

The general malaria of London, and the peculiar malaria of Pimlico, investigated, and the means of their economical removal ascertained / by Andrew Ure.

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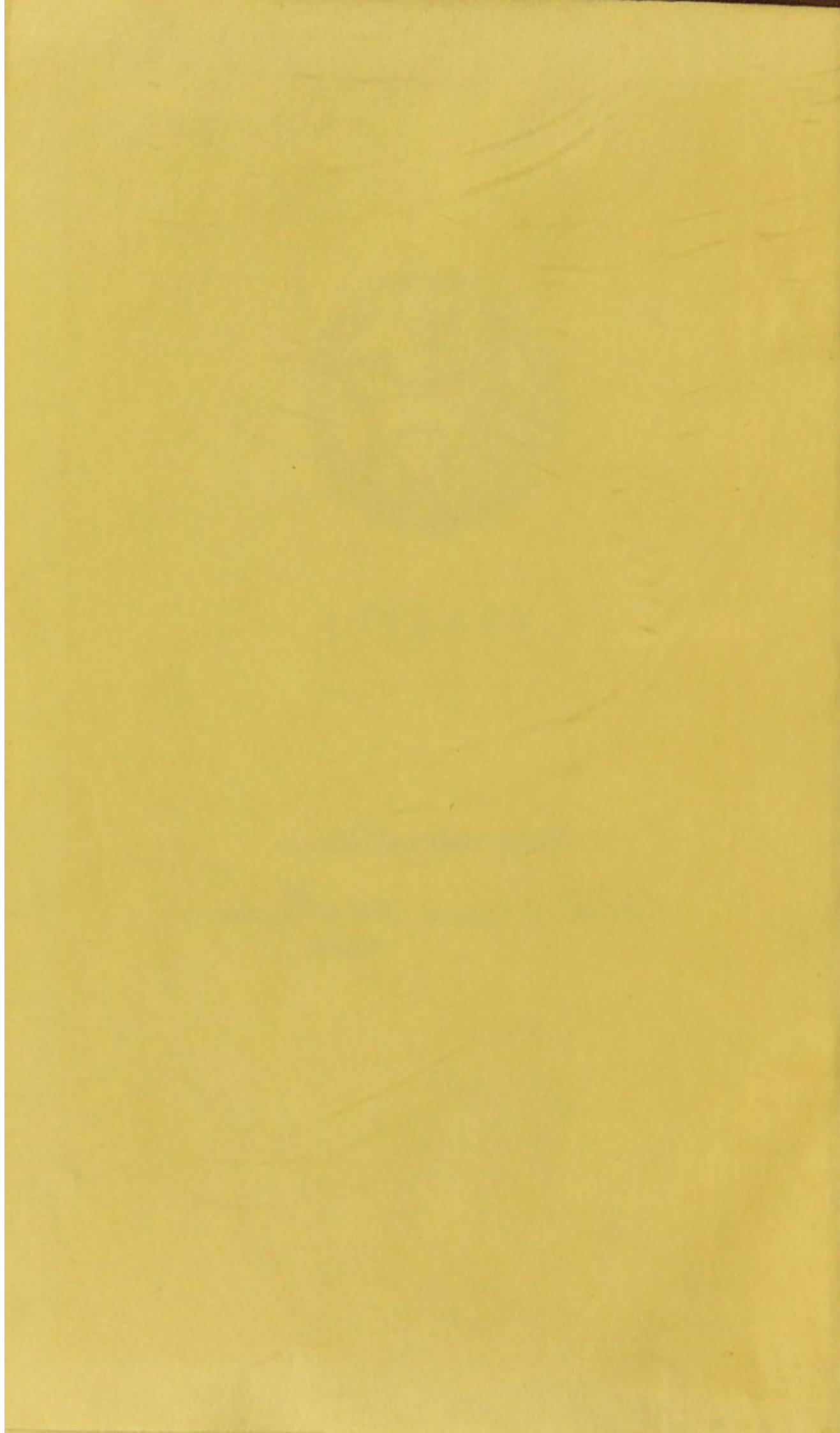
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To the Marquess of Breadalbane
From his obliged *THE* *faithful Servt.*
The *Author*

GENERAL MALARIA OF LONDON,

AND THE

PECULIAR MALARIA OF PIMLICO,

INVESTIGATED,

AND

THE MEANS OF THEIR ECONOMICAL REMOVAL
ASCERTAINED.

By ANDREW URE, M.D., F.R.S., &c.

24, Abchurch Lane

“ Sulphuretted hydrogen produces immediate decomposition of the blood, when
admitted to the lungs.”—LIEBIG.

LONDON:

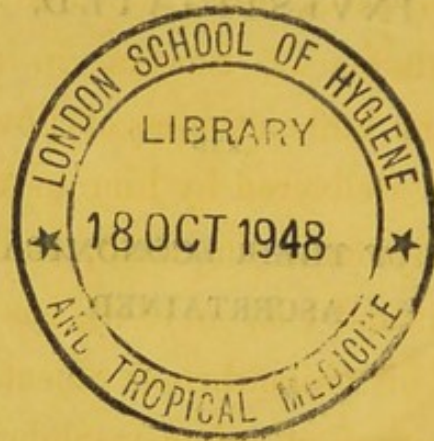
Wm. S. ORR & CO., 2, AMEN CORNER, PATERNOSTER ROW.

1850.

34740

GENERAL MALARIA OF LONDON

SPECIAL MALARIA OF PINNAC



BY ANDREW CURE M.D., M.R.S., &c

[Handwritten signature]

...of the blood, when ...

LONDON:

... & ...

PRINTED BY W. CLOWES AND SONS, STAMFORD STREET.

P R E F A C E.

VISCOUNT EBRINGTON, now Chairman of the Metropolitan Commission of Sewers, in an interesting "Lecture on the Unhealthiness of Towns, its Causes, and Remedies," delivered by him in the Mechanics Institute, at Plymouth in 1845, and published by Charles Knight and Co., in 1846, has clearly traced the outlines of his philanthropic object. He adduces three main sources of urban insalubrity: 1. Insufficient supply of fresh water; 2. Accumulation of putrescent filth; and 3. An inadequate quantity of fresh water for drinking, cooking, and washing. He makes manifest the intimate connexion between these three evils, by asking "How can you ventilate to advantage if, instead of fresh air, the window admits only poisonous gases? How can the sewers be kept clear, or the house, person, or clothes clean, without an abundant supply of pure, soft water?"

At the public meeting held in London on the 6th of February, 1850, the Bishop of London, who presided, said most justly: "There was reason to lament

that the provisions made for improving the sanitary state of London had, up to this time, proved by no means satisfactory." On the same occasion Lord Ashley observed that "The condition of the metropolis in a sanitary point of view was not only perilous to those who resided in it, but was an absolute disgrace to the century in which they lived. The water they drank, the air they breathed, the surface they walked upon, and the ground below the surface, all were tainted and rife with the seeds of disease and death. The state of the sewerage was in many parts in such a condition, as to be the seed-plot of disease and death. Then, to crown all, the Thames itself, which should be the source of health, refreshment, and salubrity, was polluted by everything foul and pestilential."

(5)

THE
GENERAL MALARIA OF LONDON,

&c. &c.

IN the following brief Essay I hope to be able to make such a contribution towards abating the great evils, so well portrayed by these three distinguished philanthropists, as may become an individual whose earlier years were spent in the study of medicine, but whose prolonged, mature life has been diligently devoted to the practice of chemistry, and chiefly to its highest and most difficult function, that of *analysis*. The pursuit of truth, irrespective of interest, passion, or prejudice, ought to be the sacred duty of every professor of this marvellous department of knowledge; but it is deplorable to witness how often sophistry is preferred to sound logic, hypothesis to experimental fact, and darkness to light, when sordid ends are in view. It is greatly to be lamented that chemistry, embracing as it does in its modern expansion all the properties and transmutations of material forms, should be scantily, if at all, cultivated in our magni-

ficent seats of learning, and hence not comprehended in its rudiments or even in its alphabet by our otherwise accomplished literary statesmen. Hence it is we hear of paraffine candles made of Irish turf being extolled in the House of Commons, and of a spurious composition candle, made mostly of wax, being put into the hand of our Prime Minister, as an earnest of the means of giving comfort and peace to Ireland. Hence, Great Britain possesses no scientific tribunal, as France, Germany, and even Russia have in their Academies, composed entirely of men of approved science, and not swarming, like our Royal Society, with vain dilettantis, having the form of philosophers, but strangers to their power or methods of research. In those countries of the continent, disputes involving questions of physical science are speedily, cheaply, and satisfactorily settled by competent judges; whereas in this country they are implicated in the fictions and chicanery of lawyers, equally ignorant, presumptuous, and sophistical, then disposed of by a jury no better informed, after being mystified by well feed professional witnesses, often little impressed with the sanctity of an oath, as an appeal to the Omniscient Judge for the perfect truth of their testimony in all respects. A witness of this stamp will launch out into a *mare ignotum*, and deliver as verities things which he has not seen, and which are afterwards proved to be Munchausen fables.*

* See the Evidence before the Coroner's Inquest at Pimlico, in the *Times* of October 23, 1849.

I recommend the following admonition of a great moralist to all who mount into the witness box,—“the person who takes an oath imprecates the vengeance of God upon him if the oath he takes is false.” However general these introductory sentiments may now appear, they will be found peculiarly appropriate to our subject in the sequel.

The malaria of London, as the emanation of an immense Augean stable, for the cleansing of which only the joint Herculean powers of modern mechanics and chemistry, when well directed, are at all competent, was first strongly pressed on my professional studies by Mr. Phillips and Mr. Gotto, chief surveyor and assistant surveyor of the Metropolitan Commission of Sewers. These two gentlemen, entire strangers to me, called at my house on the morning of the 13th of October, 1849, bringing with them a bottle of greenish coloured fetid fluid, and some lumps of a soft, greenish-white, stony matter, both of which they requested me to analyse. Mr. Phillips said the fluid was taken by himself from the inside bottom of a sewer, and the earthy matter from the outside arch of the same, in Kenilworth-street, Pimlico, in which five men had been killed by suffocation with poisonous gases in the course of the previous evening and morning. The dead bodies were of a bronze-blue colour, more particularly about the mouth, neck, and breast.

In the surveyors' report of Messrs. Phillips, Gotto, and Lovick, presented to the Board of Commissioners,

and read at their general meeting on the 17th of October, it is stated, concerning the fatal sewer in Kenilworth-street, that it "is of brickwork, 418 feet long, 4 feet high, and $2\frac{1}{2}$ feet wide. Where the sewer now terminates at its southern end a temporary wall was placed to prevent mischievous boys from getting into the sewer. It was intended, as the street progressed, to continue it to sewers which discharge into the Thames;" but only three houses were as yet built in this branch street, and these had been occupied only a few months. "The northern end of the sewer is connected with the sewer in Warwick-street," which is long and well-peopled, and runs nearly at right angles with the former. "There are no gulley-drains" (side holes in the arched top), with the exception of two close to Warwick-street, laid to take off the surface-water, which in consequence soaks into the ground, and *penetrates into the sewer*. The two gullies and all the drains are trapped (closed with valves); no sewage, therefore, other than from the three houses, runs directly into it. The accumulation (deposit) is about one foot in depth, consisting of earthy matter and rubbish, covered with a dark, green, fetid fluid.

"Upon carefully examining the ground forming the sides of the trench made over the sewer to get at the men, Mr. Phillips noticed at one place a stratum of green coloured matter, six inches thick, about five feet above the sewer. He immediately procured some of this matter, which consists of lime refuse,

used in purifying gas. Its smell being similar to the putrid smell issuing from the sewer, he thought it probable that, when the men entered the sewer to measure the deposit, it was full of gas emanating from this lime refuse, from its having impregnated the surface water which, in its passage downwards, saturated the adjacent ground, and percolated through into the sewer. The men died immediately under the spot where the lime refuse was found.

“In order to ascertain whether the accumulation in the sewer was impregnated with this gas, he went to its lower end and there filled a bottle with the fluid, which, with the refuse he had previously taken out of the trench, he carried to Dr. Ure, and requested him to analyse. Dr. Ure has done so, and we beg to append his report upon the subject.

“The ground around the sewer is, in our opinion, still charged with deadly gas, which, if allowed to remain, will continue to find its way into the sewer as well as into the adjacent vaults and houses, and the sewer will be unsafe to enter. We would, therefore, beg to suggest that the ground, down to the level of the sewer, be at once removed, deodorised, and buried under inspection in some unobjectionable place, where it cannot again exert a baneful influence, and we would suggest that measures be taken to prevent any deleterious deposit of this nature from being placed in future near to or in connexion with any of the sewers.

“In all our experience in the sewers we have met with no similar case. It is of so extraordinary and exceptional a character that, apart from the catastrophe itself, a close investigation of the subject, with a view to the adoption of such measures as the development of the whole of the deleterious causes may point out, is of the utmost importance, and is a point to which we would beg respectfully to direct the special attention of the commissioners.

“To what extent the trapping of the openings into this sewer may have influenced its unhealthy condition is one important point, which we believe would be elucidated by this investigation.

“JOHN PHILLIPS, Chief Surveyor.

“E. GOTTO, Assistant Surveyor.

“T. LOVICK, Assistant Surveyor.”

October 16, 1849.

Report by Andrew Ure, M.D., F.R.S., Professor of Chemistry, of the analysis of a watery green fetid liquor, taken from the bottom of a sewer in Kenilworth-street, Pimlico, and of a greenish earthy matter, taken from the ground over the sewer; both of which were placed in my hands by Mr. John Phillips, Surveyor to the Commissioners of Sewers.

“I find that the earthy matter is the refuse lime of gas-works, impregnated with sulphuretted hydrogen, certain Prussic acid compounds, and a little am-

monia, as hydrosulphuret. These three substances are all exceedingly noxious to life in their separate state, and they are liable to be liberated by the action of the carbonic acid of the atmosphere, to be washed out by the rains, and to percolate down through the crevices and joints of the arched roof of the sewer. That this is the case, is demonstrated by the analysis of the water in the sewer, which has exactly the green colour imparted to pure water by the calcareous compound, possesses the very peculiar fetid smell of sulphuretted hydrogen, and affords to chemical re-agents the characters of this gas, as also of Prussic acid and ammonia. Certain animal exuvia may also be readily detected in the said water, as urine, &c., the whole forming a mixture remarkably deleterious, and emitting most offensive and oppressive exhalations, so that paper dipped in a solution of silver or lead, and held over a vessel containing some of that green liquor, becomes immediately of the glistening black colour, corresponding somewhat to the hue imparted to the skin and blood of persons killed by breathing an air impregnated with such matters. The presence of the Prussic acid, or sulphocyanogen poisons in these effluvia is a striking peculiarity, proceeding, no doubt, from the layer of gas lime imprudently shot as a filling-up rubbish over the sewers. It is not to be wondered at therefore that a very few inhalations of the atmosphere in the said sewer should have caused asphyxia and death in Mr. Wells and the man who accompanied

him. I may observe that sulphuretted hydrogen and carbonic acid gas, both present in that sewer, being in mixture with Prussic vapour, form an air heavier than that of the atmosphere, and thereby would be found to prevail chiefly near the bottom of the sewer, so that Mr. Wells and his companion, on stooping down to search for the dead bodies of the workmen lying there, would come to inhale the concentrated gaseous poison, and drop instantly down on their faces, in which position their own bodies were observed to lie.

“ANDREW URE.”

“*London,*
24, *Bloomsbury-square, Oct. 15, 1849.*”

At the coroner's inquest held in Pimlico on the 18th October, and reported in the journals of the 19th, Mr. Phillips stated in his examination upon oath, that “the deposit could not have been the result of house-drainage, seeing that as yet there are only three houses in the street. The sewer is not yet completed; there were, in fact, no means of ventilation. The deposits from house-drainage were not sufficient to account for the gas. The deposits consisted of earthy matter, sand, filth, and water, quite different from house sewage. I can account for the foulness of the drain. Immediately after the accident I examined the sewer, feeling confident that the house deposits had not been sufficient to cause the mischief. Close to where the men were found

dead, I found a layer of lime that had, I presume, been used at a gas manufactory for the purpose of purifying gas, which I believe is an unusual thing to be found in a sewer. It was about six inches in depth, and extended through the whole of the open portion.* *I never knew such a material to be put in a sewer or near one before.* I was curious to know what it consisted of, so I got a piece which had been thrown up and smelt very badly, and I found a precisely similar smell as at the head of the sewer. I procured a bottle of the fluid from the sewer and took it to Dr. Ure for analysis. I wanted to see whether the constituents of the fluid and solid matter were the same. The accumulation was in a semi-fluid state, and was to the depth of about a foot in the sewer. I felt convinced at the time that its presence was the cause of the gas and the deaths.

“I concluded that the surface water, passing through the lime, had caused the generation of the poisonous gas, and consequently the accident. I have been in many sewers all over the metropolis, constructed similarly to this and often very full of deposit, *and in none except this were the emanations dangerous to life.* I believe that there is no sewer in London im-

* The portion of the crown of the arch broken open, to get at the dead men, and lift them out. A larger portion of the sewer was afterwards stripped of its covering of street filling up, under the direction of the surveyors, and a bed of the gas refuse, fetid lime, was found there, 18 feet long, 4 feet broad, and $2\frac{1}{2}$ feet deep; in weight about 12 tons; right above the fatal portion of the sewer, where the men dropped down dead.

mediately dangerous to life: I have frequently passed through them and stirred up the deposit with my feet.* I have passed through miles of sewers, and never found a sufficient accumulation of poisonous vapour to be immediately dangerous to life: gas often escapes from the coal-gas mains, and I took a Davy lamp to prevent explosion."

The Surveyors' Report and mine to the Commissioners were published next morning in the newspapers, and excited a strong sensation everywhere, but especially among the building craftsmen in Pimlico—a numerous and influential class in that rapidly growing district, with whom the gas refuse lime was a much more tender point in their body corporate than was at that time conceived, because enormous quantities of it had been used there to fill up and indurate the sunk, swampy ground. Accordingly, a number of them got placed on the inquest as jurymen, with the foreman at their head, aided by the attorney of the chief builder of the whole region, to advocate their cause, and perplex, if possible, the dispassionate, straightforward testimony given by Mr. Phillips and me. Instead of a solemn tribunal convened in the spirit of a venerable law, to judge calmly of the cause of the sudden deaths of five vigorous men, there was a noisy mob, jostling one another to and fro, while the foreman vociferated a multitude of preposterous, irrelevant questions, superseding the functions of the

* The feet and legs are protected from the soil, often two to three feet deep, by long boots.

coroner, who at last exclaimed, "You have taken the matter out of my hands; I will give it up, and have nothing more to do with it."

When Mr. Phillips complained of the ill usage to which he was subjected, he was told by an influential actor in the bear-garden scene, that the building faction was resolved, at all hazards, to obtain a verdict of acquittal in regard to the noxious operation of the gas-lime refuse, and to get the whole blame thrown on the Sewers' Commission, for neglecting to cleanse the drain. This sinister purpose was in a great measure gained at an adjourned Coroner's inquest, a few days afterwards, at which the utmost tranquillity reigned, because the craftsmen and land-jobbers of Pimlico had it all their own way. Several chemists had been set to work in the interval, and were brought forward to rebut or neutralize Mr. Phillips' testimony and mine, by declaring on oath that "the gas-lime has in no way contributed to the fatal result, and that no Prussic acid or cyanogen compounds could be detected in the mud of the sewer (in Kenilworth-street), nor in the fluid which floated above it."* The main arguments they relied upon to prove a negative, in support of these bold, sweeping affirmations, were three:—

1. That the chemical tests employed by them showed no reaction of Prussic acid or its cyanogen compounds.

* *Times*, October 23, PIMLICO SEWERS.

2. That the crown of the sewer arch was not stained green by the percolation of the fluid.
3. That the excrementitious matter from the three houses was sufficient by its corruption to generate the poison gases.

The first argument was doomed to a suicidal end, after a brief existence of eight days, for their chief orator, the one admired and lauded of the jury, at that day's inquest, announced, in a formal report presented to the Board of Commissioners on the 1st of November, that *Prussian blue* did actually exist in the mud of the said sewer.

What renders this confession the more astounding is, that on the same day his chemical coadjutors and fellow witnesses, published in the newspapers elaborate denials of their leader's admission, obviously for want of all rational concert in concocting vindications of their views, and in their haste to meet the demonstrations of the truth of my first Report to the Commissioners, contained in a supplementary one inserted in the 'Daily News,' 'Morning Chronicle,' 'Herald,' 'Post,' and 'Advertiser,' of the 26th of October, but rejected by the 'Times,' for reasons best known to its Editor. In that second Report, aided by Mr. Lewis Thompson, the only British chemist distinguished for any important discovery on the cyanogen compounds, I proved that in the green fluid of the fatal sewer, both in the sample lifted by Mr. Phillips on the 13th, and in another, by Mr. Thompson, on

the 24th, there was so much Prussic acid as to afford, by the usual process of the apothecary, 15 drams per gallon, of Pharmacopœia strength, a quantity sufficient to kill 15 men.

The second argument was too absurd for a chemist to adduce, for the green colour caused by sulphuret of lime dissolved in water, is speedily destroyed by carbonic acid, a gas always present in the atmosphere and the soil, by which sulphuretted hydrogen is disengaged and a chalky deposit is left, coinciding with the porous mortar joints.

The stress laid on the third point was ludicrous, because the three houses, occupied by small families for three or four months, could not generate one fiftieth part of the putrid excrement which existed in the sewer of Friar-street, Borough, and others, traversed with impunity by surveyors and scavengers.

It may be added that no amount of negative testimony in such a case, nothing of the *non mi ricordo genus*, can outweigh the proof by positive production of Prussic acid, Prussian blue, and other cyanogen compounds, as exhibited in a wine-glass at the inquest by me, and as afterwards obtained by Mr. L. Thompson, Mr. Keates, Mr. Scanlan, Mr. Anderson, and other practical chemists. The testimonies of all these individuals are quite unimpeachable. They have received no fee for defending a client, and are men of undoubted integrity and intelligence. Nor is the detection of Prussic acid and cyanogen compounds, a matter of the least intricacy or uncertainty to a toler-

able chemist. Even I, though professionally engaged to make the analysis of the contents of the sewer, and of course bound to vindicate the truth of my statements, as well as to rebut false accusations against my employers, the Commissioners and Surveyors, may be held to be unbiassed, for, at the end of three months, I have received no remuneration whatever for my labour. The Commissioners received from me four successive reports; the fourth being final, in which I completed the chain of evidence and refuted all counter-statements.

The great importance of the Prussic acid proof consists in its serving to trace the poisonous effluvia of the sewer to the gas-lime, from which alone it can proceed; because, though putrefaction of organic matters gives birth to sulphuretted hydrogen, it never generates any Prussic acid compound. Cyanogen may be produced from animal substances, but only by the action of fire. I never supposed that the presence of Prussic acid vapour could have had any considerable part in poisoning the men. I viewed and stated it, as the *indissoluble link* in the chain of causes for tracing the poison to its true source. The editor of a monthly journal mystified himself in this respect. He said, "The supposition that some cyanogen compound existed in the mud or even in the liquid of the sewer, would be irrelevant. It must be shown that these compounds existed in such a form as to contaminate the atmosphere of the sewer." The critic discovers here, either an amazing ignorance of the point at

issue, or a total want of the organ of logic. Assuredly, if cyanogen compounds of any kind, or in any degree, be found within the sewer, they prove the percolation of the peculiar soluble principles of the gas-lime, with its sulphuret of lime and sulphuretted hydrogen. Every tyro in chemistry knows that sulphuret of lime, by condensing oxygen very rapidly, renders air unrespirable, and that carbonic acid gas is poisonous not only of itself, but also by disengaging sulphuretted hydrogen from the sulphuret of lime. Moreover, hydrocyanate of ammonia was found in the contents of the sewer, and its vapour is nearly as noxious as that of Prussic acid itself.

There is every reason to believe that the pernicious gases, thus shown to have instantaneously destroyed five valuable lives, are secretly exercising their morbid influence throughout the large district of Pimlico, over which their generator, the gas-lime refuse, has been most extensively distributed during a period of many years. It would be absurd to suppose that the deposit of 12 or 14 tons, disclosed by a fatal accident in a little cross street, comprehended the whole of this novel source of malaria. The fetor proceeding from the carts loaded with gas-lime having become a subject of complaint by the inhabitants of Pimlico, the carts were afterwards made to travel by night. Much of it was also imported in covered barges by the canal. Of late years the gas-lime has been partially deodorized by ventilation at the gas-works, before which

its suffocating fumes were hardly tolerable even to men accustomed to offensive smells. At present, though it is transportable without causing much nuisance, it still retains its sulphuret and cyanide of lime—two most virulent principles of sickness, disease, and death.

It is the course of divine Providence, rightly interpreted and applied, to educe permanent good out of transient evil. Should the Kenilworth tragedy lead to the discovery of hidden sources of danger to life, pervading a region occupied by a most distinguished portion of British society, it will realize that beneficent dispensation.

That some mortal agency of peculiar power is exercised in that patrician district is manifest from the Report of the Registrar-General of last December, which states that the mortality in the Belgrave district of St. George's parish was greater than that in its other districts in the proportion of 33 to 8, or *rather more than fourfold*. How well this mortality corresponds to the known morbid agency of sulphuretted hydrogen, will appear by the following description given by Dr. Alfred Taylor in his valuable treatise on Poisons:—

“This gas, when respired in its pure state,” says he, “is almost instantaneously fatal. It is found to destroy life even when it is allowed to remain in contact with the skin, though the animal is breathing wholesome air. Eminent chemists have shown that air which contains 1-800th part of it kills dogs, and

that with 1-250th it will kill a horse. One fact is worthy the attention of medical jurists, namely, that the respiration of an atmosphere only slightly impregnated with the gas, may, if long continued, seriously affect an individual, and even cause death. The men who were engaged in working at the Thames Tunnel, suffered severely during the excavation, from the presence of this gas in the atmosphere in which they were obliged to work. The case was referred to me for examination by Sir I. M. Brunel, in 1839. The air, as well as the water, was found to contain sulphuretted hydrogen, which trickled through the roof. The gas issued in sudden bursts, so as to be at times perceptible by its odour. By respiring this atmosphere, the strongest and most robust men were, in the course of a few months, reduced to an extreme state of exhaustion, and several died. The symptoms with which they were first affected were giddiness, sickness, and general debility; they became emaciated, and fell into a state of low fever, accompanied by delirium. In one case which I saw, the face of the man was pale, the lips of a violet hue, the eyes sunk, with dark *areolas* round them, and the whole muscular system flabby and emaciated. Chloride of lime and other remedies were tried for the purification of the air; but the evil did not entirely cease until the Tunnel was so far completed that there was a communication from the one side to the other, and free ventilation throughout." pp. 810, 811.

We have in this graphic but dismal description, a picture of the condition, as to malaria, of the inhabitants of Pimlico, who live under the malign influence of an atmosphere vitiated by emanations of sulphuretted hydrogen from the immense deposits of this gas-lime waste, distributed along with other rubbish in that quarter to raise the surface to its actual level, 10 or 12 feet above the old, and also to harden the ancient marsh land. The bronze blue of the victims of the gas in the sewer agrees with the violet hue observed in the lips of Dr. Taylor's patient.

Gas-lime, as a filling-up, offers a strong temptation to the builders ignorant of its noxious nature, because it may be had for the receiving at several gas-works. It cannot be employed as a manure, for it kills plants. Perhaps it may be urged by some persons that the quantity of this stuff that is produced can be of no consequence when scattered over a large surface; but a slight view of our gas-works' statistics will show the vast magnitude of its production.

About 370,000 tons of coals are annually consumed in them. Every ton of coals requires for the purification of its gaseous products about three-quarters of a bushel of quicklime, which, multiplied by 370,000, gives the total amount equal to 7725 chaldrons of lime per annum, a quantity, if piled up, approaching in bulk to that of a little hill. Its weight, also, is much increased by absorption of sulphuretted hydrogen, carbonic acid, Prussic acid, &c.,

gaseous matters which would be most injurious to coal-gas, both as to light and health, for the purpose of burning in houses or shops. This lime, so charged with noxious gases, on being exposed to rain in the ground, gives out soluble sulphuret of lime, sulphuretted hydrogen gas, and certain Prussic acid compounds, forming a mixture capable of rendering air confined in a vault or chamber, speedily irrespirable, and deadly poisonous. No gaseous combination is so instantaneously destructive of every principle of vitality as the mixture of Prussic acid vapour and sulphuretted hydrogen, evolved from the ammoniacal liquor of a gas-factory on the effusion of an acid. A single inspiration extinguishes life completely, as was exemplified in a case at Marseilles, in Mr. Philip Taylor's works a few years ago, and publicly reported in a *procès verbal*.

Let any inhabitant of Pimlico, who has any doubt as to the powerful operation of the carbonic acid gas so abundant in the atmosphere, the waters of the surface, and of wells, in disengaging from gas-lime intolerably detestable gaseous poisons, make the following simple experiment. Put a little of that stuff called commonly by the workmen *blue billy*, from its colour,* into the bottom of a tumbler or tea-cup, and decant upon it a bottle of fresh soda water. The stench speedily exhaled will be so oppressive as to

* Due principally to sulphur, iron, and occasionally a trace of Prussian blue.

require the tumbler to be instantly put outside the window.

It is somewhat surprising that, in the modern activity of enterprise, the manufacture of so valuable a pigment as Prussian blue, and that of Prussiate of potash, so extensively used by calico printers, should not have been made in this country from gas-lime, generated in such vast quantities, and applied heretofore only for purposes pernicious to the community. In France, indeed, and also in Belgium, patents have been obtained for extracting both of these commercial articles from gas-lime, and beautiful Prussian blue has been offered by sample for sale some months ago in London by Mr. Black, agent in the Adelphi. I have recently received, however, from an eminent manufacturing chemist, a sample of pure Prussiate, made from that refuse stuff, and I have no doubt, therefore, that my Kenilworth investigation will lead to the permanent establishment of that manufacture, and thereby provide a sanitary outlet in future for that source of pestilence.

The quantity of Prussic acid existing in gas-lime varies somewhat with the nature of the coals, and their treatment in the gas-works. From an experiment, detailed in my fourth and final report to the Commissioners of Sewers, dated November 8, and published in the newspapers, it is stated "that Mr. L. Thompson and I procured at a gas-work in London, from the hands of its engineer, some fresh gas-lime; and we find that water saturated with it" (such as pro-

bably filtered down into the fatal sewer) “affords per gallon 1911 grains of matters dissolved in it; viz., of lime 1330, ammonia 301, and sulphur 280, or about $4\frac{1}{2}$ ounces. The sulphur comes forth as sulphuretted hydrogen, in vast volume, when any acid, even the carbonic acid, is made to act upon it. One gallon of that gas-lime water gives off 836 cubic inches of that noxious gas, or about 3 gallons in measure, by means of dilute muriatic acid. The amount of Prussic acid may be estimated from the fact that the watery solution of fresh gas-lime produces, with the due and necessary addition of copperas (sulphate of iron), one ounce of Prussian blue for $3\frac{1}{2}$ gallons.”

It may be here proper to explain briefly how the Prussic acid, &c., are generated from coals by ignition in the retorts. Newcastle and Durham coals contain upon an average 2 per cent. of sulphur, and 1 of azote, beside their carbon, hydrogen, and earthy matters. In the 370,000 tons annually worked up for gas, there must be, therefore, 7400 tons of sulphur, and 3700 of azote. One pound of sulphur is equivalent to the production of nearly 12 cubic feet of sulphuretted hydrogen; hence, from 7400 tons of sulphur, a volume of that mortal gas so prodigious would be produced as, if let loose, would poison the whole atmosphere of the houses in London, as it has, from its density, rather an alacrity in sinking than in rising, like proper coal-gas. Fortunately, in slaked lime, either damped only, or stirred with water into a creamy mixture, a cheap substance

has been found capable of arresting and condensing the whole of that poison. This plan is now so judiciously carried on by skilful engineers, that the coal-gas distributed in the metropolis contains hardly a vestige of sulphur. The lime, however, has not destroyed, but merely fixed it meanwhile in an inactive state, so to speak, from which it may, like a torpid snake, be again revived by due appliances, as we have seen.

The azote, amounting to 3700 tons, combines partly with hydrogen to form the ammonia, so largely produced; partly with carbon, to form cyanogen; and partly with carbon and hydrogen to form Prussic acid. "Prussian blue contains, in its best commercial state, very nearly half its weight of Prussic acid, or cyanogen; hence 2 ounces of the best Prussian blue afford 50 ounces of Prussic acid, Pharmacopœia strength, a quantity competent to kill 400 men, at the rate of one dram for a fatal dose."* Prussian blue consists of 5 parts of cyanogen and 4 of iron, or, ultimately, of nearly 2·7 of azote, 2·3 of carbon, and 4 of iron, in 9 parts or pounds. Thus 30 grains or tons of azote being equivalent to the generation of 100 grains or tons of Prussian blue, the vast store of this precious commodity hitherto shrouded and wasted in a nuisance refuse, becomes a very remarkable phenomenon in our factory kingdom. This neglect is the more surprising, as the ground in and

* My Fourth Report, presented to the Commissioners of Sewers, 8th November, 1849.

all around the Westminster station of the Chartered Gas Company is deeply dyed blue by the action of the Prussic acid of the blue billy upon the iron in the soil. The percolation downwards by the action of rains here, represents that down through the crowns and sides of tunnels, which are so porous that in wet weather there is a continual trickling into them, as all their surveyors know, as is experienced in the drying of wells behind streets along which sewers are made or deepened, and as is visible to all the world under the arches of our bridges, and particularly under the arches of the Greenwich railway. In fact, were it not for that permeability of the tops of sewers, the pavement of the streets would in many places become a water-logged compost of mud and sand.

That the Prussic-acid compounds are never generated in the most putrid accumulation of night-soil, has been proved by the experiments of Mr. Thompson, Mr. Anderson, and myself, upon the contents of that very foul sewer in Friar-street, Borough. Another very complete demonstration has been afforded by the skilful chemists charged with the working up of the great Parisian *voirie* at Montfaucon, or general reservoir of night-soil from multitudinous *fosses* or cesspools. Every useful ingredient, fluid and solid, is worked up profitably there for various purposes, but never has a trace of Prussic acid or cyanogen been found.

The nature and magnitude of the peculiar malaria

which pervades Pimlico having been demonstrated by an ample induction of undeniable facts, it would now serve no good purpose to specify the localities in which the greatest quantities of gas-lime were buried, and where of course the malaria most abounds. I proceed to point out an efficacious remedy, and the best means of applying it.

The nearly dead level of that district having a fall of only 1 foot in about 3400, continuous streams of fresh water cannot be maintained in the sewers, except at an enormous expense; but the noxious gases in the sewers may be completely removed by the introduction from time to time of some sulphate or chloride of iron, both very cheap and plentiful commodities in the north of England, joined to a system of ventilation by the power of fire. By the salts of iron, the night-soil and other excrementitious matter of houses may be so perfectly deodorized as to render the removal of the thicker deposit, by means of scavengers and covered drays, quite inoffensive; while by means of a small furnace, placed near one end of a sewer, and connected therewith by an underground iron pipe, such a steady current of atmospheric oxygen may be drawn through the sewer as to decompose and consume all the poisonous gases and vapours which at present affect the health of the inhabitants by regurgitating from the sewers through the drains into the houses. By this two-fold application, the air of Pimlico would become as sweet as that of an upland country region. A very few furnace

stations would suffice under the direction of skilful engineers, of whom none is more competent for the task than Mr. Cubitt. No blame could justly be imputed to this gentleman for using the gas-lime, for had he been at all aware of its chemical composition, he would certainly never have allowed a pound of it to come upon his valuable building-grounds. The transmission of fresh air, once or twice a-week, through a series of tunnels, may be effected readily by arrangements similar to those introduced by Mr. Buddle into coal-mines, and which are now perfectly methodized. The furnaces may be set up in any convenient corner or back building, and connected with the sewers by iron tubes—care being taken by the surveyors so to regulate the gulley-holes and other orifices as to cause the fresh air to pervade every branch and turn of the tunnels, and to be finally passed through the fire, up through the ashpit. Drainage thus organized will render the duty of the sewage scavengers wholesome and safe. Flushing, or driving a torrent of water through such tunnels as require it, should not however be neglected.

The plan thus sketched in outline is neither new, difficult, doubtful, nor costly. It has been long practised with success in many chemical factories, for the destruction of noisome vapours and gases. Such a salubrious system must be deemed indispensable, especially for all low-lying, horizontal, alluvial grounds near the river Thames. With adequate slope in the sewers, the flushing plan, in so far as it is organized,

may be found sufficient. Wherever an accumulation of putrescent excrement exists, the salts of iron may be used, of which sanitary resource the cities of Lyons, Troyes, Metz, Amiens, and about twenty other towns of France, avail themselves, under the direction of their manure companies, in preparing profitably large quantities of scentless night-soil. From M. Gaultier de Claubry's official Report to the *Conseil de Salubrité of Paris*, inserted in the *Annales d'Hygiène Publique* for October, 1848, it appears that the transport in carts of the stuff so treated at Lyons occasions no nuisance whatever to the several villages through which it passes to the general dépôt, six or seven miles from the city.

Before removing, by manual labour, the more consistent night-soil from certain imperfectly-ventilated sewers, the air should be thoroughly renewed by such mechanical means as I pointed out and described in the sequel of my first Report to the Commissioners of Sewers on the 16th October, 1849, but which by an unaccountable omission was not published with it in the newspapers next day. It was there shown how the ventilating fan so generally used in the Manchester factories and elsewhere, being made of about a one-half horse-power, and mounted on wheels, might be transported anywhere, and worked conveniently by two or three men. With an upright discharge-pipe 10 or 12 feet high, and an induction-hose of leather, connected air-tight with a gulley-hole or other orifice of the drain, the air of any sewer, however long and

tortuous, might be made completely salubrious, and thus prevent the possibility of suffocating any more scavengers, while the discharged air would be so diffused in the atmosphere as to cause no nuisance. Such machines would cost little and last long, and be little liable to derangement.

The formidable and gigantic labour of clearing London and the Thames of the prodigious mass of putrescent offal and filth daily generated by upwards of two millions of human beings, with their subservient animals, may, in my humble opinion, be successfully performed by the modern resources of science judiciously applied in the following way:—Let a well or tank of moderate capacity be excavated at the outlet or *débouchement* of each main sewer into the Thames, and let pumps be fitted into it, to be worked by steam-power. Let there be erected, at a suitable height, one or more cast-iron pipes, in a nearly horizontal line, with a slight slope eastwards, over each bank of the river. These pipes must be extended onwards till a convenient locality be found for the reception, filtration, and manipulation of the sewerage. This station should be on somewhat elevated ground, with a gentle slope to the river, so that it would have the great settling-basin at the summit, furnished with ramifying canals for letting off by sluices, through basket-work or otherwise, the watery parts, amounting to probably 99 hundredths of the whole bulk. This slightly impure water should be run off through sloping pipes, terminating near the bottom of the middle of

the Thames, so that little if any of it could be carried by the flood-tide to the surface of the river so far up as Woolwich. The thicker and denser part of the sewerage is to be drawn off by a sluice near the bottom of the reservoir into the settling-tanks, from which the supernatant semi-fluid portion—a rich manure, similar to the *eaux vannes* of Paris—might be run off, deodorized, and transported in barges to fertilize lands accessible from river-banks or the sea-coast. The deposit in the settling-tanks is to be deprived of smell by peat charcoal, and at the same time so thickened as to be removable by manual labour to sloping ground under sheds, for the purpose of being so much dried as to be transportable in bulk for sale, to any port of this country or its nearest colonies. Such a compost, being of uniformly good quality, and prepared under responsible scientific administration, would fetch a remunerative price, and produce a good rate of interest for the money expended in the whole enterprise.

The range of vertical columns which support the horizontal tunnels in the line of the river-banks need not be unsightly, and could be erected without disturbing or depreciating the property in warehouses, wharves, or docks: thus all the annoyance occasioned by excavating a tunnel conveyance would be avoided. The columnar props may however be discontinued, and the main-pipes be laid in the earth, as soon as the banks of the river, or grounds through which they pass, permit. Care should be had to avoid such bends

in these mains as would be likely to cause their obstruction from any kind of offal. The sewerage at the further extremity would of necessity rise so as to issue at its original hydrostatic level.

The size of the main-pipes and general magnitude of the scheme may be approximately estimated from the quantity of water distributed by the several water companies of the metropolis, and of the average rain that falls over the space occupied by it. It appears that the quantity from six of the companies is about 52 millions of gallons on each of the six working days, or for 313 days per annum. This quantity does not include what is distributed by the Kent and Hampstead Companies; the former of which supplies Deptford and its populous neighbourhood. It may therefore be assumed that 60 millions of gallons of watery fluids are run into the Thames each of the six working days; for the raising and conveyance of which, along with that which falls from the clouds, provision must be made by judicious engineering.

The collateral advantages of the sanitary processes thus briefly indicated cannot be too highly estimated. The City of London would be thoroughly salubrified by the abstraction of its putrescent offals, and its noble river might resume its pristine poetical title of "the silver Thames." Nor does there seem to be any insuperable difficulty, in the present state of scientific skill and bold enterprise among our illustrious engineers, which could not be certainly overcome.

Useful employment would be given to great num-

bers of the idle population of Ireland and the Highlands of Scotland, in digging the peats or turf of the bogs or mosses, in drying them, and in converting them into charcoal, in ovens constructed on the plan of the railway coke-ovens. Such charcoal, well-made, has a fertilizing virtue on land. The vessels which import it to the depôt on the Thames would become carriers of the manure which had been prepared with it, to the several store-stations throughout the kingdom.

Lest any one should entertain doubts concerning the quantity of Prussic acid compounds generated in the manufacture of coal-gas, and distributed in Pimlico by gas-lime, the following unimpeachable documents from unbribed, unbiassed, and most competent chemists, are appended.

It has been shown that Prussian blue suddenly made its appearance in the disastrous sewer on the 25th of October, caused by the furtive addition of sulphate of iron to the pre-existing solution of Prussiate of lime, and that the presence of Prussian blue (Prussiate of iron) was publicly recognized and admitted by a doctor of philosophy, on the 1st of November, who had a few days before denied the existence of any such compound in the contents of the sewer, before a solemn tribunal. As the same philosopher also admitted the presence of hydro-sulphuret of ammonia, he might have learned from his chemistry that this substance and Prussian blue were incompatible (*non bene conveniunt nec in unâ sede*

morantur), and that therefore the Prussiates would ere long come forth in a fluid form like the scotched rattlesnake, to alarm, by its hissing, him and his coadjutors, as is proved by the succeeding analyses.

1.—REPORT from MR. KEATES.

“My first examination of the fluid from Kenilworth sewer was made on the 24th of October last. On the morning of that day I went to the sewer and procured from it a quantity of the sewage fluid, and also some of the gas-lime, overlying the sewer. The fluid was strongly alkaline, and in it I found, without the least difficulty, a very considerable quantity of a soluble cyanide, which could indeed at once be detected by any of the means ordinarily used to indicate the presence of Prussic acid. I also found that the gas-lime when digested in water, yielded soluble cyanogen compounds in large quantity, which could in like manner be detected with the greatest ease and certainty.

“On the 3rd of November last, I obtained a second quantity of sewage fluid. I likewise detected Prussic acid, though much less than in the former specimen.

“On the 28th of November I again went to the sewer in Kenilworth-street, and very carefully procured some of the fluid from that part of the sewer which had been opened, but five or six feet within the arch. From this specimen I estimated the quantity of Prussic acid present, and I found it equal

to $6\frac{1}{2}$ grains of the acid, of Pharmacopœia strength, to every pint of the fluid ; a quantity which I think, Sir, it would prove a somewhat hazardous experiment to swallow ; albeit, if I remember rightly, one of the gentlemen who examined the contents of the sewer, offered to perform that feat with all the acid which could be extracted from a much larger quantity of the sewage fluid.

(Signed) T. W. KEATES,
Analytical Chemist."

5, *Tillotson-place, Waterloo-bridge Road,*
December 15, 1849.

2.—REPORT of Mr. ALFRED ANDERSON.

"On the 27th of November I obtained, by my own hands, two gallons of the clear liquid floating on the mud of the sewer in Kenilworth-street, as well as a portion of the mud itself. A considerable part of this fluid I handed over to Mr. Scanlan, and reserved the remainder to myself for chemical examination.

"I found the clear fluid slightly alkaline to test papers, and it exhaled a peculiar odour, such as I have never before found in sewers or cesspools. On rubbing a small quantity of it with carbonate of lead and filtering into a mixture of sulphate of iron, mixed with a little muriatic acid, I obtained Prussian blue. A precipitate of carbonate of lime was obtained on the addition of carbonate of soda ; and the blood-red colour, characteristic of sulpho-cyanogen, was obtained

by the addition of perchloride of iron. The quantity of Prussian blue from one pint and a half of the fluid of the sewer, amounted to 7-tenths of a grain (three and 7-tenths grains per gallon), equivalent to two grains of absolute Prussic acid, or 100 grains of the Prussic acid of Pharmacopœia strength.

(Signed) ALFRED ANDERSON,
Experimental Chemist."

*Friar-street, Borough,
December 12, 1849.*

3.—REPORT from Mr. MAURICE SCANLAN, Superintendent for these many years of the great chemical laboratory of Messrs. Davy, Macmurdo, and Company, and well-known to the chemical world by his important researches and discoveries.

"I have examined the contents of a gallon bottle of fluid, taken from the sewer in Kenilworth-street by Mr. Alfred Anderson, and handed me by him on the 27th of November. This fluid was colourless, smelling of sulphuretted hydrogen. It restored the blue colour of reddened litmus paper, afforded a precipitate of carbonate of lime on the addition of an alkaline carbonate; and when tested in the usual way with appropriate salts of iron, gave immediate and abundant evidence of the presence of Prussic acid and sulpho-cyanogen compounds. After the removal of the sulphur, by carbonate of lead, I found one gallon of the liquid to contain Prussic acid equal in quantity

to four and one-third grains of dry Prussian blue. The persulphate of iron caused in the desulphuretted fluid the characteristic blood-red colour of sulphocyanogen in great intensity. A similar blood-red colour was exhibited by the fluid distilled from the sewage liquid mixed with phosphoric acid, when the persulphate of iron was added to it.

(Signed) "MAURICE SCANLAN.

"*Chemical Works,*
"25, *Great George-street, Bermondsey.*"

These documents illustrative of the continuance of much Prussic acid in the sewer, several weeks after the coroner's inquest, during which interval it had been to a great extent stripped of its gas-lime covering, by orders of the surveyors, may be fitly concluded by that of Mr. Lewis Thompson, an eminent experimental chemist.

"SIR, "London, December 15, 1849.

"On the 23rd October last I procured a genuine sample of the fluid contents of the sewer in Kenilworth-street, Pimlico, and at the same time a small quantity of the gas-lime refuse lying upon the arch of that sewer. The gas-lime, when treated with water, gave a solution containing sulphuret, sulphocyanide, and cyanide of calcium. The fluid of the sewer contained exactly the same three ingredients, with a portion of organic matter, and hydrosulphuret of ammonia. The quantity of hydrocyanic (Prussic)

acid which the fluid of the sewer yielded on distillation, was in the proportion of 18 grains to every imperial gallon, an amount equivalent to 900 grains of common medicinal Prussic acid of the strength ordered by the London Pharmacopœia of 1836.

“I have since examined five different samples of fluid taken from separate parts of the same sewer, and found the same three ingredients above mentioned in each sample. I have, moreover, analyzed with much care a great variety of fluids collected from various sewers in London, but without finding even a trace of any one of the three substances in question, and by which the fluid of the Kenilworth sewer is peculiarly distinguished from that of all other London sewers out of Pimlico. As it is physically impossible that the sulphuret, sulphocyanide, and cyanide of calcium contained in the fluid of Kenilworth sewer could have been generated from natural causes, the inference that they were brought there by percolation from the superincumbent mass of gaslime refuse seems to my mind absolutely irresistible. Such being a candid review of the chemistry of the subject, I have no hesitation in declaring my unqualified conviction, as a medical man, that the atmospheric air of the Kenilworth sewer must have been vitiated by the percolation from above, in such a way as to render it altogether unfit for human respiration.

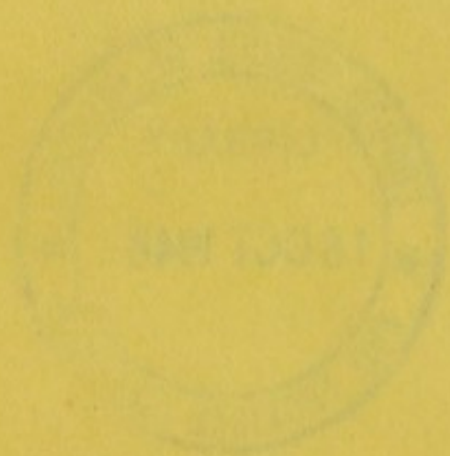
(Signed) “LEWIS THOMPSON,

“Member of the Royal College of
Surgeons of London.”

Dr. Ure, 24, Bloomsbury Square.

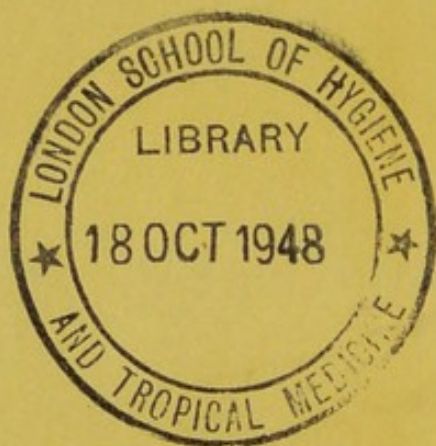
... which the fluid of the sewer yielded an alkali
... in the presence of its gases to every
inert carbon, as a result equivalent to 200 grains
of common medicinal Ferrous acid of the strength
ordered by the London Pharmacopoeia of 1836.
I have since examined five different samples of
this sewer fluid, separate from the main sewer,
and found the same three ingredients above men-
tioned in each sample. I have moreover analysed
with much care a great variety of fluids collected
from various sewers in London, but without finding
even a trace of any one of the three substances in
question, and by which the fluid of the Kenilworth
sewer is peculiarly distinguished from that of all other
London sewers out of London. As it is physically
impossible that the sulphur, sulphuric acid, and
cyanide of calcium contained in the fluid of Kenil-
worth sewer could have been generated from natural
causes, the inference that they were brought there by
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time reference to my mind absolutely irresistible.
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pheric air of the Kenilworth sewer must have been
vitiated by the percolation from above, in such a way
as to render it altogether unfit for human respiration.

(Signed) Lewis Thomas,
"Member of the Royal College of Physicians."



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