-street sewer, and two men were burnt.

In 1851, an explosion of coal gas took place in the sewer in Broad-street.

In 1852, by the ignition of sulphuretted hydrogen in an ancient sewer in John-street, Minories, two men were injured.

In 1852, a similar ignition took place during the exploration of an ancient sewer upon one side of Coleman-street.

In *November* 1852, two men were killed by entering an unventilated sewer in Compton-street, Clerkenwell, owing to the presence of large quantities of sulphuretted hydrogen.

In 1854, an explosion of coal gas took place in the sewer in Castle-street, Holborn, and a man was burnt.

In 1854, two similar explosions took place in the Threadneedle-street sewer.

In 1855, two similar explosions took place in the Milton-street sewer, and a workman was burnt upon each occasion.

In 1855, an explosion of gas took place in a sewer in Brompton-crescent, Fulham-road.

In *July* 1855, two of the officers of the Metropolitan Court

of sewers narrowly escaped suffocation whilst engaged in surveying the sewer in Suffolk-street, Southwark.

On 1*st November*, 1855, two flushing men, whilst traversing the sewer in Suffolk-street, Borough, were burnt by an explosion of gas.

In 1856, an explosion of coal gas took place in the William-street sewer, and one man was injured.

In *August* 1857, three men were suddenly killed by an escape of carbonic acid gas from a drain into a sewer constructing in the Whitechapel-road.

APPENDIX B.

Analysis of the Drainage of One Thousand Houses within the City of London, taken indiscriminately from all parts of its area.

Total number of plans of house drainage ..	698	
Ditto houses	1,000	
Total length of drain 12 inches diameter ..	2,607	feet lineal.
Ditto 9 „ ..	18,138	„
Ditto 6 „ ..	33,472	„
Ditto 4 „ ..	501	„
Total length of horizontal drain	54,718	„
Total length of vertical 4-inch pipe, measured up to surface of ground	2,330	„
Total length of drains both vertical and horizontal	57,048	„

Total number of inlets communicating directly with the drains :—

From water closets	1,165
„ gullies	529
„ sinks	381
„ rain-water pipes	429
„ waste water pipes	192
Total number of inlets	2,696

The length of vertical drain pipe is measured up to the ground level only; the rain-water pipes are generally carried up to the tops of houses; the sink and waste water pipes to various levels, but frequently to the tops of houses also: they are when above the ground level, in all cases, of iron, lead, or zinc; none of those lengths are included in the abstract.

APPENDIX C.

CITY OF LONDON SEWERS.

Table showing difference of Temperature between the Interior of Sewers and the External Atmosphere (in shade).

APRIL 1853.

	PLACE OF OBSERVATION.	Date.	Hour of Day.	Clear Internal Size of Sewer.	Level of Sewer Invert above Ordnance datum.	Direction of the Wind.	Temperature.		Temperature of Sewer.	
							In External Atmosphere in Shade.	In Sewer.	Above External Atmosphere.	Below External Atmosphere.
		1853.	h. m.	ft. in. ft. in.			Deg.	Deg.	Deg.	Deg.
1	Fleet Street	April 15	9 19 A.M.	5 0 by 3 0	30·99	N.E. & N.W.	49	55	6	..
2	Water Lane	,, ,,	9 45 ,,	5 0 ,, 3 0	12·64	,,	49	52	3	..
3	Chancery Lane	,, ,,	10 10 ,,	5 0 ,, 2 4	42·05	,,	48	52	4	..
4	Fetter Lane	,, ,,	10 28 ,,	4 0 ,, 2 4	44·28	,,	48	53	5	..
5	Castle Street	,, ,,	10 55 ,,	4 0 ,, 2 6	53·81	,,	48	52	4	..
6	Holborn	,, ,,	11 15 ,,	5 6 ,, 4 6	47·91	,,	48	52	4	..
7	Great New Street	,, ,,	11 40 ,,	4 6 ,, 2 7	36·18	,,	49	52	3	..
8	Holborn Hill	,, ,,	12 0 NOON.	5 6 ,, 4 6	18·30	,,	51	53	2	..
9	Poppin's Court	,, ,,	1 20 P.M.	4 0 ,, 2 6	16·09	N.W.	53	53	0	..
10	Bride Lane	,, ,,	1 45 ,,	4 0 ,, 2 6	9·46	,,	52	53	1	..
11	King Street, Snow Hill	,, ,,	2 20 ,,	4 1 ,, 3 3	28·99	,,	53	56	3	..
12	Holborn Bridge	,, ,,	2 45 ,,	13 0 ,, 12 0	8·80	,,	53	54	1	..
13	Giltspur Street	,, ,,	3 15 ,,	4 0 ,, 2 6	42·91	,,	52	55	3	..
14	Old Bailey	,, ,,	3 45 ,,	4 0 ,, 2 6	33·19	,,	53	52	..	1
15	Fleet Lane	,, ,,	4 30 ,,	5 0 ,, 2 0	21·39	,,	53	50	..	3
16	Duke Street	,, 16	9 30 A.M.	4 0 ,, 3 3	34·49	,,	53	53	..	..
17	West Smithfield	,, ,,	9 55 ,,	4 0 ,, 3 3	33·59	,,	53	52	..	1
18	Fann Street	,, ,,	10 50 ,,	4 6 ,, 2 6	49·31	,,	54	53	..	1
19	Aldersgate Street	,, ,,	11 20 ,,	4 0 ,, 3 0	43·19	,,	54	56	2	..
20	Little Britain	,, ,,	11 45 ,,	4 3 ,, 3 3	40·69	,,	54	56	2	..
21	St. Ann's Lane	,, ,,	12 10 P.M.	4 9 ,, 2 9	41·09	,,	56	56	..	..
22	Gresham Street	,, ,,	1 30 ,,	5 0 ,, 3 0	40·86	,,	56	56	..	..
23	Nicholl Square	,, ,,	1 55 ,,	4 0 ,, 2 6	42·53	,,	57	54	..	3
24	Red Cross Street	,, ,,	2 25 ,,	5 0 ,, 3 0	40·76	,,	56	54	..	2
25	Barbican	,, ,,	2 50 ,,	5 0 ,, 2 6	43·35	,,	55	52	..	3
26	Bridgewater Square	,, ,,	3 10 ,,	3 6 ,, 2 6	49·89	,,	55	52	..	3

29	Fore Street	,,	,,	10	10	,,	4	9	,,	3	0	34·61	,,	57	56	..	1
30	New Basinghall Street	,,	,,	10	35	,,	4	0	,,	2	6	29·88	,,	56	58	2	..
31	Philip Lane	,,	,,	11	0	,,	4	0	,,	2	6	38·88	,,	55	53	..	2
32	Fell Street	,,	,,	11	20	,,	4	0	,,	2	6	41·03	,,	56	52	..	4
33	Goldsmith Street	,,	,,	11	45	,,	4	0	,,	2	6	44·31	,,	56	highest 59	3	..
34	Angel Street	,,	,,	12	5	P.M.	4	6	,,	2	7	43·46	N.W.	56	56	..	..
35	Paternoster Row	,,	,,	3	15	,,	5	0	,,	2	9	41·50	,,	60	52	..	8
36	Newgate Market	,,	,,	3	45	,,	4	6	,,	2	5	44·66	,,	highest 61	51	..	10
37	Distaff Lane	,,	,,	4	30	,,	4	0	,,	2	6	32·17	,,	60	59	..	1
38	Little St. Thomas Apostle	,,	19	9	20	A.M.	4	0	,,	2	6	22·52	S.W.	55	52	..	3
39	Queen Street	,,	,,	9	49	,,	5	0	,,	2	9	32·69	,,	57	53	..	4
40	Old Jewry	,,	,,	10	29	,,	5	0	,,	3	6	30·51	,,	56	54	..	2
41	Coleman Street	,,	,,	10	55	,,	5	0	,,	3	6	32·39	,,	57	54	..	3
42	Eldon Street	,,	,,	11	25	,,	5	0	,,	3	3	26·61	,,	56	53	..	3
43	Blomfield Street	,,	,,	11	45	,,	5	0	,,	3	2	25·34	,,	59	51	..	8
44	Baker's Buildings	,,	,,	12	7	P.M.	5	9	,,	3	2	29·68	,,	58	52	..	6
45	Dunning's Alley	,,	20	9	30	A.M.	5	9	,,	3	2	30·05	N.W.	49	49	..	..
46	Bishopsgate Street Without	,,	,,	9	55	,,	5	6	,,	3	3	33·78	,,	51	52	1	..
47	New Street, Bishopsgate	,,	,,	11	10	,,	3	6	,,	2	3	35·84	,,	50	52	2	..
48	Devonshire Street	,,	,,	11	35	,,	3	8	,,	2	3	42·88	,,	52	50	..	2
49	Houndsditch	,,	,,	12	0	NOON.	5	0	,,	3	0	34·13	,,	54	50	..	4
50	Ebenezer Square	,,	21	9	25	A.M.	4	0	,,	2	6	36·28	S.W.	lowest 46	lowest 48	2	..
51	Gun Square	,,	,,	9	50	,,	4	0	,,	2	6	33·24	,,	46	48	2	..
52	Aldgate	,,	,,	10	15	,,	4	9	,,	2	6	36·84	,,	46	53	7	
53	Billiter Street	,,	,,	10	40	,,	5	0	,,	2	3	40·46	,,	46	49	3	..
54	Jewry Street	,,	,,	11	0	,,	4	0	,,	2	6	30·88	,,	46	51	5	..
55	Cooper's Row	,,	,,	11	20	,,	4	0	,,	2	6	28·82	,,	46	48	2	..
56	Mark Lane	,,	,,	11	45	,,	5	0	,,	3	0	33·54	,,	46	49	3	..
57	Easteheap	,,	,,	12	7	P.M.	5	0	,,	3	0	32·14	S.E.	46	51	5	..
58	Fenchurch Street	,,	,,	1	20	,,	4	9	,,	2	9	37·20	,,	50	50	..	..
59	St. Mary Axe	,,	,,	1	40	,,	4	6	,,	2	4	42·44	,,	48	48	..	..
60	Trogmorton Street	,,	,,	2	5	,,	5	0	,,	3	0	29·94	,,	50	51	1	..
61	Threadneedle Street	,,	,,	2	27	,,	4	6	,,	2	6	40·26	,,	50	49	..	1
62	Bishopsgate Street Within	,,	,,	2	50	,,	5	0	,,	3	0	35·92	,,	50	52	2	..
63	Thames Street	,,	,,	3	15	,,	5	0	,,	3	3	5·02	,,	50	50	..	..
64	Cannon Street	,,	,,	3	40	,,	5	0	,,	3	0	32·82	,,	49	51	2	..
65	Laurence Pountney Lane	,,	,,	4	6	,,	4	6	,,	2	6	22·98	,,	49	50	1	..
													Mean	52·46	52·52	..	..

CITY OF LONDON SEWERS.

Table showing difference of Temperature between the Interior of Sewers and the External Atmosphere (in shade).

JULY 1848.

	PLACE OF OBSERVATION.	Date.	Hour of Day.	Clear Internal Size of Sewer.	Level of Sewer Invert above Ordnance datum.	Direction of the Wind.	Temperature.		Temperature of Sewer.	
							In External Atmosphere in Shade.	In Sewer.	Above External Atmosphere.	Below External Atmosphere.
		1848.		ft. in. ft. in.			Deg.	Deg.	Deg.	Deg.
1	Fleet Street	June 26	9 0 A.M.	5 0 by 3 0	30·99	....	62	61	..	1
2	Water Lane	,, ,,	10 15 ,,	5 0 ,, 3 0	12·64	....	61	60	..	1
3	Chancery Lane	,, ,,	11 15 ,,	5 0 ,, 2 4	42·05	....	62	64	2	..
4	Fetter Lane	,, ,,	12 45 P.M.	4 0 ,, 2 4	44·28	....	65	63	..	2
5	Castle Street	,, ,,	1 45 ,,	4 0 ,, 2 6	53·81	....	64	65	1	..
6	Holborn	,, ,,	2 30 ,,	5 6 ,, 4 6	47·91	....	67	61	..	6
7	Great New Street	,, ,,	4 0 ,,	4 6 ,, 2 7	36·18	....	66	60	..	6
8	Holborn Hill	,, ,,	4 45 ,,	5 6 ,, 4 6	18·30	....	67	62	..	5
9	Poppin's Court	,, ,,	5 45 ,,	4 0 ,, 2 6	16·09	....	64	61	..	3
10	Bride Lane	,, ,,	6 45 ,,	4 0 ,, 2 6	9·46	....	64	60	..	4
11	King Street, Snow Hill	,, 27	9 0 A.M.	4 1 ,, 3 3	28·99	....	65	60	..	5
12	Holborn Bridge	,, ,,	10 30 ,,	13 0 ,, 12 0	8·80	....	64	62	..	2
13	Giltspur Street	,, ,,	11 45 ,,	4 0 ,, 2 6	42·91	....	66	62	..	4
14	Old Bailey	,, ,,	12 45 P.M.	4 0 ,, 2 6	33·19	....	67	63	..	4
15	Fleet Lane	,, ,,	1 30 ,,	5 0 ,, 2 0	21·39	....	66	64	..	2
16	Duke Street	,, ,,	3 15 ,,	4 0 ,, 3 3	34·49	....	63	65	2	..
17	West Smithfield	,, ,,	4 15 ,,	4 0 ,, 3 3	33·59	....	64	63	..	1
18	Fann Street	,, ,,	6 30 ,,	4 6 ,, 2 6	49·31	....	62	60	..	2
19	Aldersgate Street	,, 28	9 0 A.M.	4 0 ,, 3 0	43·19	....	68	65	..	3
20	Little Britain	,, ,,	10 15 ,,	4 3 ,, 3 3	40·69	....	64	65	1	..
21	St. Ann's Lane	,, ,,	11 30 ,,	4 9 ,, 2 9	41·09	....	65	66	1	..
22	Gresham Street	,, ,,	12 0 NOON.	5 0 ,, 3 0	40·86	....	67	64	..	3
23	Nicholl Square	,, ,,	1 0 P.M.	4 0 ,, 2 6	42·53	....	70	62	..	8
24	Red Cross Street	,, ,,	1 45 ,,	5 0 ,, 3 0	40·76	....	71	64	..	7
25	Barbican	,, ,,	3 30 ,,	5 0 ,, 2 6	43·35	....	70	62	..	8
26	Bridgewater Square	,, ,,	4 30 ,,	3 6 ,, 2 6	49·89	....	65	61	..	4

29	Fore Street	,,	,,	11	30	,,	4	9	,,	3	0	34·61	....		64	highest 68	4	..
30	New Basinghall Street	,,	,,	12	15	P.M.	4	0	,,	2	6	29·88	....		69	64	..	5
31	Philip Lane	,,	,,	4	15	,,	4	0	,,	2	6	38·88	....		69	62	..	7
32	Fell Street	,,	,,	2	15	,,	4	0	,,	2	6	41·03	....		69	62	..	7
33	Goldsmith Street	,,	,,	3	45	,,	4	0	,,	2	6	44·31	....		66	60	.	6
34	Angel Street	,,	,,	4	30	,,	4	6	,,	2	7	43·46	....	highest	72	63	..	9
35	Paternoster Row	,,	,,	5	30	,,	5	0	,,	2	9	41·50	....		68	60	..	8
36	Newgate Market	,,	,,	6	30	,,	4	6	,,	2	5	44·66	....		64	64	..	..
37	Distaff Lane	,,	30	9	0	A.M.	4	0	,,	2	6	32·17	....		63	64	1	..
38	Little St. Thomas Apostle	,,	,,	10	0	,,	4	0	,,	2	6	22·52	....		64	60	..	4
39	Queen Street	,,	,,	11	0	,,	5	0	,,	2	9	32·69	....		66	60	..	6
40	Old Jewry	,,	,,	11	45	,,	5	0	,,	3	6	30·51	....		69	63	..	1
41	Coleman Street	,,	,,	1	0	P.M.	5	0	,,	3	6	32·39	....		69	67	..	2
42	Eldon Street	,,	,,	1	45	,,	5	0	,,	3	3	26·61	....	lowest	55	57	2	..
43	Blomfield Street	,,	,,	3	45	,,	5	0	,,	3	2	25·34	....		66	65	..	1
44	Baker's Buildings	,,	,,	4	30	,,	5	9	,,	3	2	29·68	....		66	63	..	3
45	Dunning's Alley	,,	,,	5	30	,,	5	9	,,	3	2	30·05	....		65	63	..	2
46	Bishopsgate Street Without	,,	,,	6	30	,,	5	6	,,	3	3	33·78	....		64	61	..	3
47	New Street, Bishopsgate	July	1	11	15	A.M.	3	6	,,	2	3	35·84	....		63	lowest 56	..	7
48	Devonshire Street	,,	,,	12	15	P.M.	3	8	,,	2	3	42·88	....		63	61	..	2
49	Houndsditch	,,	,,	1	15	,,	5	0	,,	3	0	34·13	....		62	62	..	..
50	Ebenezer Square	,,	,,	3	30	,,	4	0	,,	2	6	36·28	....		60	60	..	..
51	Gun Square	,,	,,	4	30	,,	4	0	,,	2	6	33·24	....		59	58	..	1
52	Aldgate	,,	,,	5	30	,,	4	9	,,	2	6	36·84	....		60	61	1	..
53	Billiter Street	,,	,,	6	15	,,	5	0	,,	2	3	40·46	....		59	60	1	..
54	Jewry Street	,,	3	9	0	A.M.	4	0	,,	2	6	30·88	....		63	60	..	3
55	Cooper's Row	,,	,,	9	45	,,	4	0	,,	2	6	28·82	....		63	60	..	3
56	Mark Lane	,,	,,	10	45	,,	5	0	,,	3	0	33·54	....		67	62	..	5
57	Eastcheap	,,	,,	11	45	,,	5	0	,,	3	0	32·14	....		69	62	..	7
58	Fenchurch Street	,,	,,	12	45	P.M.	4	9	,,	2	9	37·20	....		70	60	..	10
59	St. Mary Axe	,,	,,	1	30	,,	4	6	,,	2	4	42·44	....		68	60	..	8
60	Throgmorton Street	,,	,,	3	30	,,	5	0	,,	3	0	29·94	....		65	60	..	5
61	Threadneedle Street	,,	,,	4	30	,,	4	6	,,	2	6	40·26	....		63	60	..	3
62	Bishopsgate Street Within	,,	,,	5	30	,,	5	0	,,	3	0	35·92	....		65	61	..	4
63	Thames Street	,,	,,	6	30	,,	5	0	,,	3	3	5·02	....		64	59	..	5
64	Cannon Street	,,	4	10	0	A.M.	5	0	,,	3	0	32·82	....		67	62	..	5
65	Laurence Pountney Lane	,,	,,	11	0	,,	4	6	,,	2	6	22·98	....		65	60	..	5
													Mean		49·69	61·92	..	..

CITY OF LONDON SEWERS.

Table showing difference of Temperature between the Interior of Sewers and the External Atmosphere (in shade).

OCTOBER 1857.

	PLACE OF OBSERVATION.	Date.	Hour of Day.	Clear Interval Size of Sewer.	Level of Sewer Invert above Ordnance datum.	Direction of the Wind.	Temperature.		Temperature of Sewer.	
							In External Atmosphere in Shade.	In Sewer.	Above External Atmosphere.	Below External Atmosphere.
		1857.	h. m.	ft. in. ft. in.			Deg.	Deg.	Deg.	Deg.
1	Fleet Street	Oct. 16	11 30 A.M.	5 0 by 3 0	30·99	N.N.E.	67	61	..	6
2	Water Lane	,, ,,	1 40 P.M.	5 0 ,, 3 0	12·64	E.S.E.	66	62	..	4
3	Chancery Lane	,, ,,	12 5 ,,	4 0 ,, 2 6	37·64	,,	67	61	.	6
4	Fetter Lane	,, ,,	4 25 ,,	4 0 ,, 2 4	44·28	,,	68	62	..	6
5	Castle Street	,, ,,	4 50 ,,	4 0 ,, 2 6	48·71	,,	68	62	..	6
6	Holborn	,, 17	2 15 ,,	5 6 ,, 4 6	47·91	S.S.W.	66	62	..	4
7	Great New Street	,, 16	3 55 ,,	4 6 ,, 2 7	36·18	E.S.E.	68	62	..	6
8	Holborn Hill	,, 17	1 30 ,,	5 6 ,, 4 6	18·30	S.S.W.	67	64	..	3
9	Poppin's Court	,, 16	3 0 ,,	4 0 ,, 2 6	16·09	E.S.E.	68	61	..	7
10	Bride Lane	,, ,,	2 25 ,,	4 0 ,, 2 6	9·46	,,	highest 68	61	..	7
11	King Street, Snow Hill	,, 17	3 0 ,,	4 1 ,, 3 3	28·99	S.S.W.	63	65	2	..
12	Holborn Bridge	,, ,,	11 55 A.M.	13 0 ,, 12 0	8·80	,,	67	68	1	..
13	Giltspur Street	,, 19	10 50 ,,	4 0 ,, 2 6	42·91	Calm.	62	65	3	..
14	Old Bailey	,, ,,	11 35 ,,	4 0 ,, 2 6	33·19	,,	62	62	..	..
15	Fleet Lane	,, ,,	12 15 P.M.	5 0 ,, 2 0	21·39	,,	62	62·5	0·5	..
16	Duke Street	,, ,,	1 45 ,,	4 0 ,, 3 3	34·49	,,	62	64	2	..
17	West Smithfield	,, ,,	2 15 ,,	4 0 ,, 3 3	33·59	,,	61·5	65	3·5	..
18	Fann Street	,, ,,	3 35 ,,	4 6 ,, 2 6	49 31	,,	61·5	67	5·5	..
19	Aldersgate Street	,, ,,	4 0 ,,	4 0 ,, 3 0	43·19	,,	62	68	6	..
20	Little Britain	,, ,,	4 30 ,,	4 3 ,, 3 3	40·69	,,	62	67	5	..
21	St. Ann's Lane	,, ,,	5 0 ,,	4 9 ,, 2 9	41·09	,,	61	64	3	..
22	Gresham Street	,, 20	10 45 A.M.	5 0 ,, 3 0	40·86	Do. & N.N.E.	57	64	7	..
23	Nicholl Square	,, ,,	11 25 ,,	4 0 ,, 2 6	42·53	,,	58	63	5	..
24	Red Cross Street	,, ,,	12 0 NOON	5 0 ,, 3 0	40·76	,,	61	67	6	..
25	Barbican	,, ,,	1 35 P.M.	5 0 ,, 2 6	43·35	N.N.E.	61	67	6	..
26	Bridgewater Square	,, ,,	2 20 ,,	3 6 ,, 2 6	49·89	,,	61	67	6	..

29	Fore Street	,,	,,	4	55	,,	4	9	,,	3	0	34·61	,,	58	67	9	..
30	New Basinghall Street	,,	21	10	50	A.M.	4	0	,,	2	6	29·88	,,	61	67	6	..
31	Philip Lane	,,	,,	11	30	,,	4	0	,,	2	6	38·88	,,	61	62	1	..
32	Fell Street	,,	,,	12	0	NOON	4	0	,,	2	6	41·03	,,	60	63	3	..
33	Goldsmith Street	,,	,,	1	25	P.M.	4	0	,,	2	6	44·31	Varied.	60	62	2	..
34	Angel Street	,,	,,	2	15	,,	4	6	,,	2	7	43·46	,,	61	63	2	..
35	Paternoster Row	,,	,,	3	0	,,	5	0	,,	2	9	41·50	,,	60	64	4	..
36	Newgate Market	,,	,,	3	35	,,	4	6	,,	2	5	44·66	,,	61	60	..	1
37	Distaff Lane	,,	,,	4	10	,,	4	0	,,	2	6	32·17	,,	59	62	3	..
38	Little St. Thomas Apostle	,,	,,	4	50	,,	4	0	,,	2	6	22·52	,,	61	62·5	1·5	..
39	Queen Street	,,	22	10	40	A.M.	5	0	,,	2	9	32·69	N.	48	60	12	..
40	Old Jewry	,,	,,	11	10	,,	5	0	,,	3	6	30·51	,,	48	63	15	..
41	Coleman Street	,,	,,	11	55	,,	5	0	,,	3	6	32·39	,,	48	63	15	..
42	Eldon Street	,,	,,	2	0	P.M.	5	0	,,	3	3	26·61	N.N.E.	48	55	7	..
43	Blomfield Street	,,	,,	2	35	,,	5	0	,,	3	2	25·34	,,	48	55	7	..
44	Baker's Buildings	,,	,,	3	15	,,	5	9	,,	3	2	29·68	,,	48	54	6	..
45	Dunning's Alley	,,	,,	3	45	,,	5	9	,,	3	2	30·05	,,	lowest 48	lowest 53	5	..
46	Bishopsgate Street Without	,,	,,	4	10	,,	5	6	,,	3	3	33·78	,,	48	54	6	..
47	New Street, Bishopsgate	,,	23	10	55	A.M.	3	6	,,	2	3	35·84	Varied.	56	62	6	..
48	Devonshire Street	,,	,,	11	40	,,	3	8	,,	2	3	42·88	,,	56	64	8	..
49	Houndsditch	,,	,,	12	15	P.M.	5	0	,,	3	0	34·13	,,	57	62	5	..
50	Ebenezer Square	,,	,,	1	45	,,	4	0	,,	2	6	36·28	,,	57	63	6	..
51	Gun Square	,,	,,	2	25	,,	4	0	,,	2	6	33·24	,,	60	63	3	..
52	Aldgate	,,	,,	2	55	,,	4	9	,,	2	6	36·84	,,	60	highest 70	10	..
53	Billiter Street	,,	,,	3	20	,,	5	0	,,	2	3	40·46	,,	60	62	2	..
54	Jewry Street	,,	,,	4	0	,,	4	0	,,	2	6	30·88	,,	60	65	5	..
55	Cooper's Row	,,	26	2	0	,,	4	0	,,	2	6	28·82	Calm.	60	64	4	..
56	Mark Lane	,,	,,	2	45	,,	5	0	,,	3	0	33·54	,,	61	63·5	2·5	..
57	Eastcheap	,,	,,	3	35	,,	5	0	,,	3	0	32·14	,,	59	64	5	..
58	Fenchurch Street	,,	,,	4	15	,,	4	9	,,	2	9	37·20	,,	59	62	3	..
59	St. Mary Axe	,,	,,	4	50	,,	4	6	,,	2	4	42·44	,,	61	64·5	3·5	..
60	Throgmorton Street	,,	27	10	50	A.M.	5	0	,,	3	0	29·94	S.E.	61·5	66	4·5	..
61	Threadneedle Street	,,	,,	11	30	,,	4	6	,,	2	6	40·26	,,	62	64	2	..
62	Bishopsgate Street Within	,,	,,	12	15	P.M.	5	0	,,	3	0	35·92	S.	60·5	61	0·5	..
63	Thames Street	,,	,,	1	50	,,	5	0	,,	3	3	5·02	,,	60	61	1	..
64	Cannon Street	,,	,,	2	35	,,	5	0	,,	3	0	32·82	,,	62	64	2	..
65	Laurence Pountney Lane	,,	,,	3	15	,,	4	6	,,	2	6	22·98	,,	62	64	2	..
													Mean	59·9	62·97	..	..

CITY OF LONDON SEWERS.

Table showing difference of Temperature between the Interior of Sewers and the External Atmosphere (in shade).

DECEMBER 1849 AND JANUARY 1850.

PLACE OF OBSERVATION.	Date.	Hour of Day.	Clear Internal Size of Sewer.	Level of Sewer Invert above Ordnance datum.	Direction of the Wind.	Temperature.		Temperature of Sewer.	
						In External Atmosphere in Shade.	In Sewer.	Above External Atmosphere.	Below External Atmosphere.
	1849.	h. m.	ft. in. ft. in.			Deg.	Deg.	Deg.	Deg.
1 Fleet Street	Dec. 29	10 0 A.M.	5 0 by 3 0	30·99	....	31	42	11	..
2 Water Lane	,, ,,	11 0 ,,	5 0 ,, 3 0	12·64	....	31½	41	9½	..
3 Chancery Lane	,, ,,	11 30 ,,	5 0 ,, 2 4	42·05	....	32	40½	8½	..
4 Fetter Lane	,, ,,	12 0 ,,	4 0 ,, 2 4	44·28	....	32½	43	10½	..
5 Castle Street	,, ,,	12 30 ,,	4 0 ,, 2 6	53·81	....	31½	41	9½	..
6 Holborn	,, ,,	1 0 P.M.	5 6 ,, 4 6	47·91	....	33½	42½	9	..
7 Great New Street	,, ,,	2 0 ,,	4 6 ,, 2 7	36·18	....	34	41½	7½	..
8 Holborn Hill	,, ,,	2 30 ,,	5 6 ,, 4 6	18·30	....	33	41½	8½	..
9 Poppin's Court	,, ,,	3 0 ,,	4 0 ,, 2 6	16·09	....	33	lowest 40	7	..
10 Bride Lane	,, ,,	3 30 ,,	4 0 ,, 2 6	9·46	....	33	41½	8½	..
11 King Street, Snow Hill	,, ,,	4 0 ,,	4 1 ,, 3 3	28·99	....	32	42	10	..
12 Holborn Bridge	,, ,,	5 0 ,,	13 0 ,, 12 0	8·80	....	32	40	8	..
13 Giltspur Street	,, 31	9 30 A.M.	4 0 ,, 2 6	42·91	....	31	44	13	..
14 Old Bailey	,, ,,	10 0 ,,	4 0 ,, 2 6	33·19	....	32	43	11	..
15 Fleet Lane	,, ,,	11 0 ,,	5 0 ,, 2 0	21·39	....	33	41	8	..
16 Duke Street	,, ,,	11 30 ,,	4 0 ,, 3 3	34·49	....	33	42	9	..
17 West Smithfield	,, ,,	12 0 NOON.	4 0 ,, 3 3	33·59	....	34	42	8	..
18 Fann Street	Jan. 1, 1850	10 0 A.M.	4 6 ,, 2 6	49·31	....	lowest 30	42	12	..
19 Aldersgate Street	,, ,,	11 0 ,,	4 0 ,, 3 0	43·19	....	31	44	13	..
20 Little Britain	,, ,,	11 30 ,,	4 3 ,, 3 3	40·69	....	32	43	11	..
21 St. Ann's Lane	,, ,,	12 0 NOON.	4 9 ,, 2 9	41·09	....	33	44	11	..
22 Gresham Street	,, ,,	1 0 P.M.	5 0 ,, 3 0	40·86	....	33	43	10	..
23 Nicholl Square	,, ,,	2 0 ,,	4 0 ,, 2 6	42·53	....	33	42	9	..
24 Red Cross Street	,, ,,	3 0 ,,	5 0 ,, 3 0	40·76	....	33	42	9	..
25 Barbican	,, ,,	4 0 ,,	5 0 ,, 2 6	43·35	....	33½	42	8½	..
26 Bridgewater Square	,, ,,	5 0 ,,	3 6 ,, 2 6	49·89	....	33½	44	10½	..

29	Fore Street	,,	,,	3	30	,,	4	9	,,	3	0	34·61	....	33	44	11	..
30	New Basinghall Street	,,	,,	4	0	,,	4	0	,,	2	6	29·88	....	33	50	17	..
31	Philip Lane	,,	,,	4	30	,,	4	0	,,	2	6	38·88	....	33	41	8	..
32	Fell Street	,,	,,	5	0	,,	4	0	,,	2	6	41·03	....	33	41½	8½	..
33	Goldsmith Street	,,	9	9	0	A.M.	4	0	,,	2	6	44·31	....	highest 34	44	10	..
34	Angel Street	,,	,,	9	30	,,	4	0	,,	2	7	43·46	....	32	highest 52	20	..
35	Paternoster Row	,,	,,	10	30	,,	5	0	,,	2	9	41·50	....	32	42	10	..
36	Newgate Market	,,	,,	1	0	P.M.	4	6	,,	2	5	44·46	....	33	43	10	..
37	Distaff Lane	,,	,,	1	30	,,	4	0	,,	2	6	32·17	....	33	52	19	..
38	Little St. Thomas Apostle	,,	,,	2	0	,,	4	0	,,	2	6	22·52	....	33	44	11	..
39	Queen Street	,,	,,	2	30	,,	5	0	,,	2	9	32·69	....	33	43	10	..
40	Old Jewry	,,	,,	3	0	,,	5	0	,,	3	6	30·51	....	33	50	17	..
41	Coleman Street	,,	,,	3	30	,,	5	0	,,	3	6	32·39	....	32	44	12	..
42	Eldon Street	,,	,,	4	30	,,	5	0	,,	3	3	26·61	....	32	44	12	..
43	Blomfield Street	,,	,,	5	0	,,	5	0	,,	3	2	25·34	....	33	44	11	..
44	Baker's Buildings	,,	10	9	30	A.M.	5	9	,,	3	2	29·68	....	32	43	11	..
45	Dunning's Alley	,,	,,	10	0	,,	5	9	,,	3	2	30·05	....	32	41	9	..
46	Bishopsgate Street Without	,,	,,	10	30	,,	5	6	,,	3	3	33·78	....	32	42	10	..
47	New Street, Bishopsgate	,,	,,	2	30	P.M.	3	6	,,	2	3	35·84	....	32	50	18	..
48	Devonshire Street	,,	,,	3	15	,,	3	8	,,	2	3	42·88	....	32½	44	11½	..
49	Houndsditch	,,	,,	3	45	,,	5	0	,,	3	0	34·13	....	32½	44	11½	..
50	Ebenezer Square	,,	,,	4	30	,,	4	0	,,	2	6	36·28	....	32	43½	11½	..
51	Gun Square	,,	,,	5	0	,,	4	0	,,	2	6	33·24	....	32½	44	11½	..
52	Aldgate	,,	12	9	0	A.M.	4	9	,,	2	6	36·84	....	31½	50½	19	..
53	Billiter Street	,,	,,	9	30	,,	5	0	,,	2	3	40·46	....	31½	44	12½	..
54	Jewry Street	,,	,,	10	0	,,	4	0	,,	2	6	30·88	....	31½	44	12½	..
55	Cooper's Row	,,	,,	10	30	,,	4	0	,,	2	6	28·82	....	32	50½	18½	..
56	Mark Lane	,,	,,	11	0	,,	5	0	,,	3	0	33·54	....	31½	43	11½	..
57	Eastcheap	,,	,,	11	30	,,	5	0	,,	3	0	32·14	....	32	51	19	..
58	Fenchurch Street	,,	,,	12	0	NOON.	4	9	,,	2	9	37·20	....	32	50	18	..
59	St. Mary Axe	,,	,,	1	0	P.M.	4	6	,,	2	4	42·44	....	32	44	12	..
60	Throgmorton Street	,,	,,	1	30	,,	5	0	,,	3	0	29·94	....	32	44	12	..
61	Threadneedle Street	,,	,,	2	0	,,	4	6	,,	2	6	40·26	....	32	43	11	..
62	Bishopsgate Street Within	,,	,,	2	30	,,	5	0	,,	3	0	35·92	....	32	50	18	..
63	Thames Street	,,	,,	4	0	,,	5	0	,,	3	3	5·02	....	31½	42	10½	..
64	Cannon Street	,,	,,	3	0	,,	5	0	,,	3	0	32·82	....	32	51	19	..
65	Laurence Pountney Lane	,,	,,	3	30	,,	4	6	,,	2	6	22·98	....	32½	43½	11	..
													Mean.....	32·37	43·98	..	..

CITY OF LONDON SEWERS.

Table showing difference of Temperature between the Interior of Sewers and the External Atmosphere (in shade).

SUMMARY OF OBSERVATIONS.

TIME OF YEAR.	TEMPERATURE IN EXTERNAL ATMOSPHERE (IN SHADE).			TEMPERATURE IN SEWER.			MEAN TEMPERATURE OF SEWER.	
	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Above External Atmosphere.	Below External Atmosphere.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.		
Summer	72	55	65·04	68	56	61·92	..	3·12
Winter	34	30	32·37	52	40	43·98	11·61	..
Spring	61	46	52·46	59	48	52·52	0·06	..
Autumn	68	48	59·90	70	53	62·97	3·07	..
Average of Whole Year	..	..	50·24	..	..	55·35	5·11	..

APPENDIX D.

From evidence taken before Select Committee on Sewers, 11th July, 1834.

2426. Mr. MICHAEL FARADAY called in and examined.

We merely refer to you, Mr. Faraday, in order to ascertain whether you have read over the evidence given before this Committee by some of the medical gentlemen who were examined here?—I have done so.

2427. And what do you think of the practicability of the plan which they have suggested of purifying the air of the sewers; do you conceive that on so large a scale a current of air can be created?—I think it possible; but my judgment now, as it was in a conversation with Mr. Fuller, is suspended with regard to the practical application of the plan.

2428. It is upon the practical application of the plan that everything turns, for we do not wish to recommend a mere theoretical improvement?—I think the principle is good, but whether under the new circumstances one could decide beforehand it could be successfully applied, I cannot say. I have my doubts whether it would ultimately be successful at an expense which could be borne; but the data required to be considered are so numerous, that it is impossible to get at the result without an experiment. I should say the object is so great, and the plan so correct in principle, that if it could be tried on a small scale of the sewers, it ought to be tried.

2429. But it might be tried perfectly on a small portion of

the sewers, because if a furnace of a moderate size applied to a small sewer on limited dimensions would produce the effect which these gentlemen anticipate, and which you seem to think practicable, you would have the data necessary for calculation as to a larger sewer?—Most decidedly; but when you say a furnace of small dimensions, that is the first difficulty that has occurred to me, though I do not think it has occurred to any other witness that has been examined. I doubt whether the consumption of the coal would not be very large indeed to produce the draft required. I merely would give you the data or the numbers as a reason why I suspend my judgment. If I therefore mention a quantity of coal, you will not take it as an assertion on my part that it would be the quantity required.

2430. You may guard the assertion in any way you please; but the Committee will be happy to have any data with which you can furnish it?—It is said in the evidence that 360,000 cubical feet of air may be passed in one hour through a sewer 6 feet by 3.

2431. Is this to Mr. Fuller's evidence or Mr. Walker's that you are speaking?—I think to both. Supposing the air were passed through a fire, which I think is the proposition, it could consume nearly a ton of coals in an hour; but I think it possible by the construction of a furnace in which much might be heated not passing through the fire, that perhaps a fourth part of that coal might produce the temperature required to obtain the draught. It is this and such other circumstances that induce me for the present to suspend my opinion with regard to the practical application. I think it is worth the trial, if it can be done on a small scale, because the object is good and the principle is correct.

2432. Do you conceive that this principle might be tried in any isolated sewer or any small branch of the sewers?—I should

imagine perfectly ; but I am not acquainted with the construction and connection of the sewers so as to answer the question.

2433. And what, in the event of creating this current of air the effect of what are called the gully holes would be. You see that is the difference in principle amongst these gentlemen ; some maintaining the gully holes ought to be stopped up entirely by traps, which is an additional expense, and some supposing the in-draught through the gully holes would merely increase the general current of air, and facilitate the operation ? —The closing of the gully holes, either altogether or in part, I think must depend on experience. If all were left open, it is impossible the draught could reach to the further end of the sewer, and if all were closed, the draught itself might be retarded, and not so good an effect obtained as if some were opened.

2434. Then, if this plan were adopted, you would treat the gully holes like the ventilating traps in a mine, to open and shut to create particular draughts ?—I imagine that would be quite essential, and I am not sure that with different winds different sets of gully holes must not be opened and closed, according as the wind bore up and down one street or another.

2435. You conceive the possibility of such a plan as this, if not attended with too much expense, producing effects that would be highly conducive to the general health of the metropolis, so far as getting rid of the noxious vapors that now arise from the sewers goes ?—Certainly.

2436. You have no other suggestions to make with respect to this plan ?—No ; I would wish to guard my opinion in the same manner, as the evidence which has already been given by Mr. Fuller is guarded, by saying, " I cannot give a strong one until something like an experiment is made."

2437. Should you think the expense of that experiment, on a sufficient scale to enable you to pronounce as to the practicability of the plan generally would be very great?—I think it would not be very great as compared with the importance of the object, but I am not acquainted sufficiently with the sewers to have a strong opinion on that head.